TRACING STUDENTS’ UNDERSTANDING OF INSTANTANEOUS CHANGE

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Abstract of the Dissertation

Tracing Students’ Understanding of Instantaneous Change

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Students are often taught higher level math the same way their teachers were taught, using textbook models, function, and graphical representations. Modern research in mathematics education encourages teachers to create situations where students are able to experience math to develop understanding. The Catwalk problem was designed to develop a students’ understanding of a fundamental concept of calculus, instantaneous change. This research will address the following questions, 1. What physical and mathematical knowledge and strategies do students use to solve this problem? 2. What mathematical arguments do students use to support their solutions to the problem? 3. How do, if at all, students distinguish between instantaneous and average rates of change, and 4. If so, what methods do they use?

This problem asks that students find the speed of a cat in two particular still photographs out of a series of 24. The problem solution called for the development of a conceptual understanding of instantaneous change as opposed to average change. Because the difference in the cat’s velocity before and after the frame was dramatic, some students were opposed to representing the change as an average. The students used mathematical models including data sets, graphical evidence, and velocity calculations to argue knowledge they developed from experiencing the catwalk firsthand. The students
developed a physical model that allowed them to experience kinesthetically what they witnessed the cat do in the photographs. This physical experience guided the mathematical and verbal arguments of the students, both for and against the use of average velocity to solve this task.

The Summer Institute was fundamentally a research institute (Maher 2005). The students were given specific problems so that the researchers were able to gain insights into how the students thought about solving the problems as well as what the students learned from the problems. Given a learning situation instead of a research situation, the same outcomes are desirable (development of physical and mathematical understandings of instantaneous change). With minor encouragements educators can extend this problem to include the conceptual understandings of limits and continuity. We also learn that higher mathematics can be experienced, and internalized through that experience.
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Chapter 1 – Introduction

1.1 Statement of the Problem

This study will address the development of high-school students’ early ideas relating to instantaneous rate of change as they work together in an informal, summer institute environment. Specifically, I will examine how this concept is developed in the context of a rich mathematical problem, Cat Walk.

1.1.1 The Problem - Cat Walk

Eadweard Muybridge (1830 – 1904) was a photographer born in England who crossed the United States in the 1880’s. In order to settle a bet, (whether all four of a horse’s hooves were off the ground at the same time while a horse was in motion) Mr. Muybridge developed a means of taking pictures at split second intervals. These pictures as well as many other pictures of animals and humans in motion were published in 1887 in a book entitled Animal Locomotion. One of the animals that Mr. Muybridge captured on film was a cat in motion:

Figure 1 Catwalk Photographs
The 24 pictures were taken in time intervals of .031 seconds against a backdrop of 5 centimeter lines, every 10th line was heavy.

The problem studied in this paper is based on these photographs and the following questions:

Based on information you can gather from the photographs:

1. How fast is the cat moving in Frame 10?
2. How fast is the cat moving in Frame 20?

1.2 Instantaneous Change

The New Jersey Core Curriculum Content Standards (NJCCCS) indicate that students in the State of New Jersey will learn to use the Cartesian Coordinate Plane by the end of the fourth grade, first by learning how to plot points in the first quadrant (NJCCCS 4.2.4C.1 Adopted January 9, 2008), and in all four quadrants by the time they finish the seventh grade (NJCCCS 4.2.7C.1). The NCTM Standards encourage students by the time they finish sixth grade to “Explore relationships between symbolic expressions and graphs of lines, paying particular attention to the meaning of intercept and slope.” (NCTM Principles and Standards for School Mathematics Copyright 2000, pg.222)

According to the NJCCCS, as soon as students are able to plot points and draw lines that connect points, they should be able to “Draw freehand sketches of graphs that model real phenomena and use such graphs to predict and interpret events” (NJCCCS 4.3.5C.2) particularly as they apply to “changes over time” and “rates of change”. Examples that the State uses to illustrate these standards deal with growth rate of plants over time and changes in temperature over time.
Both standards tell us to pay attention to meanings and different interpretations. The NCTM Standards tell us to pay attention to the meaning of slope, and the New Jersey Standards tell us to pay attention to slope, citing examples of events that have already happened. However, neither Standard addresses at an early stage the idea that the motion and the events that we are considering in these examples are events that can and often do occur continuously.

A problem then arises when it becomes important for a student meaningfully to think about change that is occurring at a specific moment. It is natural to think of that event as a static occurrence that happened in isolation instead of being part of a fluid spontaneous occurrence that could be measured instantly.

In the middle grades, students are expected to learn that in order to assign value to the slope of a line they need two distinct pairs of coordinates and then are asked how to determine a representative value of the slope of that line. At some time in high school we begin to ask our students to think of events that do not transpire with consistency or linearity. The focus is on isolated graphical representations generated by a function that may be removed from any authentic context. The function may be monotonic or constantly changing or fluctuating either in an increasing or decreasing manner or in some cyclical pattern. When viewed in the context of a problem presented in text-book form, the representation of the problem is one in which the event was considered to have happened already and therefore there is no actual motion; the problem is static. Consider an example: A baseball is hit at a point 3 feet above the ground at a velocity of 100 feet per second and an angle of 45 degrees. The path of the ball is given by the function $f(x) = -0.0032x^2 + x + 3$ where y and x are measured in feet. Will the baseball clear a 10-
foot fence 300 feet from home plate? (Precalculus, Larson/Hostetler 6th edition page 32). The problem identifies velocity, angle of elevation, path of the ball and is even illustrated by a graph of the function overlaying a baseball player. Even considering the choice of the word ‘is’ at the beginning of the problem, the language suggests a situation in which the ball was already hit, thus suggesting no need for us to consider any type of change; the problem is solved by applying routine algebraic procedures.

High School textbooks do not address what it means to examine the slope of a curvilinear representation or even how to measure the slope of the curve (Precalculus, Larson/Hostetler; Precalculus, Blitzer). Generally speaking, if the textbook does not ask a question regarding the slope of a curve, the idea is not addressed in a math class. Consequently we do not ask if you require two points to determine that curvilinear slope. We do need to ask what it means in the context of a problem when the behavior of a curvilinear function at \( x = c \), and \( x = c + \Delta c \) is drastically different, and how is this difference interpreted while thinking about a problem. What are you actually measuring when you find the slope of a curve using two points?

When examining the slope of a curve, the concept of one point creating a line of tangency that represents the phenomenon of motion as represented by data is not intuitive. Motion must be looked at as a continuously changing event that can be modeled by data and functions, and is not just identified by a graphical representation. Speiser and Walter (1996) emphasize the idea that motion is a paradigm for most of calculus, the part of mathematics that examines change. (Speiser and Walter1996)

The concept of instantaneous change, something that is interpreted as the slope of the line tangent to a curve, is principle to the definition of derivative (Calculus, Stewart...
For any student to be successful in a course in calculus, the student must first be able to make the paradigm shift from static representation in algebra, to that of algebra in motion. This paradigm shift will allow us to measure the data that is the function and interpret what it represents rather than trying to understand the influence of a function in isolation (Speiser and Walter 1996)

1.3 The Purpose of the Study

The purpose of this study is to trace students’ development of the idea of instantaneous change during the course of solving the Cat Walk problem. I propose to identify the methods that students used to develop their solution(s) to the problem, as well as ideas that were discarded by them. Also, I will trace whether the students were, if at all, influenced by the ideas of others.

1.4 Research Questions

The Cat Walk problem was designed to promote the development of students’ building the fundamental idea of instantaneous and average rate of change. This research will investigate the following:

1. What physical and mathematical knowledge and strategies do students use to solve this problem?

2. What mathematical arguments do students use to support their solutions to the problem?
   a. How, if at all, do students relate to the differences between instantaneous and average rates of change?
b. What were the methods they used to identify the instantaneous rate of change of the cat in frames 10 & 20?

1.5 Necessary Conditions for the Research

A few necessary conditions should exist in order to study the development of mathematical ideas. An appropriate authentic problem should exist that has as its underlying structure the mathematical ideas that you are trying to elicit in the students’ construction. The topic should encourage students to communicate and argue mathematically both in written and verbal forms, and in small and large settings. The problem should also build on a student’s prior mathematical knowledge (Lesh and Lamon, 1994). Since all students learn at a different pace, depth, and manner, the problem should also afford and encourage students to take different avenues to a reasonable solution.

Another necessary condition is the environment in which it occurs. A thoughtful authentic problem requires that the participants be able to communicate at various levels (written, verbal, technologically, by example) and freely with several other participants. Researchers in the room should only provide direction to student queries, in other words questions should not be answered directly rather with a question that might provide thoughtful direction. As part of the environment there should be enough different materials available for student use that would encourage different levels of learning and student experimentation.

There should also be a rich data base that will allow examination such as the Rutgers Summer Institute held in July 1999. The data should include videotape (digitized videotape), student and researcher notes.
1.6 Background

The data for this paper will come from a longitudinal study initiated in 1989 with a class of 18 first grade students in Kenilworth NJ (funded in part by NSF grants MDR 9053597 and REC-9814846). The study followed these students from elementary school through high school and beyond tracing their development of mathematical ideas. The elementary years of this longitudinal study were spent in the classroom environment up to six times per year for up to three days per visit. The students were asked to think about mathematical ideas in open settings and present arguments they felt were convincing to themselves and others, and by extension they were asked to consider general forms of their solutions (Maher, 2002).

For a time the high school in the community was regionalized which forced students in this study to attend other high schools both public and private. When the town high school was reopened in 1997 many of the students were reunited and voluntarily continued the “Rutgers Math” as an after school type program, taking place either in people’s houses or in the school after hours (Maher 2002).

As a part of this study, Rutgers ran a two-week Summer Institute for high school students in July 1999. The institute ran at the David Brearley High School in Kenilworth but was not limited to the students at the high school. Many of the participants of the longitudinal study were present. The final three days of the institute were devoted to the Cat Walk problem. None of the students present had taken a class in calculus. (Annenberg 2000)
Chapter 2: Methodology

2.1 Data Source

The main sources for the data are the following:

1) Videotapes that have been digitized capturing students’ behavior as they work on the task,

2) Written work as well as downloaded graphing calculator work of the students collected after the sessions and

3) Researcher notes. Triangulation of data provides multiple sources and provides for greater validity of transcription and conclusions. (Creswell, 1994)

My research will focus on what a camera captured for one of the three groups of students who worked together on the problem over a four day period. Table 1 included Jeff, Brian, Romina, Magda, Ankur, and Aquisha. Also, a roving camera captured the movements of the students when they left the table. I will trace the ideas that these students developed and/or discarded over the three days that they worked on the problem and the solution(s) they presented to the entire group. A coding will be used to tag new ideas, obstacles to ideas, and critical insights, which will be traced.

I will focus on what understandings students make regarding average and instantaneous change, what differences they identify, and how these differences develop their solution and arguments.

2.2 The Setting

The students worked primarily in the Library of the David Brearley High School in Kenilworth NJ. The students were arranged around three tables of five or six students.
Some of the activities that led to the development of solutions took place in a hallway adjacent to the library. Most of the tables had two camera’s recording students’ work, with microphones on each table. Individual researchers monitored student progress maintaining contact with specific tables. At most tables there was at least one camera with table top microphones to capture student activities as well as conversation. Located at the front of the room was an overhead projector used to project data from the students calculators to a screen to present ideas or share conclusions. This video data will form the data for the development of student ideas.

### 2.3 Data Collection

A common thread in the analysis of data from this project has been the analysis of video data, student work and researcher notes. While we cannot say for certain exactly what a student is thinking at any moment when engaged in a mathematical problem, we can piece together evidence, and infer student thought using the video data, and student work.

#### 2.3.1 Student Work and Researcher Notes

During the course of the longitudinal study, students have been encouraged to make notations of ideas as they work as well as mathematical work they performed in effort to solve a problem. This work is available as useful data for this paper, as well as the researcher notes taken during the work sessions.

The use of videotaping has limitations. For example, Martin (1999) points out that where we place cameras and microphones even with the intent of maximizing exposure to student work can result in inadvertently influencing students’ work (Martin,
Using available student work and researcher notes that are available, I will at times be able to re-enforce or disprove what might seem to be a students’ thought process.

2.4 Data Analysis

I will begin using the analytical model described in Powell, Francisco and Maher (2003) with slight exceptions. I will view the video data to gain an overall conceptualization of the students’ activity. The first viewing will be observational: in the second viewing I plan to make casual notes of what appear to be important events. Later, the video data will be transcribed. While transcribing the data I will make notes in the margins to code for new ideas, obstacles to ideas, and critical insights. Each transcript will be verified for accuracy. Critical events will be flagged and traced to examine the research questions. For this study, critical events will include events that demonstrate a significant or contrasting change from previous understandings, or evens that lead to evidence of mathematical reasoning (Powell, Francisco, and Maher, 2003). I will code these events and follow their development throughout the videos in an effort to determine if it is an idea that leads to a solution (as presented as a group solution) and how it develops, or if it was an idea that leads nowhere, or one that is revisited later.

I will compose story lines based on identified critical events and how the events developed or didn’t using student work and researcher notes as further evidence where possible. From these storylines I will finally develop an analysis that traces evidence of critical events from inception to the development (or not) of particular mathematical thoughts about the solution to the catwalk problem.
Chapter 3: Theoretical Framework

This study is built upon a constructivist theory of learning, the notion that humans learn by ‘wrestling’ with a problem, not in isolation, rather by collaborating with peers and teachers (Dewey 1910). The Catwalk problem used as the basis for the data in this study was chosen by Professors Robert Speiser and Chuck Walter to elicit students’ thought about instantaneous velocity without having previously participated in a calculus or pre-calculus course. There was no specific mathematical instruction prior to Professor Walter’s introduction of the task at the summer institute. The Catwalk problem was at the end of the Summer Institute where students had been working on solutions to other authentic problems in the same environment.

The environment of the summer institute was conducive to collaboration and communication among participants. The students were situated around three large circular tables in the room which enabled verbal as well as written communication. Each student was provided with a written form of the task as well as several copies of the cat in motion. Students were also provided with transparencies, markers, notebooks to record their work, and graphing calculators. Each table had a dedicated camera and cameraman to record the visual data. On top of each table were microphones to record the students’ conversations with each other and researcher/facilitators.

The Summer Institute was held in the library of the David Brearley High School. The room was large enough to accommodate the student tables, mounted cameras, and gives teacher/researchers mobility about the room to interact with the students.

3.1 The Rutgers Longitudinal Study
The study followed the mathematical growth of a cohort of students from first grade through High School and into adulthood. The first years of this study occurred in the classrooms of the Harding Elementary School tracing the development of mathematical ideas in algebra, combinatorics, probability, and eventually pre-calculus in High School. The studies of mathematical growth eventually lead to studying the reasoning behind the development of ideas.

The problems that the students were asked to work on were not traditional problems or problems that their teachers would normally have as they were not part of the school curriculum. The problems required the students to use prior knowledge and representations to build new meanings and develop convincing public justifications for their answers (Maher 2005).

The National Science Foundation (NSF) awarded Rutgers two grants to support this research. The first grant (MDR9053597, directed by C.A. Maher and R. B. Davis) was awarded in the fourth year of the study expanding the researchers work to Colts Neck and New Brunswick, NJ. The second grant (REC9814846, directed by C. A. Maher) expanded the original Kenilworth project to include the students’ mathematics education in high school and beyond. The Rutgers longitudinal study is now in its 22nd year.

In the longitudinal study, researchers took on a new role, that of facilitator rather than traditional teacher. The role of facilitator required that the researchers pose problems that encouraged students to make sense of new mathematical ideas. The students were encouraged and expected to communicate with other students, argue or justify their work and then convince other students and teacher/facilitators of the validity of their ideas, strategies and solutions. The students became accustomed to ‘convincing’
others of their solutions and the complexity and high standards that were necessary in order to make that convincing argument (Maher 2002).

Chapter 4 Literature Review

This study addresses how students develop the concept of instantaneous change in the context of an authentic task that could either be approached mentally or physically. An underlying part of this study is the use of an authentic problem in the development of a mathematical concept as well as how students develop the concept of instantaneous change while trying to ‘solve’ the catwalk problem.

In most calculus textbooks, especially those that are prevalent in high school classrooms, (Larson/Hostetler 8th Ed., Stewart 6th Ed., and Thomas/Finney 9th Ed.) the idea of instantaneous change develops graphically using the ideas of limits and secants. Instantaneous change in many places is defined as occurring when the denominator of the difference quotient approaches zero. Some textbooks go into depth to describe average velocity and then identify instantaneous velocity as developing through shortened time intervals (Varberg/Purcell/Rigdon 9th Ed.), then identify this as a limit. As is the problem with math education in general goes the problem of calculus. Teachers teach what is in their text book in a manner that is comfortable to them as well as how it is presented by the publisher. This is typically the same way they were taught the same material (Lessons in Perspective, 1997).

Many identifiable difficulties in teaching mathematics are the same at all levels. Primary to the list of difficulties is the degree of teacher knowledge (Ball, Lubienski, and
Mewborn). If elementary and middle school math teachers have only adequate knowledge of the material and are not comfortable with the content there is little room for student achievement and consequently little room for discovery. Alternately, if a teacher has succeeded in taking many advanced math courses, there is little proof that this helps student achievement either (Ball 1991). The knowledge necessary to teach math meaningfully is not found in the upper level courses, rather courses that encourage students to develop multiple representations of the math or the ways in which different representations connect with each other (Nathan and Koedinger 2000). If a teacher has extensive knowledge of advanced math but not the underpinnings of that math, it is unlikely that they will be able to construct authentic problems designed to develop mathematical thought such as those described by Lesh and Lamon. Inadequate teacher preparation and comfort with the material also prevents substantive classroom discussion about the math (Ball, Lubienski, and Mewborn). Calculus is no different, teachers that are not prepared to discuss the underpinnings of calculus such as limits and instantaneous change, cannot teach toward cognition of important concepts.

Textbooks present the material in a manner that promotes little or no cognitive mathematical thought on the part of the teacher or student. Consequently teachers that traditionally teach calculus give little thought to the underlying mathematical concepts, or the types of problems that constructively develop those concepts. Teachers that are aware of the underlying concepts are able to present the material in a manner that exposes students to the material in a more meaningful way making discovery of patterns possible by the students (Goldin).
Solving challenging mathematical tasks that promote the development of specific knowledge requires time, freedom and diverse personal experience (Speiser, Walter, and Maher, 2003). All three of these are commodities that few teachers have in conventional classroom situations. We frequently give away our freedom and time at the behest of covering a curriculum in the time allotted. However, the success of the courses we teach relies on the strength of the understandings we develop within our curriculum.

In earlier papers Speiser and Walter write about their use of the catwalk problem with college students. They address the notion that calculus has traditionally been seen as mental, and as such leaves the data that model functions in the background. In order to make sense of the mathematics we need to study the real physical behavior of functions (1994).

Speiser and Walter (1996) write further about the different physical methods some of their students used to model the cat’s motion. They indicate a need to make and examine ‘strong connection between what derivatives and integrals record and what our bodies feel’ (1996, p. 352). Students need to experience instantaneous change by motion, argument, drawing, measuring, and making the mathematics happen (Speiser and Walker, 2003).
Chapter 5 – Critical Events

5.1 Physical Knowledge or Strategies

There are two ideas relative to physical motion that are important to this problem: the motion of the cat in pictures and the perceived motion of the cat as recreated by the students. Both ideas lead ultimately to the understandings of average and instantaneous.

5.1.1 The Motion of the Cat in Pictures

The challenge of the problem was for the students to identify the speed at which the cat is moving in two frames (10 and 20). In order to answer these questions, it was important for the students to understand what the cat was actually doing (R4, 7/13/99 line 36) across the photos as a whole. Some important observations were made by the students, such as the difficulty of making the cat move the way the photographer wanted him to move (lines 8 to 29). Angela made the observation early that all frames on the sheet took point seven one seconds (in total) (line 35), indicating “it’s not that long a time”. Other observations are made as the students begin to make calculations based on the pictures. Brian observes the distance traveled (37) “For the first six pictures the cat’s only tooken, take, taken one step. That’s all he’s moved, just one, like...”. Magda comments on the appearance of the cat (74) “Look his paw’s stretched out and his tail is bent”, as well as apparent motion (82) “because this is like accelerating and then it’s picking up speed...”
5.1.2 Aquisha’s Constant Speed

One of the first arguments for the cat moving at a constant speed came from Aquisha. Aquisha observed that since the cat is only moving one box from frames one to five and one other box up to frame ten, “he’s moving the same” (7/13/99 tape 1, line 630), implying a constant speed. Magda asked a clarifying question (634) “So he’s accelerating at a constant speed?” which Aquisha agreed to (635). Covering two boxes in ten frames indicated to them a constant speed and not a constant acceleration. Benny challenged Aquisha’s statement by explaining that in the first six frames the cat moved one box, and then moved another box in the remaining frames up to ten – a smaller amount of time (639, 641). In this simple argument, Benny indicated a basic mathematical knowledge of acceleration.

Benny repeated a similar argument to R5 in line 701 making the conclusion that “He’s taking less time to move approximately (the same distance) so his acceleration is picking up from here to here” (Benny is comparing the distance the cat moved in the first six frames to a similar distance in frames 7 to 10). In Line 731 Aquisha agreed that the cat was accelerating and explained what lead her to believe the cat was ‘moving the same’; “…it looks like he’s moving about the same rate, but it’s because here his head’s in the same place, you know.”

5.1.3 The Motion of the cat as recreated by the students

On 7/14/99, R4 suggested the transposition of Aquisha’s representation onto the floor (690), to see if “we could move like the cat”. This activity occurred first in the library where the institute was housed, and subsequently in the adjacent hallway where there was more room. The tape for the floor was laid on July 14.
In both instances (library and hallway), Romina and Magda were instrumental in laying the tape line down, calculating the distance proportions, and making the appropriate markers. One continuous length of tape was placed the length of the library area and the hallway with perpendicular strips of tape representing the distance the cat traveled in the photos. Each perpendicular strip was identified by its corresponding frame number. In the library it was written on the tape itself, in the hallway it was identified by markings on the perpendicular strips of tape and a paper tent with its identifying frame number on it. The measurements were taken from Romina’s notes. The scale the students settled on in the library was 10 cm on the floor to 1 cm in the photo (884). The scale in the hallway was five times that of the library. Neither activity happened until the next day.

*Figure 2 Library Tape Line*
5.1.3a Aquisha’s Line

On 7/14/99 Brian and Ankur noticed that Aquisha was doing something different. She was creating a line out of smaller lines created from finding the distances the cat traveled by overlaying transparencies (58 – 70)

Magda suggested that Aquisha take her line and make a proportion out of it using one box = .36 cm, to find the actual distance the cat moved. (162) “Set up a proportion and see if that actually matches what exactly he traveled. Like point three six on the graph equals to five centimeters in real life.” Ankur did the work and came up with 130 cm. Ankur was not present at the institute on 7/13/99 and questioned Magda if that was a given in the problem (178) and the question was never answered.

Later that morning Aquisha described for the group how she created the line and proportion to check her work (619), “This um represents from frame to frame um what the cat traveled. Like this one’s from frame one to two, and then this is from two to three up to twenty four.” Each dash on the following illustration (figure 4) represents the distances the cat moved from one frame to the next as measured by its nose.
Aquisha pieced the smaller dashes together to create one long line that represented the motion of the cat linearly. During Aquisha’s presentation she described what she did and how she used proportional measurement and calculations to affirm her accuracy. (621) “...we used a ruler to um measure what each box would be with the ruler, because um the papers not, on the paper it’s not the same as the grid. Because on the grid it’s five centimeter boxes, but really on the paper it’s um, point three six we found out. By using the ruler. And um, this was like the proportion we set up to see if the numbers we got by using the ruler were correct. And we came up with it exactly. To one hundred thirty centimeters here for the total distance. And the same with the proportion. And um, this is just all the distances from the, from um the paper, from this one that I did (holding up the first transparency). I connected them and I um came up with, and I measured it with the ruler and it was about nine point five centimeters which was a little off of nine point six six, but it’s got the same...” The final line Aquisha created was bi-colored to distinguish the different lengths (see figure 5).
Observations from the students came from Benny and Jeff. Benny observed that it showed distances traveled (623), and Jeff compared it to Mike’s graph from the previous day (625) stating that it gave a sense of the cat’s speed.

### 5.1.3b The Library Line

Early in the session on 7/15/99 R4 asked the group for suggestions for the activity. One suggestion came from Shelley (7/15/99, line 124) who seemed concerned that the library line might not be large enough to be demonstrative of the motion of the cat. Shelley’s suggestion was that they move out into the hallway from the beginning (followed up later with line 158 after the walk), and if they didn’t do that, the person that was doing the walk should take the same size steps (124) so that “…they have to sort of run faster to the next one.” This statement prompted a male voice off camera to observe that by taking the same size steps “…like he could go faster” (127). This subsequently prompted agreement from Angela, Brian, Jeff and Romina (128, 130, 139, and 142). Romina added however that she didn’t see the cat as jumping, but it did speed up and that’s what they would be doing, indicating not only an understanding of the motion of

![Aquisha's final line and proportional computation](image-url)
the cat in the photos, but a relationship between the photos and the physical motion the students would experience (142).

Matt made the first walk (149) and kept pace (foot) with the rhythm of a garbage can beat (approximately 1 beat per second). In the early intervals (frames) his speed and foot movement matched the tape and the beat of the can. When the intervals become too big to make using the same rhythmic, small steps he was taking, he began to take approximately the same size (small) steps making the marks on the beat with his right foot each time. This showed a small difference in his overall speed, but a much greater difference in his foot speed in order to continue to hit the tape marks.

After Matt’s walk, Angela identified Matt’s motion as “defeating the purpose of measuring out each step” (150). Matt stated that by making smaller steps he had to “move faster” (151). At this point Matt seemed to be making a connection between the cat and his own foot speed.

Romina agreed with Angela that Matt’s motion defeated the purpose of the experiment because, according to Romina, they wanted to see (it) accelerating (155), “like going faster and faster. And we don’t see that.” Despite the fact that Matt’s foot speed nearly doubled, his physical being did not move any faster across the room. Matt suggested that if they made a longer line it might make a difference (If we made it bigger, we probably...) (156). Romina finished his statement with “And then you’d be like running then” (157). This seemed to be the final impetus for the group to create a longer line to the hallway so the movement of the students would be a more dramatic representation of the possible motion of the cat.
After Matt’s library ‘run’ Benny questioned what the motion of the cat and acceleration looked like.

5.1.3c Motion Ala Benny

Benny argued that the time constraint was making it difficult to determine the motion of the cat (7/15/99 prior to the hallway tape line exercise, but after the library tape line). Benny stated that when we move, we don’t move at the speed of camera’s taking our pictures, rather to our own “how we’re moving” (161). This is apparently a reference to our own idea of what our motion is, or should be. Benny further argued that the cat didn’t make the moves or motions it did because of a set notion of time, rather the cat moved the way it did because it planned to, or was incited to in some way regardless of the camera’s timing (161). “Because the time isn’t judging how the cat’s moving, it’s just the cat moving...”

Benny indicated that he thought that the group should “move freely” (161) along the line and “find out how much time it takes us to move all the way down”. According to Benny this motion from interval to interval would be better for judging how quickly the cat’s moving (speed as a function of distance and indeterminate time).

Benny seemed to be relating what the cat’s motion was in the pictures to what the cat’s motion might be under normal circumstances, that is, when no one was timing the cat. In Benny’s attempt to understand what the cat was doing, he was not considering that the camera timing was not used as an impetus for the cat’s motion, but rather as a means one hundred years later to determine the speed of the cat. The cameras were used initially to provide photographic evidence of the motion of the cat as thoroughly as
possible. The nature of the timing became beneficial to this particular problem over one hundred years later.

Benny took this same concept and applied it to Victor’s run in the hallway. Benny had Victor run without time markers and then tried to figure out how long it took for Victor to go from mark to mark. By doing this Benny did not realize they were not imitating the cats’ motion at all, but rather timing Victor on an independent run over preset intervals, almost as if Victor were the new cat they were studying. (352)

5.1.3d Acceleration and Benny

Benny defined his notion of acceleration in line 165 by taking a series of quick steps, and identifying them as accelerating. Benny then took a few plodding steps and identified them as “not accelerating”. Here Benny identified acceleration with quickness, and “not accelerating” with a plodding motion, or slowness. Benny did not show any gradual or sudden change of speed, only exemplars of what the names meant to him.

Ashley tried through some either inaudible or gentle statements (166, 168, and 172) to engage Benny in a conversation. Benny’s reaction to each overture was to agree quickly each time Ashley made a statement. Ashley finally made the statement emphatically and loudly (for Ashley), “You walk first and then run because that’s what the cat did. Walk and then run.” (179) Benny then walked the line in a measured pace hitting each mark at about a beat per second. When he was finished, Benny indicated that he was not sure if he physically changed speed despite covering larger distances in the same amount of time. Benny asked (181): “Now the question is am I picking up speed?” Ashley replied that he did, and Benny asked (183) “Or by covering a faster, more of a
distance am I picking up speed?” Ashley responded with (184) “You’re picking up speed when you get to bigger...” (intervals?) This seemed to convince Benny that even though his rhythm of movement was not changing his speed, it was because of the greater distances he traveled (185). His lack of physical momentum overall seemed to make him wary of his own acceleration, similar to Matt.

Romina summed up the conversation with “So in the same time you cover more distance. So you’re going faster” (189). This final statement of Romina’s indicated that she had an understanding of acceleration, as did Ashley in line 184.

5.1.3e Hallway Line

Brian made the first run (351) to a rhythmic one beat per second banging on the lockers. Brian, hit each mark on the beat. Between marks ten and eleven Brian had to run to make the remaining marks on the beat. With the exception of the 15th mark, where he was apparently running too fast and stopped to wait for the beat to catch up, he made every other mark on the beat at a fast jog. This run went without comment from the rest of the students or researchers present. The significance of the run was that it closely imitated what the students’ data said the cat did (except at mark 15), and there is no evidence from the rest of the students or researchers present that they recognized it.

Benny encouraged Victor to make the next run. While in the library Benny spoke about the need to (161) “move freely”. The reason Benny wanted this freedom was to get a feel for the motion of the cat without the constraint of time. Benny indicated that if he could witness Victor making the run “freely”, he could count how long it took to get from mark to mark. The implication here is that if he knows the time it takes Victor to make the marks he will be able to calculate the speed.
Immediately prior to this run, Victor spoke to R5 about how to best proceed with the run. It was Victor’s idea that the runner should keep an internal count (one one-thousand, two one-thousand…, lines 308, and 314), while hitting the marks on every internal count. When Victor made the first attempt at the run, he could be heard softly counting one one-thousand, two one-thousand…, as he made an even walk. Victor hit the first ten marks (including the first) on time (his internal time) and then misjudged the distance to the eleventh mark and stopped.

Victor began the run again with Benny determined to count alongside him. Victor repeated his performance earlier and when he got to the eighth mark he began to run. He is no longer hitting each mark at the time interval he hit the earlier marks as he is running too fast (362). When asked why he wanted Victor to do that, Benny indicated that he realized the cat was picking up speed as it went along, and that he wanted to “see how much time it took for him to go from interval to interval” because “the cat was picking up speed as it went” (367). When asked by R4 (370) “Do you think it’s reasonable that he was going like the same amount of time from interval to interval?” Benny replied it was.

It is clear that the two young men had very different ideas about what they were doing during their experiment. Victor had the intention of making the run as the cat did counting ‘internally’. Benny thought that Victor would be making the run as he thought the cat might but without the restriction time placed on the cat. Further, Benny wanted Victor to make this ‘free’ run so he could determine the time between marks to calculate speed later. I believe that when Benny heard Victor counting internally, he thought Victor was counting how long it took him to move from mark to mark (an earlier instruction from Benny to Victor (361); “And count how much time it takes you to get
from black tape to black tape”). At this point it is evident that Benny is not clear on the necessity of consistent time intervals to determine how fast the cat moved in the photos. It is clear that Benny understands speed in this case as a function of distance and completely independent of a fixed time interval. It is also possible that when asked by R4 if it is reasonable that the intervals were the same and Benny responded affirmatively, that he was responding quickly as he had responded quickly to Ashley previously, seemingly without thought or conviction. Had Victor made the run on the marks and time intervals correctly it is possible that Benny might have made the connection to speed as a function of distance and fixed time intervals.

At the end of the hallway exercise, Benny made the run three times himself with students clapping a rhythm as he ran. His final run is on time and on the marks all the way down the hallway. It is possible that after watching other students make the run, he has determined that the time interval from mark to mark should be the same as R4 suggested (370), or he was simply imitating the behavior of his classmates and still unclear about the time interval. However, he did not stop attempting the run until after the third run, indicating that he might have felt he finally got it right.

Immediately after the line experiments and returning to the library, some of the students offered observations from their experiences. Victor, referring to an earlier graph displayed by Romina (433), stated that whoever ran that course “could kinda feel it, because in the beginning they was running at a constant rate of speed, then it slows down, then it pick it up...” After Victor’s statement Romina recreated the graph which Victor referred to as a position versus speed (443) graph. Romina projected the graph (Figure 6 Speed/Distance Graph) and commented on how it represented what happened
in the hallway; “it looks like it follows what we did out there running, or what they did out there running” (490).

![Speed/Distance Graph](image)

**Figure 6 Speed/Distance Graph recreated by Romina in response to Victor’s statement.**

Benny recognized the tape models as “more of a visual explanation, not… like a mathematical explanation” (482). To Benny the visual distance between marks was representative of the acceleration. “Like overall you could just see things … in a better way… you could actually see like between point ten and eleven the distance where he picked up... I mean this is where the speed begin to get faster”.

One other notable statement came from Victor suggesting that they should have scaled the time interval the same way they scaled the length (484). “Would have been something like one point one and a half versus something like just one second which would actually kinda gave you more of a realistic pace than what just one second did”. The scaling of time would have changed the time between marks from one second per beat to approximately 1.5 seconds per beat (.031*50 = 1.55, or about 40 beats per minute). This suggestion is reinforced by Angela’s statements that they are “bigger than a cat” (485), and does suggest that Victor recognized the proportionality of the experiment as well as the need to accurately recreate the motion of the cat in as many ways possible in order to understand what the cat was doing. Victor’s idea to change the
time between intervals also reinforces the idea that his and Benny’s experiment truly were based on different premises. Victor’s was simply an internalization of the timing or rhythm of the beat, as Benny’s was a means of determining the speed the cat was traveling in a more ‘realistic’ or ‘free’ setting.

5.2 Mathematical Knowledge or Strategies

The students used some mathematical strategies that ultimately lead to their understanding of what the cat was doing, or his speed, and other strategies were abandoned because they were not seen as helpful by the students. One strategy (proportionality) was used initially by the students and abandoned only to be used subsequently in different applications.

5.2.1 Exact Measure v. Proportional Measurement

Early in the computational process (7/13/99 tape 1) Magda decided to measure the size of one box (140) pursuant to Romina’s questioning whether the boxes are all five centimeters (134). Magda found it difficult to accurately measure the size of one box using the millimeter gradations of the ruler, so she measured the distance between heavy lines (every tenth box) and divided by ten (156) (the number of boxes between the heavy lines), and determined that each small box was 3.6 millimeters. Magda quickly made the conversion (156 and 158) from millimeters to centimeters stating “So it's three point six, actually point three six centimeters for five...centimeters.” Romina and Magda began to measure the motion of the cat (by the distance the nose moved (Romina - line 102)) as accurately as possible using a centimeter ruler.
As Magda measured the distances from frame to frame, Romina recorded them. After Magda made the third measurement, she noticed that the cat had not yet traveled one whole box, yet she has already made measurements in excess of .45 (cm). (284) “One little box is point three six, and where I measured right here, that’s where he basically touches the box and I already measured like point four five, and it’s like only point three six”. Magda was making a connection between what the cat physically moved (5 cm intervals) and what the photo’s represented (.36 cm intervals) in terms of distance.

Aquisha had not at this time made the same connection or witnessed Magda’s conversion between the stated 5 cm distance and the .36 cm distance on paper. Aquisha reminded the group (317) “So if you add all this other shit up, it add up to five centimeters right? Because that’s how much one box is?” (319) ... so you’re doing fine.” Romina and Magda accepted this summary from Aquisha and continued to make measurements for the next frames. Aquisha noticed that after Magda and Romina recorded their measurement for frames 5 to 6 that the total distance moved is point seven seven (364), and that it (358) “should add up, add up to five centimeters...”. This time Romina and Magda supported their measurements using Aquisha’s earlier argument indicating the cat actually moved (367) “a little more than like one box if you look at the nose”. To Romina and Magda this was a valid estimation of how far the cat traveled at this time (5 cm plus the little extra). Aquisha suggested estimating how far the cat traveled between frames and making that add up to five centimeters (390), “Why don’t you just guess, like you look at it and say well it looks like he moved a quarter of the box, and then..., figure out how many centimeters that is, so you make sure that we come to
five centimeters”. Romina dismissed this “Cause we’re close, cause it’s a little more than five centimeters”.

Magda questioned how far the cat has traveled after they measured the tenth frame making the observation that the cat “should have moved fifteen” centimeters and Romina added the distances up to 12.7 cm. Magda indicated that this was not close, to which Romina responded: “Close enough”. Romina has clearly accepted that there must be a certain amount of error in their measurements.

Aquisha stated at this time that she didn’t understand what Romina and Magda were doing, and that the chart “doesn’t add up”. Magda became frustrated at line 472 because she thought initially it should add up to .36 cm per box before Aquisha convinced them that .45 was close to 5 cm. Magda stated their problem as “I was calculating it wrong here because it’s supposed to add up to point three six.” Magda called this “convert(ing) to the actual measurement”.

With the help of Victor, Romina and Magda created a proportion to translate the ruler measured distance into the actual physical distance the cat traveled (figure 7):
centimeter parameter. Aquisha made the assertion that the measuring was off (602), and Romina and Magda were at a loss for anything else that they could use to measure more accurately (603, 610). Aquisha again indicated that estimating by eye (611) would at least make it add up to five centimeters per box (615).

Magda and Romina finally abandoned exact measurement and the use of proportions to define the motion/speed of the cat nearly 25 minutes later when Magda asked in line 898: “How about we just estimate or something?” Aquisha reiterated her position that by doing that they could always add up to five centimeters (899).

5.2.1a Other Significant uses of Proportion

On 7/14/99 (621) Aquisha clearly described during a presentation to the whole group the reason for using the proportion they did and how she used it to find the total distance the cat traveled to create her line. Aquisha illustrated the difference between what they measured on the paper, and the size it actually represented (.36 cm per box on paper compared to 5 cm in actual size). By measuring using the centimeter ruler, Aquisha determined that the cat traveled 9.6 cm on the paper. …“the papers not, on the paper it’s not the same as the grid. Because on the grid it’s five centimeter boxes, but really on the paper it’s um, point three six we found out. By using the ruler. And um, this was like the proportion we set up to see if the number we got by using the ruler were correct. And we came up with it exactly.”

Figure 7 Aquisha's Proportion
5.2.2 Regression Equation

Table 3 (Milin’s table) came up with a regression equation (7/13/99 tape 2) that they said does not make any sense (lines 6, 8, and 10). Shortly after the second tape of 7/13/99 began, Victor showed Magda how to find a regression equation, and even suggested they use a quadratic function (82, 88, 90). After Victor showed Magda how to find the equation (we must assume they did get an equation because we do not see the calculator at any time, but the conversation steers us here), Magda put the calculator down and did nothing more with it. Equations for regression can be seen on Romina’s tables and a model is seen overlaying the data points on the time – distance graph, however no other mention is made of it, nor is it used.

5.2.3 Romina’s Tables

From the very beginning (7/13/99), Romina assumed the role of record keeper (172) for her table. Without any prompting by the researchers in the room or other table members Romina developed a table to record the group’s data (figure 8). Her first table was created using exact measurements of the distance the cat moved. This idea was abandoned in the first day but the format remained.
The first column marked ‘Frame’ is the frame that contains the speed of the cat they are calculating in that row. The next column indicates the frames involved in the calculation. The third column represents the distance traveled between frames divided by the (constant) time difference between frames (.031 seconds). The final column is the speed the cat is traveling in the frame mentioned in the first column, measured in centimeters per second (224, 226). A table indicating distances in converted proportional measurement was started but not created as the issue of inaccuracy (inaccurate measurements making the distance per box add up to more than 5 cm) stopped the process before Romina got past the first line.

Romina’s second table imitated the first in basic format:

![Figure 9 Romina's Second Table](image)

Here the first two columns are identical to the first table (the frame speed happens ‘in’, and the frames the speed is measured between). Romina has inserted a row marking accumulated distance followed by the estimated distance the cat traveled as measured by
eye divided by time between frames (Magda, 959). Romina has added an additional column between D/T and Speed. This column represents accumulated time.

5.2.4 Romina’s Graphs

Romina and Magda created different graphs on their calculators based on the data that they have plugged into their calculators from data in Romina’s notebook (7/14/99 beginning at line 300). One graph that they developed was a time and distance graph (distance on the x axis, time on the y-axis).

5.2.4a Time v. Distance

Romina is aware that there is a problem with the graph based on what she thinks it should display. Romina believes that the cat should generally be accelerating or at least moving at a steady pace at times throughout the graph, and that the cat should be moving slower in the beginning and faster at the end (knowledge developed by creating data tables). Romina indicates that there is a problem with her graph beginning in line 329 “Yup, it doesn’t look very nice though. See ours shows him accelerating the whole way through.” And more specifically in line 331 “But it shows him going faster at the beginning.” R4 asked if that “check(s) with what Aquisha has in her deal?”(332) Aquisha indicates that it does not hold with here representation for essentially the same reason as Romina in 331, “It’s just that... you guys are faster ... when it’s slowing down” (335). The graph that Romina created was a function where the dependent and independent variables are reversed. If it is recognized as such from the beginning reliable and accurate interpretations of the graph could be made as though it was created conventionally. Both Romina and Aquisha are correctly interpreting what they see on the
calculator as if it were a traditional time v. distance graph with time displayed on the x-axis.

In response to R4’s question about what the axis’ represent, Magda and Romina indicate that the vertical axis it time and the horizontal axis is distance (360). R4 remarks that he will have to turn the calculator over to match the graph with others (361), “I’ve got to turn this calculator to match with somebody I have to turn it like this (turning the calculator over).” This prompts Romina and Magda to redefine in their calculators what the axis’ represent. When R4 checked back and asked: (415) “So, you happier with that?” Romina responded (416) “that makes more sense”, and Aquisha indicated that she “thinks” it agrees with her graph now (419).

Romina makes a quick presentation of their time/distance graph to the whole group (517). She indicated on the graph where the cat was walking and later where it was running. Notice that this graph is a series of plotted points with a curvilinear function overlaying the data points (most likely the graph of a regression equation). There is no mention of this during the presentation by either the other students in the room or any questions from researchers about the meaning of the graph. There is no mention of discrete or continuous graphing although all of the data they have looked at and presented was discrete.

Figure 10 Romina Presenting a Distance V. Time Graph
5.2.4b Distance v. Speed

Romina also presented a speed/distance graph (y axis is speed, x axis is distance). Romina compared this graph to a graph Mike presented a day earlier and pointed out what she saw as similarities and differences. Some of Romina’s interpretation was flawed.

![Image of speed versus distance graph]

Romina pointed to the beginning of the graph indicating that there is a little difference between her and Mike’s graph. Here she begins to say that it is going fast, hesitates, removes her hand from the graph and restarts at about the ninth frame (top of line before the 45 degree move to the right) and interprets the rest of the graph appropriately. In line (517), “And it’s a little different from Mikes because it shows, it shows like the cat, it’s going like fast, it’s going like, we kinda agree with Mike at the first part where it’s walking, (this is where Romina moves her hand) it’s going at a like a constant rate. But then it shows our, when it starts like its gallop, it kinda like pauses a little bit (at the tenth mark) and then starts accelerating faster and faster until it reaches like a climax, and then it just comes down. Like so toward the end that’s where the cat’s stopping.”
5.2.4c Velocity v. Time

Romina displayed a graph of time and velocity (7/15/99) which reminded Mike of a graph of his previously but doesn’t have it any longer. Mike used this opportunity to question the accumulated time markings on the x-axis. Romina’s x-axis is identified as time and the marks she used were intervals based on .031, the time difference between frames (.031, .062, .093…). Mike is uneasy with these markings (“that’s what I had a problem with before”). It is not clear at this point, whether Mike is uneasy because the markings should read differently, or if the markings are actually a part of a computation in his mind.

Mike observed that in order to measure “the speed of it”...”you divide it by the time it took to go from that frame to that frame...” Mike confirms that this is what Romina did in line 560: “So for each of those measurements you’d have to divide it by .031, right?” Continuing in this same conversation Mike expresses his confusion about why they would “divide by .031, and then dividing by .062, it’s dividing by a larger number each time”. Romina tells Mike that the graph makes sense and that the reason for the markings is that they had to “picture the cat going through it”. “Through it...” might be a reference to continuity of motion. Mike agreed that it seemed to make sense but is still unsure about the division by larger numbers (differences) (562). No one has informed Mike that they never divided by larger numbers, or what the numbers actually signify.
Matt joined the conversation and described what the graph was doing, not how the calculations were made (571, 573). Mike decided to be direct and ask specific questions about the graph. First, what the axis’ represented (line 574), and exactly what Romina used to figure out velocity (583 and 585). Romina responded to the representations as “The ‘x’ is time, and the ‘y’ is velocity” (576), and the computation portion by stating that they did what he was saying, (584 and 586 as above). “Each and every time...” (Mike 585)

At the end of the conversation it developed that Mike thought the graph was created using accumulated time calculations like an earlier graph of his that was discarded (608 - 612). Mike was apparently concerned that the group had mistakenly used a graph inappropriately as he had. There is no evidence that Mike understood the axis markings could have been represented by anything as long as they defined some order. The conversation was based purely on the misunderstanding that a notation on an axis does not necessarily identify a divisor.
5.3 Instantaneous or Average?

Before we discuss the ideas the students present about instantaneous or average we need to identify some disparities in the way they portray or communicate their decisions. First there is the idea of the speed of the cat IN frame ten. This is the verbiage used in the original question; “How fast is the cat moving in frame 10?” IN frame ten begins to take on significant dimension with Romina and eventually a large part of the group of students.

Secondly there is the definition of instantaneous. Most students have an intellectual handle on the definition of the word but not the concept. Benny verbalizes the greatest difficulty with instantaneous.

5.3.1 Benny and Instantaneous

Toward the end of the first session on 7/13/99, (Tape 1) Romina responded to a question posed by R3 about dividing a distance by .31 (1041, 1043), “You remember Benny said there was ten centimeters between the beginning and the end of the cat..., and you all divided it by point three one? Ten times point zero three one.” Romina questions whether that type of computation is an average (1053) “That’d be like an average though wouldn’t it?” This caused Benny to question what they meant by average (1054), “what do you all mean when you all say average? Where are you all getting average from?” Victor defined it as (1057) “…not instantaneous per se.” Benny agreed and further stated how he defined instantaneous (1058); “…if it moved whatever for the whole thing, then that would be instantaneous”, indicating his lack of understanding of instantaneous by confusing it with average. Victor corrected Benny by saying “No, that whole thing would be an average” (1059), and that “…it’s instantaneous at ten” (1061), which
Benny agreed to. Notice Victor used the word ‘at’ when referring to where it is instantaneous. At this time Victor seems to see no spatial definition to frame ten (IN) by saying it is ‘instantaneous at ten’.

5.3.2a ‘In’ Frame

(7.13.99 tape 1) Romina asked Victor about the rate designation of dividing centimeters by seconds by telling him the problem and leaving the rate she comes up with to be confirmed or argued. Instead Victor continued the computation of an average based on an error in Romina’s statement.

(232) Romina: *This is how far we moved in frames one to two, how far it moved. And then we divided that by how much time so, three one seconds (should be .031, not .31). So, centimeters divided by seconds, does that go... so it is moving three point two two five eight one centimeters per second...*

(233) Victor: *Then you want to divide that by ten (.31/10 = .031) and you get...*

(234) Romina: *Well that’s, that’s what speed it’s moving in frame two.*

Romina’s mis-statement prompted Victor to divide by ten indicating he was calculating an average. Romina heard the calculation for the average and quickly identified the value as what is happening in frame two. Despite the confusion in the computation, confirmation that this is what happens IN frame two comes in lines 248 - 250:

(248) Romina: *So hold on, so this speed was, is this considered the speed in two, in frame two?*

(249) Magda: *Yeah.*

(250) Romina: *OK.*
A case can also be made that this is the beginning of Romina’s doubt or questioning of In Frame or Between Frames. By asking this question (248) indicated that there is either doubt or confusion in Romina’s mind. There was evidence that Romina understood the measurements were from one to two (table notation), and that the division was for one interval (table notation). However she assigned the results of her computation to the ‘space’ that is frame 2. As she used this data to fill in her tables, she identifies in her first column every time the frame that the velocity calculated at the end of that row contains.

Further evidence in the computation process that Romina saw the speed as happening in a frame came the next day (7/14/99) when R7 questioned the data in Romina’s notebook and what the columns that she created represent. At the end of the description (208 – 211) R7 asks what “this is?” (208) indicating the final column on the right of Romina’s notebook. Romina answered “The velocity he runs”(209). R7 reiterated the statement replacing the word velocity with speed, and Romina states (211, 213): “The speed he’s going in that frame. (Tapping the place where the frames are indicated on her paper with a pen when she says ‘in that frame’)”

The significance of the word ‘IN’, especially with Romina, is the amount of activity that she ascribes to frame 10. Frame ten is an instant in time (Aquisha’s definition) captured by a photograph. The amount of time it took to actually take that picture is not known, we can only assume that it took less than the interval between frames.
5.3.2b The Beginning of Frame 10

Further evidence that Romina ascribed size to frame 10 came on 7/16/99 when she presented her groups conclusions. Romina stated that the cat had moved (677) “from eighty to two hundred, like there’s a lot going on in frame ten.” Romina indicated later in the same dialogue that there is dimension to frame 10 by stating there is a beginning (and an end) to the frame while defending an argument against average (673). “…like because if you’re going like technical the guy could be like ‘well I meant at the beginning of frame ten what the speed was. Or the guy could say at the end of frame ten.”

5.3.2c Between Frames

On 7/16/99 Romina and Magda were discussing what they were going to report on (lines 479 to 486) and what other groups were reporting on. Romina identified what all groups have as “the betweens” (478). Groups 2 and 3 have the average speed not the speed for frame ten because all they have been able to identify are the speeds between frames. When Ankur questioned Romina about the speed she was going to present (line 483 – “Our is the speed in frame ten?”), Romina stated that the speeds she was presenting is “between nine and ten and ten and eleven”(484).

5.3.3 Arguments for Average

At different times students decided that the use of an average is the most appropriate means of determining the speed of the cat in frame ten. Romina argued that average was not appropriate given the activity of the cat between frames nine and ten, and ten and eleven.
5.3.3a Brian’s Parkway Analogy

Brian had decided that it is appropriate to use an average speed to identify the speed of the cat in frame 10. Brian stated in line 291 that “I kind of like the average.” When faced however with needing an exact answer and having inexact data (308) “…if we think the numbers are off, the average is gonna be off too, so what’s the point?”), Brian may still like the idea of using the average but sees it as useless if the data is not good. When R7 posed the hypothetical situation of them having confidence in their data, Brian becomes more confident in the use of the average speed (341) “I would like, I would like it. That’s just my opinion. I would like it.” R7 questioned Brian about why he would like to use an average and Brian developed an analogy based on driving on a Parkway. (Lines 351 and 353) “But just say, just say, I’m going thirty on the Parkway..., ...and like we pass one exit, I’m doing thirty. And two exits down I’m doing sixty. Wouldn’t it kinda suggest that at the middle exit I would be doing forty five?”

By creating this analogy, Brian is justifying how it would be appropriate to take the average of the two intervals for the speed in frame ten. Romina counters with (386) “You can’t determine what point that is”, agreeing that Brian will hit 45 MPH (389), but you have no way of determining where that will happen (within the interval). Romina illustrates her point with (397) “Because we just said how like he couldn’t actually have been doing forty five. Like he could have, but then on the other hand he could have like sped up like right after the first exit and done sixty all the way down. And just kinda stayed at sixty.”

Brian immediately draws the connection between the Parkway analogy and the motion of the cat in frames nine to eleven (398) “Isn’t this one where like he’s getting
Brian tries to use this connection to bolster the Parkway analogy using mental images of the cat’s motion and hand motions to demonstrate the movement of the cat. Brian indicates through a series of hand motions what the differences between his and Romina’s perceptions of the cat’s physical behaviors are from frame nine to eleven (403). Brian illustrates Romina’s idea of the cats’ motion using his flat hand in an arching motion imitating a cat’s leap slowly at first then quickly at the end. His own motion is a steadier speed from start to finish.

Brian started this transition with (398) “Isn’t this one where like he’s getting ready to jump though?” And he was correct. Both Brian and Romina however got lost in the idea of a jump. The motion Brian made was indicative of a cat in mid air (leaping), and at this time the cat is still on the ground. The connection here however is the type of motions that he and Romina were making with their hands reinforced their own positions on the motion of the cat. Brian was still trying to keep the cat at a constantly increasing speed from nine to eleven, where Romina was identifying the slower motion in the first half of the ‘jump’ (frame nine to ten), and a much faster second half (frame ten to eleven). This was consistent with Romina’s identification of the motion of the cat earlier (5.3.2a), which is why she is opposed to using an average speed here.

5.3.4 Romina Questions Average use by other groups

During Table three’s presentation (7/16/99), Victor identified the formula their group used to determine the speed in frame ten as

\[ V = \frac{1}{2} (V_i + V_f) \]

Victor defined \( V_i \) as the change from frame nine to ten divided by the change in time (0.031). Victor
also defined \( V'_t \) as the change from ten to eleven over point zero three one. Victor further identified the values they used and the actual calculations (525).

At the end of Victor’s presentation, Romina asked the question (570): “How do you take the average, where do you, I’m saying is that right in the middle of frame ten? And that’s the speed it’s going?” Romina stated that at the beginning of frame 10 (568 and 570), “you start at frame ten with the two..., whatever that two divided by .031 is”, and “you end frame ten with seven divided by…” These are references to what Romina was developing as a chunk of time. Romina was describing the nine-ten interval as the start and the ten-eleven interval as the end, similar to Victor’s \( V'_t \) and \( V'_t \). Romina questioned if the average of the start and the end is (570) “right in the middle of frame ten? And that’s the speed it’s going?” Very important here is the repeated use of the word ‘in’ when referring to frame ten.

It is clear that Romina believed that the average of two numbers lies exactly in the middle of the two numbers. To apply an average to frames nine through eleven would mean that ‘In’ frame ten that position that is the middle of the frame would correspond to the exact middle of the two velocities between frames nine and ten, and frames ten and eleven. Romina was clearly confusing an instant in time (the photo) with the properties of “between frames”. The picture of the cat is a still photo with no measurable dimension of time. Because however there is a great difference between the speeds of the cat preceding and following frame ten, Romina attributed the ‘space’ that is the photo to containing change in motion. While this cannot happen, it allowed Romina to understand the complexity of an average in this situation. The average speed is the exact middle speed value between frames nine-ten and ten-eleven. Frame ten lies directly in the
middle of frames nine and eleven, therefore the average speed should lie somewhere ‘in’ frame ten (presumably the center).

According to Victor the average velocity of 145.161 cm/s lies directly between frames 9 and 11. Romina believed that it did not lie directly in the middle of the two frames (therefore exactly in the middle of frame 10 as Angela suggested - 720) because the difference was too great between the calculated velocities of frames nine-ten and ten-eleven.

Representation of Victor’s model:

![Figure 13 Victor's Model](image)

Representation of Romina’s model:

![Figure 14 Romina's Model](image)

The circle represents the approximate area (frame 10) where the cat’s motion is changing. According to Romina (580), “he’s going so many different speeds in that one frame.”
5.3.5 Romina Argues Against Average ‘In’ Frame

Romina continues to debate the use of average as a solution to the problem beginning in frame 714 (7/16/99) with Table 3. Milin suggested taking the middle of a range of numbers. What numbers Milin is referring to is unclear as he is off camera (712). He might be referring to the numbers Romina had on the screen as velocities between frames nine-ten, and ten-eleven. Angela identified frame ten as ‘an instant’ (713), “an exact instant” (717), right in the middle of the two numbers (720) (“in the center of those two numbers.”). The definition that Angela has created for ‘instant’ is why she feels confident that an average would work.

Romina was maintaining that while the number that represents an average is between the two frames (nine and eleven), it was not necessarily in the middle “...but he has to go up that much in frame ten” (714), “…If it goes up that much, where’s your exact instant?” (718) Angela maintained that the exact instant is “in the center of those two measurements” (720). It is clear that Romina understood that frame ten was exactly in the middle of the other two frames, but not that it was an instant in time. Romina’s argument was based on the idea that because the velocity differed so greatly from frame nine to eleven, the number determined to be the average velocity could lie anywhere in that area, and not necessarily in the middle as is evidenced by further use of Brian’s Parkway Analogy.

Using Victor’s model for computing average velocity as:

\[ V = \frac{1}{2} (V_i + V_f) \], and

\[ V_i = \text{distance between frames 9 and 10} \cdot \frac{.031 \text{ sec.}}{.031 \text{ sec.}} \],
\[ V_i = \frac{\text{distance between frames 10 and 11}}{.031\text{sec}}. \]

Using Victor’s numbers

\[ V_i = \frac{2cm}{.031\text{sec}} = 64.516 \text{ cm/s} \]

and

\[ V_i = \frac{7cm}{.031\text{sec}} = 225.806 \text{ cm/s} \], then

\[ V = \frac{1}{2}(64.516 \text{ cm/s} + 225.806 \text{ cm/s}) = 145.161 \text{ cm/s} \]

Angela and Victor made arguments that the cat traveled 145.161 cm/s in frame ten, directly in the middle of frames nine and eleven. The only way middle can actually be defined here is between equal time frames (see figure 15).

Visually:

![Figure 15 Visual Representation of Angela's and Victor's Argument](image)

Romina’s argument was that the speed 145.161 cm/sec does not fit in the middle because of the disparity of the surrounding velocities (714). The average of the velocities surrounding frame ten is 145.161 cm/sec as Angela and Victor suggest. Romina viewed the inequity between the pre and post distances as an indication that the average cannot happen right in the middle of the surrounding frames. A possible visual representation that signifies Romina’s concerns might show the location of frame ten as a function of distance and velocity rather than the constant time.
5.3.6 Romina’s Argument Against Average Using Brian’s Parkway Analogy

Romina used Brian’s initial use of this analogy (recall that Brian used this to promote a constant increase in speed from exit nine to eleven to emphasize the use of an average) to show that an average is not appropriate. Romina used this analogy to mimic the premise of the Catwalk problem (798); “… there’s exit nine ten eleven on the parkway, this is how we thought about it…, (800) At exit nine you’re going thirty miles per hour. At exit eleven you are going sixty. How fast were you going at exit ten? You don’t know, you could have sped up like, you could have been going sixty there, you could have been going, you could still be going thirty.” After Romina stated the new analogy, there was some conversation between Matt and Mike about Matt changing his position on using an average. R8 brought the conversation back to Romina’s interpretation of Brian’s analogy. R8 asked (817) “And she wants to know how fast you were going at exit ten”. Victor quickly stated that would be going forty five (818), and Milin qualified his statement by adding (820) “…if you accelerate constantly you’d be going forty five.” Jeff stated that Victor has no way of knowing that the car accelerated constantly and Matt agreed, stating that it could speed up to sixty five, or hit traffic (821). Matt’s statement was the first indication that parts of the large group (aside from Romina and Table 1) were considering deviating from the average.
There was further conversation in lines 822 – 828 indicating that what happens between exits 9 and 11 was not known. In lines 830 and 832 Milin indicated his change of opinion from average by: “I’m saying, I say if the cat accelerated constantly, which I’m pretty sure it didn’t, then you could average it.” “I don’t think it would so...”. Matt’s change of opinion is confirmed in line 833, “We can’t average that. The second, the second one at twenty you can average out. But that first one at frame ten you can’t do it.”

5.4.1 When is Average Appropriate?

As Matt stated at the end of 5.3.6 there was consensus amongst the groups that it would be appropriate to use an average to determine the speed of the cat in frame 20. Matt defined this for R8 and R10 later (937), “So, in frame 20 when you have... moving the same distance from one frame to the other, so you have two frames and you’re moving the same distance. That means there is a constant there. A constant speed you’re going between those two frames... there’s a safer bet than knowing that you moved the same distance, than knowing that you moved from two to seven.” The final statement “you moved from two to seven” is a reference to the distances between frames nine-ten and ten-eleven.

When asked by R10, why he could bet on frame 20 and not frame 10 Romina indicated (1018) “This one’s more constant.” Matt finished or enhanced Romina’s statement by indicating that the distances measured from nineteen to twenty and twenty to twenty one (1019) “This is from nineteen to twenty; this is from twenty to twenty one are the exact same distance.”
At the beginning of the presentation process, Romina presented her groups conclusions regarding the speeds the cat is traveling. Her transparency (figure 16) indicates under the wavy line that there is a constant distance the cat has traveled immediately before and after frame 20 (10 cm), and the calculated velocity of the cat (322.581 no calculated units identified).

Figure 17 Romina’s 7/16/19 Presentation
Chapter 6 - Conclusions

The Catwalk Problem was originally designed to introduce students to the concept of instantaneous change or velocity prior to their study of calculus. The purpose of this paper is to identify the ways students developed a sense of a derivative (Speiser and Walter 1994) essentially a mathematical representation of instantaneous velocity. As the data suggest the students developed a strong understanding kinesthetically, as well as mathematically. Although the concept is typically taught using graphs and function notation, the underlying premise is that of motion. For this reason it is important to study the way students develop this knowledge using both physical and mathematical experiences.

The students in this study developed ideas about acceleration, velocity, continuous and discrete representations, data collection, different mathematical functions, average change, and instantaneous change. The students also determined which mathematical concepts would not help them solve the problem and summarily dismissed them or let them fade away. All of the above were developed in the context of a rich authentic problem.

There were three tables in the room with five or six people at each table. The students at the table on the first day were not necessarily the same students in subsequent days. There were sections of time devoted each day to large group discussions. For these reasons I did not limit my findings to a study of the problem solving of students at only one table, although Table 1 was the focus of my study. As conversations between and among tables occurred both informally and as part of large group discussions, the
boundaries and concentration on a single table blurred. The subsequent findings are based in large part on the agreements of Romina, Magda, Aquisha, Jeff, Brian and Ankur. Participants in large group discussions from other tables also provided ideas that were either dismissed by table one, or used to create their own arguments.

6.1 The mathematical ideas that were abandoned

Some of the mathematical ideas that students used in working on the problem involved measurement in centimeters, proportional conversions and measurement, scale, and speed calculations. More advanced mathematical ideas that were introduced included regression equations, derivatives, and a variety of individual graphic representations.

6.1.1 Exact Measurement

Much of Magda and Romina’s original struggles centered on their inability to reconcile their measurements with the information they were given from the constructs of the problem (5.2.1). They knew that each box behind the cat represented 5 real centimeters that the cat traveled, yet when they took their measurements they did not add up to the same 5 centimeters. The group even took the same data and converted it into a .36:5 centimeter scale. The data still did not balance out exactly to the constructs of the problem (5 cm per box traveled). This incongruence led to the group abandoning the use of exact measurement in favor of estimations that could be made to add up to the five centimeter markings seen in the background.
The members of the table recognized that there was some error in what they were doing (estimating the distance of the cats movement) and that knowledge played a part in their determination of what would be part of an appropriate final answer.

6.1.2 Derivatives

Early on the first day of the problem (7/13/99) Romina asked Victor what he was working on and Victor described a formula that he learned in class (formula for projectile motion $-16t^2 + 32t + 5$) indicating that it (the formula) “…gives you like something for velocity.” (215) Victor goes on to state that based on that formula (Victor’s velocity formula), acceleration would be $-32t + 32$. The beauty or irony of this statement is that Victor was able to calculate an elementary polynomial derivative correctly. Victor indicated in line 240 that he learned to make that calculation in a calculus class. That derivative represented the instantaneous change in velocity of the motion of a projectile - not the instantaneous motion of the cat, but a projectile (a construct with which he was familiar with) which he was trying to adapt to the catwalk problem. (Victor was one of the students that attended the summer institute from another school district. Victor studied calculus in a traditional program.)

There were errors in Victor’s statements. The original formula was a position function not a velocity function, and the derivative represented velocity, not acceleration. What does provide evidence that he had a traditional calculus course that focused on rules and procedures was his ability to calculate a derivative correctly as well as the knowledge that the derivative of a velocity function is an acceleration function. The unfortunate message from this was that after taking a course in calculus, Victor was unable to define
instantaneous change in terms of the catwalk problem, or know the type of function he
was initially considering.

6.1.3 Regression Equations

After a break on the first day of the problem, Benny was trying to determine a
regression equation that would model the motion of the cat. Benny asked Matt what to
do on the calculator when Matt volunteered that they have come up with an equation, but
(8) “…it doesn’t make sense.” Not long after this dialogue Victor showed Magda how
to find a regression equation and even suggested the use of a quadratic. After they find
the equation (we have to assume they do as the calculator is not visible but an equation
and graph is displayed a few days later) Magda put down the calculator. This is the end
of substantive discussion of a regression equation at table 1, although equations that have
no foundation in Romina’s table are visible on the top and bottom of her second table.

Figure 18 Romina’s Second Table using estimated distances

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There is little further mention of regression equations, yet Romina did use one to overlay a time/distance graph that she presented on a subsequent date. However, there was no recorded conversation then about the line representing the regression equation by any of the researchers or students.

6.1.4 Aquisha’s line

Aquisha spent most of the first two days of the workshop measuring the distance the cat traveled between frames by drawing a line the length of the cat’s movement (resembling a dash) on a blank transparency placed on top of overlaying transparencies of the cat photos. Aquisha then carefully copied the dashed lines end to end onto another transparency using two different colored markers. She then measured the length of the line and compared it to the overall distance the cat traveled in the pictures by proportional calculation. Her result was very close to the actual distance traveled by the cat (a difference of .01 cm on the photographs).

The line Aquisha created was a thoughtful, continuous representation of the cat’s motion. All data before and after are discrete indicators of either distance data that the cat has traveled or computed data representing the cats’ speed. I will address other graphical representations later that have ‘lines’ on them.

By representing the cat’s movement in this manner, Aquisha gave a sense of the different distances the cat moved during a constant time interval. Jeff indicated that this representation allowed him to see when the cat was traveling at a constant speed, where he was accelerating and where he ‘launches’ (Jeff’s terminology) toward the end. R4 referred to this representation as a model for the library and hallway lines.
There were a few minor differences between Aquisha’s line and the data that Romina and Magda recorded from their measurements. The measurements for Magda and Romina’s first table (5.2.3 figure 1) indicate an increase and decrease in speed until the ninth measurement where the cat began to pick up speed again. Aquisha’s representation showed an unmeasured constant distance traveled until the eighth measurement (5.1.2a figure 1). It is not known if Aquisha’s lines were ever measured. There is no video evidence, nor student or researcher data to indicate that it was. On 7/15/99 while the hallway line was being created, R4 had a discussion with Aquisha that confirms (from Aquisha, without measurement) that the lines never got shorter; there were times when they were the same size, but never smaller. Aquisha also indicated here that because she didn’t have a “...photocopy of a ruler”, she was not able to make the measurements as they were too small to measure.

There are no further references to Aquisha’s line after the conversation that she has with R4 in the hallway.

6.2 The Mathematics that were used

Most of the mathematics that the students spent time on was elementary, considering the level of problem they were working on. Early measurements in centimeters, proportional calculations and scale are the topics I refer to as elementary. I will not speak of them in detail other than to mention that the students needed the fundamental knowledge from these topics to solve this more complex problem.
6.2.1 Romina’s Tables

Throughout the early days of the problem, Romina and Magda collected data through measurement and estimation, and recorded them in organized tables. As different ideas or needs presented themselves Romina altered her tables to reflect these needs. For example, the first table was created using exact ruler measurements. Romina’s columns included the number of the frame (for now I will refer to it as the frame measured ‘to’), the frames involved in the distance measurement, the distance/constant time, and the speed in centimeters per second. Below are the first few entries of her first table on 7/13/99. Notice that the distance is entered as a decimal centimeter even though there is reference made at this time to measurement in millimeters.

![Figure 19 A Portion of Romina’s First Table]

Romina’s second table reflected measurements made by estimation. There are other entries to the table as a result of discovered need.
The first two entries remained the same (the ‘to’ frame and the frames involved in the calculations). The next major column marked D/T is the estimated distance and constant time computation. The last column is identified as speed and is shown in centimeters per second.

There are two new columns: one is an accumulated distance: the second an accumulated time. The accumulated distance is a result of the inaccuracy of measurement that the students were experiencing. Magda stated in frustration a number of times that the measurements could not get any more exact given the tools they had to work with (110 year old pictures and rulers). Theirs was an effort to make the data they were recording match the constructs of the problem. The accumulated distances between frames never matched the multiples of 5 centimeter measures represented on the background of the pictures. For example, Aquisha estimated that the cat moved one whole box by the sixth frame (7/13/99 line 358) meaning that the cat would only have moved 5 centimeters. Romina’s table indicates an accumulated total distance of 5.9167 cm. Magda countered Aquisha’s claim (360) stating that the cat actually moved a little
more than 5 cm, so their measurement was reasonable. This type of implied error helped
determine how the group would handle future challenges. When charged with helping
settle a bet in a high stakes situation, the students made either qualified decisions or no
decision at all due to the inherent error in measurements within the group and fostered by
differences in measurements between the groups.

6.2.2 Romina’s Graphs

Using her last table, Romina entered data into her calculator. Apparently she used
at least frame number, distance, accumulated distance, accumulated time and velocity.
The graphs that she created were time/distance, speed/distance, and time/velocity.

6.2.2a Time v. Distance Graph

Romina and Magda initially created a time/distance graph that displayed distance
on the x-axis, and time on the y-axis. While this is not completely wrong, it is difficult to
interpret if you are not aware of the way your axis is labeled. When questioned by R4
about the similarities to her linear representation, Aquisha initially indicated that the
graph was increasing more quickly when the cat should have been moving slowly and the
speed was not increasing as fast as it should have farther on in the graph. This indicates
that either she was not aware that the axes were reversed, or she believed that Romina
and Magda had the wrong data in their lists. R4 challenged the way her graph was set up
based on any similarities to Aquisha’s line (5.2.4a). After Romina and Magda reversed
the axes Aquisha, Romina and Magda indicated that the calculator image was more
understandable.

Later that morning Romina made a presentation to the whole group. The first
graph that she displayed was this time/distance graph. This graph was comprised of
discrete data points. Additionally Romina had a curvilinear function (most likely one of the regression equations that is evident on Romina’s first table) superimposed over the data points. This did not seem to surprise any other members of the group, nor did it create any conversation.

![Figure 21 Romina’s Time/Distance Graph](image)

The nature of the photography indicates continuous motion of a cat. The cat did not move, stop and pose and then run again twenty three times. The cat ran continuously and the camera recorded its progress or movement. With the exception of the first graph Romina displayed, neither of her other graphs indicated continuity of motion, but rather discrete data.

### 6.2.2b Speed v. Distance and Time v. Velocity Graphs

Romina displayed two other graphs. One of the two was displayed on the same date as the Time v. Distance graph from the previous section (Speed v. Distance) and the Time v. Velocity was displayed on the following day.

On the Speed v. Distance graph, speed was on the y-axis, and distance on the x-axis. Romina was not particularly comfortable with this graph as she was not sure initially which axis contained speed or distance. It was through the help of Jeff, Brian
and Magda that the question was resolved. Jeff and Magda answered the question by checking the settings on their own calculators. Brian answered the question through reasoning, (7/14/99 line 530) “...cause how could the distance go down then? The ‘y’ s gotta be .....speed...”

Unfortunately, Romina was not able at the time she originally displayed the graph to discuss the importance of the graph. She decided it was appropriate to do so after creating the time/distance graph. Notice here that the data points are connected. This graph is not superimposed with a regression equation; the data points are simply connected. This connection indicates that there is some relationship between each data point, not necessarily a trend developing over time. It is reasonable to assume that the connectivity was a thoughtless action, either something done by the calculator as a default response, or by Romina as a natural reaction. Romina did not refer to the connections, nor did anybody else. The importance of this type of representation was lost at that time.

The following day Romina was asked to display the Time v. Velocity Graph. This graph shows time on the x-axis and velocity on the y-axis. The graph as shown now was discrete. When Romina initially created the graph on screen, it immediately
displayed as a series of connected data points similar to the way the previous graph was connected. It was at the request of R4 that she remove the lines. When R4 made the request, there was no question from anybody in the room as to why the lines should or should not be there, simply tacit approval or acceptance of the request.

Figure 23 Romina's Time v. Velocity Graph

Mike questioned Romina about the time markings on the x-axis. Romina used the accumulated time column on her data table to mark the x-axis. Mike made the interesting observation that he thought she divided each distance by the accumulated time in this graph to get the displayed velocity. Mike saw this graph as the actual calculation to obtain velocity. Romina was able to defend her position in using the accumulated time as simple marking on the x-axis. Indicating also that the graph was a representation of the dependency of velocity on time, not distance divided by time producing velocity.
6.2.3 Models

The students were given a written problem on a sheet of paper, photocopies of a cat in motion on paper and transparencies, paper, rulers, markers, and calculators, and masking tape later on. From these supplies the students created their own mathematical models. The students created charts, not one chart, but multiple charts, each one born from the errors inherent in the problem, none of which could be reasonably anticipated. Each time a new chart was created, it evolved into a chart with a greater amount of important and more precise information. From these charts developed graphs. Three different graphs that illustrated speed, distance and time in important ways.

From these charts also the floor tape lines were developed, scaled and measured. The data were scaled to appropriate sizes to suit the different forums. From these models (lines) the students developed a kinesthetic understanding of the motion of the cat. Previously the students’ knowledge centered on the data in their tables and interpretations they could make depending on what they saw in the pictures. After the tape line experiments the students had experienced (or witnessed) the motion of the cat. The students who did the experiment generally found that they could not accomplish the task accurately in one attempt; generally two or three were needed to reasonably imitate the motion of the cat.

The students came back to the library after the hallway exercise and indicated that the model they used in the hallway helped them understand not only the places where the cat accelerated visually and physically, but the photos and the graphs now made more sense to them.
Aquisha did not make charts. Aquisha drew lines (dashes) that were the measurements (lengths) the cat traveled between frames. Aquisha was not interested in calculated velocity in the beginning (first two days), rather she was interested in an accurate depiction of how the cat moved through the frames. In an effort to make sure that her line was accurate, Aquisha determined the overall distance the cat traveled in all frames and checked it against her line using proportional measurements (.36 cm in the photo’s to 5 cm in actual distance the cat traveled).

Interestingly, the final accurate line that Aquisha assembled from smaller dashes was the model for the library and hallway line. Aquisha, it can be argued, was the first and only student to consciously represent the motion of the cat continuously. Her model represented the way she saw the motion of the cat and the drawing made it impossible to interpret otherwise.

6.3 The Motion of the Cat

The students discussed and discovered the motion of the cat in two different ways: First by discussing what they could interpret of the cat’s movements as observed in the photographs and second by what they experienced in the tape line experiments.

6.3.1 Motion as observed in the photographs

At the very beginning of this problem, R4 tells the students how the pictures came about, the history of the photographer, and the constructs of the event. The students are then encouraged by R4 to speak about the photographs and any observations they have about the photographs at their tables. At this point the students discussed the part of the cat that they will use to mark its progress, the overall amount of time the experiment
took, the distance between boxes and darker lines as well as the progress the cat could be observed making (speed or velocity).

There is no question the pictures that constitute this experiment are moments in time. These are still shots of a cat in motion. There is motion surrounding each picture that is implied but not captured, however the cat is not actually moving in any picture. The time interval between pictures is amazingly small (.031 seconds) for photography or any technology in the 1880’s, as well as the time interval it took to capture a still photograph. The speed of the photography at that time could be compared to machine guns that were manufactured at the time and used through World War II (Maxim guns). These guns were capable of firing up to 600 rounds per minute, or ten rounds per second, not 24 rounds in three fourths of a second. This dimension was eventually lost on most students, certainly those at table one.

While the students made measurements of the progress of the cat, calculations were made about the speed of the cat between frames and were compared to observations of the cat in the frames. For example the number of boxes the cat covered in a certain amount of frames compared to the same type of observation later in the group of photographs indicating either a change in speed or a constant speed.

While observing the movement of the cat in the photographs, the students made mechanical mathematical observations and calculations. Magda took measurements, and Romina recorded the measurements and made velocity calculations. Aquisha drew lines representing the distance the cat traveled from frame to frame and made observations based on her perceived length of each line (she never actually measured the lines to determine if there was a discernable difference indicating any change in the cat’s speed).
Given an authentic problem such as this, the students displayed a variety of problem solving skills as well as using different mathematical skills to address the problem. The motion of the cat in this problem remains ‘fundamentally ungraspable’ (Speiser and Walter 1996) given the discrete data set that is the 24 photographs.

6.3.2 Motion experienced

Aquisha’s line provided an example for R4 to refer the rest of the students in order to create a physical linear representation on the floor for the students to ‘act out’ the motion of the cat. Two lines were created, one in the room the students were working in (the library) and another in a hallway adjacent to the library.

6.3.2a The Lines

Using the data from Romina and Magda’s second table, the two students laid the tape line on the floor of the library as well as the hallway. The line in the library was not long enough to observe any of the participants make a discernable change in speed (as predicted by Shelley). Matt was one of the two students to make the walk (Benny was the other) in the library. Both men kept pace hitting the tape markers, with the can beat (Mike was beating the bottom of an empty garbage can in a steady rhythm). The steps they took were uniformly short and for the first several marks they were one per mark. After the first nine marks it became impossible to maintain the same rhythm with short steps so the students increased the number of steps between marks, as well as the speed of the steps between marks so that on each beat they were still able to hit the mark.

The overall speed of Matt or Benny’s total body did not change much if at all. Their foot speed did. This observation affirmed Shelley’s earlier prediction that they needed more room as the lack of change in Matt’s overall speed precluded the group
from distinguishing any change in velocity of the student. As Romina remarked “it defeated the purpose”. (5.1.2b)

In the library the students were able to begin making distinctions about the motion of the cat. Benny identified acceleration physically as a series of quick steps, and the ‘not’ accelerating by making plodding steps. In both instances he was using physical representations to illustrate his perceptions. Whether the perceptions were correct or not, his model was a physical one in response to their physical exercise or model. By making these motions Benny illustrated that his physical perception of acceleration was that of speed, not changing speed. Acceleration to Benny according to his physical model was quick movement, not movement more quickly.

Benny made the line walk similarly to Matt. The same uniform short steps that sped up as the distance dictated. Benny questioned at the end whether he was “picking up speed?” Or “by covering a faster, more of a distance am I picking up speed?” Romina, Magda and Ashley independently indicate to Benny that because he was covering greater amounts of distance in the same amount of time he was accelerating. These comments made by Romina, Magda and Ashley at this time indicated at least a mathematical understanding of acceleration.

R4 questioned whether Benny thought it took him the same amount of time to cover greater intervals and Benny agreed that it did. This prompted Benny to volunteer that the rhythm of the motion was what the problem was for him.

Here Benny has a revelation of sorts. Benny indicated that the cat did not move to the rhythm of the cameras. The cat moved freely. If he or any of the other students were allowed to move freely and then time how long it took for him to move from mark
to mark they would be able to measure the speed accurately. At this point it does not occur to Benny that is what actually happened. The cat was allowed to move freely (ignoring any foreign impetus the cat had to run the course) and was photographed as it went. The purpose of steadily timed consistent photography was to thoroughly record the motions of the cat as it progressed, not monitor or calculate its movement.

Benny correctly stated that the cat did not move to a rhythm of the cameras, but rather the cat moved freely. The timing of the cameras was not important (other than for thorough coverage) until over one hundred years later when a few mathematicians wanted to know how fast the cat moved. Being able to rely on a consistent time interval is helpful. The cat didn’t care about the timing of the cameras.

Benny carried this idea out into the hallway. It was Benny’s idea that Victor should move freely along the tape line, imitating the speed of the cat as he went. There should be no rhythmic beat to indicate where the cat should be at any point, only Victor moving and Benny counting how long it took him to get from the ninth mark to the tenth mark. Victor made two runs. On the first run he halted after the tenth mark and restarted. The second time, he went from a walk to a run at the eighth mark and did not slow down or change speed further until the end when he stopped. It appeared that Benny was unable to time Victor from frame nine to ten.

R4 asked Benny if it was reasonable to assume that Victor traveled at the same amount of time between intervals, and Benny agreed that it was. Benny still indicated that he had to get Victor to run again to time him.
Later back in the library Benny indicated that he developed a good idea of the cat’s acceleration using the line as a visual aid. He referred to the line as a visual explanation rather than a mathematical explanation.

At this time Benny stated that he was able to tell where the cat picked up speed between points ten and eleven due to the distance between the points. Benny is beginning to understand acceleration as a function of distance and some kind of time (either consistent at .031 seconds between frames, or the arbitrary timing of a person running freely).

Ironically, Victor agreed to run not because Benny asked him to, rather because of a conversation that he had with R5 earlier. Victor did not feel it was appropriate to have someone counting and banging on a locker for him. He indicated that he needed to internalize the count for his own run and would be counting to himself in his head. On his first run you could hear him softly counting “one one-thousand, two one-thousand...”, until he got to the tenth frame and misjudged the distance to eleven and had to start over. It was this absence of distinct external counting that gave Benny the feeling Victor shared his ‘free’ motion idea. In reality Victor was trying to internalize the count.

Also of interest is the fact that Benny was the last student to make the run. Benny making the run was not necessarily interesting; it was what happened while he made the run that was interesting. While he made his run the remaining students kept time by banging on the lockers in a one beat per second rhythm. It took him three attempts, but on the third attempt, he successfully hit every mark on the established locker beat. It is impossible to tell if he was successful imitating what the other students were doing, or whether he realized that the locker beat was analogous of the cameras.
On a final note, the first person to run the line in the hallway was Brian. He ran it
to a beat per second locker rhythm, and he ran it accurately with only one small mistake.
He managed to get to the fourteenth mark ahead of the locker beat and hesitated before he
proceeded to get back on beat. Brian kept a slow pace in the first eight marks, began to
move a little faster at the ninth and tenth and then moved into a fast jog to the end (except
at mark 14). This accomplishment went completely unheralded by any of the researchers
or other students. All of the other students making the run had difficulty managing the
pace of the first eleven frames.

6.3.2b Romina on the lines

During an interview after the Summer Institute (7/19/99) Romina described to the
interviewer that the tape line (65) “made sense of it”. The students had the data, they
determined the numbers for distance and velocity, and they had the time intervals. None
of it made sense to them until they could actually see where it (the cat) accelerated or
slowed down. Back in the library after the tape line, Romina displayed a Time v.
Velocity graph that she indicated followed what they did in the hallway running.

6.4 Average or Instantaneous

In order for us to understand how the students at table one finally answered the
problem posed, we need to understand how Romina viewed each picture. To Romina
there was a beginning, end and middle of each frame. As well as the ‘betweens’, the
distance the cat traveled between each frame (5.3.2). First we will examine how Brian
helped define instantaneous by an analogy he thought of to foster the use of average
velocity.
6.4.1 Brian’s Analogy

Brian used the local Parkway as an analogy to argue for the use of average. In short, Brian’s argument was if you are driving at 30 MPH at one exit, pass another and at the third exit you are driving 60 MPH it would stand to reason that you are traveling at 45 MPH at the second exit. Romina, Magda, Jeff and Ankur took this opportunity to use this as an argument for not using the idea of average. Jeff primarily thought that you had no way of determining how fast you were traveling between the first and third exits as long as at the first you were doing 30 MPH and at the third you were doing 60 MPH. At one point he even suggested you could get off the highway and back on as long as you still met those two marks, or you could vary your speed significantly between the exits.

Romina used this analogy to a finer degree. She identified the exits as exit nine, exit ten, and exit eleven; making the parkway exits synonymous with the Catwalk frames. Here again, Romina indicated that while the car will travel at 45 MPH somewhere between exit 9 and 11, they have no idea where that will happen.

6.4.2 'In' Frame 10

How fast is the cat moving in frame 10? This is the essential question of the problem. What does “in frame 10” mean? As discussed earlier each frame or picture is a quick moment in time. It is at least quicker than .031 seconds. One can reasonably assume that the author of the original problem worded this so that the student would have to think about the idea of instantaneous, and that average would not be appropriate. The problem becomes the meaning of the word ‘in’.

Used as a preposition ‘in’ implies space, either physical or imagined. This is how Romina thought of the word ‘in’. This space is what created sufficient doubt in Romina
to prevent her from accepting the use of average as an answer to the problems posed by
the researchers.

Initially Romina used the idea of ‘in’ to identify where the calculated velocity
could be found (5.3.2a); “So this speed ... is considered the speed in two, in frame two?”
This notion of speed in a frame expands later to include a changing speed or a place
where something or a lot of things happen (5.3.2b). At one point Brian and Romina
discussed the cat’s motion in frame ten using hand movements, from smooth movements
(Brian) to a movement that indicates a change of speed (Romina). Brian’s hand
movements indicated his sense of physical motion in general; Romina’s indicated her
sense of the cat’s motion.

Romina’s argument is simple. As evidenced by her tables, the distance between
points increase as you go from frames 9 to 10, and frames 10 to 11 and on up. Whether
the measurements were the exact measurements they created initially, or the estimated
measurements they ended up with, there was an increase in distance. The increase in
distance was not constant between the two sets of frames. According to Romina and
Magda’s measurements the distance from frame 9 to 10 was an estimated 2.5 centimeters
(estimated measurements made by Magda without a centimeter ruler) while the distance
from 10 to 11 was an estimated 6.25 centimeters. These measurements yielded velocities
between the frames of 80.6452 cm/s and 201.613 cm/s respectively. The disparity
between the two sizes and velocities was so great that Romina could not see the average
(141.1291 cm/s) of either being a center value. According to Romina, if the average
value was in frame 10, then frame ten had to be sufficiently large to encompass that
value.
A mental image Romina might have that would represent dimension in frame ten might be:

![Diagram of frame 10 interpretation](image)

*Figure 24 Illustration of Romina's interpretation of Frame 10*

In this instance the average velocity (141.1291 cm/s) could be found somewhere in the arbitrary circle that represents frame 10, absolutely not in the middle of the frame though.

Romina and Angela debated a key point on 7/16/99 during a group presentation. Angela’s argument was that frame 10 is right in the middle of the two surrounding frames so it is going to be the average location, and represent the average value. Average location equals average value, or just average equals average. Romina’s argument was that the surrounding velocities differ so greatly, the average value cannot happen in the middle of frame 10. This is also where Romina started to refer to frame 10 as having a beginning and an ending.

This argument is what convinces me that Romina, Jeff, and Magda all have a strong concept of what instantaneous represents. They all argued at different times about what happens ‘in’ frame 10. They argued that the computed average is not the correct answer because there is so much changing in the frame that the computed average might not belong in the middle of frame 10, and the middle of frame 10 (which should be the point of average value) is the center of 9 and 11.
One of the devices that the researchers used to motivate the students to find a solution was to create a scenario that presented a sense of urgency. The researchers chose one of the student’s classroom math teachers and identified him as the CEO of the company they all worked for, and handed out a memo from the CEO that indicated he had a lot of money riding on a bet that his researchers (the students) would be able to give him a particular velocity for frames 10 and 20.

All three tables in the room agreed that he should not make the bet on frame 10 based on one common issue for all tables, a second issue for table 1. The overall issue was one of inaccuracy. Because of the inaccuracy of the transparencies and the lack of a tool to make an accurate measurement all three tables came up with different velocities between frames. The groups all used the same type of calculation to obtain the velocity, but the distance measurement from frame to frame was never the same value amongst the groups. Table 1’s second issue was that of average. They would not make the bet primarily because they could not come up with a value that was representative of the instant in time that the center of frame 10 represented.

Frame twenty was further evidence that Table 1 understood the concept of instantaneous change. All tables agreed that the velocity immediately prior to and immediately after were the same creating a constant velocity. Taking the average in this case would give the same value that an instantaneous measure would have given. Romina indicated that average was acceptable here, that the average value was happening in the middle of frame 20. Interestingly, all groups insisted on the CEO making his measurements because they felt theirs could be wrong. This was based on the fact that all groups actually had different distance measurements. They were consistent before and
after, but they were different between groups. And if the CEO was going to wager his money, they felt comfortable making the computation just not the measurement.

There is video evidence after Angela and Romina’s argument that other students who had originally decided on the average value being appropriate changed their minds. Both Matt and Victor made statements prior to the end of the session indicating their reluctance in using an average for frame 10.

6.5 Conclusions

Most of the students in this study had spent many hours over many years working on this type of problem as evidenced by a comment early on by Brian (7/13/99 line 67), “You think it would be that easy? This is an eight day freakin’ problem with no answer!” There were a few other students in the room from an urban central New Jersey school district that had not experienced these types of problems.

The students who were in the longitudinal study were accustomed to creating models and then arguing or creating convincing arguments for their solutions. When asked to work on this type of problem, the students in the longitudinal study had become accustomed to being given the latitude to construct appropriate models, and generous time to develop their answers. They were also accustomed to not being given a concrete solution to their problem.

This problem was no different. The catwalk problem asks “How fast is the cat moving in frame 10?” There is no doubt that the students were not able to come up with a solid answer with which they were comfortable. Part of the reason for this was the inaccuracy of measurement the students were dealing with; another underlying reason was unwillingness by some to accept the use of an average for the answer. Some of the
students went into the final day of the problem willing and comfortable to accept the use of an average as an appropriate answer. At the end of the final day there is video data showing most of the students at least questioned the use of an average. Many understood that an average was clearly not appropriate.

As I stated at the beginning of this chapter, the purpose of this problem is to develop an understanding of instantaneous velocity, a topic typically taught mathematically using graphs, function notation and some elementary functions. This exercise illustrated for these students the inappropriate nature of an average. Did the students develop a sense of instantaneous change? For a few it absolutely did. Romina, Magda, Jeff, Ankur were absolutely convinced that average was not appropriate, or at least instantaneous velocity is not appropriately measured using average velocity.

Romina argued against the use of average in frame ten because she didn’t know exactly what was happening in frame ten, or specifically what was happening in the center of frame ten. Frame ten is a moment in time; as Angela mentioned, it is an instant in time. To use an average as a measure of an instant would indicate that the middle value of the surrounding velocities satisfactorily describes what is happening in that frame. Romina understood that she didn’t know what happened in that frame and was unwilling to use an average. After laying the tape on the floors representing the movement of the cat, with Magda actually running the line, and all of them witnessing their colleagues run the line, Romina was convinced that something important happened at (or in) frame ten. There was something that compelled the cat to make the change in speed, and that averaging a slow speed with a fast speed could not correctly identify how fast the cat was moving in that instant.
A question remains as to the speed of the cat in frame ten, or frame twenty. The answer may not be important. What is important is the development of the conceptual understanding of instantaneous change. Knowing how fast the cat is moving is unimportant; knowing how he is moving is important.

6.6 Limitations

This study presents data and conclusions based on observation and documentation of the actions of students in a small group setting. These students were given freedom of time, necessary resources and were left alone to develop and argue both physical and mathematical solutions to a specific problem. The students in this study were also given the freedom to create physical models in locations other than the location in which they were housed. Future studies could be made regarding the effect these freedoms (time, resources, mobility, and independence) have on the development of ideas presented in this study.

6.7 Implications for Further Study

As stated earlier the Catwalk Problem was originally designed to introduce students to the concept of instantaneous change or velocity prior to their study of calculus. This study identifies mathematical and physical topics that students use to develop their own conjectures and arguments in the constructs of the catwalk problem. A similar study of this problem in a more typical classroom situation (45 to 60 minutes, over several days) would help to validate the findings of this study.

The researchers involved in this study were there to investigate how the students thought about the problem and developed their ideas. The researchers created two
different scenarios (a CEO of a company placing a bet, and the urgency of the CEO’s demands) to encourage the students to come to a solution. The researchers did not aid the investigations in any way other than to instill a sense of urgency and importance through these scenarios, and to provide appropriate resources. A study of what mathematical and physical concepts the students can develop from targeted extensions of this problem are also worth studying for further validation of the findings of this study.
Chapter 7 - References


Abstract

Chapter 8 – Appendices

8.1 Researchers

R1 – Carolyn Maher
R2 – Robert Speiser
R3 – Alice Alston
R4 – Chuck Walters
R5 – Janet Walters
R6 – John O’Brien
R7 – Arthur Powell
R8 – Tim Sweetman
R9 – Kathy Spang
R10 – Ralph Pantozzi
R11 – Elena Steenken
R12 – John Francisco
Every little red light in the room is on, so I suppose that we’re uh, ready to go. You’ve undoubtedly seen that there’s been some changes. One change of course is that we have a new cast, the organization of people is a little different. And uh, so we’re, you have a new uh teacher here. So I hope you’re not nervous. You can let me be nervous or all of you. And we’ll uh, we’re going to think about something that’s a little bit new I hope. In fact, we’ve been over the course of this last week, thinking about a lot of things that have to do with, with change. And we’re going to continue with that that theme this morning. Now we’re going to present you with some, some new information and then try to build out of this new information a, uh new exploration. So let me pass you, or ask people to pass you a, a uh page which has some photos on it. They are going to become the basis of our explanation. I’ll put a Xerox overhead copy of this up here. And we can (CW focuses cat transparency on screen), now you have the advantage of having a much larger view of this I think than, than I do on my little sheet although the projection looks pretty good. But it’s exactly the same thing. So, just look at this for a little bit if you will, and I’ll tell you a bit of history of this. Kind of a story. (2:54) These are as you see twenty four pictures, twenty four frames of a cat in motion. These pictures were taken by a very famous photographer by the name of Eadweard Muybridge. Let me write that down because he doesn’t spell his name like you might think. (Researcher CW writes his name on the whiteboard)
This is going to be important to us why?

My first inclination is leaving out the (inaudible, but points to the first ‘a’ in Eadweard) and pronounce it ‘Edward’ but that’s what it is. These photos were taken by Mr. Muybridge somewhere in the early eighteen eighty’s. Eighteen eighty one, eighteen eighty two, somewhere in this area. Now this set of photographs may not be too spectacular as we think about the kind of things we can do with photos today. But you think about what was available in eighteen eighty for taking such photographs I think this is rather remarkable. Let me tell you a little more history of, of this whole set.

These photographs appear in a, a book of such photos, about two hundred such plates that uh was published in eighteen eighty five by Mr. Muybridge. And the title of this was “Horses and Other Animals in Motion”. So, in this book you see a whole collection of plates like this of a wide variety of animals. Horses of course as indicated. Cats, dogs, camels, birds of various kinds. He was very interested in trying to get a sense on what the motions of animals really was. Indeed this, this was sparked, or at least the efforts that he made were sparked by uh an interesting situation. There was a, there was a question around the country, strange as it may seem, but particularly on the east coast and in San Francisco, about whether or not a horse which was trotting, ever had both feet off the ground, or all of his feet off the ground at the same time. Actually it came out of a, a wager that two prominent folks had, had made on this issue and it kind of then developed into a larger question. (6:06)

So this problem, this is something they just couldn’t seem to settle. No amount of of rationale or reasoning could really bring this question to a close. And so Muybridge devised an ingenious way of photographing a horse in motion that in fact settled this issue.

And what came out of that then, in further um instances where these other animals in motion. Now think a bit about what, what goes on here. This, these photos are, you’ll notice that the cat seems to be on some kind of a platform. This is a
set up that he did at a gentleman’s riding park in Philadelphia at the time, and there’s a backdrop to the cat. Kind of a grid. Or it actually is a grid isn’t it? And the dimensions of that grid, each, each line is five centimeters apart. And if you look in the lower right hand corner you see that indeed these photos were taken at an interval of let’s see, I guess it’s the lower left hand corner. The, these photos were taken at an interval of point zero three one (.031) seconds a piece. So this is the interval between these photos. He did this with twenty four different cameras. (8:04) Not one camera, twenty four different cameras which he configured with an electric device to trigger the shutter at precisely these intervals. Twenty four cameras, I think, to me that’s just amazing.

4 Jeff How did he get a cat to go from a walk to a run, like how do you… (Inaudible question)

5 R4 That’s a real good question. What do you think?

6 Victor I don’t know, what was the question

7 R4 Jeff ask it a little louder.

8 Jeff Um, How do you know your cats going to start to gallop at the right spot if he starts out walking and then goes to a gallop?

9 R4 What would you do?

10 Benny Spank it.

11 R4 Sorry. Say again?

12 Benny Hit it or something, like tap it.

13 R4 Tap it. Benny says he would tap it. Any other ideas? Do any of you have cats by the way?

14 0:09:15 Romina I don’t like cats.

15 R4 OK, so imagine your cat, how would you …

16 Jeff Yeah but… Like my cat wouldn’t be…, like first I wouldn’t be able to get him walk to make a straight line like that (laughter) he wouldn’t be in position for me to you know… like what.. cats usually like kinda turn around and like (inaudible) you get it to kinda continue on in like a straight
line and get him to do what you want him to do. What? What do others think? (Angela’s statements are inaudible)

Did you hear what Romina said, or Angela said I’m sorry? (Angela and Jeff’s statements are inaudible.)

Yeah, so you throw him in this like box thing right? Or however this box thing I imagine it’s like an “L” shaped thing right? Like what keeps him from like walking toward you, or why…, why would he…

He might have taken a bunch of pictures

He might have taken a bunch of pictures, it’s not like he did it once

Imagine how many pictures you have to waste if you take twenty four pictures each a time.

Mike.

Did the floor move?

No. This is eighteen eighty. Remember eighteen eighty. So Matt, Matt you said something about, you thought (inaudible from Matt) (Inaudible conversation from Jeff’s table)

Just throw a ball, give him something to chase after.

Something to chase after?

It works like that for my cat I know. Like if you pulled a string in front of it, he’d go after it.

Mine, like mine stops. He stops, he’d get evil and go straight through it.

So this is not a simple experiment. Somebody, somebody here I think said something about maybe doing this more than once, is that… Did somebody say that?

Well obviously he’s not going to do it in one shot, I mean if he could do it in one shot that’d be great. You know?

Might have been lucky.

Unless it took him a long time to do it you know.

OK, so even just getting this information is not a trivial matter. I mean not only are the technical aspects of it difficult in terms of what kinds of
things were available and how he must of ingeniously set this up, but then there is the problem of getting the cat to do what you think you want it to do. And within that little frame. Angela what was your remark about the time frame?

35 Angela It’s only point one seven, point seven one seconds. So it’s not that long a time.

36 0:12:15 R4 Not even a second. So there are indeed some really remarkable things contained here. OK. Let’s think about this a bit. Let’s think about, about the motion of this cat. And in some sense how we might begin to describe… We have a particular set of questions that we would like to use to start this discussion. And so I think it would be helpful for you to have these questions now. And then we can begin to think about the cat. So I’ll visit around with you, others will visit around with you. Try to get a sense of how you are starting to think about this.

37 0:13:26 Brian For the first six pictures the cat’s only tooken, take, taken one step. That’s all he’s moved, just one, like…

38 Victor Right. (A researcher visits the table and hands out transparencies of the catwalk pictures and paper with the problem written on it)

39 Magda What’s the question on?

40 R4 May I turn this off so that the noise level… would that be OK with you?

41 Victor That’d be fine.

42 Romina They’re like tied together (separating the transparencies). I don’t know…

43 Magda Let’s see. Hold on, is it 5 centimeters between those little ones or between the darker lines?

44 0:15:05 Romina I believe it’s the little ones. Because you have to …

45 Brian In between each dark line is fifty centimeters… Ten boxes..

46 Romina Oh OK

47 R4 Is there a question I could ask that might be kind of technical, it sounded like, maybe it was not.

48 Romina Each box is five centimeters right?

49 R4 Yes
50 Romina Little box
51 R4 Yes each of them, each of them, each of the lines…
52 Romina Else that cat.. (Romina makes an indication of smallness with her fingers and draws laughter from Magda) A little cat.
53 Magda I didn’t even think of that. He was doesn’t look like five centimeters, and I was like uhhh.
54 Romina I don’t know, let’s see. Let’s make my lines a little darker here. (Romina darkens the lines with marker) OK so, we have to figure out the speed for it?
55 Magda Yeah, so I would say…
56 Romina See my tenth frame doesn’t have a dark line. Does yours?
57 Magda It’s like this one right here and probably that one. Look at the edge. (Romina holds up the transparency) (Magda pointing to her paper) Like you see it here
58 Victor Go from this frame to the last frame you see that he moves about… (inaudible)
59 Romina Those lines are dark.
60 0:16:54 Magda Don’t we have to just measure how much he moved from this picture to this picture and divide it by 2?
61 Romina Or two times point oh oh three one?
62 Magda Three one three two..No like ten times, because that’s per... per picture.
63 Romina Yeah, so…
64 Magda Times ten would be point three one right?
65 Romina Hun, you’re going to measure how far they are from this picture to that picture?
66 Magda Yeah, how much he moved, and then you divide it by the..
67 Romina But she’s, the cat’s going different speeds every picture.
68 Victor Uh huh (agreement)
69 Magda Oh is it really?
70 Romina Magda
Brian: You think it would be that easy? This is an eight day freakin’ problem with no answer.

Magda: All right scratch that idea.

Romina: Let’s see. Look, between nine and ten there is like no difference. There’s like a difference I can’t measure.

0:17:50 Magda: Look his paw’s stretched out and his tail is bent.

Romina: Magda, I’m confused.

Benny: See the boxes have a certain difference between them?

Magda: Five centimeters.

Benny: Five centimeters?

Magda: Yeah

0:18:08 Benny: What’s that crap, walk hangin’ together what’s that all about? The cat walk ten together, point zero three one seconds, what’s that all about?

Romina: Each frame is point oh three one seconds, it starts off walking and ends up

Magda: Yeah, because this is like accelerating and then its picking up speed so yeah you’re right. If he was only going at the same rate…

Romina: Give me your formula for acceleration. Don’t give me that look because I know you know it too.

Magda: Acceleration is velocity divided by time? Isn’t it?

Romina: Anyone have velocity?

0:19:00 Victor: OK what I said was, alright if you look at the nose of the cat is at one line over the darker line.

Romina: Uh huh

Aquisha: So if you say this is the darker line because it seems darker than everyone else, it’s like one, two, three over, so three minus one equals two. So two times five right, five centimeters per box is ten, ten centimeters. Then each frame is marked at point zero three one seconds per frame.

Magda: I see that but, he’s not moving at the same velocity

Romina: Yeah, the cat’s ac., the cat’s accelerating. It’s not moving at the same…

0:19:32 Victor: Oh right, OK Damn.
Damn, that would have been too easy
Yeah I know.
I guess try to figure out the velocity between boxes maybe?
That’s what I’m thinkin.
But the, the change…
Between ten and eleven, I mean nine and ten
But the change is so small it’s like you can’t even get a number out of it
Yeah, well where’d we get that like…
Like two and a half and
Yeah but would…
Three and a little bit. Right? We’re at… we’ll judge it…. we’re hold on… Are we gonna judge it by where the nose is?
We gotta see where we gonna judge it by first.
Yeah. You wanna do the nose?
Or the feet.
Sorry I’m just like moving…
Hey Vic
What?
We gonna judge it by the nose?
I guess we might as well, why not?
OK, so the nose.
It’s about as approximate as you can get from frame one to frame ten.
Yeah, because basically… Yeah, whatever.
Cause even in a race that’s what they go by, the nose.
Alright
But in the first ten frames he’s not really accelerating that much.
Benny: Nah, especially not by the nose, or the head. Because if you look...

Magda: What could, what other part could we go by, the tail?

Victor: Nah, because it moves too much so...

Romina: I guess, no I think the nose...

Brian: It moved this much. (indicating an interval on a ruler) It’s a whole lot.

Romina: …is the best part to go by.

Brian: Just think I can go like this (waves his arm up and down 6 times) but it doesn’t still mean I moving like fifty miles an hour you know. My body’s not moving, I’m not going anywhere

Magda: So how about we figure out like...

Victor: I’m guessing, I think you gotta assume it’s constant acceleration right?

Benny: Yeah

Victor: So then would it really matter if you take each interval whatever...

Magda: Yeah, but it would go a lot faster as you accelerate.

Romina: (After Magda started to talk) That would give you kinda like the just uh...

Victor: Right.

Magda: Don’t you, when you accelerate go faster?

Romina: Yeah. (As Magda reaches for a ruler) Is that a centimeter, the thing?

Magda: Yeah.

Romina: Each one of those boxes is five centimeters right?

Magda: I don’t know if this is five...

Aquisha: I don’t like this copy

Benny: Yeah, you can’t see like the lines and...

Benny: Yeah.

Aquisha: They’re like cut off and stuff.

Magda: I want to see like, how big the box is.
Romina You want to try going frame by frame?
Magda I’m just trying to measure like how big’s the…
Romina Like in comparison?
Magda It’s like three millimeters.
Romina So, three millimeters equals five centimeters?
Magda Uh, huh. That’s a good one.
Romina Ugh. Isn’t that, isn’t that just point oh three? Or point three?
Magda Why are you doing this to me? You know I can’t do this.
Romina Three three millimeters is point three centimeters or point oh three centimeters?
Magda Point three I think.
Romina Point three, look at the ruler Magda, its point three.
Brian and Benny It’s point three?
Romina OK, do you want, do you want to do this frame by frame?
Magda Let me see this…
Romina It’s gonna suck though. That’s twenty four frames Magda.
Magda It’s thirty six, thirty six divided by, thirty six divided by ten? Is that ten? One, two, three, how many? I believe, one, two,…
Romina There’s ten.
Magda So it’s three point six actually. Point three six. Centimeters for five…
Romina Point three six…
Magda Centimeters, don’t forget to use centimeters.
Romina Getting right technical here huh?
Magda What?
Romina Going technical.
Magda Yeah because, six…I don’t know.
Benny So in point zero three one seconds it moves a certain amount of…
Magda Yeah, so how would I measure how much it moved? Because it looks like…

Benny By the millimeters. You can measure by the millimeters how far it travels by the nose. (pointing at Magda’s cat paper) See the nose changes. Like right here the nose is at this, at the end of this box, and right here it moves a little bit. Like that. You know it's like…

Magda Yeah.

Romina That’s gonna be tight.

Benny Yeah, but that’s too much math for twenty four boxes. There’s gotta be a short cut or something.

Magda It moved two millimeters

Romina OK hold on, we’re gonna have to break out like paper. I’m the official like note taker.

Magda OK, two millimeters

Romina Ok. Hold on. What’s today’s date first of all?

0:24:49 Magda Thirteenth

Romina OK, let’s see, cat. Frame one to two. (taking notes)

Magda He went two millimeters on our scale.

Magda & Romina So that’s point two centimeters.

Benny Hold up. Hold up. You see these boxes right here? It’s like two dark lines right here. See that? That’s where the cat is, starts. And I think as it moves, like you know it goes from like box to another box like that (making hand gestures).

Magda Because this line and that line is the same as this line and that line.

Benny And then …

Magda And this line is the same as all those. It’s not like...

Benny And then you see how, you see how, right here it’s changing and then it’s getting further past that line, and further past and then as…

Magda Yeah, but it’s the same line…

0:25:47 Romina At first it goes so slow that it looks like it’s not even moving.
Benny: Uh, huh.
Romina: Like that just like it literally… I think it just like picked up its leg.
Benny: These boxes are helping us measure like how he’s traveling, because if you look right here, he’s towards the end, then if you look right here he’s almost to another one.
Romina: Yeah, look at that but then... How would you figure out that? You have to like measure.
Benny: Yeah,
Magda: The little box, it’s like two millimeters.
Benny: See you can measure this whole box…
Magda: It’s not even two millimeters
Benny: See what I’m sayin’ you can measure this whole box, and then judge it by how when he breaks this box. He’s in a whole ‘nother box right here. So, if you found out the distance that’s in here…
Magda: Yeah, but we’d have to find out how he accelerates don’t we?
Benny: That’d help. That’d help you find out how he accelerates. Because this is a, like instead of measuring from small box to small box, you have a big box right here.
Magda: Uh huh.
Benny: Know what I’m saying? He gets out of that box and, and, and um, what is this, he breaks that box in number fifteen, and he goes to a whole ‘nother box. You see what I’m saying?
Romina: I don’t see what you’re saying.
Magda: I have no clue.
Magda: (Laughter) But how does that help us?
Benny: Instead of, instead of…
Magda: I see he is moving from box to box, but like how does that help us from here to here? (Benny shrugs)
Romina: You can keep going, I’m I have a hard time comprehending, I’m an idiot.
Benny Yeah, I see what you’re saying. I see what she’s saying.

Victor He’s saying but what?

Romina What are you doing?

Victor Nah, umm, OK. In class right, (rips paper out of book) we learned this formula that was like negative sixteen tee squared plus thirty two tee plus five for your distance, whatever.

Magda, Aquisha, Romina Whoa, whoa, etc (choral)

Victor Alright

Romina Tee squared, I lost you there.

Victor Negative sixteen tee squared right.

Romina What is that?

Victor It’s the formula for velocity that we learned in class. It’s like negative sixteen tee squared plus thirty two tee plus whatever your distance was and that gives you like something for velocity. And then for acceleration it would be negative thirty two tee plus thirty two. So I’m trying to see if this works in here whatever, but then again I don’t know it does.

Romina I’m going to take the dumb way. Point one centimeters?

Magda We’re going to move..

Romina Hold on, but point one centimeters ready? Do we divide that by two times point oh three one?

Magda Yeah, point…

Romina Like two times point? Or just point three one?

Magda Point oh three one, don’t you?

Romina Cause, yeah, from here to here is…

Magda Yeah cause isn’t it rate of change over time difinity?

Romina There it’s moving three point two two five eight one centimeters per sec, per what?

Magda No, that’s not right.
Romina Yeah, that would be…

Magda That would be a lot.

Romina Basically it would be miles per hour.

Magda Actually that could be it.

Romina Alright if we divide how far we moved by point oh three one seconds what would that give us? Like what what, like…

Victor What?

Romina This is how far we moved like from frame one to two, how far it moved. And then we divided that by how much time so, three one seconds. So, centimeters divided by seconds, does that go… so it is moving three point two two five eight one centimeters per second.

Victor Then you want to divide that by ten and you get…

Romina Well that’s, that’s what speed it’s moving in frame two.

Victor Yeah

Aquisha You going to do that for every…?

Romina Yeah, I really didn’t want to.

Magda Yeah, you have an easier way? He has something (indicating a conversation that victor and Benny are having next to Romina)

Romina I don’t understand that so. Did we learn that? What, what class did you learn that in?

Victor Calculus

Magda We didn’t get that far

Romina Oh yeah, OK.

Magda Shall we continue?

Romina I guess so.

Magda This is going to be so… It’s not going to be accurate.

Romina Hold on Magda, no Magda, you’ve gotta go from two to three.

Magda Yeah, I know, that’s why I’m marking…
So hold on, so this speed was, is this considered the speed in two, in frame two?

Yeah,

OK

I think. (Pause as she measures) One point five, point one five

Point one five. (uses calculator) Oh wow! (writes in notebook) (Pause, victor is talking to Benny off camera. Some conversation is audible about derivatives, velocity and acceleration)

Brian you want to come over here?

We’re doing it the dumb way, so…

So anyone have any questions, any frame, I’ll tell them.

I’m just screwing with numbers.

I’m going to say, point two (Benny is returning to his seat) (Laughter) How accurate can you be with this ruler?

So once you get um all the distances up to frame ten right, what you going to do with that?

Well I can tell you, then I will be able to tell you the…

How he’s moving, how fast he’s moving in…

In every frame. And like…

Yeah, because if we, because we’re doing it one by one.

See this is how fast it’s going in frame two. This is how fast it is going in frame three, this is how fast it is going in frame four.

Right.

Is it?

Yeah. So now we’re going to figure out how fast it’s going in frame frame, frame five, six, seven, eight. And we’ll do it for every single one so if anyone has a question on any one I can tell you how fast it’s going.

Alright, OK.

We can present that (indicating his work), we’ll figure out data for you, you just see if your
Victor: number match up.

Romina: Figure, go with an equation, if your numbers match up with our numbers then you got the right equation.

0:32:36 Victor: Right

Magda: Yeah but our numbers might not be really accurate because how accurate can you be with like (Magda drops her ruler)…

Romina: Yeah because (speaking over Magda)

Magda: Seriously

Victor: We’ll see…

Romina: Go Magda, we’re almost there.

Magda: Hold on.

Romina: We’re a quarter of the way there. A fifth of the way there?

Magda: Can’t be because he only moved one box. We already have him moving point four five and a whole box is point three six so it’s… I can’t do this.

Romina: Hold on but this is per second, this is per point oh three one. This whole thing is not even a second.

Magda: Yeah I know that now but I’m saying the distances I measured four point five and like this he doesn’t even move one little thing, and one little thing is point three six.

0:33:35 Victor: Well that could be a point at where he stops.

Romina: Hold on, what do you mean point three six.

Magda: One little box is point three six, and where I measured right here, that’s where he basically touches the box, and I already measured like point four five, you know, and its like only point three six. See what I’m saying?

Romina: So, I just rip the three four out?

Victor: Not really, just keep going.

Romina: No, I, she’s saying like, he, like the cat from here to here only moved one box, and one box is point three six for us?
Magda Uh, huh.

Romina But when she did her numbers from where, from that frame to that frame, if you add up her numbers he already moved point four five. So he moved too much.

Magda Yeah, so…

Aquisha He only moved one box.

Victor What, why would you want to add those numbers up?

Romina Because those only moved like one little square (pointing to Aquisha’s paper) one little square like that and… (Aquisha mutters, unintelligible)

Aquisha It’s a little more.

Victor But, umm, why would you want to add those numbers up? What’s the purpose for it?

Romina That’s just how far he’s gone. Like in frame two, in, in the fourth frame, hold on – Magda what frame are you in? Frame four? (Magda nods up and down and mutters assent) In frame four he only, he’s only gone…

Victor Point two.

Romina Yeah, point two seven

Victor He hasn’t gone all those other distances.

Aquisha speaking over Magda (pointing at the paper) he’s gone five centimeters.

Aquisha If it’s one box isn’t one box five centimeters?

Benny Yeah

Romina Uh huh. Yeah but like when we measured it by the ruler its point three six millimeters.

Victor He moved point two from this point right here to that point? That’s what you’re saying?

Magda Excuse me?

Victor He moved from this point to this point, from three to four, he moved point two?

Magda Yeah

Victor That’s what you’re saying?
Benny: He’s judging by the nose, how far the nose goes.

Aquisha: Are you measuring this in millimeters of centimeters?

Magda, Romina, Victor: Centimeters (choral)

Romina: Just put the point one…

Victor: They’re doin’ a proportional conversions I think. You know like three millimeters is equal to five centimeters, that’s what you’re sayin right?

Romina: Yeah.

Victor: Right (directing conversation to Aquisha)

Romina: We just converted it in to like it was three millimeters so it was point three centimeters.

Aquisha: So if you add all this other shit up it add up to five centimeters right? Because that’s how much one box is?

Romina: Yeah.

Romina: (to Magda) So you’re doing fine.

Magda: Yeah

Romina: Thank you. I was there with you too Magda don’t worry.

0:35:57 Romina: OK, four five…

Magda: Let’s see how far he moved. (Brief small talk between Romina and Magda)

Aquisha: Line up the distance to make sure we stay… and get to like…

Romina: Yeah, she’s measuring. I’m dividing. Delegating a little bit. He’s coming up with a brilliant equation.

Magda: It’s a little more than two.

Romina: How little? Point two…

Magda: (throwing her hands up) two

Romina: No you can’t have point two.

Magda: Point two two.

Romina: Oh,
Magda: I’m saying it’s a little more than two millimeters.

Victor: Right now I’m just trying to figure out how fast he is going at frame ten without having to go from frame to frame to frame. All right. Now so far I have the cat moving at nine point six one centimeters per second, at the rates they’re going it seems it’s gonna get there sooner.

Romina: Yeah, we’re almost there. Five six. Mag you want more room?

Magda: Thank you.

Romina: No problem. I’m here just to make you comfortable.

Magda: Look, it even was like a millimeter. It was like a millimeter basically.

Romina: OK.

Benny: Ya know what I think we should do? Since then each one is taking a full step, in all six pictures he’s taking a full step, and y’all measuring how much...he’s taking a full step, so we get how much it traveled from, for each step. Know what I’m saying. And divide that by what like..

Magda: The time.

Benny: Yeah. I mean, I don’t know. Something.

Victor: Let’s see how far we get with this. It moved how much?

Magda: Point one.

Romina: Does it point three?

Victor: Point three millimeters or centimeters?

Magda: No, just point one for...

Romina: Point two three. Give me a number, I had..

Magda: Point one, he moved only like a millimeter from this frame to this frame.

Romina: Oh OK so it’s point one (recording data in workbook).

Magda: By where the nose is going yeah.

Romina: Can he slow down? Is that possible?

Magda: Shouldn’t.
Victor: Exactly.

Magda: Yeah, but…

Romina: He could…, Right there, he has, he’s just extending his paws right? He just moved his body forward a little.

Magda: Uh huh

Romina: It’s possible.

Aquisha: From the first box to the sixth box, he is supposed to have moved one of those little boxes? Should add up, add up to five centimeters right?

Benny: Yeah

Magda: Little more than one.

Aquisha: Does it?

Magda: Does it?

Romina: What does it add up to?

Aquisha: Point seven seven.

Magda: It’s a little more than…

Romina: Yeah it’s a little…That’s OK. That’s good.

Magda: It’s a little more than like one box if you look at the nose. Probably going…

Romina: But can it go, can it go slower like that?

Magda: I don’t know. Can it?

Romina: There’s no acceleration, can you slow down?

Magda: No.

Aquisha: I don’t think you can find that out so I could see by my ? it doesn’t…

Romina: But only… but there measurements.

Magda: (Magda and Romina are talking at the same time) what do you think?

Romina: From your measurements it didn’t move.

Magda: I know, but the way you look at the picture his paw moved.

Romina: His nose didn’t.
Victor: Well you had him moving at the same uh, at the same speed as frame two?

Magda: So I was right.

Benny: So what did we say, we said the point zero three one was from box to box right?

Magda: Yeah

Benny: Now he moved, if we’re doing it, per, if we’re judging, if we say each box was five centimeters right. If we look at his nose, he starts at this box here (making notations on Magdas’ catwalk pictures) then at the end; he ends at this box here. So that means he traveled one whole box. You see how this is, from here to here that’s how far he traveled.

Magda: Uh huh

Benny: That’s one whole box, five centimeters. Now if he moved from box to box at point zero three one…

Magda: So do, do we just multiply point oh three one times how many frames he moved and divide that?

Benny: It’s something… it’s something that you gotta… Somehow you gotta plug it somewhere. I mean I don’t know how but you gotta…

Romina: Do you want to just keep going with this? I don’t know.

Benny: Yeah keep going with that.

Magda: I don’t think it’s right though.

Aquisha: Why don’t you just guess, like you look at it and say well it looks like he moved a quarter of the box, and then… know what I mean? And then figure out how many centimeters that is, so you make sure that we come to five centimeters.

(While Aquisha is speaking Sherly comes over to Magda and asks her a question that I cannot make out completely about a formula for velocity. Magda indicates that she remembers something about velocity but not the exact formula.)

Romina: Cause we’re close, cause it’s a little more than five centimeters.

Magda: He can’t go slower, he can’t like just stop accelerating you know. He’s accelerating and what, he likes tries to slow down here and start accelerating?
Romina: He’s just not moving.

Victor: Lets see where he, where it takes you.

Romina: (to Researcher) Can we ask you something? Can something stop accelerating? No matter how far you divide it into time up?

R3: Think about it. What would a cat…I mean think about what it’s doing.

Romina: It’s, it’s feasible.

Magda: I think it can, because its accelerating…

Romina: See that’s where its paws are kinda just like, getting ready to start moving. Start, maybe that’s where he’s changing into his gallop. Look cause his hind legs come together and now they’re gonna about to push off again.

Aquisha: I don’t think he stops, I don’t think he slows down either, there’s too little time to do that stuff.

Romina: Start running. Go from a walk to a run.

Aquisha: I mean if it does, how are we gonna figure that out?

Romina: I don’t know. The, our numbers add up though, it’s not like…You wanna just keep going?

Magda: Sure we could go up to ten but…

Romina: Oh, then we gotta go up to…

Magda: Let’s go up to ten first.

Romina: We’re on frame seven right?

Magda: Yes Ma’am. (pause) Point one.

Romina: What?

Magda: Point one. He’s not moving a lot. His like body is like crunching.

Romina: That’s cuase he’s, its getting into its gallop. I’m telling you Magda. So it’s the same thing? That’s possible.

Magda: Another point one I’d would say.

Romina: Another one?

Magda: He’s not moving a lot, he’s moving another point one.
Romina So it’s point one divided by oh point oh three one again?
Magda Yeah, I would say it’s like point two.
Romina Frame eight right now we’re frame eight.
Magda Point one. From eight to nine it’s point one. From nine to ten it moves point two.
Romina I’m on eight. Six to seven for this one (pointing at Magda’s cats), seven to eight for that one. Seven, eight to nine…
Magda Point one.
Romina Point one again?
Magda Uh huh. Then it’s like point two, I can’t really tell but it looks like it. We’re done. I think he moved like one, two, three, one two, three, one, two, three, four, four, so he moved three. So he should have moved fifteen. Is that like close to fifteen?
Romina From where?
Magda From the beginning.
Romina I’ll just put them all in my calculator. (Using Calculator) I could do this all in my head, but I’d rather… (working) point one two seven.
Magda It’s not close but…
Romina Close enough
Magda Oh no… yeah it’s over, its twelve point…
Romina OK this is what we did. Cause right here he is just walking so he’s accelerating. But then when he, like now from here to frame about ten he is changing into his gallop…
Benny Yeah
Romina So he’s, like kinda like his forward paw is kinda like stay put or no stays put and he brings his hind legs together then he pushes off again, and that’s when he starts to gallop in frame ten. That’s why he kinda slows down and speeds back up, or stays kinda still because his hind legs are just kinda moving.
Benny His acceleration begins to change at that time.
Victor OK
Romina Do you want us to keep going with this? Is your equation matching up yet?

Victor No because um it doesn’t take into consideration all that stopping.

Benny Somebody please tell me the equation for acceleration.

Aquisha I still don’t know how he gets… how you guys are doing this (pointing to Romina’s chart). It doesn’t add up. You know what I mean?

Romina We just added it, we just added them all up, and it, it moved about… how much it moved? Two boxes…

Aquisha Ten in two boxes

Romina Yeah

Aquisha Ten centimeters

Romina Ten centimeters, and that’s what it is. It moves a little more than ten boxes, so it’s like a little bit more. We got like just a little more than a centimeter

Aquisha Than one centimeter?

Romina More than…

Aquisha That doesn’t make sense.

Romina Ten.

Aquisha More than ten centimeters?

Romina Yeah. It moves like, it moves twelve I think.

Victor Twelve centimeters?

Romina Doing like what we’re doing.

Magda It moved like two boxes and a little bit. (victor groans) It’s twelve point seven.

Victor Twelve point seven? (exclamation)

Romina You want to keep going?

Magda I’m just trying to figure out how like…

Aquisha Point one seven.

Victor I multiply that by one point six six seven. (pointing to Aquisha’s paper)
Aquisha Point one seven.
Magda Point one seven. Point one seven.
Aquisha Is that what you got?
Romina No.
Magda We got one point two seven.
Romina Maybe I could have just added wrong though.
Aquisha You got what?
Magda One point two seven, which is twelve. Isn’t it?
Aquisha Which is… I don’t understand what you guys are saying. I don’t get it.
Romina I have the same thing though
Aquisha Can you try to explain this to me one more time because I’m confused.
Romina I don’t think I can explain it. Ok.
Magda I don’t think I can either.
Romina Now how can we just move the decimal place over? I just assumed we can do it. Because it fit.
Magda We’re not doing this right, because we we didn’t change it into centimeters yet, like this number we’re just doing it by – so one point two seven (throws pen down). Forget it I don’t know what we’re doing. It doesn’t equal five centimeters.

Like I was saying before, I was calculating it wrong here because its supposed to add up to point three six.
Romina Uh huh. Is it still supposed to add up to point three six?
Magda It is because we never converted it to the actual measurement.
Aquisha So this is not really in centimeters?
Romina It is in centimeters but…
Magda We have to…. So point one centimeters, we got to change it into the actual measurement.
Romina Yeah like this is like actual. Like - like this is actually what it is on our paper.
Aquisha Oh OK that’s what I wasn’t getting cause…
Romina: Yeah, but like, so instead of it can’t equal to five centimeters because it’s not in proportion. We haven’t like put it into proportion yet.

Aquisha: Oh.

Magda: So we have to put it into proportion and then the speed will be right. It actually isn’t right here (pointing to Romina’s cat paper)

R4: Could, could you tell me what your discussion is about? I haven’t been close to this table here, I was just wondering if you might help me.

Magda: Basically what we did, we measured like each box and it’s like point three six centimeters and it equals five centimeters right?

R4: You, you physically measure each box on the page

Magda: Yeah, no basically I measured from this line to here and it was like

R4: Oh I see.

Magda: three point six

R4: You measured it though…

Magda: And divided it by ten because I got the average.

R4: Ok, I see what you’re saying.

Magda: So each box has point three six centimeters but in actuality it equals five centimeters. You know what I’m saying? On paper…

R4: I think I see. So, so if we were looking at the real situation it would have been five centimeters but here we’re looking at a..

Magda: Yeah

R4: A picture

Magda: And now the problem here is we, on paper it is point one centimeters but in reality its more.

Romina: It’s like… Proportional

Magda: Yeah

R4: I see. I think I see. So you’re talking about how to get from what you measured on paper to…

Magda: The actual like…
What the, what the real situation may have been when you look at the… If we were there at Gentleman’s Riding Park when it happened right?

Magda Uh huh

OK

So how do I change it

Thank you.(Leaving) (quickly returning) Let me ask one more… what are you measuring?

Uhh, the nose.

The nose.

How far the nose moves from frame to frame.

Ok thank you.

Ok.

We don’t even know if it’s working.

So I have, we have to convert like point one centimeters we have to make that..

How do you convert that? How do you set up a proportion?

Five centimeters or point three centimeters you say you have?

Yeah. Point three six centimeters equals five centimeters.

Right

And now we’re doing…

So then all you do is um, five centimeters which is the actual (writing on a scrap paper) over your fake I guess, I don’t know. Point three six right? That what you’re saying? Centimeters then what do you have.

How do you do proportions? (Pantozzi leans on Magda’s chair)

Proportions?

We have simple questions, nothing too big. How do you multiply?
Victor Whatever you multiply what you get for your first, I mean from frame one to frame two.

Romina Um, just point one.

Victor Point one right and then you x them and multiply across the way.

Romina And I have to do that for every single one.

Aquisha Just do this.

Brian (Off camera, cannot tell who he is talking to) I’m just screwing with every kind of number possible.

Romina Thirteen point eight eight eight nine.

Brian Just trying to find a constant rate for ….

Victor Nah, then don’t you divide by zero point three one? (Brian can be heard in the background telling someone “they are doing some weird shit”)

Aquisha Oh yeah, that’s what she’s doing here (indicating Aquisha’s scrap paper). Right? Right here?

Victor Right

Romina That’s what I meant.

Magda But the distance doesn’t make sense.

Romina So it more, it’s not 148 centimeters per second (laughing). That’d be one fast kitty! Ok hold on. Its…

Magda Sorry.

Victor No it’s moving…what did you get? Thirteen something? I got one point three eight eight eight nine (1.38889).

Benny So hold on look…

Romina Five divided by point three six (5/.36)

Victor Right, times…

Magda Point five, point five (.5)

Victor The proportion is um…

Magda It’s point five because its five times point one.

Victor Yeah and then divided by point three six.

Magda So twelve point three six (12.36)
Romina And divide that by point oh three one (.031)

Benny How many seconds,

Aquisha That makes sense.

Benny I just want to ask you this question right quick.

Romina Twenty four centimeters per second

Benny How many seconds, one, two, three, four, five, six, seven. Seven boxes it’s moving point zero three one seconds per box, how much time is that? Seven times zero point, I mean point zero three one?

Magda Point two one seven seconds

Benny Two point one seven, where’s the…

Magda Point two one seven seconds.

Benny Point two one seven seconds.

0:54:00 Romina Is that…I can’t work in centimeters I can only work in like… forty four centimeters isn’t a lot though right?

Brian Forty four centimeters is over a foot. It travels like four and a half feet in this whole thing

Victor But that’s in a second, and this whole thing is less than a second.

Magda How much?

Brian Four and a half feet.

Magda So its not, but its not moving like , its not

Romina A whole second. So it could travel over a foot in a second?

Brian How, I overheard them point three two three uh…

Benny How do you determine speed?

Romina We have point three two three.

Brian You have that somewhere?

Romina The first speed.

Magda Distance moved divided by speed (to Benny).

Brian He heard, I heard them say something.
Romina: You’re eavesdropping.

Magda: I’m gonna go ask them.

Brian: No, but he’s wrong. I heard him say point three two three meters per second but…

Romina: No we’re point three two three centimeters per second. So do we do that whole conversion thing so it’s forty four centimeters per second? (to researcher) do we have to convert this?

R10: Convert it to what?

Brian: Forty four centimeters per second…

Magda: If we’re setting, If we’re setting up a proportion here we have to convert it to the actual thing.

Romina: I don’t want to.

Magda: But that, that’s wrong because this is point four six and only move the box and the box is point three six so our measurements are a little off

Romina: Does this make sense? Does this make sense though?

0:55:29 Magda: Yes, switching it yes.

Romina: So just start all over again huh?

Magda: Can you tell us if this makes sense?

Aquisha: I did these, the first four.

R3 (At this time Aquisha and Romina continue a conversation beginning at line 598) Can you tell me what it is you just did because I got pulled away?

Magda: Well we actually changed, like we set up a proportion and we changed it into like the actual measurement.

R3: Can you tell me what each number means?

Magda: Five centimeters is the distance, the actual distance of each box. You know. And point three six is, well we measured with a ruler so, and x is the actual distance and point one is, well we measured the change.

R3: For the post to move is that what you mean?

Magda: Yes from one frame to the other
So what did you get?

So what we got was, the actual distance that the cat moved is one point three eight eight centimeters.

One point three eight eight centimeters.

From one, from frame one to two.

OK and and…

And that we divided by point oh three one. And then we got some number, we got forty eight, forty four point eight centimeters per second. ---

(Unintelligible) Forty four.

(At the same time Magda is speaking to Researcher AA Line 573) No I didn’t do this part, I only did this I changed this to the actual

(Romina is writing on a fresh page in the notebook) Frame one to two, it is point one centimeters. The point one centimeters is one point three.

It’s one point three.

Divide that by point oh three one equals forty four point eight centimeters per second. So we have to do all that, that work for every single one?

Uh huh. It’s not gonna add up. The measuring was off.

We can’t measure any more accurately.

I know.

Oh, Thank you. (conversations merge back to one as Researcher AA leaves)

What are you trying to do?

Our numbers just don’t add up.

To what?

Five

What’s a more accurate way of measuring this? Because, this, won’t work.

I was just thinking of looking at the box and seeing if it moved half the box or quarter of the
box and see how many centimeters that is. Know what I mean.

612 Romina Uh huh.

613 Aquisha So instead of using that ruler cause..

614 Magda Because it’s not accurate.

615 Aquisha Then it’ll add up to five.

616 Romina Because like from a certain one frame to another frame it moves one whole box and then that’s five centimeters a box. So like one, going from that one frame that first frame to, I don’t know what frame it does that it should up, add up to five.

617 Aquisha It’s gonna be way over five the way that…

618 Magda Yeah, we found that out.

619 Benny Nah really?

620 Aquisha We have like eight in the first four, over eight.

621 0:57:43 Magda Uh huh, so how should we do this?

622 R3 Could you say that one more time, this, this argument about what they should add up to? (to Romina)

623 Romina Well huh…what frame does it go, does it move one whole box? Frame six?

624 Magda From one to five. No… six is a little over, so five I would say.

625 Romina One, from frame one to about like five on this (holding up pictures and pointing), see like the cat starts off right here

626 R3 Uh huh

627 Romina And at frame five it’s moved over to the next uh, next line.

628 R3 Oh so it’s nose is …

629 Romina And it moves a whole box, and the whole box is five centimeters. But when we do our conversions like and we go from frame one to five if our numbers equal up to more than five centimeters, equal up to like eight centimeters. But it can’t be because it only moved one box.

630 Aquisha You know what? If you say that it’s one to five he’s moving one box, and then up to ten he is
moving two boxes then he’s moving the same. You know what I mean?

Romina

About the same.

Benny

Say that again.

Aquisha

Because you say that, well they’re saying, from one, but you’re saying from one to ten he moves two boxes right? One to five he moves one box, then the other five he moves another box.

Magda

So he’s accelerating at a constant speed?

Aquisha

About the same, yeah, it’s what it looks like.

Romina

But it can’t be

Benny

Look, he’s not accelerating at a constant speed because it’s taking him…

Brian

He didn’t even move in the first six boxes

Benny

It’s taking…, this is one step. It took him that, it took him that long to move one box

Romina

Yeah but then it also takes him…

Benny

To get to this, this is a whole (a)nother step. This is cut short right here. Know what I’m saying.

Magda

Acceleration… (another conversation)…over time

Benny

This is a whole…, He’s accelerating (making motions across the paper with his hand)

Jeff

Acceleration equals distance traveled times time?

0:59:41

Magda

Over time.

Romina

Delta ‘d’ delta…, Delta ‘d’ delta ‘t’

Jeff

Delta ‘d’ delta ‘t’, That’s what I thought it was honestly.

Romina

Yeah uh, huh.

Aquisha

It’s hard to measure his nose…

Magda

(To Jeff) Aren’t you making a lot more progress than we are though?

Jeff

Everyone’s trying to reinvent the wheel. You just gotta…

Aquisha

It’s hard to measure his nose or his legs because here his neck is like this and his arm is out, and then over here his head’s up more than his feet
Romina I know, if we stick with the nose at least it’s kinda
constant.

Aquisha Maybe just his whole body, whatever is sticking
out.

Romina Nah, I think we ought to keep with like one body
part.

Aquisha But it, his head moves back here. Know what I
mean, like he shrinks to to to get more power to
leap so that’s gonna be hard.

Romina I know, if we stick with the nose at least it’s kinda
constant.

Aquisha Maybe just his whole body, whatever is sticking
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out.

Romina Nah, I think we ought to keep with like one body
part.

Aquisha But it, his head moves back here. Know what I
mean, like he shrinks to to to get more power to
leap so that’s gonna be hard.
R5 You think we’re going to do that?

Romina Yeah, I’m gonna go on a limb and say yeah.

R5 OK. So, what would be another way to measure? Because I heard you say you’re worried about being accurate enough so that you can prove it so that the numbers match. So what else were you considering besides the ruler? What were you doing?

Romina We did it first by dividing. Like we took like a bigger like someone who could measure like a little bit more accurately and divided it.

R5 What do you mean?

Romina Like we took like this like Magda did, like this whole box and divided it by ten to get point three six centimeters. Her little box.

R5 So each little box is…

Benny Five centimeters

R5 Five centimeters?

Magda Yeah but on paper it’s point three six centimeters. So we like set up a proportion, know what I’m saying?

R5 Oh, you did that, so that your ruler measurements…

Romina Yeah but then we have to measure from like how far the nose moves in each frame, and its so small that’s kind of hard.

Benny (Romina, Magda, Victor and Aquisha continue a conversation off camera that begins on line 704 and they merge at 736) That’s why I just, I just take it by distance from each step from here to here (pointing to cat pictures, seemingly from frame one to frame ten), and that’s one step. He’s taken one step from here to here. And from here, he starts, he starts at this box, which is… he starts right there. And from here to here he moves one box you know. See where his nose starts?

R5 Yeah

Benny At that box right there? And this box (pointing from frame one, to frame six on the pictures) he moves one whole box from here to here. So he moved five centimeters.
R5 From this whole thing (gesturing to the top row of the cat pictures) he moved five centimeters.

Benny Yeah, and since these interval is point zero three one seconds, so this interval is, interval is point zero three, this interval is point zero three. So I took the time, I took the whole time.

R5 Which was what

Benny Point two one seven seconds.

R5 So, recap for me that he traveled this far in that amount of time?

Benny Uh huh

R5 OK, and so how far was this again?

Benny That was five centimeters

R5 Five centimeters in that amount of time.

Benny Uh huh.

R5 And that takes care of all that top row of frames.

Benny Uh huh, and another thing that helps is, is this kind of, is these dark lines right here. And if you look at it, he’s um from here, he starts here in the second box, he starts right here at the second box, if you want to judge it by the tenth, the tenth box. The asterisked box, he moves one whole box. See before it took him point two one seven seconds to move from here to here, now it’s only taking him this, these are my boxes times this which will be shorter than that. He’s taking less time to move approximately so his acceleration is picking up from here to here.

R5 And does everybody in the group understand, have you all discussed that with them?

Benny Yeah, his acceleration picks up from here to here. And from here to here, and here to here. Now if I could figure out a formula for acceleration, I could plug in the time and the distance traveled and then hopefully… But the problem is I don’t know the formula for acceleration.

Victor (Simultaneous off camera conversation) I have a question for you.

Romina Yeah, and there’s three, two other ones.
706  Magda    Yeah, do the same thing?
707  Victor   I have a question for you. When you were measuring right. You were measuring from this line right here to where the nose was right? Now, where’s the problem. Right here from frame five to six, are you still measuring from this line right here to that line, or is it from this line to that line? To the nose.
708  Romina   From… what we do is like from here, like we measure in between each frame. So from where the nose is here to where the nose is here is what we measured. So in just these two frames and divide that by point oh three one.
709  Victor   So don’t you think that instead of, don’t you think you should add that to your previous measurement?
710  Magda    Yeah, but then we have to divide…
711  Romina   Yeah, then we have to divide by a different time frame.
712  Aquisha  I think we should just do his whole body…
713  Victor   His whole body?
714  Romina   You can’t do his whole body because it’s not like…
715  Victor   Oh you mean his chest.
716  Aquisha  Anything that sticks out the furthest.
717  Magda    It’s the nose that’s sticking out the most in every picture.
718  Aquisha  No not really, look at number ten.
719  Magda    Yeah number ten, yeah that’s true but other than that its…
720  Romina   That’s where we are, so we did measure what was sticking out the most.
721  Victor   It seems like…
722  Aquisha  Because here he is still moving but his heads in the same place in all these pictures.
723  Victor   But think about like this. Even in track right they never move, I mean…
724  Aquisha  They measure what touches the line first.
725  Victor   Nah, it’s the chest. Its always the chest. That’s why you see them leaning forward right…
Aquisha: Ahh

Magda: No but like here like its one, two, three, four, five. Here he’s one, two, three, four, five, six, seven.

Romina: Yeah, he’s going faster there

Magda: Yeah but that’s what I’m saying it’s like…

Victor: In horseracing they do it by the nose because that’s the farthest part that sticks out

Aquisha: But I think it means, like because what I was saying before, it looks like compared to how we did the boxes, like if he moves one box up to five or two boxes up to ten, it looks like he’s moving about the same rate, but it’s because here his head’s in the same place you know. Even though you know he’s moving faster right?

Magda: That’s what I’m saying. Instead of point one it’s point oh five

Aquisha: Yeah. So it makes more sense if we say like…

Magda: Yeah, see what… He’s moving faster here than he’s moving here like the head wise.

Aquisha: Yeah, that’s what I’m saying. So if we do by the nose like he’s not going to be moving

Romina: (Benny is back with the rest of the table, not R5) That looks very familiar, that equation. Definitely acceleration.

Magda: Yeah you can figure out the acceleration here because the initials speak…

Romina: We don’t want acceleration we just want speed in a certain frame.

Magda: Yeah

Benny: I know what the time, I know the time and we lookin’ for acceleration…

Romina: No we’re looking for velocity.

Benny: We’re looking for velocity?

Magda: Yeah, how fast the…

Romina: They just want the speed… they just want to know the velocity at frame ten and at frame twenty. I’m sure they’re going to ask us that stuff later but…

Victor: If you can find the um, acceleration, you can multiply that by time.

Magda: That’s what I think they’re asking for.
Victor  The time gives you velocity anyway.
Romina  Yeah, that was the question.
Benny  How fast he travels.
Magda  How fast does the cat move…
Romina  How fast is the cat moving in frame ten?
Benny  You sure it’s, You sure it’s velocity?  What’s velocity? What’s velocity?
Magda  The speed it’s traveling.
Benny  The speed it’s traveling? OK
Magda  So, how fast it’s going right?
Benny  Yeah, how fast it’s going.
Magda  Don’t take my word…
Benny  Just needed to get my vocabulary straight.
R5  So where did you leave off.  I kind of got lost on…
Romina  And then we realized that because we were in centimeters that in order to divide it by point oh three one seconds we had to convert that like in proportion to the five centimeters.  So then we did, I don’t know where that, I don’t know where that ended up but we did like a proportion.
Magda  It’s like we set up a proportion as five centimeters divided by point three six centimeters equals x over whatever the change in…
Romina  Which for our first one was point one.  We figured that out we got one point three eight eight nine and we could divide that by the time and we got forty four point eight centimeters per second.  But when she was adding up like… then once we reached frame five and like our numbers on the… those numbers should add up to five but they added up to like eight.
R5  Why?
Magda & Romina  Our measurements
Romina  We’re hoping measurements.
124

Magda Were inaccurate.

Romina Like we’re see, we’re eyeing over what to measure exactly.

Magda How about can we just do like five frames at a time kind of a deal?

Benny Yeah

Romina If you want.

Magda Can we?

Benny Yeah, all you have to do is find out the distance.

Aquisha If you do that your going to get the same thing.

Benny Yeah. Your going to get the same thing but it’s shorter. You don’t have to keep measuring.

Aquisha Because these first five frames he is moving one box, the second five he is moving another box. That’s why I said the whole body or it didn’t make any sense that he keeps getting faster. If you measure his everything like up to the paw too, then it’s three boxes.

R5 It’s getting faster. You said its getting faster, and that’s and that’s what Ben also indicated correct?

Romina When we did it like this he slowed down.

R5 He slowed down?

Romina Yeah.

Magda He didn’t actually slow down.

Romina He didn’t actually slow down.

Aquisha It’s just that one part of his body doesn’t move.

R5 Which part.

Magda His head (choral response)

Aquisha Whereas his legs don’t move you know?

Romina Like right here is like, this is like like frame like six through nine is where he is converting from like a walk to a gallop.

R5 Uh huh
Romina: So his like front paws are kinda like, and like this part of his body (making gestures to the front of herself) which we’re measuring is staying put while his two hind legs are coming together in order to like come together and like leap up.

R5: Ahh

Romina: So they’re kind of the same but, still moving, but just moving his backside. (pause) This makes no sense.

1:10:25 R5: So how have you decided to deal with that?

Romina: We haven’t. That’s, that’s what we’re arguing over.

R5: That’s where we are.

Magda & Romina: Yeah

R5: Is how to deal with, can you rephrase it again for me. I want to make sure I think, I think I’ve got it. It has to do with the way its body is gathering?

Romina: Uh huh

R5: So it’s rear is like moving but it’s head isn’t.

Magda: Isn’t, yeah.

Romina: We’re measuring…, we have to measure like the same body part, we should be measuring like to be consistent.

R5: Ok and you have been measure… go ahead…

Aquisha: But I’m saying you could be consistent in measuring the whole cat.

Benny: yeah

Aquisha: That’s what I’m trying to say because his whole body is moving you know.

Magda: So should we start from like tail to here and see how much the body moved? Like from frame to frame to frame?

Romina: But that’s not gonna make sense because the body scrunches up.

Aquisha: So just measure what’s sticking out the most. It’s still part of the cat, you know.

Benny: What I would say is… they asking me how fast the cat is moving. Can I say, is for every five, for
every five centimeters it’s moving, would it take a
certain amount of seconds. Would that be
something like speed? For every, every five every
five centimeters it moves, it takes a certain amount
of time. Isn’t that something like speed? Like if I
say, wow for every ten meters I walks it takes me
time five minutes, can I judge a speed by that?

808 Magda Every ten meters you walk, it takes you five
minutes that is a speed.

809 Benny Would that be a speed?

810 Aquisha Yeah that’s what this is. Yeah, here.

811 Benny Now…

812 Magda So your looking at ten meters for five seconds.
That what you’re saying?

813 Romina Uh huh

814 Benny See the cat from, from point one to point ten

815 1:12:08 Magda Was a little more than two boxes.

816 Benny Was a little more than two boxes, now that’s ten
centimeters.

817 Aquisha Ah, so you’re trying to say, to add up all the time
there…

818 Benny Yeah, add up all the time in between that.

819 Aquisha This ..urm… box and say he is moving that
many…

820 Benny Yeah, per however many seconds that is. From
one to ten.

821 Magda Three point one seconds. No, point three one
seconds. So he’s moving like…

822 Benny Point, Point three one times ten. That gives you
how many seconds.

823 Aquisha No, point zero three one, so it’s…

824 Benny Point zero three one times ten.

825 Magda Which is point three one.

826 Aquisha Yeah

827 Benny That will give you the total amount of time from
one to ten.

828 Aquisha So ten centimeters every point three one seconds.
Benny: No that won’t give you his total acceleration. That’ll just gives you how fast he’s traveling from one to ten. Because he’s picking up speed all through this.

Magda: Uh huh

Benny: That’ll just give you from one to ten.

Aquisha: So we’ve got to find out how fast he’s moving in box ten.

Benny: Then we figure out how fast he’s moving in box twenty. So we start off in box ten, we start off with box ten. So we say he’s moving how fast…, how much time did it take him to move that ten centimeters.

Magda: Hold on, so let’s see. Say he moved a little like, cause he moved a little more than one box, I mean two boxes didn’t he? That’s what it looks like. Doesn’t it? In frame ten. Doesn’t it look like he moved more than two boxes?

Benny: No, that’s just an estimate.

Magda: OK, so ten centimeters divided by three…, point three one

Benny: Nah, not divided by point three one.

Magda: Yeah, it is. So we can figure out how much he’s moving per second. (inputting data into a calculator) So he’s moving thirty two point two five centimeters per second. (Pause) three, no thirty two point two five. So (writing on paper in front of her), its thirty two point two five centimeters per second. And that’s in box ten. He’s moving at that speed.

01:14:24 Benny: (getting up from table) I’m going to go see…, I’ll be right back.

Brian: Point one oh seven five two seven meters per second.

Magda: What?

Brian: That’s the answer.(mumble) there’s no answer. If we come up with something close to this I’m gonna be happy.

Magda: Why? What did you do?

Brian: Just messing around with stuff

01:14:42 R3: What’d you do Brian?
Brian: Absolutely nothing

R3: But you came up with a number?

Brian: Stolen off them! No, I was, I was stupid. Like I didn’t even do the whole, I just found the change between frame nine frame ten.

R3: And how much was it?

Brian: Three centimeters.

R3: Three, three centimeters you (inaudible) able to do it.

Brian: Yeah I guess. I haven’t been paying attention to them. I’ve been in my own little world.

R3: Yeah I know.

Brian: And uh, I divided that by the time each frame,

R3: By point oh three one

Brian: The interval each frame, yeah by oh three one.

R3: Hmm

Brian: And uh, came up with an answer.

R3: Which was?

Brian: Point oh nine three.

At this point Magda and Romina are having a conversation, starts at line 893 and continues to 922)

R3: (At this point Magda and Romina are having a conversation, starts at line 893 and continues to 922) Now, would you..

Brian: I, I multiplied. The rate of change by the uh, interval between frames. I’m just messing with stuff here.

R3: You did, let’s see, you had three centimeters.

Brian: Yeah that’s the amount of change.

R3: Oh three one.

Brian: That’s the distance it changed. And the difference between the pictures was point oh three one.

R3: In time.

Brian: Yeah, so…

R3: Uh huh. Ok. And the difference in distance? Was three?
Brian: Three, yeah. And I don’t know why I did this but I came up with that, I multiplied three by point oh three one.

R3: Uh huh

Brian: If you divide you get a really stupid number.

R3: Why do you think it’s stupid?

Brian: Because it’s decimal.

R3: Do it again. What do you get when you divide three by point oh three one?

Brian: Ninety six point seven seven four two.

R3: Which would be…

Brian: Way too big for anything that I’m doing right now. I figure I’d come up with a small number. So I multiplied it.

R3: Oh, so if it moves three centimeters in point zero three one its going to move less than one second?

Brian: What?

R3: What are you trying to prove?

Brian: I’m just trying to find this speed that it’s going right here.

R3: In, in what unit? Speed per hour? Speed per…

Brian: Second

R3: Oh, ok.

01:17:00 Brian: I’m just messin’ with numbers, it’s probably completely wrong.

R3: Wait here a minute more. You’ve got, you’ve got this… (indicating a ratio written on her pad of paper)

Brian: I did not even use that. That’s not even a part of it.

R3: What did you get when multiplied..?

Brian: Point oh nine three

R3: Ok

Brian: I’m just thinking there’s thirty nine inches in a meter so…

R3: There’s three centimeters in point oh three one
seconds, you would go this much in one second (pointing to work on her pad)?

894 Brian No (shaking his head). That’s not what I’m trying to say. I’ll work on it some more. (Researcher leaves) I hate this thing so much.

895 R3 Keep working on it, it’s a good idea.

896 Brian I’m not coming back after the eleven o’clock break. I’m not. I’m forefitting.

897 01:15:22 Romina (Magda, Romina and Aquisha are having a conversation simultaneously starting at the 01:15:22 mark.) I honestly think this way was the best, we were making the most progress.

898 Magda How about we just estimate or something.

899 Aquisha That’s what I said in the beginning because you always add up with, come up with the whole box you know? Like if you look at it you say he moved a quarter of a box here, and then another, you know what I mean?

900 Magda Why don’t we do that?

901 Romina Is this good for the first one at least?

902 Magda Can we say, can we say it moved like…

903 Aquisha One centimeter.

904 Magda So you moved a quarter of a box.

905 Romina So then it’d beee, more than one point something.

906 Magda Yeah

907 Romina One point three eight eight eight nine?

908 Magda A quarter of a box is a quarter of five centimeters. A quarter of five centimeters is like one point two five. Right?

909 Romina Yeah, which is so close to that though.

910 Magda Uh huh (nodding here head up and down)

911 Romina So then for like frame three, for two to three. What is it?

912 Magda He moved another quarter. Agree? (to Aquisha) He moved another quarter of a box? From two to three would you say?

913 Aquisha (Aquisha is off screen) Uh, huh.
Magda: Ok so another…
Romina: So another one point three eight nine nine?
Aquisha: What?
Romina: Oh, did you want to put another point two five? Should I cross this out?
Magda: (Tearing and crumpling paper make some of Magda inaudible)…So we don’t have to do the proportion any more.
Aquisha: So this answer is pretty much is whatever you make it to be.
Magda: At least we can back up.
Romina: So, what is it?
Magda: It’s one point two five divided by point oh three one. It’s forty point three two centimeters. Per second. From two to three .(?).another quarter of a box. (Resume with Brian. He is expressing his unrest with this problem)
Romina: Now were just kinda like wingin’ it. No ruler.
Aquisha: So it adds up to five, around, around five, not eight.
Magda: This is great. Five divided by three. Five thirds.
Romina: No you gotta do five divided by three diamond enter (while doing it on her calculator)
Brian: This calculator ain’t too great.
Romina: What if we didn’t know that and our whole next year we had to.. (she is writing in the notebook)
Magda: One point six divided by…
Brian: Supposed to be the world calculator and the other one’s better.

Magda: OK and there he moved like…

Aquisha: Between four and five.

Magda: Between four and five, what did he move? He moved like…

Aquisha: Not even a quarter.

Magda: Yeah.

Aquisha: Will it, yeah… it’s like half because… well not really no.

Magda: Would you say like a quarter of a box?

Aquisha: Yeah

Romina: I’d say less.

Aquisha: Nah, because he’s behind the line then he’s in front of the line. You know what I mean?

Magda: Yeah. So…

Aquisha: So it’s like…

Magda: But see that means he slows down.

Romina: We had this, the same thing happened here too. It’s all right.

R3: Can you explain what you’ve got. This is, this is from frame one to frame two?

Magda: Uh, huh.

R3: And you’re getting the speed for that one? And this is from frame two to three and the speed for that one?

Magda: Uh huh.

R3: And from frame three to four and the speed for that one?

Magda: Uh huh.

R3: And, and. and you just keep going? That what you’re saying?

Magda: Yeah, basically. So, now we’re not like using the ruler, we’re just estimating.

R3: I see, I see what you’re saying. And and so what was the problem that you were worried about?
Romina: It’s not going to be as…, when you asked us how dah a dah…, I looked at it.

Aquisha: If we do it this way (pointing to Romina’s notebook), do we have to do all this or do we just have to look from nine to ten?

R3: That was what Brian was saying.

Romina: Yeah we can, we can look from nine to ten.

Aquisha: And that would be it.

Romina: Well I’m saying, we’re just figuring out every single one like to have like a…

R3: I think it would be interesting.

Romina: Yeah.

R3: What would it be from nine to ten?

Romina: Just whatever it moves.

Aquisha: Like half a box.

Brian: Two centimeters.

Magda: So it’s half a box. So two point five divided by point oh three one… eighty centimeters per second.

Brian: Multiply it.

Magda: By what?

Brian: The point oh three one. Shouldn’t divide… you get a small number which is good. That’s what I was doin’ until she screwed me. She was just like…

Magda: Why did, why would you multiply?

Brian: So you can get a small number.

Romina: That’s good thought it’s centimeters.

Brian: What?

Romina: Don’t we like…, put a second. Its more than a full second, but I’m saying it’s not like that much.

Brian: Eighty centimeters.

Romina: No it’s like what, two…
134

984  Brian  It’s almost three feet.
985  Romina  That’s not…, that’s reasonable.
986  Brian  I don’t know.
987  Magda  How much is he move by the end?
988  1:21:18 Aquisha  But by then he’s almost leaping.
989  Romina  Yeah by then he’s like at full gallop.
990  Aquisha  Yeah, yeah.
991  Magda  So should we just say he’s moving eighty point something per second? Centimeters per second?
992  Romina  Well, I’m on still four five here.
993  Aquisha  On the last box, how many boxes did we move?
994  Magda  All right so let’s go on.
995  Romina  I’m on four five.
996  Magda  From four to five, there’s about a quarter or so. One point two five (1.25) on the first one.
997  Romina  All right let’s see what his speed goes back to
998  Magda  He doesn’t even move. He doesn’t move like…
999  Romina  See here’s where we had a problem. Here is where he stays kinda…
1000  Magda  Same?
1001  Romina  Yeah
1002  Magda  He may be moving like…, point five of a centimeter? Like a tenth of a box. (pause) Would you say point, point five?
1003  Romina  All right, I trust you Magda.
1004  Magda  Just do point five, point five up to…
1005  Romina  So he…, sixteen point one two nine centimeters per second.
1006  1:22:44 Aquisha  He moved six boxes at the end. Unless he goes past the line all the way and goes on to another line.
1007  Magda  He does. He does.
1008  Aquisha  OK
Six seven.
Six seven, it’s point five I’d say. From seven to eight I would say another point five. He’s really not moving a lot.
That’s exactly what we had before too.
Then right there he moved like half a box.
From eight to nine?
Eight to nine, he moved like half a box.
So what’s that?
Ah point, two point five.
Is the green marker over there somewhere?
So from eight to nine now he is moving eighty point six four. And ten which is nine to ten. How, how much is he moving.
Another two point like, maybe a little more.
Two point seven?
Two point six maybe, two point five, two point five. Just do the same thing.
Well I wrote two…, two point five?
Two point five, do two point five.
He moves two blocks.
Where?
Two whole…
OK, this is what we got for ten.
I’ll make this in black…
Eleven
He moves two boxes, two whole boxes.
They’re even collecting my trash.
Can you tell me what these numbers mean?
How many boxes he moved.
This number is the um, this OK. This is the frame we’re working on, each one. So like say this one, this is between,

One to two, two to three (making flipping gestures with her right hand).

Yeah this is…, I’m telling you which ones we’re measuring. And then from this because we’re not using a ruler, we just kinda went with like about how much we thought he moved. And then we just divided it by the time frame. Just one box by point oh three one.

So the big number is the distance, and this number is the time.

Yeah, I’ll write that down (places a D/T at the top of her column of distances / .031), and that’s the speed (writing speed over the far right column) at that frame. At that frame. And that’s what, that’s all that we’re doing right now.

Sounds interesting. How, can you remember what Benny said a while ago or what you all did a little earlier, the, the big, compared…, When you did ten divided by point three one, and got this. How does, what does that have to do with this?

I don’t, I have no clue. No I don’t know.

You remember Benny said there was ten centimeters between the beginning and the end of the cat.

Yeah

And you all divided it by point three one? Ten times point zero three one.

Uh huh. Which doesn’t make sense.

It doesn’t.

Ten divided by point… (doing the work on the calculator)

Why would you guys divide it by point three one?

Because it was point zero three one times ten. Right?

Oh OK.

I guess that’s how much she moved that row.

I guess that would…
Magda: That’d make more sense.
Romina: That’d be like an average though wouldn’t it?
Benny: What do you all mean when you all say average? Where are you all getting average from? I just want to know.
Brian: She’s trying to say like, he’s moving like ten miles an hour the whole way.
Benny: Now they they
Victor: It’s not instantaneous per se.
Benny: (Magda and Romina have a separate conversation beginning at 1064 and ending 1067) at It’s not, it’s not gonna be instantaneous we, if we said that for the whole thing, if we said that it moved whatever, whatever for the whole thing, then that would be instantaneous. Be we’re saying…
Victor: No that whole thing would be an average.
Benny: The whole thing would be an average, yeah.
Victor: … it’s instantaneous at ten. That’s what we want.
Benny: Yeah, the whole thing would be an average. But we just wanna talk about from one to ten. That’s what they askin’ us. Where’s the question (looking for a paper). They askin’ us how fast is the cat moving in frame ten. That’s all they askin us.
Brian: That’s why I’m thinking ooh, we only need to look at frames nine and ten.
Magda: (Simultaneous conversation from 1:26:37) So that doesn’t make sense then.
Romina: What doesn’t make sense? Our thing over here?
Magda: That makes sense. This is the velocity from frame, frame one to frame two. That is how much, that’s what he’s trying..., so when, so when we add up the whole distance divided by..., so basically, it’s the average velocity. Is it?
Magda: (Resume single conversation from here) Ok, what we gave here is the average velocity. Isn’t it? Like he’s moving like throughout. Wouldn’t it? Like if you added those up divided by ten? Wouldn’t it give you that?
Romina: I divided by nine, one two, three, four, five, six, seven, eight, nine (pointing at her notebook as she
counts). Because we don’t do frame number one because he is just standing still.

1069  Magda  Isn’t, isn’t it close kinda?

1070  Romina  Forty two point three three three three

1071  Magda  It’s closer than eighty.

1072  Benny  Now in frame ten…, let me get this. Just so I know what the hell I be talking about.

1073  Romina  I don’t…

1074  Magda  What did you figure out?

1075  Romina  The forty two point three three, what do you mean? What is that closer to?

1076  1:28:03  Magda  The thirty number she had.

1077  Romina  The thirty just kinda like an average?

1078  Magda  Yeah, because I’m saying this is like what he’s moving from here to here at that..., because like he slows down here? Kind of.

1079  Romina  That’s where he is getting into his gallop right?

1080  Magda  Yeah so…

1081  Romina  I’m, I’m, I didn’t even look at that I’m just doing numbers.

1082  Magda  So I’m saying, that’s probably is the…

1083  Benny  (Standing behind Romina speaking to researcher)...one whole second, like if I had, you know you got point zero three one? How many point zero three one’s would I have to get to equal one whole second? You would say like one second. Like a hundred? You know how point zero three one, now that’s part of a second.

1084  R5  How much of a second is it?

1085  Benny  Yeah, how much…, I’m asking you, how much? Like one third of a second? What? How much is it?

1086  R5  If you did…,

1087  Victor  She’s not gonna tell you man!

1088  R5  Can you tell him?

1089  Victor  No because I don’t know what he’s asking, but
If you read that number how would you read it?

Umm, thirty one thousands of a second. Right?

Yeah.

How many one thousandths of a second are in one second?

A hundred. A hundred thousandths. Yeah!

(Benny is talking to Researcher JW and AA) Brian, what did you get for frame ten, how fast is he going in frame ten?

Why what did you come up with?

Eighty point six four three (80.643).

Centimeters per second.

I made that in..., nah I don’t know what I did there. I got something like that though. You know, I think I tried to convert it into meters and I screwed up.

So what did you get? Just do it now! Just do it centimeters per second.

I changed the eighty into...

That’s a speed they have to accept that.

I changed the eighty into feet and found...

Why did you change it into feet if you wanted it in meters?

To come to meters like. To... three feet...

Why would you do that? Why would you change it into like two different systems? Why can’t...

Because there’s like..., I changed it into inches. I changed it into inches and there’s like thirty nine inches in a meter, and did, did division crap like that.

Well if it was cent... did you get eighty something if it were centimeters per second?

No, actually, you know what? Because I used three as mine, maybe if I used two point five

Did you get something like point eight zero? Meters per second?
Brian (working on is calculator) What happened?

Magda Point eight zero meters per second?

Romina Yeah what, what typing, what are you looking? What? By what?

Brian Doesn’t make a difference, so don’t even go by me cause, I’m not even close to anything. This is what I did. I did my three first. I did three thing. I did three divided by point oh three one, got ninety six point seven seven. Took that divided it by thirty. That broke down into centimeters I guess. To feet, studying feet. I just started in feet. Got three four two two five eight one. Divided thirty nine by twelve, three point two five feet per meter. Then did my three point two two five eight one over three point two five and got point nine nine two five five seven and that’s what I got meters per second.

Romina What did you get?

Brian Almost a meter per second.

Magda So point oh, point eight zero, like if we do it in meters its point eight zero six four meters per second. So that’s almost a meter.

Brian It’s somewhere out there. Its somewhere close.

Romina We’re close. Right? We’re on like the same page here?

R4 Romina I’m looking at what I see on there, it looks like you’re collecting data over the whole thing, is that true?

Romina Yes, we have…, did you, did you see this method yet? Did we talk to you about this one?

R4 No

Aquisha (speaking at the same time as Romina and louder) (in the first box the cat doesn’t move at all.

Romina Like what we did, ok what we did, we went, we went frame by frame. We figured out.

Magda (over Romina) That’s a good idea. (Aquisha is holding two transparencies up, one over the other. The first frame of one is superimposed over the second frame of the other)

Aquisha The cat didn’t move at all, it’s right over the same line look! (Handing the transparencies to Magda. Magda lines up the frames the way Aquisha had
Romina line up the lines. Well the first one we knew didn’t move.

Aquisha It doesn’t move.

Magda (moving one from bottom to top) let’s do it like this. It moved some.

Romina It moves about one point two five?

Magda Yeah, could, no look.

Romina Just the ears are off.

Magda The nose is off. Look.

Romina Yeah, a little bit. Its like this much (makes a hand gesture off camera) but it’s like…

Aquisha It’s like the tip of his nose much.

Romina We should have done that, huh?

Aquisha In the second one he moves just a little tiny bit more. (R4 observes that they are laying one transparency over another)

Romina A little tiny bit more.

Magda Look how about we just do this, how much the line moves.

Romina Look go Magda.

Aquisha Just line up the lines.

Magda How about we do the lines (Romina holds up a white sheet behind the transparencies Magda is holding up)

Aquisha For each one?

Romina So then this again! OK, we work up to ten and just trash our idea so come on.

Aquisha Unless these are different colors though.

Romina Can’t we, can, no.

Aquisha Color in all the cat’s in like green.

Romina Why don’t we do, we can do it on the overhead. We could see it better.

Aquisha But I mean like when you put it on top of each other

Romina yeah
Aquisha They’re both flat, so…, it’s hard to really tell. I’m gonna try that, I’m gonna color them all in like red or something.

Romina So again this…

Magda (Inaudible.)

R4 So actually, are you…, You’re thinking of building a, actually the data, representing it somehow?

Romina Yeah, we have been doing that. Yeah, and then like, we didn’t explain like, how come like in certain spots slow down, we weren’t able to explain like what the cat’s doing.

R4 So this gives you a bigger picture

Romina Yeah, so we’re not going just at ten, we’re going, we’re working our way up to ten.

R4 Uh huh

Romina Then we’re gonna go right past it. We’re gonna go right up to twenty. But you know we haven’t gotten there yet, we just get up to ten, and then start arguing.

R4 This sounds very good. I think. I’m thinking that we might want to take a short break. Would everybody be agreeable to that?

Romina Yeah, I can take a break. Because we, I mean like, we have like, we have a basic idea like we’ve done our basic idea the whole time, it’s just like our numbers and our measurements we can’t quite figure out.

Magda Basically what we were doing before, we’ve kind of like…

Romina That’s why we’re having so much trouble.

1:35:03 Aquisha I think he’s finally moving a lot more than he was, I don’t think he was moving that much. In the beginning.

Benny …is not movin’ that much.

Aquisha I think like in the fourth one he moves the most, like he starts really moving. The third one the fourth one, maybe the third one

Romina Oh, boy. I think we’re gonna have to kind of estimate most of our things anyway. Like do you guys really gonna be that much more accurate?
Magda: No.

Romina: Yeah, exactly. It’s still like…

Magda: No because look, if we do match up the lines again, because you can’t, like we have to move it box by box, it’s like moving. (putting the transparencies down) I don’t think this will help.

Romina: We can’t get, it’s, we can’t get any more accurate. I don’t think.

Brian: They got like, they plotted points, and had a graph and everything.

Romina: We could do that.

Brian: They just did regression. You know one of those regressions but none of us knows how to do it do we?

Romina: Hold it. If we, if we graphed like four point two five, four point two one, this by this, we’re gonna get like his speed.

Magda: Acceleration we’re gonna get. Because if you do the distance divided by speed your gonna get acceleration.

Romina: Are we gonna in..., I’m definitely taking a break because I’ve had it.

R4 in background: Let’s take a short break, because …

Benny: But he’s still moving.

Aquisha: I know but

Benny: (to Milin) but your saying it’s slowing him down.

Milin: I’m saying..

Aquisha: It’s gonna seem like he’s slowing down…

Milin: The nose is the best…

Aquisha: …He’s not really slowing down.

Milin: …face statement to pick because that’s the one that moves the least..

Benny: Yeah.

Milin: compared to everything else. Everything else moves a lot, so…

Benny: That’s the best place to judge it. Know what I’m sayin?
Aquisha: I was just gonna judge the whole cat.

Milin: His foot hits here right, it stays here for the next one (pointing to frames 15 and 16 on bennys cat pictures)... so you can't use the foot.

Aquisha: That's what I'm saying, use the whole thing.

Milin: You can't use the tail...

Benny: Use the..., How we gonna use the whole thing?

Milin: We can't use the whole thing, because the whole thing gets bigger and smaller.

Aquisha: (simultaneously with Milin) Just wherever he stops, whatever is sticking out.

Milin: At different times.

Aquisha: No I didn't mean that way.

Benny: Then we, if we judge by

Mike: Just use the nose. Just use the nose. Use that nose. That's, that's the thing that is always ahead of everything usually. Except for like the leg. The legs are like all over the place.

Benny: It's gonna be hard to judge. But we, we use our starting point has to be at this line right here (pointing to the first frame on his cat photos). You know that. You know the darker lines and shit like that? Use our starting point from right there.

Mike: (unintelligible) …using the cat’s nose

Benny: Yeah, yeah

Mike: So like there though, don’t say the cat, don’t say the cat moved five centimeters.

Benny: No, the cat moved from here to here (indicating the first and last frame of the top row of pictures) five centimeters.

Mike: Yeah

Benny: And we found out that the total, the total distance it moved from here to here (top left to bottom right of the pictures), we found that out. Which is as she says, is a hundred thirty centimeters. He moved from here to here (same gesture) one hundred thirty centimeters. And we found out the time it took for him to move that hundred thirty...
centimeters too. Now once you place that in your equation you should be, you know, like… you said you was working with that acceleration equation? What? Yeah.

Mike

Victor

What is that acceleration equation that you got?

Mike

There’s, like five different ones, we couldn’t get any of them to come out right.

Benny

So how, what are you all gonna use to judge his speed?

Mike

We uh, took points plotted them on a graph and we’re gonna make an equation again. Why not.

Milin

We don’t know what the regression means but we have it.

Benny

And what’s that?

Milin

We have the equation, we don’t know what it means.

Aquisha

Did you guys measure with a ruler or you just pretty much guessed?

Milin

What? The, the points?

Aquisha

The points.

Milin

Pretty much like guessed.

Benny

Let me see, you said you plotted the points. Let me see, see how you plotted the points.

Milin

Time and distance.

Mike

I don’t have it on my calculator, where’s Jeff?

Benny

Oh, you all did it on the calculator.

Aquisha

We could do too. Like they can do it, how they were doing it before. Because that’s how Romina she wants to do it.

Benny

See Milin knows none of that stuff means. You gotta explain that to…

Milin

Time and distance

Benny

1:40:16

Time and distance

Milin

Yeah

Benny

All right, so as you go up the time, oh ok!

Milin

(Pointing to his calculator) This, this is the time, this is the time right here, this point seven one
whatever seconds right?

Benny  Uh huh.

Milin  And this is a hundred thirty something.

Benny  OK.

Mike  (Returning) did you see this one he was using about here Milin?

Benny  (Mike and Milin look at a calculator with Researcher JO’B and JF looking over their shoulders at the calculator screen) OK. Oh, that’s interesting right there. So then all you gotta do is plug it in and the calculators gonna give you the equation. Oh, so that’s how you guys do it. (Benny gets up and moves away, Mike Milin and the researchers speak about what is on the calculator screen) (Victor and Aquisha remain)

Victor  I still think we’re using the wrong time though. Why we still dividing by point zero three one? Don’t you think the time moves?

Aquisha  No because each one is point zero three one.

Benny  (Benny returns off screen) Got it Baby (whispered)! You know they have the acceleration equation right?

Victor  Now, but…

Benny  Now plot the M F’ in points! Put it on there. Put it on there right, and then you get you get the equation. And you you look at the equation and how it relates to what you got. (Inaudible) It’s there man! See you know what I’m talking about.

Victor  I know what you’re talking about.
### 8.3 Transcription 7.13.99 Table 1 Tape 2

Primary Camera View: Sergey – Table 1, Tape 2  
Date of filming: 1999-July-13  
Kenilworth, NJ, David Brearley High School Library  
Transcribed by: W. Bradley Halien  
Date of transcription: October 2010  
Verified by: Kristen Lew  
Date of verification: February 2011

<table>
<thead>
<tr>
<th>Time</th>
<th>Speaker</th>
<th>Dialogue</th>
</tr>
</thead>
<tbody>
<tr>
<td>0:07:01</td>
<td>Benny</td>
<td>Once I put in the points, what do I press to get that?</td>
</tr>
<tr>
<td>2</td>
<td>Matt</td>
<td>What?</td>
</tr>
<tr>
<td>3</td>
<td>Benny</td>
<td>Once I put in the points, what do I press to get that? I only put in two points. Because you said you went exponential, whatever you call this. If you went exponential, you went quartic, you went quadratic, went all of that stuff. You still didn’t get an equation right? Matt!</td>
</tr>
<tr>
<td>4</td>
<td>Matt</td>
<td>Yo.</td>
</tr>
<tr>
<td>5</td>
<td>Benny</td>
<td>You went all that stuff and you still didn’t get an equation right.</td>
</tr>
<tr>
<td>6</td>
<td>Matt</td>
<td>What? Oh, we’re getting an equation, it just doesn’t make sense. The quartic regression thing – it don’t make sense. Just doesn’t.</td>
</tr>
<tr>
<td>7</td>
<td>Benny</td>
<td>You got the equation from the calculator.</td>
</tr>
<tr>
<td>8</td>
<td>Matt</td>
<td>Yeah, it doesn’t, it doesn’t make sense</td>
</tr>
<tr>
<td>9</td>
<td>Benny</td>
<td>It doesn’t? Now what would make sense?</td>
</tr>
<tr>
<td>10</td>
<td>Matt</td>
<td>We when you zoom out it like goes up and then it goes into a thing. And then it makes a thing and it shoots down again. (Camera returns to other side (right) of table with two researchers, Magda, Aquisha, and Romina.)</td>
</tr>
<tr>
<td>11</td>
<td>R3</td>
<td>…Compare your numbers, what you found, I just want to look at… (inaudible)</td>
</tr>
<tr>
<td>12</td>
<td>Magda</td>
<td>No we just did through ten.</td>
</tr>
<tr>
<td>13</td>
<td>R2</td>
<td>Could I look at what you did?</td>
</tr>
<tr>
<td>14</td>
<td>Magda</td>
<td>Which one? That is the wrong one. This is the after it one.</td>
</tr>
</tbody>
</table>

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16 R3 Oh, I see, you didn’t do eleven then? (Holding the paper) this is what I was trying to get an impression

17 0:08:19 R2 Can I just look closer because my glasses just weren’t focusing so well?

18 0:09:32 R4 OK, can we get back together? Begin the conversations, among yourselves, among others…

19 Magda I’m using your strategies. Where’s Romina?

20 Victor This junk sucks.

21 Magda You’re plotting the plot?

22 Victor Yeah, I’m trying to plot these points.

23 Magda (typing in the calculator) Six, new, what do you call it Cat?

24 Victor Yeah, and then you got the quadratic versus the quartic in here.

25 Magda Cat, where’s the ‘t’ in here? Ok, umm…

26 0:11:07 R4 Ok, let, let me take a second before everybody really gets going here and uh give you a bit of a plan for the rest of the, the morning. You’re, you’re all working on some very interesting things. At some point I think before we quit today it would be very helpful if we could have a time where you could share your ideas. Um, this means that you perhaps should be thinking as you’re going along about the possibility of building that uh, that, the way you’re going to to share, and what you’re going to share. So this is one thing we’ll want to accomplish in a day, when it seems right. Uh, the second thing is that we will want to end with you again doing some writing, in your groups and, individually, and maybe in sub groups depending on how you kind of organize your thoughts about the task and what has happened today. So this is sort of the, the routine I think we’ll follow. If something else happens, there are other things we can do. Remember that, just a, just a word, you know, all we know about the cat is really what we see. This is a cat that is like what? A hundred and twenty years old, or more if it were still living. That’s kind of much. So this is what we know about the cat. What we have in front of us. It’s interesting, when Professor Speiser did this with his course the first time his students in fact had to give this cat a name. Is that not right?
That’s right.

And what was that name?

Memphis.

Memphis. Sooo

We named the cat Memphis.

To, to, to many of us this is Memphis. So continue.

To the window.

What did you put it under? (pause) Distance over time so…

Are you OK Brian? Do you want to be sitting?

Nah, I’m good. I just wanted to see what was going on. (Brian is standing between and behind Magda and Romina)

X, what’s X? What did you put as x?

Um, the distance. So from like zero to five.

Go point one?

No, go by like…, point five.

Y

Is point oh three one. So…

No, no isn’t it this?

No, it’s distance over time. It’s ‘dt’ I did.

Why did you do, if this is not the same, why did you do that? I thought we were... speed.

How would that look? I might be wrong.

What?

Just graph that and see what that shows up. No because it would be like a straight line. Right?

Yeah.

That, ok so let’s put those numbers in. (pause)
Romina: Number one is?

Magda: Forty point three two. Forty point three two.

Romina: Woaaa. Hold on.

Magda: Forty point three two, fifty three point seven six. Forty point three two. Sixteen point one…

Romina: What was it, forty point what?

Magda: Three two. Sixteen point one two nine. Sixteen point one two nine. Another one like that, and eighty point six four five two. Eighty point six four five two.

(Magda and Romina’s conversation becomes difficult to hear as Benny speaks with R3)

Benny: This is the distance traveled per point thirty one. Like for the first one, for the first one he didn’t travel anything. And for the second one he traveled one millimeter for the second one. I think what they’re trying to do over there, the second one he traveled two point five

R3: Uh huh

Benny: So I’m gonna try to get a graph, I’m gonna try to get like um a graph

R3: Uh huh

Benny: That’s all

R3: They’ve been, they’ve been working with the differences in between those distances though haven’t they? These are total distances or what? (pointing to a peace of notebook paper with two columns headed by d and t. there is evidence of a y=-959….. equation to the right of the columns)

Benny: Nah, this is just, just the distance.

R3: But this table here,

Benny: Uh huh

R3: Is compared to the table they’ve got? Is it just the same?

Benny: Nah, I’m just, they’re measuring exact, exactly. (pointing to the photos)

R3: I know, I know that. But, but for each one of their entries…
The time is… (no answer from Benny) (Indicating another table on a different piece of paper) What’s the difference between this table and your table? 

Nah, what they doin…, there’s no difference except that their exacts are more exact. 

So this is point one. That’s this. 

Uh huh.

This is one point five, or I don’t know. I just would love to see you getting together. Go ahead and do what you were doing. 

(Continuation of Magda and Romina and Victor when it became intelligible again.) This is like zero, two, eighty by ten 

Do like more than eighty, because if it’s eighty point six four, make it five 

I don’t believe this. 

That that point is the same? 

It’s actually going up ah… 

How do we do an equation then? How do we do a regression? How do we do the… How do we do regression? How do we do regression? 

Y’all the data? (using Magda’s calculator, while Magda holds it) Umm this is APPS, then you go to um, you go to (x y?), then what kind of regression do you want? I suggest a quadratic regression. I think… 

I like yours better. 

I think you should try that one. 

OK 

What’s your axis? Time? 

Yeah. So put C one? 

Right. I thought. I thought, wouldn’t it be C two? Didn’t you put distance and then time on the calculator? (Magda makes a slight side to side head shake) Oh, OK. 

(staring at calculator) Right?
Right, and then you press..., and there you go. Why did you press..., you didn’t… let me see (taking the calculator from Magda) (pause while Victor works on the calculator) There’s your formula.

Oh, so I have to put the formula in?

Nah, not the right formula. (Victor is putting data into one calculator from another calculator while Romina and Brian are making small talk with R10)

Did you put those in your calculator?

(Handing Aquisha a paper) this is what he gave me.

Can I see it?

I don’t know where to go from there.

You’re using this one (out of sight)(Magda nods her head up and down)(Victor continues to make measurements and enter them onto the calculator while Romina and Brian talk to RP – seemingly not on topic)(Benny is working on his calculator and Aquisha is not visible)

What are we graphing?

What am I graphing? The distances he travels at each frame right now.

We have to present something to Mr. Pantozzi. (Screen shot of Benny’s calculator. He seems to be entering whole number values in column one of a table, and column two is decimal values that increase by .031. he appears to be up to the 21st value) (Camera refocuses on Magda, Romina RP, Brian and Aquisha)

Everybody gets different numbers about everything. It doesn’t make any sense.

What is the…, What’s the main question?

What speed is the… (louder laughter drowns out the rest of her response)

Where’s our other sheet? Is there a sheet around here? (looking under other papers on the table)

Right there (pointing to a sheet near Benny) (Reaching over) Ben, can I have that? (Reaching over and taking the sheet, she hands it to Romina)

This is where we first did.
OK. This is…
Where we had that proportion, remember?
What are, what are these numbers (pointing to the paper)
That’s just numbers that we measured.
On the, on the thing there?
Yeah, but they’re not in proportion…
But it’s not accurate.
So we did it like this, and we went in and this is like in centimeters.
What’s not accurate about, about this?
That’s point one five centimeters that we measured with that…
We had to do the proportion stuff…
You took a ruler on to that paper and measured one point five centimeters (1.5 cm),
Scaled it down…
And so then you scaled that to what it actually is in terms of the real
Yeah, we didn’t even scale…
What is what is the scale on the whole thing?
Point three six centimeters equals five centimeters.
Point three six centimeters,…
No, point three six centimeters…
…equals five centimeters
No, point three six, point three six centimeters, equals five centimeters.
That’s when you’re doing the proportions Magda?
Yeah…,
With this one we kinda like looked at it and we’re like OK that moved about…
Magda A quarter of a box.

Romina Yeah, a quarter of a box. One point two five. And then that’s

R10 Oh OK, so then he’s picking up speed…

Aquisha I’m getting this (?), how do I get this…

Romina Go to mode.

Magda mode

Romina Go over, go to functions, enter

Magda Enter. (pause) How did you get that?

Aquisha This? (holding up the calculator for Magda to see)

Magda Yeah. What did you graph?

Aquisha This is the old one. …so instead when we were doing … that’s the stuff that’s coming up. (Magda takes the calculator from Aquisha)

Magda That’s why you have to delete the things. Clear, clear, and you’re good. You can now start. I don’t know how to do… (Romina, R10 and Brian are having an unintelligible conversation)

R10 All right, so you got the speeds for each particular second?

Romina Yeah,

Magda So in each box we got the speeds.

Romina And graphed them, but a lot of them are the same.

Magda So it doesn’t really work.

(Romina, R10 and Brian are having an unintelligible conversation off topic) (again)

Magda I don’t think that would work. Because what I put into my calculator, I put in the distance and the speed instead of the time. Because the time is the same, so it’s gonna give you a straight line kind of a deal.

Aquisha Straight line?

Magda Yeah because point oh three (.03) for the time all the time, and it would just like change…., right?
Aquisha They got one that goes like this… (off camera, camera is now focused on Benny and Victor)

Magda Oh, I know.

Aquisha So maybe they put in the time, this and then that

Romina Do they even know?

Aquisha What?

Romina What you’re talking about?

Magda …the distance and the time…how did you get a different time? (Magda returns ot the table) Do you know what they did?

Benny They did the same thing that you did.

Magda They, no they added the stuff. Like they did it, and they added the times and that’s why it gives them the nice curve.

Benny Yeah, that’s what I did. That’s what mine is doing right here.

Romina What do you mean they added the time?

Magda Instead of doing it like frame by frame, they were adding it up like you know one plus two plus, you know adding it like… that’s why they’re getting like a nice curve. So…

Aquisha Oh, so they’re saying

Magda So what they’re graphing is that…

Aquisha Two point five…

Magda And then they’re graphing two point five (2.5) and then point oh six two (.062). Then they’re graphing three, four point one… (Aquisha picks up and uses a calculator)

Benny Get me back to that man, to my table.

Victor Huh?

Benny (handing Victor his calculator) Get me back to my table. They did one (1), then they did two point five (2.5), then they did four (4), then they did (5), then they did five point five (5.5). (Victor gives Benny back his calculator)
Magda Yeah, they had two point, two point five, two crossed out.

Benny Just like that (showing his calculator). That’s how they did it

Magda Four..

Benny They did it like that right? Except I’m missing a four.

Magda Yeah, they did it like that. Except we have different like…

Benny Nah this, I’m off by one of them. Like it’s a four in this one…

Magda Yeah, that’s what…, did you get the regression?

Aquisha Four point one six (4.16)

Magda Four point one six (4.16)

Aquisha Plus what?

Magda One point two five (1.25).

Aquisha Five point four one six seven (5.4167)

Magda Five point four one six seven (5.417)?

Aquisha six seven (67)

Magda Six…

Aquisha Plus point five (.5)?

Magda Uh huh

Aquisha Five point nine one six seven (5.9167), six point four one six seven (6.4167).

Magda Six point what?

Aquisha Four one six seven. Six point five…

Magda Nine one six, ok how about two point five?

Aquisha Nine point four one six seven (9.4167).

Magda Nine point four…

Aquisha Six seven. Eleven point nine one six seven (11.9167)
195  Magda  Eleven point nine…
196  Aquisha  Nine one six seven
197  Victor  (in background)  See this is close to what I had!
198  Benny  (At 30:07 Victor and Benny begin speaking off
screen.)  What did you…?
199  Victor  (in background)  see this is close to what I’ve had. 
Remember I got the quadratic regression.  Don’t these 
numbers look close to what I had before?
200  0:30:17 Benny  Uh huh.
201  Magda  Point oh nine three (.093) percent (giggle), point oh 
nine three plus point oh nine three
202  Aquisha  Point one two four (.124)
203  Magda  Point one two four (.124)
204  Aquisha  plus one oh three one
205  Magda  five six, five five
206  Aquisha  uh huh
207  Magda  point one eight six, this is like point two what?
208  Aquisha  oh, I messed up.
209  Magda  point one eight six, plus point oh three one
210  Aquisha  Hold on.  (Working on calculator) Where’d my 
calculator get messed up?
211  0:31:09 R9  Can you explain what those numbers were?  The ones 
that went down to twenty five?
212  Magda  Here?
213  R9  Yeah.
214  Magda  I just added them up.
215  R9  You added…
216  Magda  Yeah, that and that gives you two point five (2.5), and 
two point five plus this number you know…, so I’m 
just like doing it gradually.
217  Aquisha  two one seven
Magda: two one seven
Aquisha: two four eight
Magda: So, I’m doing this so I can get a graph, you know like one of those curves graph
Aquisha: two four eight
Magda: two four eight
Aquisha: two seven nine
Magda: Now we can graph them. You want to play around with numbers?
Aquisha: No.
Magda: On a graphing thing? (giggle)
Romina: What’d you do? What’s that?
Magda: We just added the numbers up so we can get a graph like you know a constant thing. (Off camera conversation with Romina, Brian and R10 about the other Researchers in the room and how Brian would have to kill himself. R10 tries to reason why they do what they do.)
Magda: You want me to like take it out so you don’t have to strain your eyes?
Aquisha: Thanks. (Off camera discussion continues. R10 tries to get everybody off of the off topic and back to work. Victor approaches R10.)
Romina: (to RP) I don’t want to do like this interview.
Magda: Are they going to give us like a project to do? (many different hand gestures by RP) If they give us multiplication, I can do that.
Romina: I can’t, no, I don’t, I can’t put up with an interview.
Aquisha: In interviews we don’t do problems do you?
Magda: In the first one is like your background, the second one is a problem right?
Brian: Two interviews…
R10: I don’t want to, I don’t want to completely, mess us up. I will get in trouble. It’s not a right or wrong answer…
0:33:30 Victor (R2 joins Victor and R10) um, I’m not ready but I took all the points, I mean, I mean, like I took, I came across and put like the points from the the distance the nose moved forward, and then the time. So it came like at the first frame was point oh three one, it moved point one six six seven, centimeters, and whatever. I have all those entire OK and I did a quadratic regression type thing and I got umm the equation. The equation was that one that is checked. And I plotted all the points…

239 R10 (Inaudible question)

0:34:20 Victor Yeah that’s the blue plotted, and then its every single point. But that’s ... (becomes inaudible)

240 0:33:41 R9 (R9 speaks to Magda while camera is focused on Victor, R2, and R10) What numbers from the chart was Aquisha typing in to graph?

241 0:33:41 Magda The the the new ones.

242 R9 Those numbers?

243 Magda Yeah, those numbers.

244 R9 And then what else? Can you graph it?

245 Magda Umm, hold on.

246 R9 Like I added these two like he said to get that…

247 Magda Yeah, and then we’re graphing, we’re adding point oh three one plus point oh three one

248 R9 To go with the times two you added those together?

249 Magda Yeah, and that’s where we got…

250 R9 distance versus time

251 Magda Yeah.

252 R9 Ok.

253 Romina This quadratic regression thing is getting out of hand. What did you do?

254 0:34:13 R9 speaks to Magda while camera is focused on Victor, R2, and R10) What numbers from the chart was Aquisha typing in to graph?

255 Magda I just set it up so you can get a graph.

256 Romina What did you get? This is my calculator? Oh good you put it in mine. Thanks.
257  Magda  No we didn’t. She’s actually putting the right numbers in. should we figure out the number for frame twenty?
258  Brian  How you doing over there Benny?
259  Magda  Should we?
260  Romina  Come on my paper is over there. (reaching across the table)
261  Magda  What’s the deal for number twenty? We don’t have to, we don’t even have to go frame by frame now. It think we should just go from nineteen to twenty, how’s that?
262  Romina  I, hold on…
263  Brian  This, this is the stupidest problem I have ever…
264  Magda  (counts to seven twice while pointing at the lowest row of photographs) One, tow, three, four, five, six, seven, one, two, three, four, five, six, seven
265  Romina  One and two, it moved like two…
266  Magda  No, it moved four and one, four and a fourth.
267  R10  (Off camera. Cannot tell if this is directed to Magda) And so what does this, what does this represent?
268  Magda  Six point two five (6.25). six point two five divided by…
269  R10  (Off camera. Cannot tell if this is directed to Magda) what are our variables then?
270  Magda  Point oh three, point oh three one. (Romina does the calculation) OK so I guess it’s wrong. (Off topic conversations.)
271  0:36:10 Brian  (to Aquisha) How are you doing over here? I’m like the director.
272  Magda  Did you put it in?
273  Aquisha  Mine won’t do it! Something that window won’t… (hands Magda the calculator) it won’t do it. Let me write that down.
274  Romina  Aquisha, is that, can I, hold on, let me just, do you want me to just write down for twenty? That one. Twenty (taking the paper handed to her from Aquisha) (Pointing to writing on the paper) Magda what is this?
275  Magda  Oh, that’s a wrong equation. Don’t bother writing it down.
Romina Hold on Mags, what’s that (pointing to the paper)?

Magda Added the numbers. You know like I told you.

Romina So this goes to…, and then you added two point five to the

Magda Uh huh

Romina OK,

Magda Yup, that’s what I did. Let’s see if this graphs now. (using calculator) OK connected points. (both Romina and Magda are working on calculators) (Victor, RP can be heard in the background – inconsistently) (long pause)

Magda Let me see, that should work.

Romina I’m getting a straight line.

Magda Here. Nine two four nine.

Romina He’s not getting yelled at, that’s bull. That’s what I got (tilting her calculator toward Magda quickly).

Magda Yeah, now I’m, now I’m doing the regression stuff so you have like how I did it.

Romina I hate regression. Hate it. (toward Brian)

Magda It’s only point nine six accurate though, but that’s alright. (long pause) I don’t like this. (Small talk between Brian and Romina. Aquisha and Magda are seen working. Victor and Benny are speaking softly, little phrases indicate Victor is helping Benny set up the calculator to graph.)

Victor Supposed to look like that.

Benny It look ugly though.

Victor Why, it makes sense.

Benny All right so if I want to find an equation for this, how do I do it?

Victor What?

Benny If I want to find an equation for this, how do I do it? (small amount unintelligible) If I find an equation for this and graph it and it goes up…(unintelligible)

Victor I didn’t use a quartic regression; I used umm a quadratic regression. You want to use quartic or you
want to try…

Benny
Exponential…

Victor
Exponential.

Magda
Oh my God! (pause) How do I delete this umm, line here? Hold on. (long pause) See like it goes up, goes down. The thing goes up, up…

Romina
He’s gonna go up after this.

Magda
Hold on, let’s see.

Romina
Because remember after frame ten, cause he goes, he’s walking, and then…

Aquisha
Do you need this paper any more, Magda?

Magda
No.

Romina
It makes sense. And now if we did it past ten, he’s just gonna do, you wanna do it past ten? Cause he’s gonna go up faster because he’s starting to leap.

Magda
Yeah, look.

Romina
Uh huh.

Magda
Yeah, so he like is accelerating…

Romina
He’s doing his walk, and then he, he kinda like changes his walk into the gallop.

Magda
But that’s, is that what it shows?

Romina
Yeah, and it changes right here, it changes its walk into his gallop. He starts his gallop and speeds up a lot.

Magda
I don’t know. Does it make sense?

Romina
Makes sense to me. But who the hell am I?

Magda
Is that what you got? (showing Benny the calculator)

Benny
What is it? What kinda umm…

Magda
The quartic regression. I have to go to the bathroom. Do I have to ask somebody?

Romina
Just hurry. (Benny picks up Magda’s calculator and hands it to Romina while she speaks to R4)

R4
Have you come to a place where you can start to share?
Romina  We might be. Speeds for ten, twenty.

R4  Is there, is there a kind of a uniform idea about those at the table? Or are they different ideas?

Romina  No, we have, we have worked together I guess.

R4  Well, yeah I know you’ve worked together, but what I want to know is if, did you come to the same results? Or do you have…

Romina  Are we all at the same place? (turning toward Victor, Benny, and Brian) All agree? Yeah.

R4  Because I don’t really care. But you’d want to know.

Romina  No, we we do.

R4  So are there questions that you have, about your work that you might want to ask from say the other groups?

Romina  Yeah, like I think we could do a lot of comparing which we need to do.

R4  What I’m thinking is that it might be a good idea if you would ask those questions. You know, If I ask a question, everybody just goes (makes a face and shakes his head side to side), but if it is something you think is, would be interesting to get responses from…, if you’d take the lead on that.

Romina  OK. I’ll try for you.

R4  Whatever.

Romina  Okay.

R4  Aquisha can, Benny can, Victor can… (Small talk off topic, while Victor continues to work with calculator and Benny is occasionally drawn into the conversation from using his calculator. At about the 48th minute Aquisha starts to look for her calculator that Romina was using and continued to copy down into her calculator the data in Aquisha’s calculator.)

Romina  (To R4) We’re just waiting for Magda, we can present whenever.

R4  You’re waiting for who?

Romina  Magda.

R4  Oh. Where’d she go?

Romina  To the bathroom.
R4 0:50:00 Ok. When Magda comes back what I’d like you two to do is go up first. Would that be ok?
Romina OK.
R4 (inaudible)
Romina No, we can go first, they can go second.
R4 (Inaudible.)
Romina Yeah, we’ll go first. Yeah, we’ll go first.
R4 OK
Romina Aquisha, what’s your last point? Did you put in the twenty point five?
Aquisha I don’t know, Magda did it. I think she might have put in the last point.
Romina What would that ..,
Aquisha I gotta check.
Romina She had to add all those numbers in though. Is that Magda’s calculator?
Aquisha No…
Romina Oh, did she do it in yours?
Aquisha I got eleven, and no she didn’t last….
Romina It might have been hers.
Aquisha You can’t even put in twenty because you have to add it all up.
Romina Yeah
Aquisha Know what I mean?
Romina Magda, we have to, we’re presenting first.
Magda 0:51:08 Oh, we are?
Romina No, I, I figured we’d go first,
Magda So we don’t go kidding…
Romina Ask them, because he wanted them to go first. I was like no, no that’s all right we’ll go first.
You know what he’s saying?

OK. Umm looking around it seems that we could begin to share some ideas from each group. So I’m going to invite the group right here to start us off and we’ll just kind of cycle around this way. OK? I’m very interested in, in us all looking closely at what each other is doing because I think there may be some, some interesting differences, some interesting similarities, and some questions that could uh, could come up. I’m hoping that these questions, when you have them, you’ll, you’ll feel comfortable with just blurting it out. I don’t think you need to formulate it in any very nice form, just get it out on the table. We’ll hammer it until it makes, uh, makes some sense. So I’ll just step back until this group feels like their ready. I think they are fairly close, and then we’ll just give it a go. See what kinds of things…

Come on let’s go Magda

I’ll stand there, I won’t say anything.

That’s cool.

(at the over head) Should we just show them what we did first?

You do whatever you want to do.

(turns on the over head) We’ll take it from the top.

Take it from the top

OK. What we did first, was like we measured from like frame to frame. And what we did was we took a ruler and we literally measured like the decimal to see how far the cat moved and we measured it from its nose. And then what we realized was that we didn’t like put it in proportion to the five centimeter, like how, every like little box is five centimeters so that was a first one. And that went in the garbage. Then what we did is we put, we couldn’t measure because everything is too small so we just kinda like looked at it and we figured we just guess how far it moved and then we’d just put it into like, like a number and then we’d divided it by point oh three one (.031), and we got a speed at like every like between every frame until we got up to ten. You can do it, you don’t have
to go every frame like to get up to twenty, we just did nineteen and twenty. That’s all we did, and then we just kinda graphed our points. (Romina puts TI projector on overhead showing her graph) And that’s what we got. And that’s the equation we got, and that’s basically it.

371    R4      Excuse me let me just (focuses over head)

372    Romina  You want to see they equal? Let’s see

373    Jeff    Wow, you did one of those…

374    Shelley Regression things? Where did you get that idea?

375    Brian    Milin

376    Romina Like is that, is that what your graph looks like? Or anything like?

377    Jeff    We have more, ours is kinda …

378    Romina See ours like, ours stops right here (pointing to the middle of the graph on the TI projector)

379    Matt    Yours kinda like tapers off but..

380    Romina Well we guessed…., we’ll show you what we uh kinda guessed at.

381    R4      Where, where is, which frames are included on that…

382    Romina One through ten are like, the points are one through ten and then like it just goes up. Like, OK what happened with us is like in this area right here it kinda like stays the same because we measured the nose. I don’t know what you guys measured.

383    Matt?    Yeah, we

384    Romina You measured the nose too? But it stayed the same, and we figured it was because, ok the cat’s walking, right, and then the nose kinda stops because it gets its hind legs together to go into like the gallop. Like, like leaping. Almost so the nose doesn’t…

385    Matt    oh so this is only the first ten points, it’s not

386    Romina    Yeah

387    Matt    Oh, Ok.

388    Romina So, like that’s why ours kinda (makes a horizontal motion with her right hand) kinda gets even there and
then goes back up.

389  Matt  Where’s the rest of it?

390  Romina  We didn’t get that far, because we spent a lot of time arguing. We just got the graph.

391  Jeff  Because we’re looking more at like from frame to frame almost like from nineteen to twenty, rather than from one to twenty. You know? Know what I’m saying?

392 0:55:52  Romina  We went frame, we went from frame to frame. We went from one to two, from two to three, from three to four, like but we just got up to ten and after that we stopped, we just…, because we like had a lot of problems with like trying to get everything to proportion. So that kind of stopped us for a couple of hours.

393  R4  So did, did, let me, did you continue with your measuring with the ruler and then converting, or did you…

394  Magda  We stopped it…

395  R4  You stopped it…

396  Romina  No we started it and then it wasn’t going anywhere…

397  R4  So that was an idea you abandoned.

398  Romina  Because our numbers weren’t, our measurements weren’t accurate enough, so when like if through our measurements, like if for every, I think it’s from frame one to five I think it is, the cat actually moves a whole, like it moves it’s nose moves from like here to there. It moves a whole box. It’s supposed to be five centimeters. With our measurements it wasn’t equaling up to five centimeters so we just figured like it was because our measurements were kinda off with such small decimals. We just did, we just decided to do it completely different.

399  R4  OK. Let, let me ask, let me ask some questions. Is, does this make sen, does this make sense to, to the rest of you? I’m a, I’m a little concerned I don’t quite understand some of these things. But I’m just wondering if, if somebody could tell me what, what they saw going on here.

400 0:57:27  Matt  As well like they said how the cats slows up I think they’re right because you see in the picture it kinda, it kinda stops and has to, it kinda stops and has to get
down, and kinda get ready to spring.

401 R4 Can you show me on there Matt? This is not part of your presentation right?

402 Matt No. But, I guess, like here on this one he starts to go down and try. And he’s gonna start to spring here. And he’s gonna slow, he has to slow up to do that, he’s not just gonna walk and go right into it so he kinda has to like, like somebody would bend their legs to jump. He kinda has to, like see how he kinda starts with that leap there? Like right here (making a mark on the transparency). Kinda pushes off both his hind legs to go. That’s kind of I guess why it has to slow down. He has to kinda get his bearings and then start to run from there.

403 R4 Are there questions or comments? OK thank you. Let’s just swing around to this group and see how things come out here.

404 0:58:57 Shelly (Turns on the over head projector and places a transparency on it) All right. What we first started with we did like, we think that that’s the final answer, but we’re not sure. What we first started with was umm, this, this is going from like the first frame all the way through the tenth, and then so this is going from the first frame all the way through the twentieth. But we weren’t sure if that was giving us the average velocity or the instantaneous. So then we did from like, this is from, just from frame nine to ten. And this is just from nineteen to twenty. Umm but we weren’t really sure which answer was right so then we graphed it.

405 Romina Shelly, what was your um, for your number like ten. Go back to that. What were your numbers? Is that like you just measured it? What’d you do to get that?

406 Shelly To get what? Oh yeah we just looked at it because it just moved like two blocks, so that was like ten…

407 Magda So that was average…, the one from nine to ten.

408 Shelly Yeah, and this was like going from nine to ten.

409 Romina Oh

410 Magda How did you get your numbers, did you like measure a …?

411 Shelly Just sort of guessed.

412 Angela We estimated.
Magda Ok

Jeff We counted the blocks.

Shelly Ok, so then to get (removing the transparency and replacing it with the TI projector) the uh, thing on the bottom we graphed all the points, all the frames from umm one to twenty, but our, our answer is different because like we’re using the, the first frame like as a still frame. Right? And then umm, and then you just, we went to trace and uhh we went to the point, the tenth frame and we, we used the, it gave us the distance and time because that’s x and y. And then we just divided them.

Matt To get velocity at that point.

R4 Shelly I, that’s a, that’s a beautiful picture. But I’m, I’m a little confused about what it really, what it represents, and I’m wondering if you could, could spell it out a little more clearly for, for me. What those, what those points are and what their, what your reading them from there.

Shelly Each one is like the point at the frame, like this is where frame one is. What?

Angela This is time, that’s distance.

Jeff Yeah, the x is the time intervals, they’re point oh three one, whatever the time interval is for each one. So each move to the right will take you that much farther to the thing. And then the distance, each box wa…, each box is a frame, and that frame is plotted on time and distance. Right?

R4 And what’s the distance?

Jeff the distance is the uh amount his nose had moved from the last.

Shelly From the beginning.

Jeff From the beginning.

Shelly Yeah

R4 From the beginning? So this is the, kind of a total distance that it has traveled up to that point. Is that, am I reading that right?

Shelly or Angela Uh huh
R4 OK

So we’re still really not sure which answer it is, we think that maybe it’s this one but then we’re not sure if that’s the average or if it’s the right answer.

Umm, I have a question.

I think it’s the average.

What does the overall line graph looks like? I mean, like is it a parabola that goes like this (illustrating an ‘n’ shape in the air) or…

It goes like that (illustrating a ‘u’ shape)

it goes like that…, oh, well my question about that is wh…,

We had one that kinda went like that (making a wavy motion in the air) and it went down at the end. But that had a…,

You just changed the the regression formulas.

And what kind of regression did you use?

Yeah, what one did you use?

(looking at her calculator) I think I used umm, just the quadratic regression

Quadratic, OK.

And then umm…

No, because my question is since the graph tends to go like this (illustrating a rising to the right with his hand in the air), it almost seems like it’s telling me that umm, it seems to be speeding up. I mean it looks like it did not meet it’s maximum point…

From, from the information we got I mean…

From the information we had…

…you could actually say that we don’t know that the cat won’t continue to, I mean logic tells you it’s not gonna happen, but I mean if you, from what we got, I mean, for all we know the cat could keep getting faster.

It makes, it makes more sense for the cat to keep getting faster than at the end of point seven one seconds just to stop.
Victor
No, no what I meant was you know it reaches that point where it reaches maximum velocity and then it just tends to slow down. You know that’s why… (Everybody talks at once. Seems to tell Victor that they didn’t want to base any of their hypothesis on what he said, or that is not what their interpretation was.)

Victor
I know.

Shelly
We really don’t know what happens after this twenty fourth frame.

Benny
But the graph knows what happens after those twenty fourth frames.

Jeff
Well we’re just assuming that he continues to climb at this rate, that’s what that graph, the graph is showing.

Benny
Right

Victor
Can you show me your equation? (Shelly displays the regression equation on the projector.
Y(sub1)=321.29850423747*x^2+ -42.30462735021*x +2.264423076922)

Magda
(In background) That’s the quadratic, the quartic, or whatever. The numbers are different (rest is inaudible)...

R4
That’s a lot of digits! Does that seem, how does that seem to you?

Shelly
I don’t know.

Romina
Like we’re cheating.

Jeff
Yeah, it’s not right dude. I don’t like it at all!

Romina
I don’t like this, whatever regression thing.

R4
Say more. Say more

Jeff
They give you the answer, that’s it!

Romina
We’re not doing any work, we’re just plotting points now we’re just asking the calculator to get it on for us.

01:05:18 Brian
That’s a crime right?

(female voice)
And there’s a problem with that? (laughter)

Romina
…you ask us like; well we should be making an equation up, but by all…
Jeff Yeah this one, this was extremely hard this one.

Romina …since it speeds up at this, you know you have that number in front of that ‘x’ or something, but we cheat.

Jeff This one was really hard. I don’t know if you tried to hold on to it or anything, I spent two hours trying to do it. I spent like ten to twelve, I mean it just, it wasn’t happening.

Romina I know but I’m just saying…, it’s a lot easier.

Jeff I mean even…

Matt I mean at the beginning we were trying to do all this stuff with like from physics, and we’re doing velocity and everything, and none of the numbers were working out. Like none of them were. So we stopped doing that and we started going into the graphs and stuff.

Romina There’s like, there’s like no way we can back this equation up. There’s like no way…

Matt Well…

Romina I understand I mean it’s not a big deal, I’m just saying…

Matt Well, no no no it’s not even that, it’s just that, there’s no way, that, that I know of any way, to account for all the times the cat might slow down during those twenty four frames, or speed up or do anything like that you know.

Romina I don’t think it’s gonna be just one graph.

Jeff I mean we can’t, I mean you can explain, you can explain the graph and explain everything. And you can do that; you just can’t explain the numbers and the thing. Just suppose, when we did it ourselves yesterday we couldn’t explain the numbers.

Romina Yeah, so…

Jeff I mean it’s like the same situation.

Romina At least we worked at it.

Matt I know.

Romina Well, we used it too. It’s not um…
Ok, so, so let me see if I understand this right. Your group has three different possibilities on the table. And one of the things you are doing presently is trying to think about what, which one of those might make more sense.

This one does. (pointing to the regression equation)

Some of you think this one. There may be others that, that would back some of the others.

Because like the other ones, even with like the second one that we did. (Putting a different transparency on the overhead and taking the projector off) It’s like, it’s like showing like the average speed in the two frames, it’s not just that one frame. So like with the graph and everything you could figure out the velocity for that like that you know exact moment I think. (looking at Shelly) Right? That’s what I think.

This is an interesting point I think, I think we could revisit this a little, a little later. Ok so hang onto this.

It’s not even, it’s not even so much that we drew, that we got that, the regression thing, and it matched up with the points. The regression comes from the points that we put in the calculator. So we, so we went one by one to each frame and measured how far the cat went, and then we measured, and then we took the time, and what that gives you is, it gives you the distance and the time. And just, and all you have to do is divide those two numbers and you, you get the rate, you get the uh, sorry the velocity at that point. That’s all that that graph really is. It’s not so much anything to do with the line or the regression…

So if you divided the distance by the time, you’ll get the velocity at that point.

Yeah.

The instantaneous velocity. Ok.

Did you like, did you guys, I don’t know if but, did you guys go like from frame one to ten, and then clump it together?

No

No like…

One to two then…
One to two, two to three, three to four…

So how come you guys got two different, didn’t you say you may have an average? One of them might be like an average?

Yeah, because they did an, they did an average and they did an individual thing.

Ok, I see what.

Ok, can we let this group come to the board up there and tell us what their thinking is?

We did this first where we took like umm the cat’s nose from like the first one to the second frame, and we took the distance, well actually from nine to ten. And we just took that small little distance that it moved and we divided it by the velocity. That’s more like an…., by the time, which is point oh three one.

We didn’t get like the answer though.

Yeah, that’s not accurate.

But there, you guys were uh graphing the distance and from the time I think. (Putting the cat pictures up) Yeah, well we graphed what they graphed. We, the distance from the nose from that, from that line throughout the whole thing, you see the line moving back? (Pointing to the pictures on the overhead) and by the time it’s here it’s all the way down there. So (removing the cat pictures and putting the TI projector on the overhead) see the graph, it looks not like that. (working on the calculator) Something like that.

It’s the same thing.

I know, but what this graph, everybody it’s not the velocity, it’s just the change in distance. But what, but what I see here is a certain velocity and another one (indicating the points on the screen). So you can’t, you really can’t do a regression, because this is uh, uh a combination of two, two functions. Two straight lines, because a regression would be like a, I don’t know, kinda, use like a parabola. Like it’s not going, it’s, first, its two straight lines. It’s going straight in the beginning. It’s walking. It’s not walking faster every second. It’s, or every point oh three, its just walking. Then, then at frame seven…

Isn’t it like accelerating there though?
Benny Yeah

Mike See how it crouches down? No this is the acceleration right here. Whenever you have a change of slope...

Matt Well yeah, but it still accelerates from the bottom to there.

Benny Yeah, it’s accelerating all over!

Mike Its accelerating, I mean these numbers are not exact like, but basically it’s a straight, it’s a slope. A line with a slope. It’s walking a certain, when you walk do you accelerate when you walk? Or do you just walk?

Romina Yeah, but the cat isn’t accelerating.

Jeff When you start from stop, you’re accelerating when you walk.

Romina He’s starting to like run or whatever.

Mike This is, that’s why this point is lower (pointing to the first point on his graph) right here. See it? It’s accelerating a little bit.

Matt But then it’s not a straight line. You can’t say its two separate equations. (Many fast overlapping comments.)

Mike Here’s the line, he’s walking right there (holding his pen over a straight part of the graph which covers the first 9-10 points). You see it’s like they’re all, it’s the same slope. This point is the same distance (pointing to the 3rd and 4th points) on the ‘y’ direction as this point as that one, so that means he’s walking at a constant rate for a very small amount of time. Then when this changes, that’s around (pointing to the change in direction of the graph) when he starts crouching down, and he starts walking, and ten is around here (pointing to graph), he starts going at this speed. This is, he’s not accelerating here, he’s actually going the same speed. That’s why all these guys are like the same apart, that’s why you see a line. So it’s two lines. It maybe a little off in there (pointing to the graph) but basically what it is, he’s walking in the beginning and going this speed (pointing to the flat part of the graph). And running at the end, going at a faster speed. So, and I, let’s see what else we got here (changing screens on the TI). I tried to plot the speed (showing a different line graph superimposed on the first graph). I don’t’ know what
that is (indicating the initial part of the graph), but he’s walking, this is the speed. It’s it’s lower because when you walk you walk slower. He accelerates up there, and you see, and he goes at a constant, sort of a constant speed at the end, because, because this is his running speed (pointing to the right side of the speed graph), this is his walking speed (pointing to the side just left of the middle), I don’t know what that is (pointing to the far left of the graph). You, I took, I took the difference between each point, between like ...

519  Matt  Pictures

520  Mike  It would just be like finding the difference between the first one and the second one and dividing it by time. Like, um finding the distance, you just use a simple equation…

521  Matt  The difference in the distances?

522  Mike  Like, here you go. I use this equation, that’s, that’s what this is right there (indicating the second graph – low spot left of center). The difference in the distance divided by the time (writing \( \frac{D}{T} = V \) on the white board), there’s your, there’s your V. There’s this line. This line’s our V. The time would be point oh three, point oh one three times one times one times you know as you go along, you know, intervals of that. And uh the distance is the difference between each and every one. So, I don’t know what that is (pointing to the second graph, far left). Don’t ask me what that is. But right here it’s going this speed (using the marker to underline on the second graph), accelerates, and sort of goes this speed (indicating rest of graph to the right). So, that, that’ll, that kind of shows you, you know, how at the end it starts running from here when it starts to crouch down (indicating middle of second graph where there is a positive slope) it starts to speed up, it accelerates. That’s what this graph shows. That’s basically it.

523  Matt  That, is that, the graph you have, that graph there…

524  Mike  With this graph? (indicating first plot graph)

525  Matt  Yeah with that graph. I always, I always remember teachers as saying, or at least my teacher says, when
that starts to slope up, and starts, and continues to climb you are only going at a constant speed, at a same speed when it’s flat. Like down at the bottom. Down at the bottom he may be going at a constant speed.

526 Mike No, that, that’s because, this, this is not um. This is not speed

527 Matt He’s accelerating; he’s not going at a constant speed.

528 Mike No, no, no

529 Matt He’s accelerating; he’s accelerating at a certain rate.

530 Mike This climb is not the speed. If this was the speed, that’s not the… this is not a graph of the speed. Everybody thinks this is a…, it’s the distance. Now it’s how far away from that line? If, let’s say, we’ll give this like, we’ll say it’s a hundred (making marks on the white board projection) units away. And each of these is ten alright. So it’s moving at a constant rate of ten every, every ca, every, every uh point oh three one seconds. Like because these are all spaced the same apart that’s why they have, that’s why they look like a line. Has a slope.

531 Benny So on the bottom it’s moving…

532 Mike So on the bottom it’s moving slower.

533 Benny Yeah

534 Mike Like they’re closer together. On the top they’re a little higher so you see it’s like a it’s a straight line

535 Benny So the distance traveling is more as the line goes up. That’s…

536 Mike This is, this is, as you can see here it’s like, this is the velocity (pointing to plot), whatever this is (pointing to second speed graph). The reason, wherever it curves, wherever it changes, that’s your acceleration, that’s where it starts to accelerate. Because the thing’s not accelerating throughout the whole thing. It’s walking, acceleration, and it starts to run. Like what you’re thinking is probably like this is the speed and it’s going faster at the end.

537 Matt No, no, no. it’s not so much…, what I’m saying is, way, the way we plotted our points, the purpose of that was…
1:15:59 Mike We probably did the same as yours.

Matt I know, I know, I know. But if you do, if you take that distance, we were always taught that in a distance time graph, whenever you use that, that slope, that curve right there shows an acceleration. It doesn’t show us speed, but it shows there’s an acceleration somewhere. Anything with a slant is going to show an acceleration. And anything that is flat is going to show something constant (making a level indication with his left hand)…

Mike …an acceleration?

Benny Now, now what’s acceleration? What you think acceleration is?

Mike Where, where, where’s the like, where, when he’s walking in the beginning, is he accelerating while he’s walking or is he just walking?

Matt He can, he can go fast…, he might be though.

Mike What I mean, what do you think, what do you think with your graph, with this graph right here (plot graph). What do you see in it? I don’t see it going faster.

Jeff I see him going faster when he’s walking.

Mike You see, you see, you think, Is this…Put it this way, do you think, is this speed the same up here or is it different? Is it the same or is it different?

 Jeff No, I see how your keeping…

Mike It’s the same speed.

Magda What numbers did you graph?

Mike I used the…

Magda Distance and the time?

Mike Yeah. This is the distance from that one line, that line that moved back. And this is the, I’m telling you, this is what I think is the speed of the, of the cat.

Milin So your saying when it starts to slant basically that’s when the…

Mike that’s when it accelerates. That’s when the…

Milin Where? On the, on the…
Right here (pointing to the 11th point). Right where this function and that function meet. That’s when, that’s where the acceleration is.

Can I show you guys something? Because I kinda… (Aquisha gets up and goes to the projector) I kinda, think that what he’s saying… What I did is I used two of these right? (Holding up cat transparencies) and I lined them up so that the first frame is over the second one, like he was umm. Like everyone else was doing. And umm I took a clear one and I showed like how far the cat moved between each frame. And if you see the lines, first they’re like really small when he’s walking they’re about the same. And then here they kind of accelerate and stay the same here.

They’re practically all the same…

So I guess that’s another way of kinda showing what he’s trying to say.

Like the distance you move is is basically, it’s the same in the beginning, then it gets bigger around seven or eight and then it’s the same at the end. It’s just running at a constant rate.

Yeah, it’s like……… it’s like a fox, know what I’m saying.

I’m saying that graph is not exact because it’s hard to see the lines in there and I don’t think he, I don’t think he’s actually moving at the same rate.

It’s probably showing the little increase that we’re talking about, the distance is not precise, it’s not exact. Know what I’m saying?

(replacing his TI one the projector ) Like right here as she was saying, the distance she was talking about is uh, the height of this one and the height of that one, if they’re like the same, you’re going to see a line.

Because that would be like the same slope.

So what does this have to do with the speed at ten, or the speed at twenty?

Well you take, ten is around here (indicating bend on the plot graph), ten is right in the middle while it is accelerating. And twenty is right here (indicating the end of the speed graph). So I think the speed at ten and the speed at twenty are gonna be pretty close to each other. Because they’re both, they’re both while it’s running. Or ten is in the beginning of it’s running.

So what your saying is twenty is gonna be a little more, but they’re both close.
Mike: Dude they’re both close.

Magda: Yeah, but isn’t he going faster when he’s running? So, the speed is not different.

Mike: He’s running at a constant rate.

Benny: Yeah

Mike: So, if….

Aquisha: What he’s trying to say is that when he’s walking, he’s walking at a constant rate, and then there is a little acceleration, and then he’s running at a constant rate. So that’s why he was saying that it would probably be two different ones. Instead of one.

Know what I’m saying?

Romina: Isn’t the cat, like I understand, I agree with that like if that… But isn’t the cat walking to like start off in order to accelerate and eventually move up to like running or whatever?

Mike: Well, this is what I believe. I believe that the cat,… this is a very small period of time. It’s probably, I mean for the point whatever seconds he’s walking. For, I don’t know how fast he’s going. But then he accelerates between these, between these frames right here. So he starts to run right here (Mike has the 9th, 10th, and 11th points circled in red), and this is where he’s running (indicating the rest of the plot graph to the right). So it’s actually a ah, a combination of two, of two, different things.

Jeff: The two different speeds…(cannot hear over female conversation at table 1)

Mike: Like in the beginning he’s going like, hold on a second, like you see how he’s going forty centimeters a second or two or you know somewhere around there? Four, two or five?

R4: That’s the speed is that right?

Mike: Yeah, that’s the speed.

Jeff: What’s, what’s, wait a minute, what’s ten and twenty speed? Like what are the speeds so we could check it.

Mike: Well ah, ten we’re going, I think, that’s a little messed up. It’s like twenty two, and by, by twenty it’s like sixteen. But it’s up there in the teens somewhere. Like this is just like an estimate. So I’m thinking like…
Hold on, what did you guys get for speeds? I have, we have like a significant difference between ten and twenty.

We go from eighty to two hundred.

Like by like twenty it’s like sixteen or fifteen somewhere around there. And ten...

Fifteen what, centimeters per second?

Yeah, centimeters per second.

See, I get, I get an increase in speed every time I divide. My numbers for distance over time.

(Speaking over Matt) We got like, at ten we’re like at around eighty, because yours is like two and a half, yours is two, and at twenty we got two hundred.

For each frame right?

ah, I get a significant difference which means that, which means that as that

What, what, what are you dividing? I mean like you going eighteen into nineteen, nineteen into twenty? Because you go down there I should be about the same.

Wait, hold one question. When the cat is walking isn’t the speed slower than when the cat is running?

Yeah, speed’s gotta be slower...

It is slower but that number up there, why it’s twenty

So why, here’s that thing here, Why’s that one..., he’s walking you have twenty, he’s running you have sixteen. So why, like I’m..., Am I like slow?

See the beginning is a little messed up, I don’t know why it’s twenty six. That’s, that’s why, that’s why it looks weird on the graph. But if in the beginning he’s walking, he’s about five centimeters or three centimeters a second, a second...

Uh huh

Then as you go down the line and he’s running, he’s going seventeen, sixteen or nine, like around sixteen and upper, or like right, right by there.

Is having like ten’s...

Ten’s like twenty something.
Jeff: So, he’s moved faster at ten then he is later?

Mike: Well no I think that’s a mistake on the probably looked, probably measurement. But it should be like around sixteen or seventeen, that’s where it should be.

Shelly: Are you saying in the beginning of the walking is constant because its walking the same like can’t it be walking slower and then walk faster?

Mike: Well I’m not saying exactly constant, that’s why it’s not all point oh four like four centimeters a second. Like but if you look, like what she said, the distances are pretty close to the same. What?

Matt: What’s your graph of? What’s C three and C four?

Mike: C three is uhh

Matt: What’s C three?

Mike: That’s just the differences. See like they’re the same differences point oh seven, point oh seven. That’s because it’s moving at the same rate. (projection of TI table on board, Matt is scrolling up through a table with headings of C2, C3, and C4) It starts at the beginning…, something’s messed up somewhere. But, see .07 around 10 and 11, they are always moving at the same rate. It’s not really changing that much. So basically it’s a combination of two graphs.

Matt: Distance is still grows though, it’s not staying constant.

Mike: Distance grows but the speed stays the same. When you’re running at uh say twenty miles, but two miles an hour (Noise at table blocks small amount of conversation). Lets say your walking at one, you accelerate to two, that’s what, that’s what the graph is basically showing. It’s walking…

Matt: Then where does he accelerate? Where is there a big difference on that, where it would accelerate?

Mike: Uh

Matt: If there’s a graph of speed it should show a big difference for an acceleration.

Mike: So, here’s your, here’s your difference. It’s see how it’s like really small numbers like point oh four. Then by six (mumble), I don’t know it jumps pretty high.

Matt: Well then why is…
It shouldn’t jump that high. It should, it should probably be around eleven, somewhere around fifteen or something right there. There’s your acceleration from four to eight, that should be around fifteen or something. And then it stays up that high by the teens. There’s your acceleration to, to that speed.

OK, could I interrupt? I’m sorry, but we’re, we’re running out of time and there are some just tremendously interesting things coming out here. What I would like to suggest at this point if I could, if I may, is that you spend about a bit of time as I promised you would just writing about what has happened here today, and you know kind of some of the questions that are kinda still on the table for you. Before we do that though Professor Speiser had a couple of comments you wanted to make by virtue of what he’s seen here today.

I, I thought, I wanted to comment on the virtue of .., I thought I would share with you what it was like when Chuck Walter and I first were working on this task ourselves before we gave it to our college students. We thought we’d take a whack at it ourselves and it was like a comedy. We weren’t sure what to measure at first. It looked like something interesting was happening around frame ten and we just pulled frame twenty out of the air. We just looked at the pictures and thought frame ten might be interesting. You know, so we started trying to imagine what we’d measure. Should we measure the total distance the cat traveled? Should we measure the changes? We end up measuring both and we started worrying about whether we measured right. Because we were, our idea was to kind of eye ball on the grid in the photo. And we weren’t sure what we had. And then when we started trying to calculate speeds, when we divided by point oh three one, we had this incredible surprise. Were these numbers making sense to us? It didn’t seem like anything that we had expected. We started thinking about what’s going on here? We, We’d start trying to make a picture of the cat’s motion you know maybe, from one to two, then maybe from two to three and we thought we had some kind of coherent picture going. And then we’d go into the next frame and WOW something happened what’s going on here? We wondered about whether we, you know when we looking at the photo’s or reading our graphs,
what uh, what the information was? It was, it was like a comedy. It took us about; it took us a couple of days. Um, and it was really interesting because I was walking around the tables listening to you and remembering, you know one of you would ask another of you a question, and ‘oh, yeah, I had that question’, Chuck, Chuck helped me with that. You know it was our sort of cooperative learning you know. This was, this was wacky. You know and then we had…, let me tell you a little more about this. I was in a calculus class where I was lecturing to two hundred and seventy students. I don’t believe in lecturing and I don’t know how to reach two hundred and seventy people all at once. So what we would do, is we’d, I give, I had a few assistants I didn’t know what to do with them. They were graduate students, they were as baffled by some of the things that were coming up as we were, so we were all just sort of talking about…. It’s astounding the conversations that we have, where we’re supposed to be experts. My God what is this? You know, what happens when you, you know what does it mean when you divide by a number? What’s a reasonable speed for this cat? Is this, is this speed that we’re calculating, does it make sense? We were all, we were thrashing through all this stuff, and it, for me was more fun than, than a barrel of monkeys. You know, that suddenly, you know, here’s the world you know, here’s the math, what’s going on? It was just…., why do we want to, you know, why do we want to inflict this on you? You know, but the… Ok so I had two hundred and seventy students, so we handed out all this stuff, just like we did to you. They were, the students were divided into groups of six and off they went. And I don’t know how many groups of six, but there was a lot. I just remember them in rows, they were in rows just going up you know it was like a theater. It was like a theater with no actor because there was nothing going on in the, you know at the podium. And I was running up the isles, talking to students, there were hands going up all over the place. What’s going on here, I don’t believe this? We were just running, there were three, you know my two assistants and I were running and then we’d try to put our heads together. What are these students thinking? What’s going on here? And it was incredible. Over a few
days, things began to slow down. But we didn’t know which way it was gonna go. When people asked us questions, we didn’t know how to answer them. And it was just wonderful, because it put us back into the chair of somebody who has gotta figure absolutely everything out. Where the higher mathematics we had were sorta breaking down, and uh, you know, you might think it’s a little perverse but we began to realize that what a wonderful idea to share with students this reality of what it’s really like to do mathematics which is this comedy of errors and confusion, and we’d laugh at ourselves. Scrape ourselves up off the road. And try again. And um, it felt, you know it felt like real life. And somehow… So that’s how we decided it was good, and we worked with our students on it a lot. And got a very strong feeling. It’s sort of like Grand Teton National Park, the trails were tough but we’d get past, when we’d get over the first pass, you know when you get over the first pass and you see where you are, you wouldn’t want to be anywhere else. I hope you feel that way too. We love the work you’re doing.

619  R4
Dr. Maher.

620  R1
Um, do you have any instructions, I sort of feel like I need to explain the change in seating. You know, um, these are guesses on our part. New tasks, new seating. But please know that we want input from you. If you want to have different seating, different groups, form your own, you know each other now. Our, our goal is accomplished now that you’re one big collection of student’s right from lots of places, if you want to work in different ways that’s OK. If you want us to set up a different table you need to tell us, OK. If you want a little bit more privacy and people move away, believe me our recorders are happy to be given another assignment because they’ve got a lot of taping writing all the time. You need to feed, we want your best ideas the best way you work, and that’s what we learn too. We need to hear from you on what these are. So that’s really you know, kind of up to you. So, give us some feedback, let us know what you like, what you want to change, it should be your show. We’re past about the middle right now, just about, and so now you, we trust you. You have to lead us and guide us and tell us what works best. OK? And so you know, I would appreciate it if some
of you would give us that feedback. We’ll try to do our best to make it the most comfortable for you. Or we’ll leave it unless you tell us otherwise, you let us know. By the way there is never any reason why you know if a few of you are working on something and you want to go to someplace else you can do that. You know, you’re not tied to, you’re not glued to your seats. You’re not glued to your particular tables. You can form new ones, and new subsets as, as you’re comfortable doing. Um, is there anything else? Chuck? Elena?

621  R11  (Camera shot of Brian writing a complaint about the food at the workshop) Just one suggestion, um, you know, we have this suggestion box over here, if you’d rather not talk to us directly but you’d like to get information to us, feel free to use that, because we do check for messages. If that’s easier or you…

622  R1  Or if you want to talk to us, send us a note they’d like to talk to you, it’s up to you. That’s ok too. We’ll set up a time and try to make that happen. OK thank you, this has been interesting to watch you, writing. (Laughter at Brian’s expense. Table begins to write in notebooks what Romina refers to a “log”.)

623  01:36:50  R1  Before you all leave, there is a question I would like to ask you, and respond on your suggestion box. Just for input for us. I’d like to know your take on the interviews. Would you prefer some small group interviews rather than individual interviews? If you prefer individual, small group, let us know with your name in your box. OK? Good. (As students finish writing in their journals they close them and leave. Tape off.)
At the beginning of the tape, three researchers are talking softly R1, R10, R5, R3 away from students: 
Are you writing comments already?

I’m writing the comments man.

We have Jeff back.

And Ankur, and Benny

Everyone just wants to be at our table. (Small talk about group changes)

Ok. Let’s uh. Did you bring, did you bring in your parkas to, to these things? I mean is it a little cold in here or is it just my…? (Many comments) Ok. Maybe we’ll see if there’s some way we can get things adjusted. I know if you’re, you know, working or running around and stuff it’s, it’s a lot different than if you’re sitting and you’re a lot colder. I have a little advantage, because I run around a lot. I have a, I have a question for you. Following still the ideas that were starting to surface in our explorations with this cat thing uh yesterday. And I am very curious, very curious. Everybody seems to have measured using the cat’s nose. OK, is that right? And I’m just wondering, because the measurements are critical in this thing. The measurements that you, you make of the distances are uh are absolutely crucial to how you’re going to be able to talk about the the problem. So I’m curious as to, as to why did you pick the nose? Why the nose, why not the end of the tail? The base of the tail? Or the front paw, or the middle of the cat or something? What, I mean there must be some, some, some sense of, of, of this, the reasonableness of choosing the nose. I’m just, I’m just curious, since everybody seemed to end up that way,
what, what that, what that might be?

8 R2 If I was the cat I wouldn’t want you measuring off my nose.

9 R4 Well, no I’m not gonna go there, OK? (Jeff raised his hand) Yeah, what do you think? I didn’t realize you were just helping Brian out, I thought you were going to answer the question. (laughter)

10 Jeff No because that, the, the nose is like the most steady part. I mean when he’s running, he could be, like his back legs could be in more, you know like when he’s, like he’s galloping. His legs are moving in different directions and the nose is kinda the most steady uh, area on the cat. I think that’s why everyone picked it because it was the easiest. Like even the tail could move back and forth, the nose seemed to stay in kinda the same spot at all times so I think it would be a good place to go from.

11 0:08:25 R4 Ok, are there other, were there other, other reasons? Other ideas? How about this group back here? What was, what, what did you all think about that? What did, what was your reason for picking the nose? That didn’t sound right did it? Choosing the nose.

12 Mike It was easier I thought.

13 R4 What did you say sir?

14 Mike You could find it, like the center of the body…. the nose is just like right in front and right against the grid so you could see exactly where it is.

15 R4 So there was something you could really focus on …

16 Mike Yeah

17 R4 In a way. Sherly did you have…

18 Sherly We all said that like before the cat would jump or something it, like the body stand. Or if like took the tail it wouldn’t be like the same.

19 R4 So you were looking at the body theme…

20 00:09:23 Sherly Well no, (inaudible)

21 R4 Oh, oh Ashley did suggest doing the tail. Where on the tail would you have looked Ashley?

22 Ashley The tip.

23 R4 The tip of the tail, Ok. (Ashley responds again but is too soft to be heard) Ok, so, so you guys chose the, the nose, for, it sounds like a couple of different points of
view. How about you all over here? Now I realize that some of these are ch, have changed a bit, but

24 Ashley (Inaudible) …it moves back and forth so I can’t use that, and the tail can go up and down to, so I can’t use that.

25 R4 Ok, is there so…, is there some, is there some sense to that, to the nose being steady? I mean does that make se…

26 Victor That makes kind of sense but, umm, you know in horse races and stuff like that…

27 R4 Uh huh

28 Victor …they go by the nose or something like that or…

29 R4 Oh, yeah.

30 Victor …that’s the part that’s the most extended out.

31 R4 That’s true.

32 Victor It’s kinda extending stuff like the feet. Whereas the feet, I mean they kind of go all over the place.

33 R4 Obviously. Yeah, Ok. Good. Well I think the plan for today is something like this. Umm, I have, I’m, I’m thinking it would be helpful for us this morning to kind of review very quickly, the uh, the things that were on the table at the end of the time yesterday. Because they were, they seemed to be sparking a lot of conversation. And it might be helpful if that conversation should, or could continue a bit. So what I’m hoping to do is start by getting a very quick recap from each of the tables uh, on the, on the uh ideas that they were, they were presenting the last time. Umm and then I think we can uh think a bit about what the implications of those ideas might be, in kind of a free ranging discussion. Amongst not only individual groups, but between groups and trading ideas and thinking about what might or might not be uh making the most sense for individuals. Umm and then I think there’s something kind of wacky that I want to try to see if you’re up for it. It has to do with this uh, this cat. And uh really is, is, is, based on something that Aquisha did um last time. Or, or at least what, what she presented. So we’re gonna, we’re going to, I hope you’ll be up for this because it’ll be something a little different than sitting at your tables.

Ok, so, would you take just a, a, a maybe just a few minutes and kind of if you would gather the um, the
ideas that you talked about right at the end of the hour. And let’s, let’s look at those things kind of quickly and see if we can get back on track with that, that discussion. So, uh take a few minutes kind of, get those things together again and I’ll, I’ll uh, I’ll then, we’ll go through kind of a quick presentation once again. Not, not in the depth we did last time necessarily, but just kind of to review.

34 Romina … (from previous conversation while R4 was talking) and we want to know what the velocity is at frame ten and frame twenty.

35 R4 Ankur, you need some stuff right?

36 Ankur Yes

37 00:13:17 Brian Explain it to me.

38 R4 Well let me give you your own stuff.

39 Ankur Just from this we gotta determine that (looking at the transparency of the cat)?

40 Romina In each, see the little grid, the little boxes, each one of those is five centimeters. (Small conversation around the table is off topic. R4 brings material to Ankur.)

41 0:14:36 Ankur So what did you do yesterday?

42 Brian Here? We just, like we got aggravated and got taped because they moved the groups around.

43 Romina What we did?

44 Brian We picked up Romina’s garbage and….

45 Romina We guessed but, I think it’s wrong because they didn’t think we were right …

46 Magda You know what we have to do. We have to do the speed and the distance instead of the distance and the time to see the like thing.

47 Romina Ok, I could do that.

48 Ankur Have to do measurements really.

49 Romina What?

50 Ankur Have to measure it.

51 Magda That’s what we did.

52 Romina Ok, we have this graph and then C3 (showing Magda the calculator). Where should I put the distance?
Magda: Sure, put speed on there.
Romina: What?
Magda: Put speed.
Romina: Distance and speed.
Magda: Yeah. Start it from here (pointing to the cat transparency in front of Romina) (Small talk about Jeff’s hair.)
Romina: What?
Magda: What are those things? Like that line?
Aquisha: huh?
Magda: What is that line
Aquisha: All them put together I’m seeing if it’s the same as the distance (wiggling her pen back and forth). Know what I mean?
Ankur: The distance the cat traveled?
Magda: Oh, like the full distance? I see. All right, should I continue doing the other stuff?
Ankur: What’s the red line mean over there?
Aquisha: Well see, I put two of them on top of each other, like two on, on, this one and this one. Know what I mean, yeah. I’m going to do this like this, see if it comes out the same. (Small talk about sports while Aquisha works.)
Magda: Ok. Mr. Quitter here? One point two five. (Romina looks over) I’m doing, I’m continuing it.
Romina: Oh I had no, I was like, what are you talking about Magda. Ok what?
Magda: From ten to eleven.
Romina: I’m still trying to graph this thing.
Magda: Hurry up we’ll graph it later.
Romina: Ten, eleven, second quit. This is frame frame eleven?

Magda: This is one point two five.

Romina: Divided by three point, no, point oh three one?

Magda: Yeah, hardly moved. This picture’s, one, two…

Romina: What’s today’s date?

Magda: A half he moved.

Romina: Twelve, he moved…, so, is that two point five?

Magda: Uh huh

Romina: We’re up to eighty (after making a computation).

Magda: Ok hold on, I can’t really see this.

Romina: What’s today’s date?

Brian: Fourteenth (small talk about a drivers test)

Magda: So that’s six, one, two, three, four, five, six. That means like one full one, like a third…, like a half.

Romina: So that would be five, seven point five?

Magda: Yeah.

Romina: Then add the, two hundred forty one.

Brian: Two forty one?

Romina: Yeah

Brian: Jesus Christ!

Magda: It’s another three and a half.

Romina: I already have stuff in there (response to other than Magda).

Jeff and Brian: What is this?

Romina: This is um how we figure out distance speeds.

Jeff: And eh, what are you gonna graph speeds against?

Romina: Oh yeah, this, this, you gotta… Magda, we’re not, we’re not accumulating time are we? When we graph we accumulate time don’t we?

Magda: We just add, I don’t know.
Romina That’s how we did it before!

Romina and Magda Yeah, that’s gonna be distance

Magda Yeah we’re gonna add it up kinda.

Jeff All right, we’re gonna put one against one?

Romina We’re not doing anything yet, we’re just gonna figure out the numbers, then we gotta like add them together

Brian All right, well I’m ready. My editor…

Magda We moved like one, one and a half again. Moved one and a half again.

Romina To sixteen?

Magda From sixteen to seventeen. Fifteen through sixteen was one and a half too.

Romina From seventeen again?

Magda From sixteen to seventeen he moves, let’s see, he moves from sixteen to seventeen, no sixteen to seventeen is um one and like a third. So it’s like five point three.

Romina Sixteen to seventeen?

Magda No. This one, this one, this one. (Romina crosses out one line in her table) So it’s…, so it’s six point six, six.

Jeff (To Aquisha) What does that show?

Aquisha I just did it twice to see if I was tracing them pretty well.

Jeff Are you?

Aquisha Uh, huh. They’re like almost, they’re exactly the same.

Magda It’s like nine.

Romina Oh, the numbers nine, I thought it was like nine squared. I was like woa.

Aquisha Did you guys measure (pointing to the first frame of Magda’s photo copy) um what each box would be?

Magda Three point six

Romina With a ruler?

Magda Yeah
Romina: What did you get?

Magda: Point three six centimeters

R4: (0:25:15) Now what… Ok, what’s happening, are, are you, are we close to being able to kind of recapture some of the, some of the uh things we were talking about yesterday? A blank.

Magda: (Still measuring) That’s like a three I estimated. (pause) Ten.


R4: I see, you’re pressing on to the, with the others now. Is that right?

Romina: No, we, we, were doing…

R4: The other frames?

Romina: No, yeah we’ve been doing this. We’re just…

R4: Yeah. You told me you were gonna…

Romina: yeah, no we just stopped at ten yesterday…

R4: Yeah, that’s what I understood you were gonna do, I mean I thought that’s what your plan was. You’re just carrying out that plan now.

Romina: Yeah. Come on Magda, twenty and twenty one.

Magda: I get ten.

Romina: Ten again?

Magda: Four point two five

Romina: Wow, this kitty’s moving now.

R4: Moved two.

Romina: So ten?

Magda: Uh, huh. (To Aquisha) Why don’t you turn the ruler around so you get millimeters?

Aquisha: Oh, yeah.

Magda: What did we get last time for nineteen to twenty? Ok well…
Romina Two hundred and one. Three hundred twenty two.

Magda Where did we get six point two five?

Romina And then ten

Magda Look because it moved two boxes

Romina I don’t know, maybe they’re just wrong Magda.

Magda Ok, oh well.

Romina At this rate…, Now I just add…, Magda. I just add?

Magda Just added up her previous numbers. Didn’t you add…, didn’t we have these added up already?

Romina We were alone from eleven to…

Magda Yeah but you need to add up from…

Romina I did, I said eleven point nine one seven six….

Magda Oh you did. Ok.

Romina Seven point five? So…

Magda (To Aquisha) Set up a proportion and see if that actually matches what exactly he traveled. Like point three six on the graph equals to five centimeters in real life.

Aquisha Oh.

Magda So if he traveled nine point three six on paper, what did he travel in real, in reality? Can’t even talk, I’m like real…., So here (taking Aquisha’s calculator) you go point three six over five equals nine point, what is it? Nine point, is it nine point three six? That’s how many? Yeah? Over ‘x’. So point three six ‘x’ equals whatever. What’s five point (to Ankur?)

Ankur divided by …, that’s roughly thirty five. One thirty.

Magda One thirty that’s it? Not one thirty point something. One thirty.

0:30:32 Ankur It’s nine point three six times five divided by thirty six. (camera is showing Ankur’s calculator that indicates the computations with a result of 130.) Point three six I mean.

Romina And I gotta continue time right? He traveled…

Magda Five divided by point three six…,
Jeff: One thirty even.

Magda: Yup, so he traveled one thirty centimeters.

Romina: Yup

Magda: Is this right? (turning the calculator to her left – toward Ankur)

Ankur: Is that how much he really travelled?

Magda: Yeah, according to that.

Ankur: Were you told how much he traveled?

Magda: What?

Ankur: Were you told how much he traveled? (No visual or auditory response from Magda.)

Romina: Um, these are the frames. In between the frames like from ten to eleven, and this is like, like the running distance there. Like how far he has run. This is like what we measured from first frame ten to eleven.

Romina: This is the running distance you mean between frames?

Romina: No, like just adding them, adding them all up. Like adding all the previous ones plus this one, plus that, the one before. This one’s just for from frame ten to eleven,

Romina: Uh huh

Romina: These are the times, and now I’m just adding the running time…

R7: Wait, this is from frame ten to eleven, the distance (pointing to the top left writing on her paper).

Romina: Yeah, and then, in centimeters. .

R7: Uh, huh.

Romina: And that’s, that’s just the time, that’s a standard. But then like we have like the running time over here. And then we divide distance by, by time, that’s our speed.

R7: So this is total running time?

Romina: Yeah. We just kinda like add ‘em up.

R7: And so you’re saying from frame ten to eleven, this represents the running time (indicating column on Romina’s paper) at what point?
Romina Yeah, to frame eleven.

Romina And why is that the total running time to frame eleven?

Romina Because that’s just eleven times point oh three one. Or maybe it’s ten, huh?

Jeff Here it goes, she did all that work and now it’s wrong.

Romina Is it, is this for frame ten or eleven Magda? Ten it has to be doesn’t it?

Magda I guess.

Romina Yeah, it’s for ten. Yeah it’s ten.

Magda That’s nine, so that’s ten.

Romina Yeah, this is ten.

R7 What do you mean ten? Is it the end, middle…

Magda Because we’re saying that the cat starts at zero right here.

R7 Uh huh

Magda So here it’s, here it’s point oh three one seconds, here it’s like point oh six two (pointing to the third frame on the copy of cat photos) seconds, and you know we’re like adding it on. So at frame …

Romina Ten

Magda Ten, yeah.

Romina It’s point three one.

R7 Uh huh. And then this is? (pointing to the last column)

Romina The velocity he runs.

Magda The speed…

Romina The speed…

Magda …it’s going.

Romina …he’s going in that frame. (tapping he place where the frames are indicated on her paper).

R7 Ok, I understand your chart. Thanks

Romina No problem.

Magda We gotta start over see what he traveled at twenty one,
he got one thirty.

217  Romina  We’re close?

218  Magda  We’re off by two boxes.

219  Romina  That’s not bad at all though. Considering we just kinda went… Two.

220  Magda  True.

221  Brian  Are we putting anything in the calculator?

222  Romina  Not yet. (Romina makes individual calculations repetitively on her calculator and records them in her notes.) (Pause)

223  Magda  Did you have a graph on the calculator?

224  0:36:05  Romina  Did you enter the C ones from yesterday?

225  Jeff  You wouldn’t give us the ones from today before.

226  Romina  I’m still figuring them out.

227  Brian  My calculator was MIA yesterday, I had no idea where it was.

228  Jeff  What are your C ones?

229  Romina  Hold on, just hold on one second?

230  0:36:52  R2  Romina?

231  Romina  Um, yes.

232  R2  I’m just looking, and I was just wondering. Could you, um, could you show me this number for ten? The one that just comes before …

233  Romina  Eighty.

234  R2  So you get a sixteen, eighty, eighty,

235  Romina  Yeah.

236  R2  Two forty.

237  Romina  Does that sound, does that sound, does that sound good? (to Magda?) (Magda speaks low and mumbles a lot. It seems that she is addressing Aquisha and not answering Romina. When R4 comes to the table and borrows a calculator from Jeff it breaks the attention R2 needed to come to resolution. Brian further interrupts.)
Jeff (To R4)  You can borrow it for as long as you like. Romina, what are you using for your C ones?

Romina The running distance (R2 taps her on the shoulder and backs away)

Jeff (To Brian) the running distances. (To Romina) And what’s your C two?

Romina I’m just gonna put it… the running time.

Magda … So, one and a half, yeah.

Romina So nine times…

Magda So one and a half, it’s one and a half

Jeff The C two…

Romina I’ll, I’ll give it to you, like plug it into your calculator.

0:38:12 Jeff But I already have C two’s in there.

Magda It’s one and a half…

Romina Is that one point two five?

Magda Six point two five.

Brian I can’t believe you put that in there! You didn’t do nothing.

Magda That’s six point two five.

Romina Magda that ruins everything. Six, it’s not one point two five, it’s six point two five?

Magda No, it’s like one and, yeah

Romina Like are you saying one like one cent, like one point two five, or like one as in five point two five?

Magda Five point two five, six point two five actually.

Romina Wow.

Magda No, just, so it’s, so you just add five to everything

Romina Oh five?

Magda Hold on, let me just check with that.

Romina That’s not cool Magda.

Magda I’m Sorry.

Romina Running times thirty, so I just add five to every single one?
R7 Could you explain to me what you’re doing? (conversation with Aquisha is too soft to be heard over males talking off topic, and Magda and Romina)

Romina (Inaudible)

Magda No, it’s um

Romina Doesn’t matter, I’m adding five to every one.

Magda No, it’s, you have to add another five to this.

Romina I’m adding five to that, and that, and that, and that, and that, and that, it’s close enough.

Magda Here so this is seven, so you have to write ten to everyone now. Add five to this one and every other one gets ten. (inaudible Romina) Because this one was at a five, and this one was at a five.

Romina So this one was twenty point six six seven.

Magda (heard counting) It’s seven point two five.

Romina Ok, now I’m adding ten to the one thirty point six six seven. (Romina works on calculator and notebook in her lap, Magda watches on. Males at table continue to talk off topic) Just for those two though right?

Magda Yeah. (Long pause. Then pointing at Romina’s book) Here, this is two hundred and one point six one three. And the next one is two hundred thirty one. (Table conversation is off topic. Magda, Romina and Aquisha continue to work independently and quietly.)

Magda (Toward Romina) Is that oh seven six seven? Eighty, eighty.

Romina Now should I put in… what was my C three Magda?

Magda Speed?

Romina My speed is distance.

R4 (Approaching Aquisha) What’s happening?

Aquisha Oh, the third time I did it, it like wasn’t in a straight line, so…

R4 Eh…

Aquisha It doesn’t measure…

R4 Kinda close

Aquisha Yeah, measures closely but not right because of that dip.
Ok, given that it didn’t go in a straight line there, do you think your measurements or your results there are reasonably consistent with the other two times?

Uh huh.

So you’re not too worried, you not worried

It’s not exactly the same. It was supposed to be nine point three five, we got nine point five. You know? But it pretty much matches up.

Let’s see, and you’ve done some measurements..., Ok, I mean...

It’s not gonna be...

It can’t...

Because all the measurements could be off a little right?

Yeah, yeah.

That’s what makes up for it basically.

I think the idea’s there right?

uh huh

That’s good. Ya, you know, the little tiny measurements that you are making there, you know are hardly a touch of the pen to the, to the page. This has got to be kind of difficult to think of but the idea I think is pretty clear.

Of course I missed the speed (still working in a notebook in her lap)

So Romina, what are you all calculating here? You’re really busy.

We’re just punching in the numbers here. We’re just putting numbers in the calculator to see, to finish off our graph.

Oh Ok. So your, you’re working to finish off that...

Yeah

That picture, then...

And after that we’re done.

Then, then we might be able to take a look at it. Right?
Romina Yeah

R4 Cool.

Magda Can I see the first ten?

Romina OK

R4 Uh oh. So Magda’s gonna check the work here. (R4 leaves and the males in the group are speaking about grades and college plans.)

Aquisha Did you guys do it again?

R9 (approaches Romina) Can I ask you to do me a favor when you’re done? Would you mind just labeling each column? Because we’re trying to guess at what you’re doing, and what you’re putting in C one, C two, and C three?

Romina OK

R9 Thank you

Romina No problem (Jeff uses Romina’s calculator to input data into his calculator. All others are in personal conversations. Magda is also entering data from Romina’s table.)

R4 We’re trying to check to see how close we are to showing some things.

Romina We’re, I don’t know how close we are because he’s just typing in the numbers, then we gotta graph them, and see where we are.

R4 OK

Romina That’s a nice one Magda (indicating Magda’s calculator). Your presentation…

R4 What’d you do, let’s see, what did you, you had some stuff from last time. (Romina was inaudible) On the first…

Romina Yeah, see we had

R4 …ten or so. (Romina returns to working on her calculator) Brian pretty fast at putting these things in? (Brian grunts)

Romina Like that? (showing her calculator to Magda)

Magda Umm, I didn’t zoom out yet. I’m setting the window now.

Romina I’m at, I just got it zoomed in.
So how far is that? What is…

Those are all the frames.

That’s all of them. All twenty four of them?

Yup. It doesn’t look very nice though. See ours shows him accelerating the whole way through.

hmm

But it shows him going faster at the beginning.

Does that check with what Aquisha has in her deal?

(y Aquisha shakes her head from side to side)

No.

What do you mean, does it check? What are we checking?

It’s just that that you guy are faster than when it’s slowing down.

He is slowing in the beginning then he gets faster.

No, that’s what she said (pointing at Romina), I don’t know.

Because…, let me see your graph. (waiting for Magda) Doesn’t it, mine…

Now is that, is that, what is that a graph of?

I think, hold on.

It’s the distance and time

Maybe that’s a good a question huh?

Distance and time.

At least for me it’s a question.

Hold on.

Distance and time.

Yeah, but I have C, I have C three and C four in there too.

Yeah, but you’re graphing, you, you’re not, because when you defined it you’re just graphing C one and C two. You’re not graphing C three again. So it’s like, you know…

Ok, I just wanted a picture. Go to graph please (to Magda)
Hold on, I have to put the right equation in there. You put all points in it so...

(Whispers something to Magda, then…) Doesn’t that mean it’s going faster in the beginning? Becomes a? then it kinda levels off?

So, is this, what is this axis represented?

This is distance (indicating vertical axis)

This is time (indicating horizontal axis)

Time, ok, ok, now I’m quite...

Hold…, is it? Or this is distance (horizontal axis) this is time (vertical axis) I think

So

Yeah this is distance this is time (horizontal first then vertical)

Oh, well wait. I’ve got to turn this calculator to match with somebody I have to turn it like this (turning the calculator over)

hold on…

Maybe I should, maybe I could switch em?

Yeah, it should be x is the distance

Hold on (picking up her pen and moving toward the notebook), this, which ones are

X is the distance, that’s (pointing to the vertical axis on the calculator) time. That’s how I put it in my calculator.

I have no clue what your calculator has.

I’m confused.

Hold it! Let us figure out what we’re doing first (to R4)

OK. You got it.

One point two five. Go to number one.

Hold on, I’m fine, I’m fine. X is C one. So the ‘x’ axis would be the distance.
Magda Which that’s how we were. We wanted the ‘x’ to be the time. Right?

Romina Uh yeah now it’s a little late now.

Magda No you just have to define the thing.

Romina How do I define this for you now?

Magda You go on the C two…(Magda makes changes in her calculator, and is showing Romina and pressing keys on Romina’s calculator. Speaking too softly and whispering about some things) (after a long pause) Maybe we should do it this way? (Romina shows Magda a graph no reaction or conclusion)

Magda Why isn’t mine graphing…

Romina Mine didn’t do it? Mine didn’t switch.

Magda Mine isn’t even graphing so…

Aquisha I think he’s looking for a graph that shows…

Magda Speed? Or well it has speed in it.

Aquisha It would come up like this (makes a drawing on paper). Distance in, in each time, know what I mean?

Magda Distance in each time, that’s what we got from here. (Jeff and Brian leave the table. Romina, Magda, Aquisha and Ankur remain)

Aquisha Do you get a straight line graph?

Magda C two

Romina Magda, mine, mine won’t it let me switch mine?

Magda Fine, because I’m, I’m getting like weird stuff too.

Romina It won’t let me, like I put in C two…

Magda Why isn’t this graphing the way I want it?

Romina Magda, mine won’t stay C two, C one.

Magda Why not? Oh, this is good. (pause) It’s like point nine nine nine correct.

Romina There we go.

Magda Did you get it to switch?

Romina Yeah (holds the calculator up for Magda to see)
Magda OK
Romina Think so? …?... What’d you get?
Aquisha (Reaching and taking Romina’s calculator) These are all the points?
Magda Yeah, just now I’m working on the equation. Yeah. Now ‘x’ is the distance. And the ‘y’ is the line.
Jeff Did you have C one to four?
Romina No. I had C four, but I didn’t graph C four.
Jeff I’m sorry. What’d you graph
Romina I graphed, hold on. (inaudible after pause)
Jeff I had this already.
Romina Yeah. But see my C one and C two was all messed up.
Jeff But I had this before you sent it to me. This graph?
Romina We had the same thing; we just didn’t finish it up yesterday. We might have had different numbers, because you always do. (Aquisha is speaking off camera to another Researcher. Complete text is inaudible)
R4 You ready?
Romina Ehh, see we didn’t have anything new to present though we just kinda...
R4 Well, I know, but that, I just kinda wanted to get everybody back into the conversation a little bit, even, you know.
Romina Ok.
R4 So that’s, that’s cool, I just wanted... People have kinda forgotten what you, what you guys are up to. So what’d you, did you figure this out?
Romina This is, (pointing to calculator) This is time (left to right motion on calculator face), this is distance (up and down motion on calculator face).
R4 Ok. So you happier with that?
Romina Yeah, that makes more sense.
R4 Does that look a little more like what Aquisha has, has there?
Romina Yeah, Aquisha, this graph agrees with yours right? That one right there?
1:01:00 Aquisha I think so.

Romina Hold on, I’m gonna…

R4 Ok. So you could, you could throw that up on the screen anyway.

Romina Uh huh. I think we hit graph though. (Group goes off task and engages in small talk)

1:01:45 Jeff What’s the longer ‘x’ C one or C two?

R4 What’s that (in an excited manner-looking at Romina’s calculator)?

Romina That’s the, you know what that is? That’s our uh, that’s our speeds.

R4 Really?

Romina Yeah. Mag’s that our speeds (showing Magda the calculator)…

Magda Against time?

Romina Against running distance.

Magda The distance?

Romina Do you want me to do it against time?

Magda I think it would make sense, distance and speed…(more inaudible)

Romina Ok does that make sense though? Because that kinda what’s nice. It’s going one speed and then it jumps and goes another speed. We didn’t, I think we screwed up somewhere that’s it. (Brian returns, R4 leaves and table returns to small talk.)

1:04:22 R4 OK. It seems to me, looking around, like there’s a possibility of doing some sharing. And uh, what I’m thinking this time of kind of doing is a little bit opposite of what we did last time. And maybe we will just start here (indicating the side of the room to the right of R4) (Table that now has Benny and Victor). Ok, and kinda cycle around this way (counter clockwise sweeping motion with arm) Ok? That’d be OK? And you could just, you could just put up on the screen what you got, what your working on. What your thinking is, and uh, let’s, let’s see what uh, let’s see what comes up. (After R4 speaks, some of table talk is inaudible.)

Romina You didn’t have anything in C four
Magda What did you, what did you put in C four?

Romina C three, in C three I put in running distance again, in C four I put in velocity.

Magda Yeah, but it doesn’t matter because I have the running distance in C one so I just defined them and…

Shelly (At projector with Angela) Excuse me Magda.

Magda Oh, I’m sorry

Angela Yeah, Magda, that’s very rude.

Magda She took that way too seriously. Ok what we did was we kinda did the average. We measured the velocity between the ninth and the tenth frame, and then the tenth and the eleventh frame, which is right up there (indicating work on a transparency)

R4 Hold, wait, sorry. Can you speak a little louder Angela, I’m having a hard time hearing you over the projector and all.

Angela We measured the velocity between the ninth ant the tenth frame, and then the tenth and eleventh frame. And then we took the average of both of them because like with everything that we were doing it was kind of giving you the, the average velocity between the two frames, which that is (pointing again to work on the transparency). Like that was actually one of our answers. Once. Um, but like it’s not the tenth frame, it’s between the ninth and tenth frames. So if we figured that if we took (replacing her work transparency with the cat photos) the velocity between these two frames (indicating with her fingers the nine/ten and ten/eleven frames), and these two frames it would figure out the average it would give me like the middle, which is the tenth frame. See that right? (putting the work transparency back up) And we got one forty five point one six one centimeters per second for velocity. Then we did the same thing with the um, with the nineteenth and the twentieth and the twentieth and twenty-first and we got three fifty four point eight three nine centimeters per second.

Romina (Asked a question in a very soft voice about a picture that Matt drew on the transparency that was inaudible, Angela’s response was soft also)

R4 What were the questions? (Loud laughter and many talking over one another) I’m sorry…, Romina what was your question? I think I heard it but, somebody answered a question. (Conversation at the table is
centered around a drawing on the bottom right corner of the transparency that was apparently a joke among the students.)

447  Angela  Any questions?

448  R4  I have a question, Ok, umm, for me I’m, I’m not quite sure what you meant by when you said between frames nine and ten and ten and eleven. The word between is kind of troubling for me.

449  Shelley  We’re measuring how much the cat moved from that, from the ninth frame to the tenth frame. And then we’re measuring how much it moved from the tenth frame to the eleventh frame.

450  1:08:00  R4  OK.

451  Angela  Do you get that now?

452  R4  I get that. So that, that, that’s where you use between.

453  Angela  Any more questions? Ok. (angela begins to collect her materials and stops when CW speaks again)

454  R4  Ok, well, Ok. Just show again, I really, I, I’d like to look at those two frames. Ten and then twenty. (Shelley puts the cat photos back up on the transparency) Ok and your work. I’m sorry to be so, so obnoxious here, but …

455  Victor  I think she might help you figure it out because what we realized at the end was that what they were doing was that, it’s like it conforms with the um physics formula of one half times the initial velocity plus uh final velocity. And if their initial velocity is figured out between frames nine and ten, and then their final velocity is figured out between frames ten and eleven, and then they just take the average was just by the half. So between both frames you could figure out frame ten. So that’s how that works out.

456  01:09:10  R4  So you’re seeing, you’re seeing the velocity that they calculate with ten, or nine and ten as being kind of an initial velocity,

457  Victor  Right

458  Choral  And then between ten and eleven…

459  Victor  …is their final velocity. For frame ten.

460  R4  Uh huh. OK
Victor: Right. Then they’re taking and dividing that by two. So. I mean because everybody here remembers that equation from physics right? Anybody? Anybody?

Romina: Yeah

R4: Anybody? Anybody? Ok so you’re (cough) excuse me. Ok. (Angela coordinates two overheads on front screen) So how does your, how does you’re your new average velocity I think you called it, right?

Shelley: Right.

R4: How does that compare with the two, the V ten, nine ten and the V ten eleven?

Angela: Like with the ones that we did with the graph or whatever its kinda like the average velocity from the first frame to the tenth frame and the first frame to the twentieth. So it was kinda off like, and I don’t remember… at the other one it was kinda like the average velocity between the ninth and the tenth, so it was, (to Shelley) it was kinda close right? I don’t remember, but anyway

Victor: See what it is, what that, they found out that um, the, you have different acceleration points across the board. Across the from frame to frame which also effects the velocity in the end right? So when you said you were just asking for frame ten they figure out that you just want to add, you just wanted between those two accelerations everything else would just be averaged off. And that’s just that.

R4: Well that’s your, that’s what you take is on, on what they do.

Victor: Yeah, exactly.

R4: Ok cool. How about at frame twenty, what’s happening there?

Shelley: We did the same thing.

R4: We did the same thing.

Angela: We did the same thing.

R4: Same thing.

Shelley: We did it…, We measured how far it moved from nineteen to twenty, and how far it moved from twenty to twenty one and then we averaged it out.

Angela: That it? Any other questions?

R6: I would just like, any of you agree, or think this is good or bad or um you understand it? Any comments
Mike I have a question. Was uh what was the velocity for ten and twenty?

Angela Ten was one point five, and twenty is fifty four.

Romina Centimeters per second. Ten is one forty five?

Angela Ten is one forty five,

Romina And for twenty?

Angela Three fifty four point eight two nine. We good?

R4 Ok, is everybody good with this? Ok. There maybe more, more questions that come up but this, this this, is good. Let’s see we, we were going this way weren’t we? Kind of uh counter clockwise.

Sherly He won’t go up.

R4 That’s ok. Somebody could go up.

Sherly But he’s the one that put it in his calculator and he did everything.

R4 But some of you know what ‘s going on. I know Robert knows what’s going on. I think Cheryl, and Sherly, I know, and Ashley, I think all you guys know what’s going on.

Sherly He’s stubborn.

R4 You want to give it a shot?

Mike I got nuttin’ to present, that’s why I’m not…

Sherly Let me see your calculator. (To Mike)

Mike It’s not, everythings erased from there.

Sherly Let me see your calculator (other male)

Robert Everything we did was wrong so we deleted it.

Sherly Why did you delete it?

Mike Because it was wrong. That’s why.

R4 So what was happened? You, you guys made some, you, you were trying something out…

Mike Yeah, I was trying something different.

R4 And it didn’t, didn’t pan out?
Mike: Not working. Yet.

R4: Yet. Ok. I really, I would, I was interested in seeing if you don’t have your new stuff ready, if, if you could say something about what you did yesterday.

Mike: Yeah, I think what I did yesterday was like, something was wrong with what I did yesterday too.

R4: Oh really

Mike: I don’t want to go into admit that I’m wrong but…

R4: (Laughter) You don’t have to admit you were wrong. Ok so you, you just kinda want to pass for now?

Mike: Yeah we, we’ll pass.

R4: OK. This table decides to pass.

Brian: You can’t pass! (Laughter)

Romina: We have something; well maybe we can trigger them.

R4: Did you say something maybe … triggered. Ok

Romina: Yeah, because we had something about there yesterday. Ok.

Brian: We didn’t have anything the other day, and we had to go.

Romina: Well let’s go.

Magda: You go because I want to figure this out. (grabs her calculator)

Jeff: I got something to work on.

Brian: Did I hear somebody clapping around here before?

Romina: (Romina goes up alone and attaches the calculator to the TI projector) Ok, we just finished. This is our time versus distance one. And it just shows like how it just, you know at first it’s going slower because its walking and then it starts going more distance because its like running galloping, whatever. And then we also graphed our uh, time, no our distance versus speed. And it’s a little different from Mikes because it shows, it shows like the cat , it’s going like fast, it’s going like, we kinda agree with Mike at the first part where it’s walking, it’s going at a like a constant rate. But then it shows our, when it starts like its gallop, it kinda like pauses a little bit and then starts accelerating faster and faster until it reaches like a climax, and then it just
comes down. Like so toward the end that’s where the
cat’s stopping. Which Mikes didn’t show that, it kinda
just showed like a constant rate at walking and
running. So, ours just kinda disagrees with theirs a
little. That’s all we did today.

Now hang on, there’s gotta be some, some questions
about, about this. I don’t think we’ve seen anything
like this yet have we? Mike what do you think? You,
you had that stuff up there yesterday…

What is this? Speed?

Tell us what your, tell us what your axis’ are.

Umm, this is…, (embarrassed smile?) Magda what’s
our uh, I think this is…, where’s your speed is this
axis, speed versus distance (indicated vertical first then
horizontal with a pointed finger on the whiteboard). Is
that it?

Uhh, the axis, your, which graph are you talking about
now?

The speed one.

The speed one? I don’t know what you defined it as.

Yeah, I this is, I’m pretty sure this is…

Speed is ‘y’

Yeah, speed and distance (indicating vertical first then
horizontal axis’)

(in background) the one that goes like that is…, time
over distance

(speaking to Magda in background) Time is here,
distance is …, we can, we can get a really nice graph.

Yeah, cause how could the distance go
down then? The ‘y’ gotta be uhh… ‘y’ gotta be
speed, it’s not speed.

So the ‘y’ is your, is speed you think? Is that what
your…

I’ll check for you. (checking settings and tables on
overhead) Yeah, our ‘y’ is speed and ‘x’ is uh, the
distance.

‘Y’ is the speed?

yeah

How’d you get speed?
Romina: Well we went from frame to frame. Like we went in between each frame and we had the distance it traveled and then divided by time.

Mike: So, like what is that shows you at that speed and the distance? Like you have a graph of just the speed up there?

Romina: Umm, that is it. That’s our speed. I don’t know why, why did we put it against distance?

Magda: Well why did you put against distance?

Romina: I don’t know why I put it against distance. But…,

Mike: That’s a graph of the speed…

Magda: How would you do time…

Romina: Yeah, we did that, we did that yesterday.

Magda: We didn’t.

Romina: I did.

Magda: Yesterday we did time versus distance.

Romina: I did, I did. Ok.

Magda: Now we did time versus speed

Ankur: Just change your C one to C two’s to make it…

Romina: Hold on, hold on, while I’m doing that does Aquisha you want to do your thing?

Aquisha: Umm

Romina: You have to.

1:19:02 Aquisha: Two seconds. Was I supposed to go up and do this now?

R4: Yeah, if you want to sure.

Jeff: We were hoping you were going to.

Romina: What do you want me to graph versus speed?

Magda: Time versus speed.

Romina: Running time?

Magda: Yeah

1:19:41 Aquisha: Ok, umm, it’s the same thing yesterday. By putting the um, two of these on top of each other (cat photo’s),
like frame one on two, you can see the distance that the
cat traveled. And um today, (putting up a
transparency) I put them all together. I connected
them to see if they matched up with uh, the um same
distance that um, using the grid of the five centimeter
boxes, and I did it again to see if they matched up.
Um, on the grid we said that the cat traveled twenty six
boxes, the five centimeter boxes. That means the he
traveled one hundred thirty centimeters. Using the
ruler we found out that each box is point thirty six
centimeters, and if the cat traveled twenty six
centimeters that it added up to nine point three six
centimeters for the total distance that she, that the cat
traveled. And um we set up a proportion to see if it
was right, the numbers that we got for the ruler and it
is because we came up with a hundred thirty
centimeters like over here. And then when I put them
all together I got nine point five centimeters, so um,
that’s what we did.

561 1:20:41 Magda (The following audio was captured at Table 1 while
camera is on Aquisha) It’s time, over speed. Ok. So
here, that’s what its showing.

562 Romina It’s showing the same thing.

563 Magda It’s showing the, as time increase – the speed
increases? At twenty three he’s accelerating,
accelerating but he slows down because he’s walking.
At ????? he accelerates, accelerates, he levels off…

564 Romina He should be leveling off there

565 Magda …then he keeps going up, up, up he reaches the
peak, and then goes down.

566 1:21:21 Romina He didn’t even let me go up there by myself.

567 Magda I was trying to help her and I can’t get this graph to ..

568 Ankur How sis you graph speed? Speed is two things. How
did you graph speed along the ‘y’ axis?

569 Romina Because we already have speed figured out.

570 Ankur You put in the numbers for speed?

571 Romina Yeah.

572 Ankur But what does speed against distance show you? Just
distance…

573 Romina It’s the same thing. It’s gonna give you a straight line
(?) Which one is this cat 2?
1:22:44 Romina Where did you get these numbers from?

Ankur I wanted to see what speed against distance when you graphed that? The distance is already involved in the speed, you know what I mean?

Magda Uh, huh

Ankur You got the speed numbers, distance was part of that equation. Now if we put distance in again, I don’t know what the hell it shows here. The speed graph by itself shows something. Doesn’t show the speed of the cat, but it…

Magda But we have and x and a y, we can’t just graph speed.

Ankur Why not? Distance against time?

Magda So it shows you speed?

Ankur Isn’t distance times time speed? Think about it, distance…

Romina I am.

Magda But it doesn’t give you the speed.

Ankur Miles per hour, that’s distance times time.

Magda Yeah, Ok. Yeah, but when we graph it, when you go to the bottom one so you get the time, but then go up to get the distance. But it doesn’t give you speed.

Ankur That graph is the speed.

Magda Alright then don’t make us look stupid then.

Romina You go up there I don’t know….

Ankur The distance the cat, no. The distance on the y, speed on the x.

Romina What was her first one?

Magda The first one? I don’t know, one point two five?

Ankur Which one’s distance, which one’s speed? Of the C’s?

Magda Umm, distance is the one, time is on the x and distance…

Ankur No, no, C 1 C 2 which ones?

Magda I don’t know. Do you have it on calculator?
Ankur Yeah.

Magda So, whatever, however you like.

Ankur Is C 1 distance, or is C 2 distance?

Magda Um, C 2 is time. C 1 is distance.

Ankur That’s not right. This isn’t right.

Magda Then put, because you have to put um, ‘X’ is supposed to be C 2, and ‘Y’ has to be C 1. Like when you define them.

Ankur Uh, huh

Magda So that’s why it’s giving you…

Romina Do you want to make a straight line?

Magda Yeah. But just points like I don’t want a line, I want like points. Like dots.

Magda Then put boxes.

Ankur That’s speed isn’t it?

Romina Why does she want this? Aquisha I think I graphed your thing. I don’t know if you want to show it.

Aquisha Ok, From the beginning?

R4 (End of background conversation. What follows begins at 1:21:42) I’m sorry. Could you just say that a little bit louder for, for me and some of these back here. They were not, we’re not quite picking up everything you say.

Aquisha Ok, From the beginning?

R4 Kind of, just kind of review that beginning again quickly could you?

Aquisha From this…

R4 From the, from the pieces that you did.

Aquisha Ok, umm, you mean from this one?

R4 Yeah, let’s go from, let’s go from uh that one. How about there.

Aquisha (replacing the last transparency with the first one) This um represents from frame to frame um what the cat traveled. Like this one’s from frame one to two, and
then this is from two to three up to twenty four.

I could hardly see them, right?

Yeah, I guess that’s when she’s walking. (Aquisha replaces that transparency now with the second) Point three six, we used a ruler to um measure what each box would be with the ruler, because um the papers not, on the paper it’s not the same as the grid. Because on the grid it’s five centimeter boxes, but really on the paper it’s um, point three six we found out. By using the ruler. And um, this was like the proportion we set up to see if the numbers we got by using the ruler were correct. And we came up with it exactly. To one hundred thirty centimeters here for the total distance. And the same with the proportion. And um, this is just all the distances from the, from um the paper, from this one that I did (holding up the first transparency). I connected them and I um came up with, and I measured it with the ruler and it was about nine point five centimeters which was a little off of nine point six, but it’s got the same…

Cool. What do you, what do you think about this? (no response) Is there, what kind of, what kind of sense of the cat’s motion can you see here, can you see anything at all? Since that’s what this is about. What do you think?

I guess you see the total distance traveled by the cat.

I used two colors so you can see like the difference that how he’s walking slow, and how he got faster.

You could see how kinda like Mike was arguing the other day how he’s going the same speed a lot in the beginning. You could see a little time where he was accelerating, and then he pretty much launches at the end. (R4 focuses overhead after soft request from female student.)

Aquisha, I think I graphed your thing, I don’t know if you want to show it.

(in background) Looks like a straight line.

That looks better to me. Does that look a little better? Move it back, make the picture a little bigger?

(in background) So that shows the speed?

You know what? With it larger like that, put those, why don’t you put those uh the way you did the the
measures with the cat overheads up there. (pulling out the two transparencies) This one?

633 R4 Yeah. This takes careful alignment right? Does that, does that picture that Aquisha has presented there, carry the same sense that some of the other graphs that you’ve seen?

634 Victor It does.

635 R4 It does.

636 Victor In a manner of speaking yes.

637 R4 Is there, is there someone, is, could, could you say why? How? What do you see here that relates to what you have on the graph?

638 Benny It’s just that you become, you could see how in some areas the umm speed stays at a constant rate, then changes slightly, then goes, then after it changes it stays at a constant rate. Like some of the graphs, like Mikes graph showed, stayed at a constant rate, changed and stayed at that constant rate. I kinda see that.

639 1:28:01 R4 How would you see that Benny? Just tell me a little more about what you’re saying. (Benny gets up and walks to the front) You want to go up there.

640 Benny Again, like Jeff said, its um how it stays small around these areas, and then as it begins to accelerate you can kinda see it’s the same, it accelerates the same amount as you go up. You know it’s similar, it’s not, it’s not staying exactly the same but it’s similar. You know.

641 R4 So if you look at that, where would you say the cats going fast? And where is it going slow?

642 Benny I say, it’s, it’s staying at like a walking pace, one, two, three, about the first three, first three umm…, what are these? These are pictures right?

643 Aquisha Each frame.

644 Benny Each frame. So I say in the first, the first um four frames I say, it’s staying at like a walking pace. And then it begins to accelerate right here (indicating the fifth line). But now that I’m thinking about it, where did we say, on the graph, where did we say it accelerated at?

645 Aquisha If you say four, it’s gonna be like five.

646 Benny Yeah
Aquisha: Because the first dot represents from one to two...

Benny: Ok, ok, ok. So I mean five. So after five it begins to accelerate. (holding his arms out) What? What? That's it?

R4: Any questions there? Go ahead. Thanks Benny.

Aquisha: (putting the cat photo’s back on the board) And this one is from fourteen to fifteen, and... this one is, I measured from the nose here to the nose in the next one. I used the lines, the thick lines to line them up. You have to move them for each, each um frame that you go to because they don’t really line up. Like if you line this one up these aren’t lined up, for the next one you have to do it for each one.

R4: It’s a remarkable idea. Janet, go ahead.

R5: It’s killing me, I have gotta ask some questions, is that ok?

R4: Sure

R5: And so, help me understand first. Think of yourself walking down the street, (walks through the room) walk, (turns around and walks back) alright walk - now, the thing I’m trying to get straight here is if I could really break down, we’re talking about velocity and stuff right? If I can really for this problem, break down what’s happening with me. Think about it ok? (walks slowly back to the front of the class) I mean we did this motion detector thing right? When we did motion detector thing and and we had somebody walk in front of that, did they get a perfectly straight line? They didn’t get a perfectly straight line? What would it mean if they got a perfectly straight line?

Choral response: They were standing still.

R5: They were standing still, and when I say perfectly straight line and you say standing still what kind of line are you envisioning? What kind of line?

Victor: Horizontal line?

R5: Horizontal line. Standing perfectly still, horizontal line, what is that horizontal line gonna tell me about how fast I’m moving?

Jeff: Not moving at all.

R5: Not moving at all, which means my velocity is?
Victor and others

R5 Zip right? Ok, now if I am moving, and I’m moving toward the motion detector, right? I’m trying to get a s, if I was trying to get a straight line. And we know, none of us really got a perfectly straight line right? If I could get a perfectly straight line, what would that mean?

Victor Constant acceleration.

R5 Is he right? Did everybody hear what he said?

Matt The motion detector measures your distance from it. So you’d have to stand perfectly still so you stay the same distance from it to get a straight line. Like if you, to get a straight, like a straight diagonal line, you’d have to move at a constant rate towards it. (Matt is talking at the same time as another male in the room off camera. Matt is consistently audible, the other is not)

1:32:57 R5 (indicating to the off camera speaker) You said same rate, you said constant rate (to Matt). Speed?

Matt Constant speed, same thing.

R5 Same thing. So rate and speed are the same thing?

Matt You have to move at a constant rate towards it to get a straight diagonal line.

R5 Alright. Did any of you get straight diagonal lines?

Matt No, because you can’t really tell if you’re moving at an exactly straight constant rate.

R5 Do you think the cat was moving at a straight constant rate?

Choral response No

Mike Not even close to, that’s why you see two straight lines..

R5 How did you get that, that, when you see two straight lines? Did everybody hear that? You get two straight lines on the graph? What if, and I’m just trying to make a connection, so you said you got two straight lines. Where were the straight lines again? Help me ...

Jeff Where he was walking and where he was running.

R5 Ok, so the graph that we saw at the end of the day yesterday, you with me? The graphs that we saw
yesterday? He’s talking about this way (horizontal arm to ground) and then we kinda like that (motioning up) How do we get those straight lines?

678 Jeff Cause he was doing a constant rate when he was walking, when he was a constant rate when he was running and in between when they kinda curved a little bit that was where he was making the transition from walking to running.

679 R5 You think that cat was being really careful to get a straight line?

680 Jeff It’s just not going to be that way.

681 R5 Not going to be that way.

682 Mike That’s just the way he walks.

683 R5 Just the way he walks?

684 Mike Yeah, that’s the way he walks, that’s the way he looks.

685 R5 Be a cat. Come on. Be a cat. What’s that cat doing? Somebody said they had a cat in here.

686 R4 I got an idea.

687 R5 What?

688 R4 I got an idea. I think…,

689 Aquisha Can I sit down?

690 R4 Thank you Aquisha, I’m sorry. Can I borrow your, your ones you stuck together? (to Aquisha) One of those? (takes the transparency she hands him and puts it on the overhead) Be a cat. Ok. I’m wondering if, if in fact we can do this. If in fact we might be able to be this cat. Look we got, if we think about this, this is how the cat moved right? Or this is, we see not only how far it went but we see kinda spacing’s of distance. Is’t that what this represents Aquisha? What if we, instead of marking this out here like this, what if we marked this out on say the floor? Yeah, maybe expand a bit so it would be not just nine centimeters long or seventeen or whatever. Make it, make it big enough that we could, we could put it out here. Every, what we could do, we could mark the frames right? We could mark frame one here frame two here, just like Aquisha did. And then maybe we could see if, if we could move like the cat. Is that a dumb idea or do you want to try it?
Jeff I say we try it?
R4 OK what’s it going to take to do this?
Romina Tape
R4 We got tape.
Romina Markers
Jeff We gotta make a scale for it.
R4 A scale. Ok, ok, ok, so here’s the deal (students are throwing out suggestions like make a centimeter an inch (Brian) turn everything into feet (Jeff), need a whole lotta graph paper (unknown)), lets take a little side trip. Why don’t each of these groups try to figure out what a scale would be, that would be, you know (waving his arms outward),
Jeff How big do we want this thing to be?
Romina Like a library length?
R4 Look, look, how much space do we have? We got like from over there to over there somewhere (pointing from his right to left).
Romina Yeah, a centimeter a foot.
Shelley Just make it nine point five meters. That’s my suggestion.
R4 Try to figure something out and see if it makes sense. OK?
Magda How about we make it by like ten? Distances.
R4 Then we’ll get back together and we’ll do it. You wanna go for it let’s do it. Try to figure out in your groups what would be a good scale, and we’ll compare the scales and we’ll see how; see what, see what seems to work. We’ll do this thing.
Romina These are all centimeters right? Seven point five and….
Aquisha I know, but I’m saying is (inaudible) (Brian, Jeff and Ankur begin to talk and the dialog about scale is covered. And the girls are facing away from the microphones.)
Magda Do you have all the measurements for us?
Aquisha Yeah
Romina  We could do it.
Aquisha  I don’t know what those little dots would be.
Magda  So now we have to do the proportion stuff right? (More loud conversation and movement of table items.)
R4  You’ve got all the data, all the distances right?
Brian  I say we make the centimeter a foot.
Romina  What?
Jeff  We have all the distances written down right?
Romina  Yeah
Magda  Actually we are pretty close because we got a hundred and thirty one, and we got a hundred and thirty.
R4  Somebody might want to get up out of their seat and see how far that is across there. Kinda get a sense of what we got. (Overlapping conversations about the amount of room available.)
Ankur  Walk meters.
Romina  A meter is too much. Because at points we have like, do, do we have ten meters? I mean every frame?
Magda  Yeah they’re increasing.
Romina  Our distances every frame? At first they’re small, but if we use meters then …
Shelley  Did you guys agree nine point five meters or something else?
Jeff  Where is, how big is nine point five meters?
Ankur  Twenty seven, like thirty feet
Magda  Yeah, but the whole thing nine point five is, is a scale. Nine point five is like what is on the paper, if you want to use real distances it’s a hundred thirty, that’s what the ‘x’ is. It’s actually a hundred thirty centimeters.
Shelley  Oh, so we’re doing not only how much the cat moved but all the frames.
Jeff  I thought we’re just doing…
Ankur  I thought we’re doing right there. (pointing to Aquisha’s drawing of the nose travel). Just here draft we’re doing.
Jeff  Yeah, that’s all we’re doing.
Shelley (Addressing R4) Do we have to have just this laid out or like every frame with this marked on it.

R4 Oh, I’m sorry. I was thinking what we could do was you know like maybe mark, here’s here’s frame one and like this would be the

Shelley yeah and just have like the

R4 Here’s frame two…

Shelley So just have this out on the floor (indicating Aquisha’s line)

R4 Yeah

Aquisha You want it frame by frame

R4 Yeah, frame by frame. We’ll just mark, here’s the, here’s the distance between frame one and two, then between frame two and three, so it’d look just like this.

Romina (As Shelley returns form R4 and R4 is still talking previous cell) Isn’t that, how many, that’s twenty four frames right there you have? She has the twenty four frames. Look at our distances. Our distances like we’ll probably use our numbers only because its, her final is a hundred thirty and ours is a hundred thirty one. Which is really cool.

Shelley He just wants that thing there (pointing to the white board). But, we’re just saying, (pointing to the white board) that’s frame one, that’s frame two…

Magda That’s what we’re saying in frame one he moved one point two five and from frame two to three he moved another one point two five. That’s what the thing is showing you.

Romina Yeah, that’s what that’s showing.

Magda Yeah, and then the next frame…

Shelley Yeah, so why is that more than nine point five centimeters now.

Magda Because that’s on paper, that’s that’s

Ankur That’s how he wants it to look though.

Romina Yeah, this is what its, are you? Like are you?

Ankur No I’m just saying like I don’t understand

Romina Like that’s what we’re doing

Brian Are you arguing with me?
Romina: Are you arguing with me or you arguing with that?

Ankur: I don’t know, I’m just saying I don’t understand.

Romina: Ankur what she, what she did, each line is how far the cat moved. That’s what we did. That’s how far the cat moved.

Aquisha: What I’m saying is that you get like smaller and stuff, I didn’t do that. Mine gets bigger, it doesn’t get small then big you know. So it looked like that. You could do it, it’s just not gonna… look the same

Romina: I’m just saying like, eventually the numbers get big.

Aquisha: (during Romina and Aquisha’s conversation) Oh, so that’s even scaled there (pointing to line on board)... So that nine point five centimeters isn’t what the cat really moved on this (indicating cat photos) All together

Magda: It is,

Shelley: That’s all they want.

Ankur: Yeah, I don’t understand why you can’t just use nine point five meters?

Shelley: But, he just, he just wants that (pointing to the overhead image) on the floor, bigger.

Ankur: Instead of nine point five centimeters, you make it make nine point five meters.

Magda: We don’t have the individual distances.

Romina: Yeah, we don’t have the distances. We’ve got to measure them.

Shelley: Oh, oh,

Ankur: You’ve got to measure them to scale.

Shelley: It’s gonna be kinda hard to measure them though because they’re so small.

R4: (at the same time Shelley and Magda are talking) Hey look if you take, if your gonna do the first movement maybe you like to think of it like a step, not a step like that (off screen). Does that make sense Brian

Brian: Yeah. Let’s go with nine point five meters. Each step is like a nice like a nice amount.

Romina: I’m with you (to Magda) I’m a little lost.

Brian: I’m with Shell
R4: Nine meters? Nine meters is how far?

Brian: It’s almost thirty feet.

Ankur: Nine and a half meters is around thirty feet.

R4: Nine meters, twenty seven, thirty feet, something like that.

Brian: There’s room in here.

Magda: How are we gonna measure that? It’s going to be so inaccurate.

R4: Got room in there (waving at the back of the room)

Brian: Yeah that’s more than thirty feet.

Magda: Why can’t we do it in like real distances?

Romina: What do you mean?

R4: Like what do you mean, real distances?

Magda: Nine point five is what it moves like on paper. But in reality it moves a hundred and thirty centimeters. Isn’t it?

Ankur: I don’t understand

Romina: The cat moves like, if we had conversions, each squares five centimeters it moved a hundred thirty centimeters

Ankur: How does she get nine point

Romina: That’s like …

Ankur: How does she get, no.

Romina: Nine point five that’s on your ruler like...

Magda: The first one’s only like one point two five centimeters.

Shelley: I get what you’re saying

Ankur: Oh, OK.

Romina: The cat actually moved a hundred and thirty centimeters. Like on the ruler…

Aquisha: What if we, what if we count movement and we put it behind here and we just mark it on that.

Shelley: (Angela joins group) So he really just did a hundred and thirty centimeters.
Romina Yeah, yeah
Shelley That would make sense.
Romina That’s that’s our numbers that we have.
Shelley Yeah, that would make sense, yeah.
Romina At times we couldn’t use meters though, because at a
time it moves nine meters. That’s what we, that’s what
me and Magda were saying, that’s all.
Ankur In real life it moved like nine meters at one time?
Romina One hundred thirty centimeters, but they wanted to use
meters as our like scale.
Shelley We could use a hundred thirty centimeters and just use
the real scale. Just use like what the cat really moved
in real life.
Brian I like the scale bigger…
Ankur A hundred thirty centimeters isn’t….
Magda Multiply by ten.
Brian The steps are gonna be like this (holding index fingers
close together)
Romina The problem with ours is, the problem with our
numbers is hers, she just said it, hers never gets
smaller. Her her lines keep getting bigger and bigger
and bigger. Ours gets smaller our numbers
Ankur How many centimeters is on that ruler?
Magda Twelve centimeters is only this much. I think you can
see that.
Romina How, multiplying by ten?
Magda The first step is only twelve point five or yeah if you
multiply by ten.
Ankur He wants to do it so like you can walk it?
Brian Yeah
Ankur And so you gotta longer.
Romina So if we do like a centimeter a foot that would be a
hundred and thirty feet.
Magda Why are you into feet?
Romina: No I’m saying if we did that. If you do that. But like that is too small to walk. Does he actually, is he actually…

Magda: The first distance…

Ankur: That’s a lot to do.

Romina: Ok

Magda: That’s twelve point, is twelve point five centimeters. Like walkable (her word)?

Romina: He takes mighty little baby steps.

Ankur: No.

Magda: So how long would multiply it by?

Romina: Twenty?

Ankur: Twenty?

Romina: How about a hundred.

Angela: Yeah multiply by a hundred and use meters instead.

Shelley: Then you’re not going to have enough room for the entire thing.

Brian: If you use the total, if you use the entire thing,

Romina: Yeah, we’re gonna hike up on the campus…

Brian: If you times a hundred thirty by ten, if you times a hundred thirty by ten…

Ankur: That would be thirteen feet all together. (All members of the group are talking at the same time.)

Romina: Ok if we multiply it by a hundred it’s a hundred twenty five? And what would it be…

Ankur: A hundred thirty centimeters would be thirteen meters.

Shelley: Like, can’t. you don’t have enough room

Magda: You can’t do that because it’s a hundred thirty meters, so you can’t multiply by a hundred because the endings gonna be a hundred thirty meters long.

Ankur: You have forty feet in this room.

Shelley: Where would you do it though, along the wall there (indicating direction with a ruler she is holding)?

Angela: Can’t we do it in the hallway?
Ankur: You could do it from here to … (pointing to the floor next to him)
Brian: If we move this table
Ankur: No if we go from there right through here it’s forty feet.
Romina: From the bookshelves straight.
Ankur: Forty feet.
Brian: It’s probably more than forty feet.
Ankur: That’s like, even from the end of the shelf, that shelf’s like twenty yards. It’s an easy forty feet.
Romina: From where that camera is, and follow it out to the table right in the middle…
Ankur: Wait. Not really, you just go right through here.
Romina: Well, for convenience
Ankur: Yeah, I’m just saying. Yeah
Angela: We should move it over.
Ankur: Right through the middle
Shelley: We actually could do it along the wall there too. Because that goes back into the bookshelves so even if you had…
Ankur: Back in the corner…
Romina: We stop at the computer though
Angela: Yeah but we have more room back there.
Shelley: Yeah, because that’s giving you like that much space (holds her hands about two feet apart), and going back to that (holds hands about four feet apart)
Romina: Yeah but that’ll be out in the middle, all the camera’s can see it though. I mean I don’t care.
Brian: They have wheels they can move.
1:48:04 Ankur: I say we do it through the middle. Thirteen meters right?
Shelley: All right, we’ll start in the middle.
Magda: So what’s the scale?
Shelley: If it doesn’t fit you guys are redoing it (pointing to Brian and Ankur)
Magda: It’s not going to fit if we’re multiplying by a hundred.

Romina: What are we multiplying by?

Ankur: A hundred thirty centimeters equals thirteen meters

Magda: Excuse me?

Choral response: Thirteen meters.

Magda: Oh. So we’re multiplying it by what?

Romina: Yeah, what are we multiplying by?

Ankur: I came up with thirteen meters, you guys figure out the rest.

Jeff: Thirteen meters?

Romina: So it would be…

Aquisha: How many centimeters are in thirteen meters.

Magda: So that’s, it’s not a thousand like.

Romina: So you just multiplied it by a hundred didn’t we?

Ankur: Yeah.

Romina: Yeah, so that’s what you’re gonna do anyway. So it would be…

Brian: Thirteen hundred would be forty two feet.

Magda: You have to multiply only by ten.

Shelley: yeah it’s ten

Magda: It’s ten, so we do what we originally said.

Romina: So it’s twelve point five centimeters?

Magda: Yeah. Isn’t that the first thing we said?

Romina: Yeah.

Jeff: That was your fault (to Brian)

Brian: I’m sure that it was.

Romina: But I thought you said that was too small, because it was only

Brian: That is, it seems too small.
Angela It seems small.

Ankur What do you mean it’s gonna be too small?

Brian That’s gonna be steps like this (showing index fingers close together)

Ankur That’s the first step. Out of, out of forty three feet it’s gonna be twelve centimeters.

Romina For a step, there’s twenty four frames Ankur. And by the end it gets to be like ten, eleven.

Magda Which is a hundred centimeters.

Romina Yeah a hundred.

Aquisha What’s wrong with that?

Jeff Why don’t we do it like that, if worse comes to worse we can make it bigger.

Romina Are we using our numbers, cause our numbers get small…

Brian All we had was to make a scale, and we made this whole big project.

Romina Let’s go who cares?

Brian Jesus Christ. That’s why girls can’t be in control of things. (Group stands up and loses focus except Ankur and Romina)

Ankur You know what you do? Get a roll of tape roll it all the way down, then you mark off.

Aquisha Do you thing that if we make a copy of this and then put it like here it would be too bad to like measure? To mark it off? Know what I mean?

Romina I think it’s because a lot of these are gonna fall in between or on line, which means the spaces are thinner than some of the lines. That’s the only thing.

Aquisha I know because I pretty much guessed, but I still end up to be nine point five (inaudible), know what I mean? (Aquisha turns around and asks R7 ) could somebody photocopy this ruler?

R7 Sure. What did you decide for uh, just the centimeter ruler?

Aquisha yeah

R7 How many rulers did you need?

Aquisha Just uh three in case…

R7 Three photocopies of the single ruler? What did you decide your scale was going to be?
Ankur: Uh, multiply by one hundred I think.

R7: Multiply what by a hundred?

Aquisha: The numbers that we’re gonna…

Ankur: The numbers that we measured off the cat

Researcher: One hundred thirty centimeters is going to equal how much?

Aquisha: Thirteen meters.

Ankur: I think the whole thing is gonna be somewhere around forty three feet.

R7: You want just three rulers?

Aquisha: No we need a photocopy. (Camera’s move to the students putting the tape on the floor, and working at making it as straight as possible.)

Romina: Hold on Magda so five, five would be fifty?

Magda: Yeah, no hold on. It’s point five centimeters so it would be like five centimeters only. Isn’t it?

Romina: No five, five, it was a whole block so it’s five.

Magda: It’s fifty centimeters then.

Romina: So, I’m gonna need another ruler.

Milin: What’s the scale though? (There are various conversations and interviews happening around the room.)

Romina: See the thing with this is, Aquisha’s keep getting bigger. Ours don’t, ours get big small big small no matter how, how fast it’s going.

Magda: It kind of stays like steady though.

Romina: It stays steady for a lot but our ending number is a hundred and thirty one, theirs is a hundred and thirty.

Shelley: Then how do hers not get smaller?

Romina: I don’t know how hers doesn’t.

Magda: It doesn’t get smaller by a lot though.

Romina: I mean it doesn’t go like (exploding hand gesture) (Romina returns to putting tape on the floor.)

Magda: Now I actually get she’s walking. We have to make her walk at like one second intervals, you know what I’m saying? The cat was moving like point oh three
one seconds per frame, she has to be walking at a like, at a better like rate. So I'm figuring out like a second first step kind of a deal.

Romina (makes a mark on the tape) That’s another seventy five. (Tape ends with Romina marking off intervals on the tape)

8.5 Transcription 7.15.99 Table 1, Roaming Camera

Primary Camera View: Sergey – Table 1
Secondary Camera View: Roaming Camera
Date of filming: 1999-July-15
Kenilworth, NJ, David Brearley High School Library
Transcribed by: W. Bradley Halien
Date of transcription: October 2010
Verified by: Josmary Adames
Date of verification: June 2011

Setting up.

This morning we are going to do.. We are going to start off, with uh, I think what must be probably Ankur's favorite activity in the, in all of the Rutgers kinds of tasks. What would that be Ankur?

(Inaudible)

See there, he's got that. So let me, let let let me just give you though kind of a, a context that might help you in this writing in terms of what would be helpful especially for um, Dr. Maher. So, let’s think about um, the kind of situation that brought these photographs to light. You remember I told you at the very beginning that um Muybridge’s photographs of horses really started to settle a bet. Um, a bet between some very wealthy people, um very influential people. And this kind of question sort of became something that was spread throughout the community, until Muybridge’s photographs finally settled the issue. So kind of playing on this, and on the idea of uh Mr. Pantozzi being the CEO of some large corporation, I’m just gonna cook up a little story here that may help you.

Suppose that uh Mr. Pantozzi and one of his esteemed
colleagues have a wager about frame 10 of these sequence of photographs. And what they, what they are going to do is try and determine how fast that cat is going and then, and then have a wager about this. So Mr. Pantozzi comes to you who are his employees let’s say, and says forget everything you are doing. You’ve got three days, maybe four, but I want, I want an answer to this from you folks. This is really important to me. Ok? So here we are. We’re at what, beginning of day three looking at this situation? And we’ve done a lot of explorations, and there are a lot more we can do. But what he wants now is uh, is some kind of progress report. He would like to know what kinds of things you are considering, what kinds of steps you are thinking are good, what kinds of possibly things you have tried that didn’t work out – I mean the whole kind of picture. What kinds of uh, what kinds of uh, situations are you looking at to help you get information. It could be a lot of different things. Ok? So what we would like to do this morning is give you a little time to reflect along these lines, and see what you would write to Mr. Pantozzi that would sort of ease his mind about where things are. Or maybe make his mind very troubled, I don’t know. You you can decide what what you want to do there. So can I just leave, if you need to get some more uh apples, muffins or whatever to help you in this writing project and thinking why don’t feel that that’s out of order. So let’s do this for a while and then we’ll – then we’ll take on something else. Now this morning again we’re going to be stopping at noon because there were interviews that will be done, so we have a little shorter time frame to work in than the usual. So just keep that in mind. And after the uh the writing I think we may want to check back to the, to the catwalk and and think about that some more. So we’ll, we’ll talk more in that about detail once we we, once we’ve thought and done this writing thing. Ok. I’ll leave it to you.

(Camera moves back to capture Jeff, Brian, Romina, Magda and Ankur getting their papers and calculators out. There are some inaudible conversations not math related while they begin to write individually. Eventually they are silent while all at the table write. Conversation turned to driving tests. Jeff finishes writing first. When teacher walks in they acknowledge the teacher for coming in)
Excuse me. I have a question for uh you guys. Um, you know yesterday when you showed me your calculations…

R7

Uh, huh

Romina

…that you guys had made. I guess you had them in your book. There’s something I didn’t quite understand.

R7

I just couldn’t understand, it was, it had to do with um, maybe you could explain to me, maybe using the picture of the cat, exactly how were you taking your measurements for the distance of the cat? From, from frame to frame.

Romina

We at first we used the ruler but that wasn’t working. So, we kind of we just looked at it.

R7

First you used a ruler?

Romina

Yeah.

R7

How?

Romina

Took the millimeter side and then like just, we saw how much it like, measured it like, the cat’s head at this point right here (pointing to the cat pictures with pen), at this point it’s right here. So we both measured it, but it was too small. Especially at first it was too small to measure.

R2

What did you measure from where to where exactly?

Magda

The cat’s nose.

Romina

Yeah, the tip of the cat’s nose is like right here, then we had to guess, guessed how far that was…

R2

You mean from here to here? (pointing to the frames on the paper) I don’t know what you say like measure like literally, like could you use your fingers and show me what you measured?

Romina

Yeah, we start no we just like looked and see where this was…

R7

Uh huh.

Romina

… then we took the ruler…

R2

In relationship to what?

Romina

No, no I’m not really sure where it was. I guess from the black line..
OK because that’s what I was wondering.

And then from the black line we measured to here and we figured out the difference, but it was too small.

So let’s see, I think you had started at frame 10, you had measurements from frame ten to eleven on your sheet?

Yeah well this is one through ten (indicating work in her notebook), and (turning a page in the notebook) ten through eleven, or no ten through twenty four.

OK, Maybe you could show me a couple of those measurements that you made from frame one to two, two to three, three to four..

Like after this, like after we did it really wasn’t working so we just kind of did it with like our eye. Like that moved like...

A quarter of the box.

A quarter of the box

Ah hah.

So we used one point two five.

That’s what the one point two five means? (Pointing to notebook)

Yeah, at five centimeters.

Ah hah, (inaudible)...and then from two to three?

It moved, we looked at it again and it looked like it moved another quarter of a box. Another one two... one point two five.

I see. And oh, that’s interesting, it looks like you, so then you said that’s what you did at first.

No that’s what, that’s our final, that’s what we did like, that was our last thing. Like. That is.

Ahh. Ok, so first time you tried to measure with a ruler, and you used this black line,

Yeah,

And you measured from the black line to the tip of the cat’s nose, is that right?

And then we did it again for that one (pointing to the cat frames), figured out the difference.

And you figured out the difference, and you did it for each of the frames?

Yeah.
R7 That’s how you got your first set of numbers.
Romina Yeah.
R7 And then the second time you did that…
Romina We only did up to ten that way.
R7 Uh, huh.
Romina And then it just got too hard…
R7 Uh, huh.
Romina So we tried all over again, we just went back to one and we went all the way through and did everyone just using our eye.
R7 Just using your eye, trying to determine how much the…
Romina Like we’d do like, we all looked at it, and then we all like whatever we thought was the best. Like she’d say like a quarter, I’d say like three eighths or something…
R7 Right. So what, what are your new measurements? Can you show me those?
Romina Yeah, these are them. The ones I showed you.
R7 Ahh.
Romina These are the ones.
R7 Oh, Ok. Yeah, I see some things first now…
Romina Oh no, that’s just what I was writing when I was doing the big line.
R7 Uh hum…
Romina I had to, I was like do that so I could check where I was.
R7 OK, so these measurements are what you did by eye.
Romina Yeah
R7 What about the um, the next page? (Romina turns the page) Yeah, but see I see here you crossed out some things.
R7 (inaudible from R2 regarding the number six entry) She said one and a quarter so I wrote one point two five. But she said one and a quarter she meant the
whole box and a quarter of another one which is five centimeters. So we just added five there and then we just, from there on I just had to add to every one. (Romina pointed to changes on the second column of here paper). And like I had to do the same thing there.

69   R7   Oh, I see.

70   Romina Then like because we went back, those were the ones that seemed kinda like odd. (indicating numbers in the far right columns that were scratched out)

71   R7   So that’s why these numbers changed.

72   Romina Yeah that’s, and then after that I had to change every number.

73   0:19:15   R7   You had to change the running distance. So your first column here is the distance that the animal has moved.

74   Romina Uh, huh like…

75   R7   The accumulated distance. Uh huh. This second column represents (indicating second calculated column)...

76   Romina The distance from like..

77   R7   Frame to frame.

78   Romina Yeah,

79   Magda The change in distance from frame…

80   R7   The change in distance from frame to frame (Pointing to the chart). Ok, so this is like thirteen point something is the total running distance up to frame ten, that’s how far he has moved…

81   Romina Yeah

82   R7   …and then this (next column) is the difference between this number and the number for from frame nine to ten?

83   Romina Yeah.

84   Magda Yeah.

85   R7   Uh huh. And these are the accumulated running times?

86   Romina This column right here (indicating the third column).

87   R7   That column.

88   Romina Yup
So by the end of frame eleven, or is this the beginning of frame eleven? It’s moved point thirty one centimeters.

It’s the end of frame ten, and I guess the beginning of frame eleven.

OK. Finished?

Uh, huh

And these are the velocities

For each frame

For each frame, so that’s how fast the cat has gone from frame ten to eleven?

Uh hum..

Right. That’s interesting. Yeah, now I’m understanding how these numbers came about. I was confused before.

I mean, especially with that, we just changed it. No one knew about that, we just kind of did that real quick.

Right

That wasn’t….

I see. But then yesterday, did you, did you, you did something with the calculator right?

Yeah, we messed up.

We just plotted them.

Yeah we plotted them… (picking up her calculator)

Can we see the plot?

I don’t have it in my calculator.

I think I have it in mine. (appears to turn calculator on and pushes a few buttons and shows R7) Alright. This is it.

Ok. That’s definitely, tell me what that plot represents.

That’s is the um, distance (marking a line from top of the screen on the left to the bottom left with marker), distance and time (marking a line across the bottom of the screen with marker)

Uh, huh. So that’s distance versus time. And then yesterday when you reported you also showed another graph.
Magda (Waving her hands) That was, that was, that was…

Romina That was wrong. We just kinda like, we graphed our velocity against time I think?

Magda Time or distance anyway.

Romina Or was that the velocity against distance and that wasn’t right so our graph was funny. We were still trying to fix that.

R7 Uh huh. What do you think you might do?

Romina I don’t know yet.

Magda I think it’s wrong totally we didn’t try anything.

Romina It doesn’t like show anything. It doesn’t like prove a point. It just… plots (inaudible)

R7 Ok. Well thanks a lot

Romina No problem, any time, any time.

0:22:03 R4 Ok. Ok. What would you, what would you think if we got back to the catwalk investigation? And it seems like yesterday we made a kinda a good first approximation to how things might go, but there may be some adjustments that we, you could make to a number of things. You know, what the scale is that they put down here, uh maybe the, you know, the kind of timing of the of the drum beat. Something that might try to give us a, what we might think of as a better representation of the cats movement. So what I would like to do is just kind of throw this open to you for discussion of what you think might be some things to try, and we can try things. I mean, we don’t have to do it right the first or second or fifth time. I mean it’s an experiment, we can adjust some of these variables, try to get, try some things to see what what seems to work. But I think this would take a lot of input from folks. So, let’s ask, I’ll ask this table, because they’ve been talkin’, what kind of suggestions do you all have that might go into this?

Victor (Inaudible)

R4 I missed that Victor!

Shelley We could do it in the hallway. Umm, and if you didn’t want to do that at first you could just make the people when they’re doing this one take the same size steps all the way through. So that that way when we get, like at
the end here they would just leap into the next thing. If they take the same size steps they have to sort of run faster to the next one.

125  R4   Ahh
126  Angela   Like make the time…
127  Male voice off camera   So like he could go faster.
128  Angela   Yeah.
129  R4   That’s interesting
130  Brian   Sounds good.
131  R4   That’s interesting. Any other ideas? Have you guys (indicating table in rear of room) thought about anything that you might adjust?
132  0:24:43  R4   What about this table? You were the, you were the, Romina you and Shelley laid this down didn’t you?
133  Romina   And Magda.
134  24:44  R4   And Magda yeah
135  Brian   I did the first part
136  R4   And Brian
137  Jeff   I supervised
138  R4   All right, so you were the construction folks for this huh?
139  Jeff   I think that’s a very good idea..
140  R4   In what sense? What would you do
141  Jeff   To take the same size steps.
142  Romina   Only because that like the cat didn’t jump, it was actually going and then it like sped up, so that’s like what we’d be doing.
143  Jeff   So why don’t we try it out?
144  R4   Let’s try it. I like Jeff’s suggestion, let’s try it out.
145  Jeff   Let’s go for it.
146  Brian   You only live once ya know?
147  R4   Let’s try some things. (As the group stands up) We can, you can run several experiments you know
simultaneously. So uh... there’s more, there’s.... there’s tape over here, there – actually we have some meter sticks today, so yeah and some, some markers. (Many students sit on book cases around the room, some are getting materials.)

148 26:25 R4 Everybody is shy, I don’t believe that. (pause) Mike, where’s Mike? Where did mike go? Mike are you going to do the drum thing again? Let’s, let’s get it, let’s see if we can find it. You wanna come out and work out here with them? I would, because they need somebody to help them push them along, and you know, get some stuff going. Where’s that, where’s that dru, yeah Roger just freaked out. We’ll make this work, we’ll make this work. Get up here where they can hear. Ok Matt’s gonna do this? (0:28:13 drum beat begins)

(ROVING CAMERA DATA BEGINS HERE
Times are marked by RC for roving camera. If no RC, that is the corresponding label of the Table 1 video.)

149 RC 0:00:26 Matt (RC) Yeah, I’m gonna do this. (Matt makes measured steps to Mike’s drum (garbage can) beat) (On the first 9 steps (frame marks) Matt is on beat, on line. After that he keeps taking smaller steps than lines still in the same rhythm, he did not speed up to match the distance)

150 28:33 Angela (RC) I think they’re taking more steps and same size steps defeats the whole purpose of like measuring out each step.

151 Matt If you take smaller steps you’d have to move faster, bigger steps...

152 Matt Like if we made this larger...

153 Shelly He wasn’t taking that many steps though.

154 Victor Right it was galloping and stuff like that.

155 Romina I think that going from step to step defeats the purpose, because we want to see it like accelerate like going faster and faster. And we don’t see that.

156 Matt If we made it bigger we probably...

157 Romina And then you’d be like running then.

158 Shelly We could make it bigger in the hall.

159 Victor Since we’re on rug right, every time he moves he causes a whole lot of friction, so he doesn’t get to move
as fast as he wants to.

Shelley’s worried about friction.

Benny The thing is, what I think it is, is that they’re taking pictures of the cat moving. And the pictures are taking point zero three one seconds to take the picture. Now if we move, it’s not it’s not the time that we using, it’s like how we’re moving you know? You, you not supposed to let the time judge how you’re moving. Because the time isn’t judging how the cat’s moving, it’s just the cat moving and it’s how, how much time he’s taking the picture. It’s not, it’s not, see we’re make, we’re make, we’re say, alright your gonna move at this amount of time (clapping his hands), and you’re moving to the beat (two short dramatic measured steps). But see we would just move freely and find out how much time it takes us to move all the way down. From interval to interval. Then we could come up to, it would be better for, you know, to judge how quickly we’re moving.

R4 How would you do that Benny?

Benny Let me walk.

R4 Can you, can you, can you, give us an example of what you’re, of what you’re thinking here? ( walks over to the line)

Benny I get over here. I walk, I walk and I’m going (begins to walk quickly on the marks) like that, that’s acceleration, we’re going (takes two plodding steps), that’s not accelerating. You know. So we found out how much time it took me to go from here (walking the line in reverse) to he…. to each interval. Like HOME (hitting a mark hard). You know how much time it took for me to go like that, then we could kinda judge acceleration a little bit better. You know. I don’t know if I’m in y’all heads right now, are we here? (making eye to eye kind of gestures with his right hand) Am I here with you all? That’s yeah!

Ashley That’s the same speed the whole time.

Benny Yeah

Ashley (Inaudible)

Benny Who the cat?

Ashley Yeah.
Benny  Yeah.

Ashley   No he’s not.

Benny    Nahhh. He’s not,

Romina  He’s agreeing with you.

Benny    Not when I, not when I went (waving his arms indicating up and down the line). Not when I’m here (making running motions), (then makes short plodding motion) you know going the same speed, but... Ahhh acceleration is something boy!

Ashley   How you walk after you run on the dash with the cat (when the camera moves toward speaker, she hides her face and does not speak any more.)

Shelley  She said: Why don’t you walk it first then run all the way through, in case you didn’t hear…, she’s not…

Whispered male voice That’s what you say.

Ashley   You walk first and then run because that’s what the cat did. Walk and then run.

(The camera moves back to Benny walking the line hitting each mark in a slow deliberate measured pace (mm=60?).)

Benny    Now the question is am I picking up speed?

Ashley   Yeah

Benny    Or by covering a faster, more of a distance am I picking up speed? That’s what I, that’s what’s confusing me right now

Ashley   You’re picking up speed when you get to bigger…

Benny    So when I travel a greater distance even though I’m going the, even though I’m not moving quickly you know, but I’m, since I’m…

Magda  Yeah, but you are moving quicker

Romina  But you have on your feet by that part.

Benny    OK

Romina  So in the same time you cover more distance. So you’re going faster.

Benny    So I’m going faster. OK.

R4  Do you think that…
Matt I think if we made it larger…

R4 Let me, let me ask you a question Benny. As you moved along here,

Benny Uh huh

R4 Was it, was it taking you roughly you think the same amount of time to take, to cover this distance (off camera), as it did back here, the same amount of time to cover this, this piece here?

Benny Yeah, uh, huh.

R4 Ok. So, so what you were doing was, was you were just walking. But your sense was that the time to go from nine to ten and the time to go from eighteen to nineteen down there was pretty much the same?

Benny Yeah

R4 OK. Is there a way we could check that? Or at least come close to checking that?

Benny Well, you said…, when we first…

0:34:11 R4 I mean I like your idea, I’m not questioning that, it’s just… What, what I’m interested in in checking it somehow.

Benny When we first started we said it was gonna judge, we was gonna start off by moving at this pace (clapping his hands in a steady rhythm). Now all the way through we was moving at that pace so it has to be the same amount of time from each one. You know? Like you, like the cat. From each interval he’s moving point zero three at zero…

Victor It’s almost the same amount of time

Benny It’s always the same amount of time.

Victor But, your velocity is gonna increase ‘cause you’re covering more distance in that time.

Benny That’s what you asked me right? Is it the same amount of time for me right? Yeah

Victor yeah

Benny yeah

0:34:48 R4 So then the question is did you feel, did you increase your velocity somewhere along, did you ask that?

RC Didn’t you? Or somebody asked it..

Benny Uh huh
You think, you said if I remember right that’s what the question was.

They said I did. Said I did, that’s what she told me.

What did, what did you feel?

Nahhh, that’s the question that I have. That I would like my peers to help me.

I think that’s a very good question.

What did you feel?

That I have. That I would like my peers to help me.

I think that’s a very good question.

I think we need a bigger scale so you couldn’t just take one step. Now at the end I mean everybody here…

Let’s try. You want to try?

Yeah, Let’s do it.

Are you up for that? (Affirmative answers as well as directions as to where it should be done (hallway))

But see the thing that’s getting me…

What’s getting you Benny?

…the thing that is getting me is that um, see the cat is not being judged on, like, like, it’s not a steady thing that the cat is being, its, its, like he’s

…the thing that is getting me is that um, see the cat is not being judged on, like, like, it’s not a steady thing that the cat is being, its, its, like he’s

Pictures

Yes, the person is taking the pictures and the cat is not saying well I’m gonna move at zero point zero three one increments. He’s just, he’s moving at a pace. He, he’s picking up his speed, and as he picks up his speed the person is taking a picture of him (imitating a person taking a picture) all the way down.

Yeah, but in order for us to model that we have to do it this way. We can’t do it the same way the cat does, or we’ll never ever see the model.

We’re trying to figure out what he does. Not necessarily, what he does at each point, not necessarily how he gets there or what, like what he does in between.

I understand what you’re saying (to Benny)

We’re trying to get as close as we can to being the cat and that’s the only way we could…

Now what are we trying to find out when we find …

Just how, just how fast he moves, we’re not trying to find out anything else about him.
231  Shelley  We’re trying to find how he changes at frame ten. You’re walking slow, and then all of a sudden the steps you’re taking are bigger. We just want to make the scale bigger so that, instead of just taking bigger steps you have to run from each thing to thing.

232  R4  Does that make some sense to you Benny?

233  0:36:50  Benny  We’re here, now we’re here! (making the eye to eye with two fingers gesture again)

234  R4  Now we’re here!  Ok.  Well let’s do it.  How big do you want to make this?  (students are talking softly) Tell you what.  What we, what we might do is just try some things in here on maybe a smaller scale to see if it starts to look good and then if you want to move out to get the whole picture we could do that. Does that make sense? Like, you know maybe we could, we could do just part of it in here for thinking about changing the scale. And, and, and try some things out, see if, see if that makes, starts to make sense?

235  0:37:35  Matt  We could only do part of it though if you make it that big of a scale.  I mean you’re not gonna get like the full effect.  Like, like you might get one to ten on one side then what are you gonna do like run over to the other side and do the other ones?  It’s not gonna work for the increments.

236  R4  Oh no.  What I’m, what I’m suggesting is that if, if what you do from one to ten seems like it’s good then maybe you could expand it somewhere else.

237  Matt  But then you’re not getting the acceleration from ten up to twenty and up.

238  Shelley  All he’s saying to get the scale right, is that we should do it in here first instead of spending all that time outside on a scale.

239  R4  Whatever you want to do.  If that’s not something that seems right to you then let’s do something else.

240  Magda  So how will we figure out a scale if it’s

241  Romina  How long is that hallway?

242  Shelley  He’s saying we practice it in here first then go outside.

243  Magda  Out there?

244  Romina  The long one.

245  0:39:00  R4  What do you think?(A lot of conversation about the best area to do the run in.  R4 ends the discussion with)  I like Shelley’s idea.  Shelley says let’s do it instead of
Shelley: Do we have to figure out the scale?

R4: Good idea.

Romina: (picking up a calculator) Magda will take a calculator for the scale.

Shelley: We need the meter sticks.

Magda: We need the uh, uh numbers. How much are we multiplying by, fifty? Fifty?

Romina: Sounds good to me. Is there going to be enough room or is it, how much you figure it will be? One point two five multiply it by fifty.

Magda: One thirty times fifty.

Romina: A hundred thirty times fifty? Ahh the whole scale haha!!

Magda: It’s sixty five, it’s sixty five meters if we multiply by fifty.

Romina: (to Shelley) is there sixty five meters in the gym? I don’t think so.

Angela: We could check.

Shelley: Well we don’t need the whole thing, we basically just need to have what is around ten.

Angela: Yeah, if it’s not bad…

Magda: No but we need the whole thing.

Angela: Yes we need the whole thing, but if it’s not that big then we just scale it a little smaller.

Romina: I really think we should just do it in the hallway, because the hallway is a lot longer. If we start in the way back it’s a lot longer than the gym.

Angela: And it’s easier to keep a straight line in the hallway because the stuff is there, the tiles in the floor.

Romina: Yeah

Magda: So what’s our scale? Thirty?

Female: Fifty

Magda: Fifty?

(Students leave library and move to hallway. Romina has Angela pace off the floor tiles from one end of the hallway to the other, and discuss the scale. Camera follows Romina, Magda and Shelley as they tape and measure the floor. Shelley is putting down the tape,
Magda is making conversions on the calculator, and Romina is measuring and marking. Roving Camera Video remains on Shelley, and others as they work at the taping project. Table 1 camera remains on students sitting on floor at the end of the hallway making teenager conversation.)

(Approaching Aquisha) (Inaudible beginning) This is like your picture in tape, just blown up right? Huh?

Aquisha Somewhat

R4 Is there differences you see?

Aquisha Yeah, because mine was small in the beginning till the very beginning then it just got bigger. Theirs gets bigger, then it just gets smaller for a while then it gets bigger. It does it again over there.

R4 Did yours just get steadily bigger all of the time, or was there some kind of places where it got smaller?

Aquisha Never got smaller, but it got, there were parts where it was the same…,

R4 The same.

Aquisha …then it got bigger, then the same. Never got smaller.

R4 Did you do that off your own measurements?

Aquisha I did it off of the, tracing the statistics, the cats…

R4 Oh, that’s right. So your, you’re, the things you’ve held were in fact right off of those two uh, those two overheads?

Aquisha Uh huh.

R4 So you didn’t, you didn’t collect the data from one picture…,

Aquisha Yeah

R4 You took two pictures and did your data collection.

Aquisha Right

R4 OK. That’s why you were so worried about being able to convert your scale to something else.

Aquisha Yeah, it’s not the same.

R4 Because the data just weren’t, weren’t there in any other form from when you made the collection.

Aquisha Uh huh
OK, that makes a lot of sense. Really why not convert your data saying what you were saying?

That’s why I was saying I needed a photocopy of a ruler, because I said that they were too small to..

To really count

Yeah, to look. It was hard to look so, I photocopied the ruler with the line on top of it and marked off the remains on the ruler

So you’re, so what you were doing, you measured each one of the real tiny lines…

Uh huh

Right on the ruler

Right on the ruler, yeah. Let’s get you a co…, we’ll, we’ll, get you a copy of a ruler and a transparency. That would do it for you right?

I wonder if the ruler copies in exactly the same scale or it shrinks it. You know how some things on a Xerox go (makes hand gestures with both hands expanding and contracting motions)

Yeah, but it says on that little thing.

Ok, so we keep the same, same kind of scale. How do you find out if somebody knows here, whether we can do that? Here, because if we can it will save us a lot of time. So you didn’t, you, your collection, you didn’t have these little small things like they do. They were there.

They were all the same (dropped tools and tapped sticks make some transcription impossible)

Particularly this one. Frame, this one must be ten. This is a big one.

This one right there? Yeah it’s ten. (Conversation goes back to marker conversations and other small talk.)

(Speaking to Benny) Alright, so did you make it all the…

No, because you didn’t have all the marks down. I was just running to where Ashley was. And I hit all the marks up till then, but I mean…, that that looks like it’s some… (looking at the rest of the line)
So what do you think? How are we going to deal with this? From having run, how much you’ve run. We’ve talked about stop watch…,

Right

I think you should have the person in their head count to uh, one one-thousand….

Like one thousand as they’re running?

Victor Right. They’re running through their head. And then they keep their own pace, they don’t have to listen to someone else to (smacks his palm with the back of his other hand).

Because that makes it too external?

Right, too external. While more or less you want internal and you could kind of see your speed.

So like if you started down there what would you be doing? How would you do it?

I’d go like…, Ok. One one-thousand, two one-thousand, three one-thousand (while pacing off across the hallway), then just increase, increasing, increasing… keep running so that every time you say one thousand whatever number, you hit yourself at the mark.

It has to be on that mark.

Right. So, that’s the way I see it.

You think that should work?

That should work. It’s more, depending upon who the person is that’s doing the running versus somebody else where, you know you kinda go, Oh. Ok you say, you had the sign you know.

I think that’d be great. Are we almost ready then?

I think so.

Do You think we should have a consensus on what we’re doing? I think you summarized it really well. (not completely audible, and after asking R5 a question, R5 calls Victor back and R9 asks Victor) Would you mind explaining to me…?

Ok. The way I saw it is the person, whoever’s doing the running right, they start off at their, at their mark and they go; one one-thousand, two one-thousand…
Counting by seconds.

...three one-thousand, right counting by seconds. And they’re saying it to their, in their head right. And then, this also makes, they know that they have to hit the mark every time they say that to themselves. So it’s more an internal thing, and you’re the one pacing yourself. Versus somebody telling you (fast tapping on the lockers with his hands) you have to hit the mark now.

(Inaudible)

Right.

Still basically try to go by seconds and still trying to hit each mark…,

Right.

…a second.

Exactly. So you know that…

So then you cover that distance in a second?

I think so, because after a while then you’re gonna have to start running.

…running?

After a while you’re gonna have to start running.

So we have to do this on a small scale? Or…

Uh, well I think the purpose of the big scale is not for measurement purposes. It’s more for visual purposes, so that you see that the person is uh increasing in velocity. Or the object that’s doing the motions. Right. However, more or less, I think that the smaller scale or the actual scale, or let’s say you blew up the individual pictures – and blew them up to real life scale, it kind of helps you with the measurements that you could be more accurate. Otherwise, just cause they call this like, if you were to measure it; this could cause a lot of umm, errors, I mean numbers to be off somewhat, because of umm proportion. If you want it really, really accurate, you blow up the pictures to real life. The pictures that we have on the transparencies, on the paper. Right. So. Exactly, make it look like a real cat, this big (squatting down and making a size gesture with his hands), or however big the cat was.
R9: Thank you.

Victor: Sure.

RC: Ok! Let’s, let’s go down here and have a look at what’s happened. See what you think as you walk down this way.

Camera follows group down to the far end of the hallway. Some small debate about either counting in their head or keeping count by banging on a locker.

R4: Ok, where are, what are, what are we really interested in?

Ashley: The speed at which he is going in.

R4: Ok. What we really are focused on kind of down in here right? (indicates to his left or the beginning frame markings) One of the places we really want to look is around ten. So… (CW stops when he hears some loud debate over the length of some of the fifth through eighth markers. Victor starts to make a run.) (little while later Brian steps up to the tape)

Shelley: Mike starts the beat so he gets a feel for it.

Brian: Am I walking that first?

Shelley: You decide. Mike start with the beat so he knows what he’s doing. So he gets a feel for it.

Mike: Am I doing it at one second or what?

Shelley: Yeah

Brian: Two Seconds

Shelley: Try one, if that doesn’t work… (pounding on locker is heard from behind the camera as Brian starts to walk. Brian hits every mark using individual steps for the first nine steps then adds steps in between picking up his pace but hitting the mark on every beat.) (for the last several he traveled at a constant rate)

Benny: I want victor to run, and I want to see how much time it takes for Victor to get to each one.

R4: Ok. This is just Victor on his own right?

Victor: You don’t even want me to count

Benny: Yeah, count. I want to see how much time it takes to get from black tape to each black tape. This black tape.

Female Researcher: Do you want to stop him?
Benny 256
Nahh, I just did it. On the next one. Trial going on here.

Victor 1:01:28
What you want me to just run?

Benny
I want you to do it how you just did it.

Victor
Oh.

Benny And count how much time it takes you to get from black tape to black tape.

(Victor keeps a steady pace in his counting to himself until he gets to the tenth one which it farther away than he was able to make. You can barely hear Victor counting in an irregular pattern one one thousand, two one thousand, trying to match his footsteps.)

Benny Oh Victor! (mumbled talking) I’ll count. You run I’ll count. And I gotta run with you. (Benny stands by mark eight) (Victor starts and stays on mark. As the marks get farther apart Victor accelerates until he is running at a constant rate going out of camera shot)

R7 0:56:59
Now, why, why’d you want him to do that?

Benny Why’d I want him to do that? Um, so I could see, see because he’s picking up speed as he goes from each one.

R7
Uh, huh.

Benny And I wanted to see how much time it took for him to go from interval to interval, that’s all. Like the cat, the cat was picking up speed as it went.

Ashley
The cat was going fast (inaudible)

Benny
What I can’t see, how much time it’s taking him to get from interval to interval?

R4
Do you think it’s reasonable that he was going like the same amount of time from interval to interval?

Benny
Yeah

R4
Or roughly?

Benny
Yeah

R4
Ok. we gotta get him to do it again.

Benny
Yeah.

R4
Give him a little rest. Shirley are you going to give it a shot?

Shirley
No

256
378  R4  Do you want, do you want, do you want a timed beat?  
Or do you want to carry it in your head?  
379  Shirley  A timed beat.  (Shirley takes a few attempts and 
practice walks.  Never completing the run (Roving 
camera has lost audio at this point).  R4 makes an 
attempt that takes him to about fifteen.  ) (AUDIO 
RETURNS  at RC 1:02:16.  Someone is clapping and 
Shelley makes the first eleven marks before stopping)  
380  Shelley  I couldn’t make it to the next thing.  From here, from 
here it was fine (pointing to first steps)  
381  Magda  But once you get to frame ten  
382  Victor  Yeah because it’s like I’m counting my steps, instead of 
just…  
383  Magda  Running  
384  Shelley  Yeah.  
(R2 makes run.  (Real well!)  R3 is talking to Benny 
with cat photos.  This is where the Table one camera 
picks back up but with a different focus.  Students still 
making the run.)  
385  1:09:38  Benny  From here to here (pointing to paper) that’s one step.  
That’s all here to here.  
RC  
1:04:37  
386  R3  Oh you mean what the actual cat is doing.  
387  Benny  (Inaudible)  I’m trying to see where that one step is on 
this.  
388  R3  Well let’s go see.  (R3 and Benny walk to the beginning 
of the line)  
389  Benny  That’d be one step.  
390  R3  From the beginning if what your saying is that the cat 
and it’s the way it’s legs are working (loud noises 
drown out conversation).  
391  Benny  Yeah, he’s like going like here to here he’s like this…  
392  R3  Yeah.  
393  Benny  …and then at frame six he’s like this.  Then right here 
he starts another one  
394  R3  Well yeah, he goes down, crouches, and then does…, 
where’s his next step?  
395  Benny  And then he takes another step right here.  See?  
396  R3  Takes another step here?
And so his next real step, where it comes down again, is where…, where’s the end of a step for a cat? from here…

To there.

… to there (pointing at cat photos first row). And then he starts this crouching thing, and where does he end it?

He ends the next step right here (indicating frame 12).

Oh, so this is the third one? (pointing to frame 13) Oh, so this is the third step, so you’re saying that that the row of of frames corresponds to a step? Does it in each place?

No, because when he goes to pick up speed…

No but you just told me that from here to here is another step.

Yeah, but see, this isn’t, it takes him a certain amount of time from here to here to make that one step.

Yeah

Then from here to here (indicating second row) it takes him a certain amount of time…,

Same amount isn’t it?

Same amount.

Ok. Is it the same distance?

Nah, yeah it’s the same, wait hold up.

I thought you just told me it was one little box up there? (pointing to top row)

Right here he’s traveling… (hand is over the top row of pictures)

From there to (indicating area on floor) here. Except it’s a much smaller space.

Uh huh. Yeah.

Ok. From here to the twelfth frame (turning to the remainder of the tape line), I’m going to stand right here and you go to twelfth frame. (Benny walks to the twelfth mark) That’s the second step, isn’t it?

But see it’s even more, it’s even more than one step

Does it matter? It means we’re not really modeling the cat’s movement, and that was bothering you in the other
Isn’t it? You take this and work on it (Victor comes up and takes paper from R3) I smelled that too. I smelled that. Man that’s what I said. You can’t really take no measurements off this. This is only the scene visually, how you accelerate.

Benny Yeah, yeah, this is just the acceleration

Victor Because look, this is almost fifty times bigger right? This is fifty times bigger so what’s that gonna prove? Know what I’m saying. Nothing. All that causes is if you were measuring more area. Introducing more error, you’d be figuring out velocities, and speeds, and all that other junk. So this is just so you could see visually how the person is accelerating. I don’t even think that you should really have a count anymore. As long as the person is counting in their head. This is (clap, clap) oh, my bad I missed. I missed a stride. You know, right, right, right. That’s just my opinion.

(END OF ROVING CAMERA DATA
Roving Camera Video loses audio. Return to Table 1 video in hallway from here. Occurring at roughly the same time as Benny R3 interview.)

(At 1:14:56 Victor makes another attempt at running. Initially there sounds like somebody is trying to make a drum beat while he moves. His fist steps are short and measured, soon after he accelerates and does not change his speed or length of stride. The drum beat has also stopped. At 1:17:20 Magda walks to the start of the line and immediately starts to walk. There is no drum or rhythm (Romina suggests that she count off in her head) and she stops after seven or eight steps. Magda returns to the line. At 1:18:28 Shelley is at the start of the line. There are a few students clapping in rhythm, and Shelley takes off matching the rhythm to the lines on the floor until the end. As Shelley turns to return, the clapping begins again, and Magda takes off. Shelley was between the camera and Magda, so that when Magda began we have no clear picture as to whether she matched the rhythm to the lines on the floor. At 1:20:10 the rhythmic clapping starts and Benny begins to run the line. The clapping breaks down and Benny stops. Benny starts again to the clapping and again the clapping stops, Benny tries to continue, but
after a few more steps he stops and returns to the start. On the third attempt the clapping continues and Benny does match all marks on the floor to the rhythm. Immediately following Benny’s run R4 indicates to the students that they need to clean up the work in the hallway and return to the library. The students return to the library in no particular order.)

424 1:23:54 R4 We’ve got a, we’ve got a bit of time left in the morning. So, I was, I was wondering what kind of questions, or what kind of responses came out of this morning’s uh little work out there? Let’s be uh, you know, kind of brutally honest with each other, and uh, bring real questions out on the table. And then maybe we can address those. (Jeff raises his hand) Jeff.

425 Jeff All right, um on the uh, on the uh brutally honest thing. I’m, I’m just a little confused, I don’t. I’m not, I thought it was good to make a model. I think that it’s always good to do something, like if you could do it physically yourself. But I don’t, I don’t see what we’re getting from doing all this.

426 1:24:43 R4 That’s a pretty brutal question right?

427 Jeff Yeah

428 R4 But I think it’s, its also right to the

429 R4 …right to the point.

430 Jeff …heart of the matter, to the point. Ok

431 Matt I just think we finally figured out like, like what Mike said, how, we thought the cat stayed the same speed. The cat doesn’t stay the same speed he’s constantly speeding up, speeding up, speeding up. So I mean, as far as that point goes, the cat staying at the same speed that’s out… (Inaudible).

432 R4 So you see that as being answered in a way that said that the cat was not moving at a constant speed, through any period of time? Ok.

433 Victor The way I see it is, I think that the uh graph whatever, that, the, this group right here come up with (pointing to table 1), Romina, and uh how it shows the change in uh speed and position in time and all that stuff. I think you could kinda, whoever ran that, you could kinda feel it, because in the beginning they was running at a constant rate of speed, then it slows down, then it pick it up, pick it up and kept on picking it up (last few words are inaudible)
So now how does that fit with what Matt said?

Well what Matt said, that he found out that he wasn’t moving at a constant speed. It was with various changes of speed. Like he was going more and more and more lets say (inaudible)

(interrupted by announcement telling the electricians that the hallway is clear) Do they have to say that? Do they have to say that?

They only flick on the library switch for that one.

I think you’re right. That’s kind of cynical but I think you’re right. That was bad. So, so, so what you’re saying is, is kind of adding to what Matt…

He said. But also proving their point.

Ok

With their graph. Remember the graph that they had they kinda had like the x is funny and stuff. They had…

The speed one? Or…

The position versus speed. Yeah. Right, right, right

Ok, that was an interesting graph, I’d, I’d like to, we’d like to, I’d like to take a look at it again sometime if you guys still have it.

See you guys said it was wrong so we erased it.

You erased it!

I don’t know, I’ll check, hold on.

Anything else?

We’ve got all the information, we could always put it back in.

Yes Ashley…

When you use a motion detector, did you use it? When we were doing that?

Did we use the, did we use the motion detector?

No, I don’t think we did.

We didn’t use the motion detector did you?
Out in the hallway?

Yeah.

No we didn’t use

Too far. Was it too far?

Who was helping me with that?

Victor Ashley this morning.

Ashley was.

What did you think, did it work alright?

It looked like it worked alright.

Tell me about what you did.

We did, we only did it from ten. We didn’t do it from back here. We’re just trying to figure out if it worked or not. We saw if like the data was collecting at the right time and stuff. Nothing pertaining to this really.

Oh

Was it working?

Yeah it’s working.

See I don’t think we have enough time if we wanted to do, If we wanted to do it on this course here and use that, I mean the increment, the the length, or the amount of time it takes to go from beginning to the end is much longer than…. I mean it only collects very briefly on the calculator. You know?

Oh no, because we changed the thing so it collects over more time.

You could….  

Yeah

So then why didn’t you try to use it?

Let’s do it!

I mean this is more of a smaller kinda easier place to do it.

Let’s try and do it here.

Were you trying to get a walk that matched the cat’s
Ashley Yeah.

R4 Is that the idea with the, with the uh, with the detector?

Ashley On a graph to see if it’s the…

R4 OK, Hang on to that just for a second ok?  Cause that, that may be something we could try right at the end.  If, you know, if that’s what you want to do.  I, I want to hear from, I want to hear what, what Benny says. Because Benny’s been a a real spokesperson for um a lot of this I think over, over this period of time and, I’d like to know, I’d like to, I think it’d be good to know what Benny’s uh take is on on all this.  Put you on the spot is that Ok Benny?

Benny Nahh, I was just saying how um, this model and the model outside, I was thinking it was more of a visual explanation, not not a um, like a mathematical explanation.  You know like…, it shows us like exactly at what point he’s accelerating, at what point is, is slowing up, and… Like overall you could just see things at a, at a, in a better way.  You know instead of just saying well where does, where does the cat pick up and, where does the acceleration pick up using the distance formula, acceleration formula, you could actually see like between point ten and eleven the distance where he picked up in between points nineteen and twenty the distance where the pi…, the distance where the strides begins to, I mean this is where the speed begin to get faster.  Just something to see.  For all eyes, all eyes on the cat.

R4 All right.  Did, did, did, every, did everyone who ran that course have a, a feeling similar to Benny’s?  Or were there others?  Were there other kinds of impressions?  (Victor raises his hand) There’s there’s Victor.

Victor Right. I ran the course.  But my concern was with, I had to ask what the scale was, and they said they had to multiply it times fifty, whatever.  And if you did the distance like that why not also do the time?  I mean, that way the distance that you would have had to travel from point to point would have been something like one point one and a half versus something like just one second which would actually kinda gave you more of a realistic pace than that just one second did.

Angela Like we also had to consider that we’re bigger than a
Victor Right. So that’s why I said since you were scaling it fifty times bigger than you should have to have a time interval fifty times…

Romina We got the graph.

Victor What happened? Oh, ok then.

1:31:35 R4 You want to put it up there? (Romina attaches her calculator to the TI projector and displays it on the overhead, focuses it and sits back down)(at the table Jeff complains about a cramp)(suggestions about focusing the projector)

Romina We think it’s the speed that it takes. We’re not just, we actually had it, our x and y, like we’re not sure if it’s exactly but from what we did out there it looks like it follows what we did out there running, or what they did out there running.

Magda (Magda walks up to the projector) The difference between this box and that box, like you see you’re like increasing in speed that’s what it’s showing and then like you’re going at a constant speed and you’re slowing down and you’re…

R4 So, where would you see the acceleration there Magda? That was something that you were all talking about.

Magda (returning to the projector and pointing to the first large positive slope) Probably from this point and that point.

Romina When you’re, when you’re going from walking, from nothing to standing there to walking, that’s where you see the most acceleration. Like then you’re walking pattern levels off, and when you’re trying to run, you see a constant acceleration until you reach like, like almost the end, and then it just like kind of stops. Just kinda slows down like a little bit and then stops.

R4 Where’s frames ten on there? Can you tell?

Brian The point that goes lower is the top part, and then the point that drops off a little bit before the uh, increase.

R4 Uh huh.

Brian That’s point ten

1:33:30 R4 That’s ten?

Jeff Gotta count backwards. Count backwards.

Brian No, because remember now they’re saying, kinda…
R4: Which, which one Brian? I’m not sure I’m following you. Show us.
Romina: I think it’s the…
Jeff: It’s the one in the middle on the left side…
Brian: I’m going with this one (goes up to the projector and points to the 17th point).
Jeff: Nah, it’s the same one that’s level with that one (Brian points to the 10th point when Jeff was talking about the 11th), No it’s the top one.
Romina: No it’s the, it’s the…
Jeff: Count backwards…
Romina: …count backwards.
Jeff: …from the other side. (Brian eventually points to the last mark) Look the last one’s twenty four, twenty three, twenty two, twenty one, twenty, nineteen, eighteen, seventeen, sixteen, fifteen, fourteen, thirteen, twelve, eleven, oh.
Magda: No, it’s twenty three cause…
Jeff: Oh, well then hey!
Magda: It was twenty three.
R4: OK, but anyway it’s right between, it’s probably in there. We could, we could take a good look at it and count it real carefully, figure, figure out where the, just an idea where that, where that is. Did it, and that, is that time? It looks like time across the bottom. Because it’s all evenly, is it evenly spaced? I mean first we had distance, you said you had distance across the bottom. (pause) Ok, I got a question for Mike. Does that look like, like the, the graph that you had for the speed?
Mike: Well the graph I had for speed I think was um, it was wrong. But… I don’t understand how why would you, it would be like what the speed and the distance right and that shouldn’t, wouldn’t it be like speed versus time wouldn’t that be a better way of uh graphing speed?
Magda: No it’s time and speed isn’t it?
Mike: Yesterday you said it was distance.
R4: Did you change the graph?
Mike: Yesterday you said it was distance. The distance.

Jeff: Looks the same as yesterday.

Mike: Yeah.

Magda: Was it, was it problem with the distance up there?

Mike: Like, where’s the thing walking to like?

R4: Is there a, is there a way on that graph you could look at it and and try and make a determine where you think it’s time or distance across the on the horizontal axis.

Romina: I don’t need, I don’t think, ugh..

R4: This is a, this is a, this is an interesting problem to solve.

Romina: This is the same exact graph I had up yesterday.

R4: It is exactly the graph.

Mike: If it’s the speed per frame it’s the speed per time.

Romina: Yeah.

Mike: It’s a speed per frame, that’s the speed per time.

Romina: I’m pretty sure, what did I use yesterday?

Aquisha: Look at the numbers and look at the numbers on the chart.

Magda: Why don’t you go…

Romina: Yeah.

Mike: If they’re the same distance from each other it has to be time too. Because the distance has changed.

Romina: At what, what do you guys want to put in here? (Pause as she works at the calculator attached to the projector) Ok, it’s C three and C four. And our C three is our distance, and C four is the speed. You want to put in time for this? (Pause while Romina changes the input on the graph) They’re the same thing.

Shelley: So now you’re doing velocity versus what?

Romina: Time.

R4: Romina, can you, can you disconnect those things so you just see the boxes?

Shelley: Which one is x and which is y? (Spoken while CW was speaking)…, Which one is x?
Magda X is the time, velocity is the y.

R6 What was the one before that?

Magda The distance it was. X was the distance and then the y was the velocity.

Victor Wait what was that? Time was what? C what?

R6 Magda what was the other one?

1:37:21 Magda Distance and velocity.

Romina Yeah, it was distance and velocity. But it looks the same.

R6 Distance and velocity?

Magda Yeah.

Romina Yeah.

Mike Like remember my graph looked like that? Kind of. Moved up like that…. I’m just, hey, your time was, how does it go from one point oh, like point oh three one to point oh six two?

Romina But you have, the only reason, I don’t know…time it’s like running through you know?

Mike Alright. That’s what I had a problem with before. I thought, well if you’re taking a difference between each frame, alright? So that the time stays the same as point oh three one dividing every time? You know, you know what I’m saying?

Romina But like, if you have like the distance between, a lot of the distances between the frame, I don’t know what you had but you have in there?

Romina We have like the difference between each frame, so…

Mike Alright. So to find the speed of it, what did you divide it by the time it took to go from that frame to that frame right?

Romina Yeah

Mike That’s point oh three one right? So for each one of those measurements you’d have to divide it by point oh three one right? But like in theirs dividing by point oh three one, and then dividing by point oh six two, it’s dividing by a larger number each time.

Romina But see it’s like, the reason we did it so many times,
because it’s like we had to picture the cat going through it. You know so it keeps on like, the graph makes sense though, it’s not like it’s like it doesn’t make sense.

562  Mike  It, it looks like it makes sense, but if you think about it, each one of those differences…

563  Romina  In your graph they, he didn’t accelerate at the end?

564  Mike  I don’t remember exactly what it did but…

565  Romina  Like but see like our our numbers show it.

566  Mike  The difference you have in there is the same information I had in there.

567  Romina  Uh huh.

568  1:38:51  Mike  But give or take a few like you know decimal, or whatever numbers you have in there. But, if you think about it you have the differences in between each frame. So the time, the time, like the time elapsed between each frame is always the same.

569  Matt  It’s not the differences in each frame. Isn’t it a change in velocity in each frame.

570  Mike  No she said it’s the differences in each frame.

571  Matt  If it’s the change in velocity, it’s not, there’s nothing to do with frame. It’s a change, there’s a change, that’s the whole velocity each frame and that’s the time for each frame. If he, he’s not gonna go the same speed. Like some of the other proportions, he’s not, he’s going the same speed in a couple of them.

572  R4  Do you need to point Matt, do you need to go up there and point to something so that people can can see, can tell what you’re saying? (Matt moves to the projector) Draw a, draw on, draw on that.

573  Matt  Where, where, where’s your graph?

574  Mike  Just answer me one thing. What is the x and the y, that’s all I want to know?

575  Shelly  Velocity and time.

576  Romina  The x is time, and the y is velocity.

577  Matt  (At the projector/front of class, but out of camera shot) This is time and this is velocity. This is his…, each of these (picking up a marker) little dots here, these are all his velocities at a certain time. So, if you see how the line goes, that’s (he is connecting the points on the graph with a marker on the projected white board) his climb in velocity.
Victor Doesn’t it seem like it’s an acceleration graph.
Matt Yeah, this is like his, this is like his acceleration
Victor Right. Because it’s uh, velo…, it’s velocity uh over time so that’s like uh you know, dt over t. you know and it’s like dt squared right?
Magda It’s acceleration.
Magda and a few others It shows acceleration right?
Mike By using his speed against time. Romina what did you use to figure out your velocity? Like what, what exactly…
Romina Umm we took, yeah, no we did do what you’re saying. We did divide by point oh three one. Like we took…
Mike Each, each and every, each and every time? Or…
Romina Yeah. Like in between each frame we took, we found the difference between the measures and then we divide by point oh three one.
Matt But you have to do that…
Romina The only reason, like it’s moving on though. Like the velocity, that’s just showing you the velocity at each frame. So each frame is like at a different time. Like the difference between the frames is point oh three one, but each frame is at a later time.
Matt But like, but like if you, if you have to do point oh three one, to find the velocities for each of these, because otherwise, it, it wouldn’t be instantaneous velocity. It would be like if you went from one to two, say there was one two, we’ll do three and four (writing on the white board). The way, the way you’re saying to do it…
Mike But like most of the where’s the C one and stuff, what are that tables? (Matt moves to the calculator and makes alterations?) Alright, tell us which two is it graphing? Like C one..
Matt C three and C four.
Mike C three and C four.
Romina C three is your time, committee time. And C four is the velocity and figure it out.
Mike C three is the time
Romina Yeah
(at the board pointing to the graph) And that’s, that’s the velocity?
Romina Yeah.
Mike Alright. That’s all
Matt Instead of putting time here, you could put, frame one, frame two, frame three, frame four
Romina Yeah, exactly
Mike Yeah I know. Alright.
Matt That’s all it is.
Mike How did you figure frame four out? You divided it by point oh three one each and every time?
Romina Yeah
Mike That’s all.
R4 So does that go away?
Matt Yeah
Mike It still looks like the graph that the other time. And, and I divided it by um changing time for each frame.
R4 Oh
Mike So that’s why I...
R4 So you were worried that they were
Mike I was worried it was the same thing. That’s all
R4 Ok. Good, good. CEO Pantozzi would be very, very happy with this kind of concern, for his money riding on the line. So you said you saw that as an acceleration graph Matt. Could you tell me a little more about that?
Matt It just, it just basically shows you like how far, how fast like, you can tell like from here to here (indicating points one to four) he goes, his acceleration goes down. And from here to here it starts to skyrocket (frames 7 to 11) and up like that. Then he evens out for a while, then it goes down a little bit, then it skyrocket up again (following the contour of the graph).
R4 So where does the acceleration?
Victor Right and when when he lands he slows down again right?
Matt These lines. This line here, and this line here. (first mark is an arrow pointing at gap between points nine and ten, second arrow between points sixteen and seventeen)

R4 And what about in between those?

Matt Where it starts to slant up (making a up and down pointed hand gesture)

Magda He’s going at a constant speed.

R4 Ah

Matt At these, at these ones here he’s going at a constant speed. (points twelve to sixteen?)

Romina They’re not exact but even when you look at our numbers, those are the same numbers, that’s why. And they’re like they’re off by maybe like a little tiny bit. You can’t see on the graph. But when he’s walking he’s pretty much going at a constant speed. And then all of a sudden he decides to speed up.

R4 This make sense?

Romina Yeah, because he probably scared the cat right? Tried to make it move, so the cat at first doesn’t it’s not thinking I gonna start off walking then run. He’s just walking like whatever, then something scares him and then he starts running.

R4 Did, did everyone hear what Romina said? Did you guy, Benny, Angela, did you guys catch what Romina said about the cat?

Benny Nahh.

R4 Say, say it, say it for these guys benefit. Because I wonder what their take is.

Romina The photographer couldn’t tell the cat, ok you’re gonna start walking and then just speed up into a run. So the cat was probably walking, he did something to make it like scare it, and then all of a sudden it like went from a constant walk, just like regular walking to like speeding up into running. Because something scared him, made him move.

Victor Right, right right.

Romina So that’s where you have the constant speed and then all of a sudden it stops, it’s scared and then it starts running.

Milin Yeah but it’s all less than a second?
Well yeah, I’m not saying he comes to a complete back, goes oh wow I’m scared, I’m gonna start running you know. It’s just like a pause.

Right, right right. What I see, what I see right is like, these constant speeds it’s like, like the first constant speed what I figure is that he’s most likely just walking. But then at the second constant speed I think, know how he just shoots up for a quick minute at that first aim that Matt had drawn up? I think that’s when he jumps up. Then while he’s in the air for that like split you know, frame right there, he’s in the air traveling and that’s constant. And that’s when he kinda comes down like after the constant speed that he separated, and then he just starts walking again. That’s what I gather if he just stops because he doesn’t keep going.

I’m not even sure, like how many steps does that cat take? Because this might be this…

He doesn’t take that many.

I’m saying, because this here, this might be (at point ten) when he pushes off, and what speed he gets to. And when he pushes off (making another mark at around sixteen) and then this up here would be what speed he gets to. And then he would push off again (making a line imitating what he thinks the graph would do in the future)

Right, right right.

Is there any way we could…

He starts here and then he pushes off and gets to this speed and he’s at that speed then he pushes off then he gets to this speed.

(while Matt is speaking) Is there any way that we would know? We just got the photographs like you said.

Got what?

We just had the photographs unless we want to ask the cat, but I think he’d be dead by now.

I was thinking…,

Nine lives.

I was thinking the same thing Dude. Let me go ask the cat, he’s probably dead.

Hey Benny, a while ago you were looking at our pictures. How many steps did you think the cat took?
1:45:59 Victor  Like two three.

Benny  Yeah like three or four maybe. Four maybe four or five maybe.

Jeff  So which one is it?

Benny  Four or five. Because at the end of, you got a picture, somebody got the thing (arms are spread wide)?

Matt  Not like four or five…

R4  The picture

Benny  It’s like four or five, oh…

Romina  I have the picture.

R4  Here, let’s throw that up there.

Benny  I need, I need the transparency. I want to take it to the board. (Benny starts to walk to projector. Brian begins an on topic conversation at the table)

1:46:21 Brian  You know how quick a split second is? There’s no way he took four steps in three fourths of a second.

Romina  I don’t know. Maybe he did only take like a step.

Brian  Three fourths of a second is fast.

Romina  I don’t know. (While Benny walks to the front (still) Matt erases the board)

(Has photographs displayed and centered on white board)  Now if you look, at the, at the first steps he begins, he begins his step right here. And if you look, he’s lifting his leg up gradually, gradually, gradually, gradually, he begins to put his foot down here, then his foot touches base right here (pointing to the sixth frame). That’s one step. Now he begins another stride right here, gradually lifts his back leg up. You could see, this is the foot we’re gonna judge it by, his back leg. And he lifts his back leg up again, and he lifts it up higher, higher, higher, then he begins to bring it down, touches base again that’s his second step (indicating frame 12; Benny is blocking any other indications on the screen with his body). Then as his speed picks up it starts to take him less time to take a step. So, (camera moves to capture complete picture on screen) in his, in his third one, his, his other leg, his front leg picks up, picks up, picks up. See he touches base here because he’s picking up speed, so he touches base earlier. At a quicker time. So that’s the third step. So then he’s
picking up his back leg, back leg, back leg, back leg, back leg, back leg, back leg touches base here (follows the frames from seventeen with ‘back leg’ as he points to the frames until twenty two). And then he begins another stride. Right here.

663 Matt Basically took like four steps.

664 1:48:24 Benny Four steps.

665 Victor Right

666 Benny You asked (taking picture off of the projector), it’s gone, it’s gone, it’s gone.

667 R4 Let’s look at this for just a sec. Ok. Let’s put it back here.

668 Matt So, I think that when he’s walking you don’t see that acceleration. You’re not gonna see on this graph like… (puts TI projector back on screen) Like this is, this is his first two steps here (indicating first seven points on the graph). When he’s walking at a constant speed. Then all of a sudden on that third step he gains his speed (indicating next five points). And this is when he lands, and then that’s his speed again (points 16 through 23). When he pushes off.

669 1:49:18 Benny Because if you remember what we did, with the other graph, it’s coming back to me yes! You remember what we did with the other graph, when we weren’t moving, the line was flat (making a horizontal motion with his hand). So when his foot comes down, he’s not moving at that time so that’s why the line is flat. That’s why you see that gradual line.

670 Matt Then when he pushes off again he accelerates.

671 Benny Accelerates then. It’s time for me to be quiet now.

672 R4 Ok, this is, this is really getting interesting. Ok. It looks to me like there are, there are, some, some, different kinds of things entering the discussion. I mean First of all we had you, you produced some data, produced some graphs, you know lots of different kinds of graphs. But there’s also in I think the mix now the ideas that are starting to come out of our, our walking, running, cat experience. And of course there’s still the photographs. I mean those photographs, what do you think? You think all they’re good for is measuring how far the cat went?

673 Victor Ok. It looks like to me, it seems like just a lot of…
Let me put these back up here.

Well, if you were ready to really get a accurate measure for frame ten or something like that, I mean because if you notice, we’re basing everything off proportions and stuff, because obviously the picture’s too small. But I believe that maybe we could take all these individual pictures and we brought them to about real length size – whatever, know what I mean? So that when you measure each square, every five centimeters we can get an accurate measurement. We could like see it better. I mean when we went outside we could see the speed change or whatever. But if you were to actually measure it, something like that, it would be like off because when we scaled it back down to real life size like be off. I mean you’re just introducing more error.

Ok.

I guess it’s just for visual purposes right now.

Ok.

I mean you could measure off of it, but how accurate can you actually get?

Right

At some point you can’t actually see the cat moving too much.

Now Benny’s got another idea I think.

Nahh, I just want to know, how did he take all twenty four, how how’s he saying all twenty four of those frames took him point seven seconds to take. That’s what he’s saying right?

Yeah

Now I don’t think, even if you tried to push a camera button…

Oh, we talked about this. (a lot of spontaneous conversation happens here)

The cameraman made it so there are like twenty four different cameras, that were timed electrically so that they go pop, pop, pop pop pop, down the, down the line.

Must a been, the brain must of not been functioning when y’all said that.

That’s ok I can barely remember it myself. Is there, is there any other information that you might come up
with from looking at those photo’s. I guess. Does it tell you, does it tell you things, like Benny was counting the number of steps. Romina suggested that the cat was frightened at some point. Is there any kind of evidence in the photos that that…

690 Mike I don’t know if it was frightened. I thought it was, just…, To me it looks like it’s just a jump it’s not even a run.

691 Victor It could be a trained cat. You could just say gallop (snaps fingers) and it just gallop. You never know.

692 R4 Wait a minute, a trained cat?

693 Victor Right, just like you train any other animal. So you never really know, it’s just what you see in the pictures. You never really know. It’s all left up to your imagination.

694 R4 You really don’t know.

695 Victor No, not really.

696 R4 You know what’s in the pictures.

697 Victor Just know what’s in the pictures. You just see the cat move.

698 1:53:50 R4 Ok, I think that’s a note we can close on for today. We’ve got, you know you’ve got these kinds, we’ve got three at least three different looks at this problem with different kinds of ways of thinking about it. So for tomorrow let’s see if we, I mean you know, Pantozzi’s gonna be on our back. He want’s, he’s gotta make a bet with this guy. He wants this answer. So we need to know what to, what to say. So let’s see what we can, what we can pull together tomorrow morning. Go for this ok?

699 Victor Now what’s his, what’s his name again Mr. what?

700 R4 Pantozzi. Is that not right?

701 Victor It is Pantozzi, I just wanted Benny to hear it again.

702 R4 Oh, ok. Now those of you that are, let’s see did people know who, who’s being interviewed, did we need to address that issue? (video ends.)
But it’s really gonna be pretty simple today. If you, if you remember the setting that we talked about I uh I think it was yesterday or the day before, with this uh wager idea from the CEO R10. You know he’s kinda got, he’s considering a wager with some of his uh very wealthy colleagues about this uh this cat problem. And how fast is the cat moving in frame ten? How fast is it moving in frame twenty? And he’s asked you thr-, these three groups as uh, researchers to uh get him some information that will help him in making these choices. So, this morning we have a memo in fact from the uh CEO detailing what he needs. And uh there’s a uh a stringent deadline on this. So, so I think that uh it would be uh the right thing to do to see if we can, see if we can meet the CEO’s demands. You know CEO’s demands are not something you just kinda don’t worry about.

Now, of course this is a memo right? So, in a company memo he can’t tell you that he’s really gonna make a wager with somebody. So, so some of the language kinda got to disguise that a little bit. A little bit here. So we all know, we all know I think what his plan is right? His plan is to think about making his wager. So is everybody pretty clear on that?

What’s uh the wager? What is the wager?

Ok. The wager is going to be on how fast is the cat moving-

And he’s…

at frame ten and frame twenty.

And he’s saying that…

He’s saying that, that, it looked to me here it says ‘Should I really make this wager?’
Jeff Yeah, but what’s he bettin’? That what about the scree?

R4 Huh? Sorry, what’d you say Rob? Or Dwight?

Jeff I didn’t know he was betting against, he was betting.

R4 But it’s gonna be, if he does it’s gonna be, it’s gonna be big ok? Because…

Brian I think you’re not answering his question.

Jeff No, I’m saying, what’s his original plan? To bet what?

0:03:02 R4 Oh.

Jeff To bet that what’s gonna happen? I don’t understand what’s gonna happen.

R4 Ok, let’s let’s make that clear. Thanks Jeff.

Jeff Alright

R4 Thank you, the, the idea is that he wants to say, here’s, here’s how fast the cat is moving in frame ten. Here’s how fast the cat is moving in frame twenty. And his colleague may have a different idea.

Jeff Alright that’s it.

R4 Ok?

Jeff That’s good

R4 And he wants to know, should I make this bet?

Jeff Uh huh

R4 If I shouldn’t why not? But if I should make this bet, tell me what I should say. And why should I say that? Does this make sense?

Jeff That makes perfect sense.

R4 Ok. So, you’ve got three working groups here. You can do whatever you need. Put your ideas together. And it will get back, we’ll get back on it around ten thirty, just in time to meet his, his deadline ok?

Jeff Alright.

R4 Cool. (Small talk about Jeff moving for the cameraman and Romina’s hair cut.)

Brian So is he gonna do this bet? Or not?

Romina I don’t think he should.
Brian Why not? Because it’s too risky. Figures are too inaccurate.

Jeff We just, we don’t know, we don’t know enough to to give him a good…

Romina We have all like very different speeds. As a group.

Brian Our numbers are inaccurate, there’s not a good chance that the number that we provide will be able to use.

Jeff We got, we got we got an hour to do this. So I think we’re supposed to do a little more than just you know, say that.

Brian I’m done. I just want to write…

Jeff We don’t have to write one do we? We gotta president of the group.

Ankur I’m no longer president it was only for one day. I just moved down to secretary.

Jeff (To R4 passing by) We still have one representative right?

Romina Well we didn’t, nobody has to say…

R4 Oh yeah, this is a, this is a, maybe a different representative. Maybe about the whole group. You guys, you guys figure out what. You know how you, how you want to make the report. We’ll obviously do some kind of presentation up here. Right? Transparencies are up here on the overhead, so… if you need those at some point, please help yourselves.

(Small talk at the table.)

Romina What are we gonna write up?

Brian I don’t know.

Jeff Well we don’t have an actual…

Romina Then you’re presenting.

Jeff Go ahead go.

Romina I had like my say. (More small beach vacation talk.)

Brian We don’t have a good answer so we can’t tell anyone like..

Romina Yeah.

Brian So, if not…, we’re on the if not why part.

Romina (inaudible)
I think we should pick out a thing and say, this is what we got and this is how we got it. But we believe it’s the right…, or something? Think of something to present.

Present our results. We got this. Show them the graph and say this and that and this and that… Then we’re gonna say, there’s so much going on in this problem…

I can’t work this calculator. It gives me mismatch dimension or something.

Smudge dimension?

What’s a smudge dimension?

No, mismatch

Oh.

(Turning to table 2) Shell, what is your speed at frame ten?

Two ninety?

And we got eighty or two oh one.

Both of them

But how close were the thing, we say they’re going two…

Eighty

And frame eleven is two hundred and one.

Big jump. Jump jump.

(inaudible)

At frame twenty he’s at three twenty two.

(toward table two) Oh, sorry. Frame twenty is three twenty two.

It’s three twenty two?

I thought you said frame ten.

Me too.

I don’t know why, I was like zoned into frame ten.

I don’t know. Is he betting like, is he gonna be like it’s going two hundred miles per hour, or two hundred ten meters per second? Or…?
Magda Probably
Romina Between eighty and a hundred fifty
Jeff That’s like saying????????? One point or fifty points.
Romina (inaudible)
Jeff Between eighty centimeters per second and a hundred and fifty? They double.
0:11:16 Magda I just say we present our number ten. This is what you should pick, because this is how we got it. dadadada.
Jeff And make the wrong decision.
Romina …make it.
Jeff I wouldn’t pick it.
Romina Yeah. I have the same problem as…, because I’m actually that inaccurate.
Jeff Just say, uh…
Magda That’s what they got.
Jeff Six hundred pi.
Romina What?
Brian Due to lack of…
Magda That what they got
Romina They got what?
Magda That’s their numbers.
Brian Due to lack of advanced equipment…
Magda Are you sick?
Romina I understand you Magda. I just don’t care. I just, I don’t know.
Magda Ashley! What did you get for frame ten?
Ashley … one sixty nine.
Magda We got a hundred sixty.
0:12:29 R7 Romina, I’d like to ask you a question if I may?
Romina Yeah. Go ahead.
What calculation are you going to give to R10? What, what’s going, what velocity do you think the cat moves in frame ten?

(turns page in notebook) Hold on this is frame two the first one?

Yeah, frame ten.

Ok, so that is frame ten. Gonna give him eighty. But I’m thinkin’ we’ll gonna tell him he shouldn’t bet on it though.

Give him eighty, but that he shouldn’t bet on it.

I think. Because our numbers are too unaccurate (her word). It’s not like we have a solid like…. you know?

When you say eighty, what are you saying?

Eighty centimeters per second.

Eighty centimeters per second. Then why are you unsure, because you say your calculations don’t balance?

Yeah they weren’t accurate at all. And we don’t have, like all we pretty much have two different philosophies.

When you say you all pretty much, you all here at the table?

No. People across the street from us.

What was theirs?

One point five.

Hold on, what was what was that?

I could swear they got one forty one.

What was theirs?

(Two conversations begin. The First conversation is between Brian, Jeff, and Ankur)

(taking Brian’s calculator) Cross any off point five?

Do two ninety divided by two. No but I’m using the numbers that…

(Small conversation, largely ignored by Jeff)

(to Jeff) Don’t do like one ten plus thirty five. (Jeff put the calculator back in front of Brian. Brian looks at the
Brian (at the same time as AP)  Now listen.  We averaged them out. Nine to ten and ten to eleven, and we averaged it out.

Ankur That’s what they did. That’s how they got their number.

Brian That’s what I’m saying.

(The Second conversation is between Romina, Magda, and R7)

R7 (inaudible under Brian’s conversation)

Romina We can’t. It’s not like we can give them anything. I don’t know, the only thing is

Magda They used from frame ten on. Because that’s where the jump is.

Romina We didn’t have like. We have the speed in between frames. It’s not like we had the speed at a frame. I don’t know.

R7 So maybe you need to say that to them.

Romina Yeah. (R7 says something to low to hear over Brian) What?

R7 I said maybe you need to say that to them, and say what you mean by it.

(Resume one conversation)

Romina I think that’s our best bet

Brian Because the speed from nine to ten doesn’t mean he’s still going at that speed in frame ten.

Romina You take the average like they did?

Brian Yeah, yeah.

Ankur Yeah, but if you take the average…,

Romina It’s not like…

Ankur That’s not the speed in frame ten.

Romina Nothing, you’re not taking like acceleration, into consideration, like deceleration. You just kinda go.

Ankur Of course he’s going faster afterwards from ten to eleven, he’s taking off there, or whatever.

Romina Hold on, what was their speed what did they get?
Ankur (sounds like) One eight one.
Romina And they got one…?
Brian forty five.
Romina So they’re accurate. (indicating table with Matt)
Jeff What’d they get?
Brian They got one forty five.
Ankur Also?
Brian They didn’t get nothing, anything (indicating Mike’s table).
Romina Hold on. Ashley, what’s your, what’s your speed at frame ten?
Ashley One sixty nine point three five.
Romina We have one forty six nine eighty.
Ashley What do you have? Romina what do you have?
Romina How we go…, the same way we got all the other ones. (Ashley comes over and takes Romina’s head and tells her how nice her hair looks. A little conversation about hair happens here)
Romina We got eighty centimeters per second.
Magda How did you get like such big numbers?
Brian Or we could just say one forty one point one two nine.
Magda How did you get that?
Romina He took the…
Jeff Averaged them out.
Romina That (flipping pages in Brian’s binder) and that and averaged them out. I don’t think you can average them, is a very good idea.
Brian It wouldn’t, it wouldn’t work.
Jeff I just think we take one forty five and run on it…
Romina Well you know you could be right.
Jeff I know.
Romina Very unlikely but…(Small talk)

Magda How did they figure it out? Those numbers out. Why am I like spinning…

Romina I don’t know, but all I want to do is drink water.

Magda Jeff, want to go find out what they like calculated it?

Romina (To Matt’s table) Shell, Shell, for your frame um ten, you guys taking the average?

Shelley Yeah, from the ninth to the tenth and the tenth to the eleventh and we averaged it.

Romina What’d you get like…?

Jeff Pretty good shape man.

Magda That would make sense.

Ankur I was gonna, I don’t know

Romina What did you get from nine to ten? (Shelley hands Romina their calculations) Let’s see. For see, at nine ten, they got sixty four, and we got eighty. So that’s the close you know?

Magda Uh huh.

Romina And at eleven they had two hundred twenty five, and we have two hundred and one, which is (makes a wagging side to side motion with her head)

Magda Yeah they, then they averaged it.

Romina But the average, I don’t think is right. Why would you average something?

Magda To find the average speed at frame ten I guess?

Brian Just say, say he’s increasing at a constant speed, from there, I mean…

Romina At some point in frame ten he has to wait to get to ninety (giggles)?

Brian No alright. I’m about to say something…, but uh. I don’t know, I’m trying to say something but it won’t come out… if the increase between this and this is that great, he’s really gotta kinda start moving, to travel the distance that he’s traveling, he’s gotta be going that fast to cover that ground…, it might be pointless apple, but…, there’s something working up in my head. (Jeff gets Brian into a conversation about a ‘hot’ girl)

Romina (handing Shelley back her paper) Shell.
286

192  Magda  But you do average it.
193  Romina  Why did you get the average of them?
194  Shelley  Because we weren’t sure if we had the average (inaudible) or we were just getting the average at that frame. So we just figured at that if we did it that way from…
195  Romina  You honestly think that’s what it is in ten?
196  Shelley  That’s what our answer is.
197  Victor  That’s what we honestly think it is. Because that’s the instantaneous velocity that we figured out right? And that’s what I think he wants. At frame ten. Well versus the other, it would have been like the average velocity (rest is inaudible)
198  Magda  But if you do it from like frame nine to eleven, you get a hundred sixty nine…, So, so what we did we can stay right there (putting her calculator down on the transparency)
199  Brian  Do you want to ask…,
200  Romina  I just don’t think averages… (yawning). I don’t know… (Ankur says something inaudible and soft) I wouldn’t bet on an average.
201  Magda  What?
202  Romina  I wouldn’t bet on the average. (Small talk.)
203  0:20:10 Jeff  I’m not getting chewed out because you guys want to walk away.
204  Romina  Uhhhh, you could do that. Present how we got from frame, frame ten, frame twenty. Give them the average that we don’t think…
205  0:20:26 Jeff  I just, I don’t think, that…, I definitely don’t think the average is right.
206  Romina  Neither do I. I don’t even think we should write (inaudible) it’s not really our idea any way.
207  Jeff  It isn’t. Has nothing to do with us. Try and everybody get close to one of theirs.
208  Brian  One forty one? Right?
209  Jeff  Right
210  Brian  Right
211  Jeff  (To R4 who is standing behind him) Are we gonna have the answer to this? How fast the cat is actually
moving in frame ten?

212  Brian  No. Never.

213  Jeff  I mean, I think that after spending three days we should find out the actual answer. I mean that sounds fair.

214  R4  Sounds fair.

215  Brian  If you could do that that would be great. I mean after three days I thought we beat the sea shell problem to death. We’re working on four with this thing.

216  R4  Four is kind of short.

217  Jeff  Yeah. This, this hasn’t been long.

218  R4  Besides if you’ve got to go you’d been out of here.

219  Brian  We need a reward. Somebody said we needed a bonus the other day. I mean this should be part of it…

220  Jeff  That was this morning.

221  R4  I’ve got a question for you. Umm, did, are, did you, did you look at these two possibilities?

222  Jeff  Yes

223  R4  Were there any connection? What did you think about that one?

224  Jeff  Uhh, we just thought they shouldn’t, shouldn’t bet on it. And uh the reason being that we just, we were, first of all it goes back to the beginning when we first got the problem. We were using our eyes to kind of judge how we were measuring it. We didn’t even really know how to measure it.

225  R4  Yeah.

226  Jeff  And that could throw off your numbers in the first place. And I mean that could start right there, I mean, a couple I mean if it’s off by a very little amount, it’s not gonna screw you up that bad. But we were, we were we already started off on the wrong foot. And then we really throughout the whole thing we didn’t know what we were doing. I mean we were just trying to, trying to get something together. You know, make a graph or do something here.

227  R4  Uh, huh.

228  Jeff  We got involved with other things that really didn’t have that much to do with his actual speed. Just you know looking at all different stuff, and we never
really…, I don’t know, I just don’t think we ever got to an answer where we actually sat down and said, well you know that’s definitely the right answer.

Romina  You have to look at it like proportionally too. And that in itself is hard, because like, you have to, you keep, each block is five centimeters but like it’s so, so hard to measure the cat’s nose, so it’s not gonna narrow it down to the accurate

R4      So you’re losing some accuracy

Romina  Yeah

R4      In the measurements.

Romina  Yeah the whole thing is inaccurate.

Jeff    We’re just, I don’t know…

0:22:56 R4  The whole thing is inaccurate.

Romina  This is, right this is what we did. Yeah, it looks about like it moved a tenth of a block.

R4      Uh, huh

Romina  We can’t, who wants to bet on that?

R4      Oh. So there’s some, still some, some serious uncertainties.

Romina  I wouldn’t, I wouldn’t put money on it.

R4      So, ok, so your report may be interesting.

Jeff    On top of it. If your gonna bet, if I was gonna say that they’re moving, I’m gonna bet on something he’s got a one infinite number chance to get this right. This guy’s got every other number, ever except that one that it could be. I mean who would, why would you take that bet? That’s ridiculous.

Brian  Smart Man

0:23:35 Jeff  It’s like terrible odds against you.

Victor  So. What’s the verdict here? Did you…

Romina  We’re not gambling on it.

R4      They’re just, they’re just thinking

Brian  We’re not gonna bet because, crappy odds. What do you guys got?
Romina … gamblers over here.

Victor We just got the same information that we shared yesterday. We’re thinking about, we told them that he can gamble on this um, on the information that we have but we will not be held responsible for any monetary losses. (Laughter and Victor walks away.)

Magda So you want to write up what we got?

Romina So in other words, Romina you want to write it up, what we got?

Jeff It’s a good idea Magda. Keep up the good work.

Brian Let’s let Magda write. Magda hasn’t…

Magda Well Brian, because you did a lot.

Brian I’m a genius.

Romina Ok,

Magda Write that this is frame eleven and ten…,

Romina Frame nine and ten or ten and eleven?

Magda Both of them

Romina Ok

Magda Then we say, we can say this is how we got, and we don’t know if we should average blah, blah, blah.

Romina (Romina writes in her journal) Distance is point five.

Magda It’s two point five.

Romina You’re right, its right there. Umm, then time? Write time?

Magda Point oh three one seconds.

Romina And then, frame…, (still writing, comparing or looking up work from her notes. Brian and Jeff are in meaningless conversation and it is getting Romina’s attention from time to time. She looks up while they are talking)

Magda You writing the one between nine, ten and eleven? (long pause) How about if we do the distance between nine and eleven?

Romina Yeah but that’s so…, don’t you think that’s a lot too though?

Magda Sure because if you do between nine and eleven that’s
how much his stride for those frames, so if he has to go through frame ten...

271 Romina But from that point that’s where his big acceleration goes.

272 Magda Yeah, so like...

273 Romina I, I honestly, in frame ten I don’t think he moved one velocity.

274 Magda Umm, he moved two boxes. (picking up a calculator) Two so that’s ten. Divided by point oh six two.

275 Romina Yeah, but that’s an average though. Not like something he’s moving…, I mean…, I wouldn’t have him bet on it. Do you want, you want to write that down? I don’t know…, I would. (R7 approaches the table) We have, we’re gonna present them what we did.

276 R7 Uh, huh.

277 Romina We’re still trying to figure out whether we’re gonna have like an average in it.

278 R7 What do you mean?

279 Romina Like the average from frame nine to eleven.

280 R7 Uh, huh.

281 Romina Like divide the two frames by point six whatever. But I don’t know. I don’t know.

282 R7 What are you trying to do?

283 Romina To find like the distance at, the speed at ten. Because he’s like in between frames, not on the frames. I don’t really…

284 0:29:12 Magda I don’t think we have the right speed at frame ten. We have the speed in between frames, but we don’t have a speed for frame ten.

285 Romina I think at frame ten he’s like jumping, he’s accelerating its probably not even the right speed. That’s what, I don’t know.

286 R7 What, what do you guys, what do the others think?

287 Jeff (Romina chuckles) Why you laughin’ at us?

288 Romina What do you guys think?

289 Brian We shouldn’t bet.

290 Romina What do you think about the average…
Brian: Ahh, I kind of like the average. I've got a little inkling of hope. But uh...

Jeff: You can’t rely on just the average.

Brian: Yeah.

Jeff: I don’t think it’s right.

Brian: Just a shot in the dark…,

Jeff: What did you just say?

Brian: You guys are bettin’ men. I’m not a bettin’ man. (Small talk and mumbling)

Romina: Should we go with the average or not? Hello, fellas…, Jeff, Brian, do you guys think we should go with the average?

Jeff: No I don’t think that’s right.

Romina: So, we…

Brian: We give them three options. We tell him to try to extend the bet to three numbers, I just spit. Give him all three numbers say, bet all three of these.

Jeff: But we don’t know if any of the three are right.

Brian: Yeah

Jeff: Are you putting the average in?

Brian: If we think, if we think…

Magda: (inaudible)

Jeff: It has nothing to do with us, we didn’t come up with it or anything.

Brian: If we think, if we think these numbers are off the average is gonna be off too, so what’s the point?

Jeff: We might as well throw it in, heck. (Small talk about lists of things to do.)

Romina: So is this all we’ve done today?

Magda: (sounds like) Shetla frame ten, twenty.

Romina: Oh yeah. Romina starts writing in her notes again while Jeff is singing)

Romina: Maybe we can have a bet on nineteen twenty. Since we… (Off topic conversations, Jeff whistles a lot)

R4: Ok, so, where are you all?
Romina: What?

R4: You, are you ready to do?

Romina: Alright.

R4: I you’re gonna, if you’re ready to do to convince the CEO to take the right step.

Romina: Yeah

Jeff: The right step is not, is away from gambling, because gambling is a bad thing…

Brian: It’s a Demon.

Jeff: And people lose like eight hundred dollars and stuff. (chuckling)

Brian: That’s cool. Sometimes I like, I feel bad like I laugh at things like that. (More small talk.)

0:38:26 R7: (looking over Brian’s shoulder at Romina’s work) Oh, oh, you did something else.

Jeff: You missed it man!

R7: Oh, oh nineteen to twenty, and twenty…,

Romina: I think like that one it’s ok to bet on (indicating the bottom half of the paper), like that one is a little easier to bet on than that one (indicating the top half of the paper). But I still wouldn’t bet on it.

R7: Why because just the numbers are the same?

Romina: Yeah, because the numbers are the same so the chances frame twenty, frame twenty is probably around twenty percent.

R7: Uh, huh. Uh, huh. You guys didn’t like the average of these.

Brian: No

Romina: No

R7: You say why?

Brian: Because we aren’t confident about these numbers (pointing to the top half of the page on the right by the word “speed’)

R7: Uh, huh.

0:39:00 Brian: If we averaged them in…,

Ankur: They get farther from what it actually is from the average.

292
So…

Suppose you were confident.

I still wouldn’t go for the average.

I would like, I would like it. That’s just my opinion. I would like it.

Did you say why you would?

I was trying to explain it before like…,

They’re not talking about average in the whole problem, I mean why would you average out to get the answer? I just don’t see…

It’s, it’s going out on a limb, saying, because if the cat’s supposedly through the whole thing moving at a constant speed, like it’s stretch, it’s galloped… From there to here like (indicating the calculations for frame 9-10 to 10-11 on the sheet), I don’t know what I’m trying to say is but if he’s increasing at the same amount the whole time he’s gotta be – I don’t know what I’m trying to say.

Me neither.

You don’t understand what I’m trying to say like, if he’s moving at a constant speed like, like every increment his speeds gonna be the same going up to try to reach two oh one.

Uh, huh.

And, ahhhh man! I don’t know, forget it.

I don’t think you can have the average speed though because like in every problem we ever do like you never average speed because it always comes out to like thirty miles per hour, but it doesn’t go thirty miles per hour. You know what I’m saying? Like, it’s always like they’re moving like they’re always accelerating..I, I don’t think you can average speed.

But just say, just say, I’m going thirty on the Parkway,

uh, huh

And like we pass one exit, I’m doing thirty. And two exits down I’m doing sixty. Wouldn’t it kinda suggest that at the middle exit I would be doing forty five? If I’m just…
Magda: No you could have sped up and like…

Jeff: That’s, that’s a stupid assumption right there.

Brian: Think though. Like…

Romina: I know because you’re probably going like, you could have been going sixty at that one.

Brian: So say, I’m standing still and then at the second exit I’m doing thirty. That means I must have floored it from the beginning or something, or it’s possible that…

Magda: Yeah but you didn’t have a like a speed, you had like increasing speeds.

Romina: Yeah, yeah.

Magda: You didn’t have one speed throughout the like…

Brian: You know if I just keep pressing down on the gas, kinda like like this (making a gesture with his hand indicating a slow pressure on a gas pedal) I’m gonna be increasing at the same time per…

Jeff: My question is, the, if the gas is like accelerator, how could you put on the gas and stay the same speed? If it’s making you accelerate?

Brian: No, I mean just slowly go down, like (another hand gesture imitating the pressure on a gas petal)

Jeff: No, oh, yeah but, totally different question.

Ankur: If you let go, you start slowing down.

Jeff: I know but if you push you go faster, so how do you keep the same speed?

Brian: You keep it at the same spot.

Jeff: But isn’t it still making you accelerate?

Magda: No

Jeff: If you, if you, it’s not, if you just touch it a little bit, you’re not gonna go, gonna go…

Brian: That’s like initial speed though.

Romina: Can’t ask Ashley, she’s a bad driver.

Ankur: …You don’t have to hit the gas as much.

Jeff: Once you hit your speed dude.

Ankur: You can barely track and keep going. (Brian turns
conversation to overdrive on the parkway saving gas.)

0:43:47  R7  So what was the result of that discussion you had?

Brian  That brakes don’t have to be old to squeak (chuckling)

R7  You guys, yeah Brian was saying something about (at the same time Romina is speaking)…

Romina  Um, the one he wasn’t going at, um

Brian  They just shot me down.

Romina  Yeah we just shot down his average speed and such.

R7  …but then he said something about, you said something about uh (looking at his pad), if you’re going thirty miles an hour at one exit, two exits later you’re at sixty; so you were arguing that at some point you had to have been going at forty five?

Brian  Yeah.

Magda  Yeah but…

Romina  You can’t determine what point that is.

R7  They don’t agree with that.

Brian  No

Romina  We agree that at some point he had to be going forty five.

Brian  All I’m trying to say is, if I’m, pushed down on an accelerator at a constant, like, at a certain, like, at a certain rate, if I keep pushing down on the accelerator, I’ll hit that exit and I’m at forty five miles an hour. You know if I’m increasing like one mile per, one mile per hour per like two hundred feet or something, you know…

Jeff  You set it all up, you’re going to-in it you can do that. If there’s a mile, if there’s an exit every mile you can set it up where you’re increasing one mile per hour every certain amount of feet. I mean you could set it up enough but…

Romina  I don’t think he can.

Jeff  …you doing it by yourself is not going to be able to do it. Definitely a cat running, nobody is going to be able to do that. (about his donut) I just spilled some powder on the table…

Romina  We shot down his average theory. That’s what we did.
R7: How so? I, I, I didn’t quite understand how.

Brian: I, I’m still hangin’ in there, I’m just not gonna say nothin’.

Romina: Because we just said how like he couldn’t actually have been doing forty five. Like he could have, but then on the other hand he could have like sped up like right after the first exit and done sixty all the way down. And just kinda stayed at sixty. He could have…

Brian: Isn’t this one where like he’s getting ready to jump though?

Romina: Uh, huh.

Brian: Are you telling me in mid jump he’s going really slow at the beginning and as he’s landing he’s speeding up?

Magda: Yeah! Isn’t he like, that’s how he accelerates?

Romina: Isn’t that why he’s jumping?

Brian: But, alright. He’s like, he’s like, he’s like this. (Getting up and making a hand gesture. The gesture is of a flat hand making an arching motion, slowly at first then fast at the end) He’s like this. Doesn’t mean he’s gonna be in the air like this (slow portion), and then go like this (faster portion). You know, he’s gonna be, he’s gonna be like this (hand gesture made at the same speed all the way).

Romina: He’s gonna be, he’s gonna be like this and then slow down. (making a hand gesture in an arching direction, slowing as it reaches the top and faster after the peak slapping the table at the end) He’s gonna be really fast in the beginning because he’s jumping, but then once he hits the ground, then he stops.

Brian: Maybe he’s going the same speed the whole way, then he hits the ground? Which is the whole frame? Or the next couple of frames?

Romina: No because you like kinda coast in the air.

Brian: Alright then. Think about this then.

Romina: Air resistance.

Brian: He doesn’t land, he doesn’t land for a couple frames. Big jump when he first starts.

Jeff: You know we went long distance running once? (mumbling about running distance while he eats a donut)
Brian I don’t know. I don’t even feel like talking about this. Because this is always like the situations where I like get really pissed off, and then you know… So I’m just gonna stay quiet. (More small talk about interviews. R1 comes to the table)

R1 0:48:20 All set?

Romina Yup.

Brian Ten more minutes

R1 Ten more minutes?

Jeff Deadline is ten thirty.

R1 Let, let me say a few words. I, we have a ten thirty deadline, and I’m, I’m a little concerned. I have a message from the business office. I noticed that there were some inquiries about um, getting paid. As I talked to the business office about that, apparently there’s a form you need to sign on Monday. When you sign that form, everything’s ready to get processed. And uh you should, then a check will be sent to your home. Ok, for all your hard work on the project. That’s the way it works in the University. Work is completed and then your checks are, are, are mailed right from business office to your home. These forms have to be filled out, and that’s Monday’s, that’s Monday’s business here. Among other things, but in response to the inquiry there is some other business here Monday too, we’ll talk about that maybe later. But I’m really concerned because uh, my job is on the line. Mr. R10 wants a report at ten thirty. And he put me in charge of this project. And you’re all the uh wonderful consultant staff that has been working to help me on this. So I, I uh like to hear. I don’t know what’s going on. I’ve been called from meeting to meeting and I’ve been really sort of distanced from what you’ve been doing this morning. And I’m sort of on…, What am I going to tell him? Well, should he, should a wager be made or not? What kind of advice? You, somebody fill me in before you fill him in, before he gets here? Is there anything you can help me with?

Victor We could read you our statements…

R1 Why don’t you tell me what the problem is exactly? Because I’m not even so sure I understand what, what the issue is here.
Victor: You need to make a wager on what the speed is at frame ten, and what the speed is at the twentieth frame as well. Bet we, after we did our calculations we…

R1: Well hold on a minute Victor, the exact speed? How accurate?

Victor: How accurate? Well…

R1: To the nearest tenth? Hundredth? Thousandth? Millionth?

Choral: We don’t know.

R1: We put this uh, we put this over the decimal.

Matt: Mr. R10 expects like…

R1: Yeah but he sent a memo

Matt: I know. Yeah but if he wants results he’s got to specify what he wants.

R1: Well he’s gonna make his wager or not make his wager and he’s, you know, how right does he have to be? You know we have to advise him.

Victor: Now when you look into our statement you will understand. We wrote ‘we believe that this will be the best position to take on the cat’s motion. However we believe that this will be an approximation rather than an exact answer. We will not be held responsible for any monetary losses.

R1: You may not get your checks on Monday. (laughter) That’s this whole group’s position? (some laughter and disparate answers within the group) I mean he has to make a decision and he’s gonna say ‘you’re not responsible for the data you’re giving him to make a wager or not?’

Matt: He never told me he was making a wager…

R1: I know, I just found this out.

Victor: He never gave us specifications you see.

R1: These CEO’s do strange things, you know. They keep their businesses moving and successful. (many are speaking at once making transcription impossible) You’re gonna tell him he’s not a good CEO…

Matt: See, see, see, this is what we came up with ok? And if he’s gonna bet, we’re gonna just say look, this is what we came up with. This is our data, but if he wants to
bet with it, we don’t know anything about it.

R1 You’ve got to advise him to do it or not. My, my real, bottom line, just tell me before he comes. This is bottom line stuff. Are you gonna advise him to bet or not? You’ve got to talk about these things.

Jeff We’re gonna advise him not to bet.

R1 You’re gonna advise him not to. Oh.

Romina … is an approximation, so…

R1 What do you mean? How approximate Romina?

Romina Like, our measurements aren’t real measurements. We kinda just looked at it and guessed and then like, and we had, we didn’t have, we only had…

R1 You don’t want him to bet do we…

Romina No, we only have like distance, we only have really like the last two in between frames. I don’t have the last, like that particular frame. And like, we’re having like arguments about whether we should average them or not so… don’t bet, you’re gonna lose money.

Jeff Yeah.

R1 Are there any conditions of betting?

Matt No

R1 Hold on, hold on a minute though. Mike. Michael. Go ahead Michael talk.

Mike How are they going to determine the right answer any way? You can’t.

R1 Why can’t you? You mean there’s no right answer? We don’t know…

Mike There is, there is a right answer. You’d have to be sitting there at the time this thing was taken with like one of them radar guns…

R1 Louder Mike, I’m sorry I can’t hear you.

Mike We don’t have a radar gun or something to measure the cat when it was taken I mean… Because I guess what we’re doing is what anyone else would do. And that’s what we’re getting. So this is the rightest your going to get here. At most, closest you are going to get.

R1 You guys, you guys have confidence in your, in your um recommendations?
Mike Not really.

Matt We don’t know what it’s supposed to be. He gave us...

R1 You don’t know how, you don’t know how fast the cat is running in frame ten and frame twenty without any kind of sort of even interval of accuracy? That you could be confident in?

Matt …that the way we been figuring it out...

R1 What have you been doing all these days?

Victor We’ve been doing our own specifications.

R1 Talk more about that victor.

Victor Well, what we did was, uh we came with uh a first answer of…, our first answer was a hundred forty five…

R1 hundred forty…

Victor …point one six one centimeters per second. So when we figure out, we just kept it logically in our heads we figured three places over to the right of the decimal, so...

R1 Why did you go to three places? You were measuring to three places?

Victor No, we were just, you know just, kind of three places, you know. I mean there were no specifications given to us so, so we kinda had to go with the flow of things.

R1 Now that you have to think about how confident you are on whatever accuracy you’re reporting don’t you have to talk about that…, I better let you take about three more minutes before he shows up. Maybe he’ll be late, fortunately if he is. Let me just give you a few more minutes. Can you, do you, think about this because I mean you know he could take a hard line here. Anything else from this table (Mike’s table)? You didn’t think so Michael, I heard Jeff say he didn’t think so…

Romina How much money is he betting?

R1 I’m going to ask him.

Romina He’s a CEO he could handle it.

R1 He could, he could be betting all of your paychecks as far as I know. You never know what Mr. R10’s gonna to do. Ok, probably stall him a couple of minutes.
Romina: We don’t need stalling. I’m good with what we have.
Jeff: You’re what?
Romina: I’m good with what we have. I’m just…
Jeff: Yeah we’re good, hey we’re cool.
Romina: I just don’t know what else they want.
Magda: Just gotta say an average won’t do it because he’s not…
Romina: I know and I don’t think anyone has the…, no one has the speed for frame ten, they only have the betweens.
Magda: No they have the, they have the average
Romina: Yeah, they have the average speed they don’t have the speed in frame ten.
Ankur: Ours the speed in frame ten?
Romina: What?
Ankur: Ours the speed in frame ten?
Romina: No. Ours is not. Ours is the speed between nine and ten and ten and eleven.
Jeff: (to Brian) That’s a nifty little trick you got there with your hands over your eyes.
Brian: My eyes are open right now everybody.
Romina: So why are your hands above your eyes?
Brian: Because my head’s too heavy. (Magda leaves her chair. R1 sits in it a few seconds later.)
R1: Um, I guess you and Jeff are gonna get call backs for interviews on Monday so we really need you here. Ok? By, by, by the Harvard folks, Ok, so will you do it? I would say if you don’t want to…
Jeff: The camera’s on at the moment…
R1: …if you don’t want to drive really all the way down one of the graduate students could pick you up.
Romina: I guess not. I’ll drive, I’ll drive back down.
Jeff: Alright.
R1: You sure you’re…
Jeff: You’re gonna drive back Monday morning.
R1: It’s gonna be, traffic’s gonna be horrible.

Jeff: Yeah, but Monday morning you’re gonna drive up here?

Romina: Yeah.

Jeff: Alright. Then I’m not gonna drive down tonight. I’m gonna get a ride. I’ll just, you can drive me back Monday morning then?

Romina: If you’re comfortable with who I might be driving with.

Jeff: I’m good. I could get a rest. It’ll save me, then I won’t have to drive down tonight. I can get a ride down tonight, and a ride back.

R1: You make sure you both come back. We need you both.

Jeff: I’ll be here…

R1: Alright

Jeff: With bells on.

R1: Ok

Jeff: Is that how the saying goes, with bells on? (More conversation about Monday’s travel.)

R1: Think about, think about the accuracy of your measurements in terms of how they really make sense in the final report. In other words if you’re going to three decimal places here, do we believe three decimal places?

Romina: We didn’t believe the starting numbers. So the decimal places doesn’t much make a difference.

R1: Did you look at the pictures of the cat? Did you look at how the body moved? How the body kinds of signals, did you look at that?

Jeff: We didn’t look at that.

R1: I think you all have a cat.

Romina: I hate cats.

R1: I have two.

Jeff: Aren’t they great? I’ve got a fat, a nice fat one. He just hangs out and he eats and sleeps and like goes outside and…

R1: This is not a Romina task Jeff, I like cats too. This is not a Romina task. Watch very carefully the body
parts. The different parts of the body and see what you notice at those different frames. (CM hands the at pictures to Jeff) Watch that carefully, only cat people can be sensitive to that. Ok? Maybe, do you have cats? Brian do you have a cat?

Brian I could cook some up. It’s uh cuisine. From domestic to farm animal like that the cat...(laughter) (R1 leaves and conversation goes back to driving to the shore. Camera moves to R1 at table 3. Audio is still table 1. Magda returns.)

If I can have your attention for a minute

Brian Oh, this is new.

R8 Yes. Mr. R10 told me he won’t be able to make it today. Like all CEO’s he doesn’t show up when he’s supposed to. So, I’ve been sent in his uh place to find out uh what you have decided for him. And uh because I don’t want to be held totally responsible just like you don’t want to, I’m gonna ask some other people to listen with me so that if we make the wrong choice I don’t get blamed. So uh, if uh Janet you could help me, and uh, chuck if you could help me, Bob perhaps, uh to listen to what they are saying so that uh, if I report the wrong thing it’s not my fault it’s your fault? Ok? Alright. So uh, what I like to know, I was told that he’d made a bet. And uh, he uh, doesn’t like to uh go back on his bets. But he’s not confident about this bet. And uh the only problem is he doesn’t have numbers for the bet but he assured this person that, that he can tell this person how fast the cat is going. And he’s willing to put money on it. (Romina raises her hand) And he’s going to look at how fast, should he tell him how fast? Or should the bet be, what would you like the bet to be Victor?

Victor If I was, no…

R8 Oh, you made something up for me. Oh, ok. Would you like to put that up? (conversation around Victor’s table) Alright, we’re going to have this group go first.

R8 How much money did he bet?

R8 Oh he didn’t tell that to me. (Victor is in the front putting groups work on the board)

Victor Ok. Now what we believe is that you can actually tell the velocity of the cat at frame ten and twenty, but uh we don’t necessarily know how accurate our numbers are, because everything we had to do we kind of like
eyeballed our measurements and um this is not a real life scale so we um can’t really get as accurate as we want. So what we did was, we used the basic physical formula of one half the initial velocity. On half times the quantity of the initial velocity plus the final velocity, and velocity is determined by distance over time. So we have one half the distance from frame nine to ten, that’s our initial velocity. And the change was in distance was two over the change in time from frame to frame which was point zero three one. Plus our change from frame ten to eleven which was seven over point zero three one. Now these are approximations and not really too exact or anything like that. And we have um a velocity of about one forty five point one six one centimeters per second. And umm give or take twenty centimeters per second due to inaccurate measuring. For frame twenty…,

526  R8  What does that mean? Give or take twenty centimeters?
527  Victor  Plus or minus.
528  R8  So how big could it be, around? What does that mean?
529  Victor  It could range from something, so actually it could range from something like one twenty five point one six one centimeters per second to, it could be between that and in between one sixty five point one six one centimeters per second, within that range. Give or take.
530  R8  That’s not very close.
531  Victor  Huh?
532  R8  Not very close then.
533  Victor  Not very close because, because we don’t have um a life model, so we can’t get real, real accurate.
534  R8  That’s a real cat, isn’t it?
535  Victor  It’s a real no, no, no, we got the pictures but we don’t have a, we have to scale everything. And when you’re scaling stuff and doing proportions your kinda introducing more error to, you can’t get accurate, real accurate. You’re introducing more error so that’s what we did…
536  1:12:30  Angela  What it was like if we were one centimeter off and it made like such a huge difference, it was like sixteen centimeters per second for the whole final velocity that we were off. If like the two was a one or if the two
was a three it stopped.

305

537 R8 One centimeter where?

538 Angela Um like see where the two is? If we were, if he had moved one centimeter instead of two…

539 R8 This two right here (pointing to the transparency).

540 Angela …or in the beginning or if seven instead of eight, or we used three instead of two. You know if we were one centimeter off it made sixteen, like it was a difference of sixteen.

541 Victor Right is measured by distance.

542 R8 So you changed a number.

543 Victor Right.

544 R8 To one?

545 1:13:08 Victor No, no, no. What we’re saying is, let’s say when we measured our distance, if we were like off by a centimeter right? Which could happen. Give or take. Then we would have been off by about six..., in our velocity, we would have been off by sixteen cent, uh, centimeters per second.

546 R8 Can you show me, I don’t understand how you did that with the numbers.

547 Victor Ok.

548 R8 Where did the sixteen come from?

549 Victor Right, right, right. Ok. Here we go. Um, let me move this for a...(removes the transparency and replaces it with the TI projector and displays a graph) All right. Um, our distance we had was two, was two right?

550 R8 Uh, huh

551 Victor Then when we found out the velocity which was distance over time, we got sixty four point five one six one. But let’s say we were off by a centimeter in our distance, so three divided by our time..., see we were off by that much (pointing to calculator which was displayed on the screen). By thirty two or something like that.

552 1:14:19 R8 That’s thirty two you said sixteen.

553 Victor Right

554 Angela But in the final, like if you plugged in that number into
the equation instead of like sixty four point five one six one, the whole answer gets thrown off by sixteen. Your final answer.

Victor Right.

R8 Not thirty two.

Victor No because um

Angela Because you’re dividing and adding another zero.

Victor Because you’re dividing and you change by a half. So that’s where the thirty two divided by a half is sixteen.

R8 Now what happens if the other measurements off too? They’re both off?

Victor Uhh, seven divided by point zero three one? You got that. And then let’s see we went eight divided by... so got two fifty eight point zero six five, plus um, ninety six point seven seven four two. And divide that by two. Right well, there you go, we would a still would have been off by thirty two. But that’s like only one of the measurements. We said sixteen that’s in case one of the measurements was off. Just one of them. But if they were both of it would be by approximately thirty two centimeters per second.

R8 What if he’s gonna bet? Then he’s gonna have a, can he attach this condition do you think?

Victor Can he attach this condition?

R8 Can somebody accept that bet for him?

Victor Well, the bet was can he actually tell? (removing the Ti projector and replacing the transparency) The um, could he actually tell? The um velocity, now you could tell the velocity but then you would have to have, you would have to say well can I, do I, accurate? Approximate? I mean, what would you like? And if the person is saying no you really can’t tell the velocity, but if you explain the rationale to them, your numbers wouldn’t rest, necessarily be very important. But anyway. So those are the speeds that we have. We have one forty five point one six one centimeters per second for frame ten approximately. And for frame twenty we have about three hundred fifty four point eight three nine centimeters per second. And if you kind of look at the picture you see that about frame twenty, he’s really taking off at almost twice or twice, two, twice the speed when uh, because he’s springing
forward from the gallop. So he’s actually using more
energy to spring forward, so you can actually see the
change of speed being that drastic from frame ten to
twenty, so… But in the end we believe that this is the
best position to take on the cat’s motion. And however
we believe that our approximation rather than an exact
answer. We will not be held responsible for any
monetary losses. We are confident that in the way we
approached the problem uh, using the formulas.
However we did not measure the distances very
accurately because again, as you said we had the
proportion of man, we kinda had the view and then
make a decision of approximately what it looked like.
We were eyeballing the distances, being that each
square on the grid was about five centimeters. And
um, we will not have, we do not suggest that he make
the wager, er, because gambling is illegally and
morally wrong. So there you go (taking the
transparency). We’re done, any ques-, oh, oh hold up
(putting the transparency back), any questions? Any
questions anybody?

566 1:17:56 Romina Yeah, I have a question.

567 Victor Right. I kind of guessed that you would.

568 Romina When you say you take the average, right? But you
say you start at frame ten with the two, it’s not the
velocity. Whatever that two divided by point oh three
one is.

569 Victor Right.

570 Romina And you end frame ten with seven divided by point oh
three one. That’s a really big jump. How do you take
the average, where do you, I’m saying is that right in
the middle of frame ten? And that’s the speed it’s
going?

571 Victor Right, right here? (pointing to transparency) Exactly,
because um from frame nine and ten it’s moving two
cent, the change from nine to ten is about two
centimeters. And from uhhh, ten to eleven, which is
the next frame over, it’s um seven centimeters. That’s
just because of the movement the cat did.

572 Romina So in frame ten though he’s going like…

573 Victor half way, something like umm…

574 Romina In frame ten he’s changing speeds so he’s going, he
starts, in frame ten he has to be somewhere he like…
Victor: He has to be like way in the middle like..

Romina: eighty to (coughing)centimeters per second to like two hundred centimeters per second. What with, when we divided our numbers.

Victor: Right.

Romina: So that’s like a big gap. Like, how do you can’t, I don’t know, why did you take an average on that. You don’t know exactly where he’s taking the … like I can understand like in the second one the average is a little bit more like realistic. Like you could bet on that one. But the first one, like he could, anywhere, like where would you, how do you decide where you…, understand where you measure.

Victor: Like where do our measurements come from? Well, what we decided was to measure on the nose, and we just decided well to uh, from frame uh nine and ten the nose was this far moved over, uh two centimeters. I mean that’s just like what we looked at and said ok this seems about right.

Romina: Yeah, that I agree with I do understand. Like, how, you can’t bet on that number because he’s going so many different speeds in that one frame? You understand what I’m saying?

Matt: Yeah, we can’t bet on it.

Victor: That’s why we try to take an average, you know. A guessed average. I mean that’s why we said that it wasn’t really, really accurate. Especially since the frames before that he was like doing all these other things. So, but the second one we’re a little more..

Romina: Yes

Matt: We weren’t recommending that one. I wouldn’t bet on it.

Victor: Sure, I don’t know. (taking the transparency) No more questions? Ok then, I guess we’re done.

R8: Recommendation? Sounds to me like your recommendation was uh don’t bet. Right?

Victor: Right don’t bet. I mean well it depends on what the actual question is. Is he saying that he can tell…

R8: Can you tell me what the question is and we’ll answer it. Go ahead.

Victor: Well, well we are not being specified on. We, there’s no real specifics on what the question is.

R8: Alright.
Victor Can you tell what the speed or velocity is at frame ten or frame twenty? Yes you can, but how accurate does he have to be uh then if he says well you have to be as accurate as possible well you still have to specify well I want it as close as to the…

Jeff I imagine…

Victor …three places over.

Jeff It’s no decimal, no decimal. Just like you’re saying uh, if we were in a car you wouldn’t be figuring out sixty point five miles per hour. It would be either, you’re going sixty miles per hour or you’re going sixty one miles per hour. I think in this case you’re either running uh a hundred fifty centimeters uh a second or per second…

Victor Right

Jeff …or a hundred fifty one.

Victor Right. But you can’t tell this velocity, I mean you can’t tell the velocity of what the cat is going but how exact do you have to be, if you have to be real exact then I tell her not to wager, but if just…

Jeff Well if you just had to be to the second, would you tell him to bet?

Victor If it had to be to the second

Jeff You think he’s gonna land in there on the three or the whatever the number it is?

Victor No, not really. We, when you have to be exact, I don’t think you should um bet on it but if it was just a tub (?), yeah you can explain to him, well this is how you do it I mean uh physics and all these other proven theorems to work and you know you would tell him ‘ok here we go’. But if he was saying well give me an accurate number then no.

R8 Ok. How about this group over here? Why don’t you show me what you would do? (indicating the table with Mike and Ashley) Mike and Sherly go to the screen) (Sherly puts their work on the overhead)

Sherly Ok, um  what we did was, um because originally we measured from the cat’s nose or whatever, but we took a point in the body that’s like doesn’t really move that much. So we took the point from the nose and the point from the base of the tail and we averaged it together for frames nine ten and eleven. And then he found the distance, the difference between the
distances and he got the velocity by dividing by the
time, and he got, he averaged those two together. And
he got the average speed. Basically for frames ten and
twenty. But they’re not accurate so.., we don’t
recommend him betting.

604 Mike Don’t bet.
605 R8 That’s it? Don’t bet? But We already bet. You just
didn’t…
606 Mike Don’t use my answers.
607 R8 We need a commitment here.
608 Mike No you said he..
609 Jeff Well then couldn’t he bet like ten bucks?
610 Mike Change the wager?
611 Jeff Well is there a wager down or not already? Did they
pick one out?
612 Romina I don’t think that’s a big issue.
613 Mike It is a big issue.
614 R8 He’s not gonna divulge to me how much he bets.
615 Victor He already bet right, so he can’t really go too much
back on the bet. I mean the question really of the bet is
can he actually tell the speed? I mean they’re not
really asking for any specific numbers, I mean, being
that that’s the uh the bet that you can tell, can or can
you not tell the speed, of the cat at frame ten and
twenty then yes you can bet. I mean there’s, he can
safely bet and that would be the argument.
616 R8 Could you write up the numbers that they had?
617 Mike Like the thing is we don’t actually…
618 R8 I want to see the difference between the numbers.
619 Mike Big difference.
620 Sherly What numbers did they have?
621 R8 I don’t know, can you tell her what numbers you had?
622 1:24:08 Victor We had uh…
623 R8 Where the one sixty nine is could you write in a
different color? (Matt brings up their transparency)
Matt: Put it up right here… (laying the transparency over Sherly’s)

Victor: Thing is we’re different. They measured a different position. Right? We measured at somewhere…, you measured the back right?

Mike: We we took like in the center of the body which probably be more, a little, little more accurate right? (Sherly is writing on the transparency)

Victor: The back needs to be straight too. (There is a lot of conversation about where the measurements were taken. Most voices are spoken over other voices.)

Mike: The base of the tail…, The base of the tail…

Victor: Oh, the base of the tail.

Mike: And the nose, and in the center wherever that was. It’s probably in the center of the body somewhere.

Victor: They measured with like in the middle of the back.

R8: So how do you choose where you’re gonna measure it from?

Victor: Well that’s all up to you.

Mike: This is what we choose, we thought it was a little more, thought it was a little more steady. (putting the cat photo’s on the screen) Alright see we took the, took the tip of the nose. Base of the tail, found the center wherever that was and that was the point we used.

R8: Tip of the nose, base of the tail…

Mike: And we used that. Thought it, wasn’t movin’ much, wouldn’t move around as much. Let’s say the head moved a little bit, it won’t be affected by half of whatever the head moved.

Matt: But even with that though, like see how the….

Victor: My question is, right here (pointing to the seventeenth frame) it’s frame seventeen. You mean, see how his back is not as elongated as over here (indicating frame twenty one)

Mike: Still I mean the center, still gonna be the center of the body. Whether, whether you take it from here, here or here to here, it’s all gonna be in the center. You know. I mean, you know what I’m saying how his head could move?

Victor: Right
Mike Sure his head could move, the middle of the body doesn’t really move too much. You know.

Victor Yeah, yeah, ok. I see what you’re saying.

R8 So yours is more accurate than theirs.

Mike I don’t, I’m not saying it’s more accurate.

Sherly (At the same time as Mike - previous) We’re just saying that’s what we got.

Mike I said that’s why the different numbers. And since all three groups did this and got three different answers. I’d say, don’t bet. Because if we all got the same number – like one forty nine point something go for it. But if we’re one sixty, you got eighty or something, and one forty just don’t bet.

Romina Yeah, we all had the same process but like…

R8 How could you all have the same process and get eighty?

Romina …(talking at the same time) I eyeballed it, I don’t know if they used a ruler…

Mike Yeah, and alright. I did this for seven eight nine eight nine and ten.

R6 Did you use a ruler or did you (inaudible)?

Mike No I took this, I measured with a ruler and I found exactly where the half is, it’s not an eyeballing, it’s exactly where the half is alright? If this was thirty two millimeters, I went sixteen over (pointing at frame 8 on the board). And I took the base of that (pointing to the cats hind in frame 10) and that to whatever the center was on that. And eleven (continuing to make the same hand motions without commentary – base of the tail, nose, center of body)

R6 With a ruler.

Mike With a ruler all three times. And I found where that point was a middle (pointing to the cat in frame nine) moved. I did the same for the, the these three.

R6 You measured the distance.

Mike Measured. Not eyeballed it, measured.

R6 Victor you did not.

Victor We kinda looked at it. Eyeballed it.
R6: You went nose to nose.

Victor: Right. Nose to nose.

R6: Ok.

Mike: I don’t know what to make of this. But I just say don’t bet.

R8: Alright, let’s hear what the, this group has to say. Because, I I want to see where this eighty came from. It bothers me a lot that we’re so far off.

Brian: I’ll give you emotional support.

R8: He won’t be happy with me when I tell them this.

Romina: Ok, like what we did is we started off with like measuring with a ruler and like where the um cat’s nose moved. But then we, that wasn’t working for us because the measurements were getting too small. So then we kinda eyeballed it and we said from nine to ten he moved about half a box, so that’s two point five centimeters. And we divided that by point oh three one and came up to eighty. So…

R8: You used the nose.

Romina: Yeah.

R8: And what did you get, nine to ten?

Mike: Two.

R8: Two.

Mike: That that’s why we put that little error thing…

Romina: And it’s just like point five of a centimeter, but really, and then we were off.

Victor: Right, right, but what we did was that um once we got the frame from nine to ten, and ten to eleven we added those up and then divided by a half.

Romina: Yeah, see we didn’t, like for this one we didn’t, we didn’t, we were gonna take the average, but we didn’t think it was right because our numbers go from eighty to two hundred. That’s like a big difference so to take an average like I wouldn’t, we, I, we just said we wouldn’t bet on an average.

Angela: Frame ten is right in the middle of those two, so its gonna be the average.

Romina: Yeah, but in frame ten he’s going from eighty to two
hundred, like there’s a lot going on in frame ten. I just don’t think you should bet on frame ten. Frame ten is too like (holding her hands up palm out waving them)... Frame ten, too much is going on in frame ten, like, like because if you’re going like technical the guy could be like ‘well I meant at the beginning of frame ten what the speed was’. Or the guy could say at the end of frame ten. But for frame nineteen through twenty if I measured, if we got our measurements right, then those stay the same. So I will bet...

678 1:29:10 Mike I mean, you take a look, her, the nose does actually move half a box but the center of the body moves a whole box. So like, I don’t know what points you should use on the...

679 Milin The body gets bigger.

680 Mike Well this is the center of the body. It’s gonna stay, if the body gets bigger (Milin starts to speak), listen, If the body gets bigger that means the nose, the head is gonna move out farther but the center is still gonna stay in the same place.

681 Milin Maybe you got the wrong center, the center could be different. (Possibly two different speakers)

682 Mike If you stretch something out the center’s gonna stay in the same place, but the ends are gonna be farther apart.

683 Milin Yeah, but that’s if you stretch it out like evenly. Like the legs could be stopping and the head could keep going.

684 Mike You still tellin’ me the head is the best place to take it? You’re telling me the head is the best place to take it.

685 Milin Whatever you want to hear.

686 Romina I think, I think he should put all his money on frame twenty, forget about frame ten.

687 R8 I’ve got an idea. What, what did you get on frame twenty?

688 1:29:52 Romina Well see from frame uhh, nineteen through twenty we have distances ten

689 Matt Three fifty four.

690 R8 Three what?

691 Matt Three fifty four.

692 Victor (Matt and Victor are speaking at the same time) That’s if we were off by one centimeter…

693 R8 What are your distances?
Victor …remember we said that for one centimeter we would be off by thirty two?

Matt Eleven, eleven.

Victor That’s it, we’re off by thirty two right there with them.

R8 Eleven, eleven, not ten and ten.

Matt That’s cause the distance…

Romina Well if we can get our measurements right, like if we all like worked together and we like really measured it we, like ten, like at twenty would be like, you could bet on that one because that one, if we could get our measurement accurate enough, or if we had like…

Magda Yeah, but they had like four hundred

Matt How about we take, we gotta give him a number. I say we gotta give him a number. Here’s what we do. Take all three measurements from all three groups, take ‘em, put ‘em together, average them, come up with a number for him.

Romina That eighty’s gonna kill you huh?

Mike Eighty’s gonna kill us…

Matt It’s still better than one group giving them eighty, one group giving a hundred…

Romina Well we can bet from eighty to two hundred then.

Milin Yeah, somewhere that big.

Matt It’s not even the eighty though. If you would take those two and average them that’s a hundred and forty which is…, we have a hundred and forty five, what is, what does your group have?

Mike and Sherly One sixty nine

Matt So I mean it’s not

Victor We got a hundred thirty two like you guys

Matt So I mean it’s not, it’s not gonna be that much of a difference.

Milin See that’s the range right there, between those two numbers. And we can pick the middle.

Angela If they’re so, like the beginning of frame ten, or end of frame ten, frame ten is like an instant. Right in the middle of those two numbers.
Romina But some, but he has to go up that much in frame ten.

Victor Well, if he says something like…

Romina That’s the only reason, that’s just our…, why we didn’t average it.

Angela Frame ten is an exact instant.

Romina If it goes up that much, where’s your exact instant? Like…

Jeff Even if it’s in the middle then have to…

Angela In the center of those two measurements.

R8 I’m looking at the bottom here, um how come on the on nine and ten and ten and eleven, how come these numbers are so different?

Matt Uhh

R8 And these are…

Matt Because the distance between them are so different.

Shelley That’s where the, that’s where the cat is changing speed.

Romina Where

Shelley Frame ten is basically where he’s going from a walk into…

R8 How do you know that?

1:32:02 Shelley He changes, you can see in the pictures…

R8 Does somebody have the pictures that we can look at? (Romina takes the group work off of the overhead and replaces it with cat photo’s)

Victor We actually did the experiment yesterday on a larger scale.

R8 Right

Victor And we walked it, we walked it and then we kind of thought also that at frame ten or something like that, we had to change our speed drastically because we had to…

R8 Which one’s ten, this one? (pointing to the overhead)

Romina Yeah

Victor … Open up our strides. So we kinda…
(Speaking over Victor) That doesn’t look like it’s moving to me, it looks like it’s playing with a mouse or something.

He’s moving forward right there.

But the thing is that his head moves, that’s where you take the measurement at.

Like you can see just look at the back leg, that’s where, he’s like walking. And that like from nine to eleven, this right here, this is where his legs are coming together and he’s pushing off. So that’s where he accelerates the most.

So he’s not actually moving though.

No, he is. That’s his first initial like push.

He, he took it from, he took it from the head and the head looked like it moved. It was tucked in on nine and on eleven it looks a little longer. From where I’m standing.

So if I take it from the head, and I, and I do this, I’m moving. Right?

If you go like this (bobbing his head) for them it’s moving…

So what are you saying, he’s not moving?

I’m saying if the center of the body, if the whole body moves, then that means the whole cat’s moving. I mean, if I shake my head a little bit…

So you’re taking the center of the body from the head.

From the head and the tail, but it’ll be…

So if the head moves then the center of the body moves..

Yeah but not, if the head moves one cent, uh one centimeter, you’re, you’re gonna, you’re gonna say one centimeter and I’m gonna be a half, if it’s off. I’m gonna be one centimeter off. If it moves by itself one centimeter, I’m only gonna be…

What if the tail’s off too?

The base of the tail. It doesn’t have, the base of the tail doesn’t really move, you know. The tail moves.

So instead of saying base of the tail

But I’m telling you the head is probably the, tail and the head, the tip of each is probably the parts that move the most except for the legs on the cat. If you’re gonna
base your measurements on those then...

R8 So if you tell me, tell me what, what’s the difference again between ten and twenty then.

Romina In twenty like even when we graphed it, you could see around frame twenty like (looking for frame twenty on the transparency), where’s twenty, like this one. Here, we graphed it and like you could see like there’s a lot of change. Here he’s constant (indicating the top row) and there’s a lot of change like in this row right here (indicating second row), but after that he’s kinda like, he’s at a, he’s going at a constant rate.

R8 A constant rate.

Romina Yeah, he’s not changing it, his velocity isn’t changing like drastically in these frames (waving her hand over the lower two rows of frames).

R8 So if I had to bet on ten or twenty. Which one would you choose Milin?

Romina Twenty.

R8 Why?

Milin It’s more constant.

Mike What did all three groups come up with?

Romina Similar numbers

R8 But you didn’t come up with the same number though…

Mike Not the same.

R8 If it’s so constant how come we can’t come up with a good answer?

Romina That’s only because our…

R8 (Talking over Romina)That’s the measurement?

Romina Yeah

Unknown That’s just from measurement.

Romina Yeah, we can get like, if we can all agree on one measurement, then they, he should just take, or maybe he should take his own number.

Jeff That’s, that’s what I’m saying, if he comes in, and Mr. R10 comes in and measured it,

Romina We tell him…
Jeff would all give him the same answer. If he came in and told us the distances, we’d all give him the same exact answer for how fast he’s going. That’d probably be the best way to go because then he’s completely in control of his own destiny, you know? We’ll do all the work for him, he’s just gotta pick where he wants us to measure from.

R8 Alright. Ok

Romina Good.

R8 Questions from anybody else in the room?

R5 I’m really worried, because my job is on the line here… And then, I don’t like the repercussions that are gonna happen if we, if we can’t give him a solid recommendation from all three groups. Because we’ve gotta come to some consensus right?

Romina Not to bet.

R5 And it’s not to bet? Ok, then we feel we’ve provided a reasonable justification about why not to bet? Ok, so can somebody summarize that for us? Because we’re gonna have to take it to him about why not to bet.

Brian There’s three groups of smart kids, and we all got different answers because we all measured from different place, like different little things there and since there’s not a whole lot of measurements, you know there’s not a whole lot of area, just a little difference in measurement will throw you off. So since we’re all measuring from kinda different spots and getting different answers. That’d be a good reason for him not to bet.

R5 So, I’m you know, I know the CEO fairly well and I’ve been in meetings with him before, man he gets furious if I come in and say ‘well I didn’t measure it…’

Victor He should make better specifications.

R5 So, say that again. What should he do?

Victor Well he should go back to the person he made the wager with and say ‘Well what are we measuring? The head? Or what do you, where are we…you know?’

Jeff That’s not, that’s not the other guys problem. He just wants to know the speed at that ten and twenty.
Victor Exactly.

Jeff The other guys holding all the cards here. He’s you know like I said before, Mr. R10’s picking one number out of an infinite amount of numbers. And this, you know, this guy’s all the other numbers so he only has one out of all of them, that’s you know those aren’t good odds. In the first place. And so I mean if he, if he wanted to come back as you said before and he picked where he wanted us to measure from and he told us this is what he wanted, I think then we can give him an answer and we tell him to bet. On that, we’d all probably get very close to the same answer, if not the same answer.

R5 Uh, huh. Ok, so you’re telling me don’t go to him and say, if I go to him and say you guys couldn’t get your act together in terms of measuring correctly, because you know, you measured eleven you measured ten, you measured you know like, agreed to not measure. If I go to him and say ‘well sorry boss but your research team’s just…’. He’s, he’s gonna, that’s not work. Right? So, if I go to him and I say ‘well we can’t come up with a specific number’, and I I really am a little worried about telling him this because you couldn’t agree on the numbers, and I really don’t want to say to him, ‘well boss if you’d a told me what you wanted exactly…’ so, I guess I’m just not getting exactly what it is you want me to tell him. Can somebody else help me?

Romina We’re also not sure about the average though like… And we, our group does agree that we should take the average from in between nine and ten, and ten and eleven.

R5 Ok, so one group says don’t take the average…

Romina And those groups say you should take the average.

R5 And you’re saying don’t take the average because…

Romina It’s not accurate.

Ankur There’s so much happening in that one frame, the cat went from stopping to basically starting…

Romina Look, but this is what we were saying, you’re going from, there’s exit nine ten eleven on the parkway, this is how we thought about it,

R5 Ok
At exit nine you’re going thirty miles per hour. At exit eleven you are going sixty. How fast were you going at exit ten? You don’t know, you could have sped up like, you could have been going sixty there, you could have been going, you could still be going thirty.

Did everybody hear that?

That’s like how like we argued with.

Exits are point oh three one seconds apart then you really don’t have much room for you know…

Yeah, but it’s also a cat, not a car.

How fast can you chase…, It’s not easy to do.

You ever try to chase a cat?

That’s a very small amount of time. If you think you could change speed five different times and then

It’s just like, for the cat like a step. Like when you push off to step, you’re accelerating to get to a speed. That’s what, at that frame is where he pushes off to accelerate. That’s his instant, that’s his like burst of power. He just goes boom and that’s his step.

Are you agreeing with them that you can’t take an average, or are you going with your group that you can take an average?

I don’t even know. I’m just saying that, you know, I don’t. I really don’t think that you can honestly say what his speed’s gonna be. Because you don’t know, like they said there’s too much going on in that frame where you can’t tell what he’s doing. Or not, you know?

I feel the same way too, you can’t really get the exact, I thought you were siding with them saying you can’t take the average. I was just wondering where your position was.

Yeah, I don’t know, you can’t really just get an exact number. You can’t get an exact, you can’t tell an exact number because there’s just too much going on in that frame.

So when can you take an average?

Like, where, at frame twenty where the numbers are so close, I mean you have the exact, most of us have the exact same numbers. So if you have the exact same numbers, the exact same distances, it’s a constant speed. So, if you can take that, and take the average of
that and come up with your speed from there, that’s a good number. If we all get the same distance from that we can give him that number and he could probably bet on that number. But in frame ten, I mean, it’s worthless. It’s not worth betting on, because you’re gonna lose money.

815 R8 So what, what do you assume, on frame ten, what did you assume when you took an average then? Because Romina said something here that if you think about what she said there might be something we could learn from it. She said you’re going, what did you say thirty miles an hour on exit nine..

816 Romina Uh huh.

817 R8 Sixty miles an hour on exit eleven. And she wants to know how fast you were going at exit ten.

818 1:41:10 Victor Forty five approximately.

819 R8 Approximately?

820 Milin Depends on acceleration, if you accelerate constantly you’d be going forty five.

821 Matt You don’t know that though. You could speed up to sixty five, hit traffic…

822 Jeff You could even went thirty miles an hour until like, like..

823 Romina Right after exit ten….

824 Jeff Yeah. And then you could have stopped then. You could even like slowed down, it could have stopped. He could have got off exit ten. And stop. And stop.

825 R8 Depends.

826 Jeff It depends. If you don’t know enough, you don’t know enough…

827 R8 What does it depend on?

828 Jeff You don’t know what happened between. If you know what happened between, you have a better shot at telling it. But since we don’t know what happened between anything could have happened.

829 R8 Now what did you say Milin?

830 Milin I’m sayin’, I say if the cat accelerated constantly, which I’m pretty sure it didn’t, then you could average it.

831 Jeff Yeah, well yeah. That’s like…
I don’t think it would so…

We can’t average that. The second, the second one at twenty you can average out. But that first one at frame ten you can’t do it.

Matt We can’t average that. The second, the second one at twenty you can average out. But that first one at frame ten you can’t do it.

Tell me a little more about what you meant by, you don’t know what happened in between.

Any, if you got a car driving thirty miles per hour at exit nine, and he was going sixty at exit eleven. You know, and you don’t know what happened right after he passed exit nine and right before he got to exit eleven. He could have slowed down, he could have sped up and slowed down to get sixty. He coulda, he coulda sped up to a hundred twenty miles per hour for exit, you know for that exit ten and slowed down to get sixty for that. I mean all you know is the beginning and the end. You have no clue what he did in between. And just because you know the beginning and the end you can’t average them out because he was going thirty went up to ninety, drove ninety til right before then slowed down to sixty. And if you averaged all that out, it’s not gonna be…

The average speed at nine.

Yeah. So you don’t, you don’t know what happened. You don’t know how quick he got there. I mean, if we knew how fast it took him to get between ten and eleven that could help us out too. Then we could average it I think. If we knew the length of time it took to get from nine to eleven, but we don’t even know that. We just know that he passed….

We do the cat we know that.

Well I’m not talking about the cat.

Well…

And but, I know but it’s, but it’s a car too and, and you’re using like an animal or machine are different things.

But there are some similarities here you’re saying in terms of how you’re, you’re viewing the difficulty.

(Softly) We don’t know if he’s accelerating I think.
Jeff (To R4) Yeah

R4 What might, what might you do, what might you need to know, in order to to say a little more clearly what was happening at exit what was it exit ten?

Jeff Yeah, I think…

Romina Is he…

Magda Was he accelerating at a constant speed?

Jeff That’s what I rather instead of like still frames I’d like a movie of him driving like in between the two places. Or if we had a cat, if we watched a cat walk through this I think that would even be a little better. Both together would help out a lot. Because you need the stills to actually start from a point and you know to actually pick out you know and stop and then know the difference between the frames that we think for the time and everything. But I think that it’s just too hard to tell with just the still pictures. I think there’s a lot of discrepancies and a lot of different things and…

R8 Isn’t that how they make movies from the still frames?

Jeff Yeah.

Romina We don’t know enough about that to comment.

R8 You ever make a little book, you make the little pictures in there and then you flip the pages and then you’re little…,

Romina That doesn’t a cartoon…

R8 You ever do that at home? So like if we took these and fanned them you think that would show you?

Jeff I don’t know, that could, that could work.

R8 That be smooth do you think?

Jeff I don’t know how he’s, I don’t know how, I don’t know how he’d look.

Brian First it would be like this, and the next think it’d be like here

Jeff Yeah but I mean the difference between, I think, yeah…

Ankur Yeah but we’re just gonna look at it.

Jeff Yeah, what are we gonna do once we get it?
Ankur Can’t measure anything
R4 So to measure you’d need the stills right?
Jeff I’m really confused.
Romina Why don’t we just ask Mr. R10?
Jeff Well you know, since the CEO is here now.
Romina Decided to stop by.
R10 Well, Oh my gosh.
Jeff We could have you tell us where you like to measure from on the cat and we can give you an answer.
R10 Every time I walk by, keep walking by and there’s um, I just been stepping in and out, and there seems to be always someone asking somebody about frame ten. So what’s this, what’s this whole…
Romina We’re just saying that you shouldn’t bet on frame ten. Do you disagree or not?
R10 I don’t even know what’s happening at frame ten.
Mike We don’t know either. (laughter)
R10 But some, some things happening that makes everybody pay attention to it I guess.
Jeff That’s what you’re betting on.
R4 You’re betting on frame ten.
R10 Your betting, what am I, what do I win?
Romina You’re the main guy here.
Jeff You’re the CEO.
R10 Sometimes this is, sometimes people send out memo’s from me with my name on it.
1:46:00 Jeff This memo (handing R10 the memo)…
R10 I’m one of those CEO’s that delegates everything. What was my, what was my original plan?
Jeff You bet, well here’s the thing. This, where’s the cat?
R10 Oh, there are questions about the cat’s motion. Ok.
Jeff Do you have the cat picture?
Romina No, this is what the problem is. We don’t, we can’t
take measurements at exact frames, so we took between frames…

890 Jeff (while Romina’s talking) Here’s the actual problem (handing R10 the page with the problem written on it)

891 Romina …and in between nine and ten the cat like, for our, our particular group, the cat starts off at eighty centimeters per second. But in between frames ten and eleven, the cat’s going two hundred centimeters per second. And you want to know what speed he’s going at, in frame ten. And we decided there’s too much going on there.

892 R10 In, in frame ten?

893 1:47:03 Romina At frame ten.

894 Ankur (simultaneously with Romina) At frame ten, what speed he is traveling

895 Jeff At that point.

896 R10 At that frame ten. So what am I gonna bet on.

897 Jeff You’re gonna bet on, you’re gonna bet on…

898 Romina You’re gonna give that guy a number.

899 Jeff you’re gonna say that he’s going….

900 R10 Oh, oh, oh.

901 Jeff Thirty miles per hour at frame ten.

902 R10 There’s a particular number…

903 Jeff Yeah, yeah.

904 R10 Because you don’t think the number for

905 Romina Frame ten and twenty

906 R10 You don’t think the number for, the number you gave me eighty or two hundred is right. Is that, is that what you’re saying?

907 Romina No, eighty is in between nine and ten (choral with Jeff), and two hundred is in between ten and eleven. You want it at ten.

908 R10 What do you mean by in between?

909 Romina Between the two frames.

910 R10 During, from, stuff you can’t see? You mean, or…
Brian
Like from nine to ten. (Magda is off screen to the right apparently pointing to things on the paper to help R10).

Magda
This is frame ten.

R10
That’s frame.

Magda
Ten.

R10
That’s frame nine, frame ten?

Magda
Uh, huh.

Romina
Yeah, we measured like the nose here and the nose there …

R10
Speed

Romina
We just did how far the cat moved here to here and divided by point oh three one.

Victor
We just made a point right here. Angela would you please repeat what you told us again?

1:48:00 Angela
What I’m saying is like if you can only take an average when something is constant, like the acceleration or whatever. Why do people take the average of your grades as your actual, your actual grade? It, it’s just like the point right in the middle, it doesn’t matter if like you know the whole thing is constant or not.

Jeff
Aren’t the grades like your average? That’s what it’s called, the average. That’s what it is.

Angela
Right that’s what I’m saying you take an average on something that’s not constant.

Jeff
You’re not asking for the average speed, it’s asking for the speed.

Milin
He’s looking for ‘the speed’ not average speed.

Jeff
And when you give your grades you ask for the average of all your grades.

R8
So what’s the difference between ‘the’ speed and average speed?

Jeff
Don’t you think the CEO should be mad for sending out memo’s with his name on it? Behind his back and everything. You guys should be worried about getting fired.

R10
I didn’t know this until I got to work this morning.

Jeff
Yeah, I mean...

Ankur
That means you guys aren’t getting fired.
So when do you know ‘the speed’, do you ever know ‘the speed’? Driving the car, driving the car, when do you know ‘the speed’?

In that frame, in frame twenty.

No, in the car.

In the car you know ‘the speed’ by ‘the speedometer’.

Oh, that’s what you mean by ‘the speed’?

Yeah, the actual speed you’re going. So, in frame twenty when you have moving the same distance from one frame to the other, so you have two frames and you’re moving the same distance. That means there is a constant there. A constant speed you’re going, between those two frames. There’s some, there may not be, there might have been something happening there but there’s a safer bet than that knowing that you moved the same distance, than knowing that you moved from two to seven. Having that big change. I mean, I’m not saying that there was no change between those two frames that the distance is the same. But there’s a safer bet in having that where there’s a same, where there’s a constant, than having a two different, two totally different numbers that are way off.

You’re still not sure what happened between nineteen and twenty.

But it’s a lot safer bet than what happened between nine and ten and ten and eleven.

What if I told you that there was a frame that we forgot to put in. Maybe there’s, maybe there’s like a frame nine and a half. Would that help you at all?

Yeah.

Yeah, but we’d just be making another average. We’d be doing the same thing over again.

Would it still be an average?

Yeah it would.

How do you get, because you said ‘the speed’, how do you get ‘the speed’? Because you know, people talk about ‘the speed’. You know, fastball I was watching baseball, the guys throwing ninety three miles an hour. Is that the speed, or is it not the speed.

They put a radar on it.
Romina: But don’t they take the speed at the end, like when it passes the batter?

Victor: It’s always faster at the initial point where the ball is released than when they, at the end when the catcher catches it. So…

Romina: So he’s throwing a lot, you can’t get an average speed, you get a speed…

Victor: You can still get an average speed in baseball. And like when you’re ah, when you’re racing down the highway… (Many talking at once.)

Romina: They take the speed when it, when the ball passes by the batter. They want to know when like, how fast the pitch is like when the batter’s gonna hit it.

R8: Somebody explain to me how that works. How do they do speed in baseball? I mean, what do they use to measure it?

Jeff: Point a gun at it…

R8: A radar gun?

Jeff: Yeah.

R8: How’s that work?

Romina: I don’t know.

R8: What is that Robert?

Robert: Doesn’t it send a beam or something?

Jeff: See how fast the balls going across this…

Milin: How cops catch how fast you’re going on the highway.

R8: How does radar, how does the radar gun work?

Brian: Didn’t we talk about this in class, how long it would take for the beam to come back or something like that?

Robert: Doesn’t it shoot a beam and like it comes back and takes how long to figure it out…

Mike: More than, more than one beam. The first beam gives you the initial distance, and the second the final and it will tell you the difference. Same thing that we’re doing like. Finds an average.

R8: So Robert says it shoots a beam, it comes back and you find the time it took to go. And you’re saying it shoots more than one beam. So I don’t really know how it works, that’s the problem I have here but… You’re saying that’s ‘the speed’. But because the cat we said
we can’t find ‘the speed’. I’m trying to find what ‘the speed’ means. That’s what I’m trying to figure out.

Brian You’re asking the wrong people.

R4 R8, I think the chairman would like to, like to have a final word here then...

R10 Well you know, like I said… I’ll, I’ll, I’ll take responsibility for the memo now. I guess I just want to know, should I, I made this bet and said I could tell the person the speed in frame ten. Ok. Or in frame twenty, you know. One or the other. I either want, if I can get either one than I’ll go with it. But I want to know, what I need to know, I need to go back to that meeting and I want to know should I call off the bet? I have just a few more minutes just to call off the bet…

Choral response from students Call it off.

R10 Well I need, I’d like to be convinced about why I should call it off. I could make some money here. So if I should really call it off…

Romina We’d like to know how much money is involved.

Brian But all of us telling you that that we all have different answers and are unsure that they’re right, isn’t that enough for you? To call it off? I mean…

Matt We’re all taking averages, they’re all approximations, we don’t have exact measurements…

Brian Yeah we don’t have exact measurements.

Romina Yeah, our measurements are even off, right off the bat. We’re not doing good.

Jeff Just off.

R10 Well let me ask you this then. If I call off today’s bet alright, could you design another bet for me to make that I could…

Jeff Make the other way. Make the other bet. The guy’s giving you.

Brian See if he can get it…

Jeff Because I mean…

Matt See if he can figure it out for you.

R2 I got a question. On frame ten, it sounds to me. Now I’m just, this is just, hunches ok, but it sounds to me
like on frame ten you’re worried, you’re worried about losing. Alright? Is that fair?

1:54:00 Victor  Because that’s the most inaccurate frame that you have.

R2  What about frame twenty?

Romina  We’re pretty good. You know what we’re gonna do with frame twenty? (pointing at R10) You’re gonna give us the measurement, how far you think it moved. and then we can give you a speed. We’ll do the math for you, just give us a number.

R10  How far I think it moved? So I need to look at the…

Romina  Yeah, how far you think it moved from nineteen to twenty.

R10  So what do I have to do? Measure,

Romina  You could do whatever you like.

Jeff  Each of those lines in the back are five centimeters.

Romina  Yeah, each little square is, five centimeters. You gotta tell us how far you think it moved from nineteen to twenty. (R10 examines cat photos)

R10  Got a magnifying glass? Each of those what are what? How many?

Romina  Five centimeters.

R10  Each of those box is really five centimeters? In real life?

Magda  Yeah.

R10  Looks like it moved one centimeter.

Brian  One centimeter?

Romina  From nineteen to twenty?

R10  From nineteen to twenty?

Romina  Yeah.

R10  Looks like it moved a fifth of the, fifth of the box.

Romina  Are you sure, are you looking at the same boxes we’re looking at?

R10  From here to here. I’m looking at the head. Look at the nose,

Romina  It starts there (pointing to photos R10 is holding)
And……there. Oh am I skipping one?

Yeah, you see that’s…

Oh, oh, oh I got it. I’m alright now. One, two, three, four, five, six seven. And one, two, three, four, five, six seven, eight, nine. Ok. So I guess I then I’m saying he moved from six, like six point nine to nine? Is that what I’m saying? Or eight?

That’s up to you. You’re, you’re the one that’s telling us.

One, two, three, four, five, six

How many centimeters in all that, we’re worried about.

I’d say, let’s say it’s at six point nine from that, right. And another one, two, three, four, five, six seven, eight, nine. Well I’m saying it moved, it looks to me like it moved six point nine on the lines to nine. You’re saying each of the lines are worth five centimeters right?

Ok, so then…

Eleven

So, one point one lines, it looks to me.

(using the calculator) So then you’re gonna bet on three hundred fifty four point weight three nine centimeters per second. But you made your own measurement up we didn’t.

So, why should, why should I, why should I make this bet as opposed to the other one?

This one’s more constant.

This is from nineteen to twenty; this is from twenty to twenty one are the exact same distance. (Many conversations (brief))

Oh, so you’re saying if I did from twenty to twenty one, I’d also, I’d also measure, if I measure this I measure one point one boxes.

Uh, huh.

And that’s why I should be confident?

See if that works

Ok.
As one of your representatives I feel I need to bring to your attention. Before you make this momentous decision about…, different groups indeed came up with some different measurements. So not everyone agrees that it’s the same. We’re similar, we’re close. But that’s why you measured it. We’re real close to your measurements, but we wanted to know because people were measuring from different places. And they’re, like if you’re a centimeter off its like sixty meters of a second that you’re off. Or centimeters. So that’s why we wanted you to take… They measured from the nose, mikes group measured from the center of the body. I guess if I’m gonna make this, if I’m gonna call off this bet on on frame ten, I guess I need a reason to, like could you state a reason for me to make a bet? Like if the situation was such, I should make a bet. If the situation is not such, I should not. Could you make a…, Depends on the motion of the cat. Right, and then you have to add to that how accurate they want the measurements anyway. If the situation is such that the cat’s moving at a constant speed, meaning that there’s the same distance between frames, then you should make your bet. But if not, in the case of the, in case of frame ten, in frame nine to ten, frame ten to eleven, it jumped from two centimeters to seven centimeters. That’s a big difference, you don’t know what happened in between there. So in that case you don’t make a bet. You know I’m wondering. I put a lot of faith in the people who write memos for me so I want to turn that, turn this over to them a little bit. You might have a good reason, but I I’m playing with hunches and I want them to inform me too. Um, we were talking about frame ten and the big concern there
was worrying you was you might lose, right? Now in frame twenty so the hair on the back of my neck is sort of suggesting maybe this, is this pah..., is this possible that we’re suggesting a situation where if we advised him right he might stand to win?

1041  Brian  Yes.

1042  R2  Oh…

1043  Jeff  You know Mr. R10, after all the conversation we had about betting…

1044  R10  Can you tell me what he just said?

1045  Jeff  He just said that if you picked the point and, and what he hears from us is what he thinks he hears from us, that you can win if you take our advise on frame number twenty.

1046  R10  Is that what you heard him say?

1047  Ankur  I think that’s what I heard him say.

1048  Jeff  So I think that all the conversation we had about betting, you especially should not be getting involved in this.

1049  Brian  He’s right.

1050  R10  True, true. Or is that in general? Or is that about even, even with frame twenty would you say?

1051  Jeff  You have frame twenty. Isn’t any sure bet that we talked about before? (laughter)

1052  R10  I understand. Um, so but are you saying that twenty is also not a sure bet, despite these things?

1053  Romina  Twenty is a pretty sure bet.

1054  R10  See I could say the general statement throughout life, you shouldn’t make any bet because, and I probably would say that because you never know what’s gonna happen. But about this in particular?

1055  Jeff  This in particular I’d feel strong. I would, I would take the bet on twenty. If I, if I was you, I would, and with you picking the point on this that you want us to go from and everything. And this guy giving you the same point and everything, like he’s not going to come back and say well I measured from the tail. Because you don’t know, I mean, do you know what this guy wants from you, where you’re measuring from with this guy? I mean who is this guy?

1056  Victor  Does he even exist?
R4 I’m not privy to that information.

Jeff If we’re saying that, if we’re measuring from the same point that you gave us in that is the point you’re measuring in the bet, I would take this bet.

Romina How much money you betting?

Victor My whole thing is right, is that if you give us per say the measurements he wants us to measure from, they wouldn’t have us. I mean the equation that everybody is using in physics, you could have got it off a simple physics book right…, I got the measurements, I got my time what do I need, why am I paying you folk for? I mean we’re just here to analyze and study situations any way.

R10 Well am I getting the same advice from all my tables about this?

R1 I didn’t hear from this table, I don’t know what they’re really advising. I’m hearing a lot of conversations…

R10 (speaking over R1) I do like to listen to everybody.

R1 …there’s a lot of serious business going here. Have you studied the cat?

R10 Would you take that bet?

Mike I would take that. I would take three fifty something.

Matt But where are we measuring from, because you’re measuring from …

Mike I’m measuring from listen, listen, listen…

Jeff From the point that, from the point that’s going to be measured by the guy when you ah, when he goes to get the answer.

Mike Hold up. You guys measured from the nose right? And what did you get for the second one? Uh, three fifty four.

Mike Alright. Well I I made a mistake on the math, not the measurement on the thing, so…, we got, what was it?

Sherley Three fifty four…

Mike Three fifty four point something

Sherley Eight three.

Mike So even if we measured from the center of the body we got the same exact number you did.
Victor: Ok then so that’s uhh..

Jeff: Take the twenty bet.

Victor: OK then take twenty.

Jeff: Let me get it on for you (to R10).

R1: What are you going to take, three fifty four point five seven eight nine?

R10: Suppose it depended, let me take the money back out and throw it at you. Suppose it depended upon umm, you know what your uh GPA was going to be. And that you, your GPA would jump up you know like a whole point or something if you want or it would drop. Would you guys take that bet?

Romina: You wouldn’t bet something so risky like that.

Jeff: What? You go for it!

R10: Everybody is working on their own, so I just wanted…, something worth it to you. Forget the money. I don’t want to…, that’s how much money I would bet. (The room is talking about different GPA’s and SAT scores. Off topic.)

R1: For a million dollars Jeff, would you rather have the million dollars or those points?

Jeff: A million dollars? But see, I wouldn’t be able to cover a million dollars. I wouldn’t be able to handle it if I lost.

R4: Ok. Mr. Mr. R10 is still not quite satisfied although he seems to feel a real, a real sense of where the things moving. What he would like at this point is for each of you to put down on paper your analysis. You’re hearing so many voices, in so many different kinds of ways, its starting to lend… So you’ve got, you’ve got a good bit of time left so think about what you want to write.

Jeff: Ok, what if you know what you want to write? I mean we’ve been talking about it for the past…

R4: Ok, then write it.
(Students are writing in their notebooks and talking about Bette Midler as well what to take to the shore house. Once they finish writing in the journal they start making a “to do” list for the weekend. Talking about the Radar gun, and it’s relevance to the cat problem.)

Ok, some people are still writing some people are done. Let me just say one thing about Monday’s our last, our last day right? And uh I think what’s happening on Monday as I understand it, you’ll get the calculators, your calculators on Monday. We’ll do a couple things with that. And maybe there’s, if there’s a prize or two, I don’t know, what Dr. Maher’s got in mind. But uh, then, then that’ll be it. So I think we’re, we’re done, done today.
As you, as you are um exchanging information from one calculator to another, let me say that we have one more little task in mind. Now we had a choice here. We could either invent a whole new setting, for this task and then that would be another couple of days work or so, on your part, or we could build on something that we’ve already done. So we chose to do the latter. So that something could be done I think in a short, short period of time. So we have now a kind of a continuation or extension of the cat. You’re all very nice because nobody really jumped up, up out of their chair and uh, started, started toward me anyway. Um, so here’s, here’s the idea of the second task. And I think this is something that you could, you could actually do fairly quickly this morning. Let me read you what’s going to be passed out to you. What Janet is passing out to you here on a paper. And this is a, this is another problem with the cat. Not the problems we’ve been doing but another problem. This problem is stated in the following way. Another student working on the cat problem produced data regarding the velocities of the cat just like you did. This student made the following claim: If in addition to the time intervals, the only data I had on the cat were these velocities, I could still determine how far the cat moved between the first and twenty-fourth frames. And in fact I could tell you how far the cat moved between any two frames. What do you think of this claim? And how could you support your view? So I’m trusting that you have these velocities that you did last few times on your calculator. If not uh, you could construct them quickly. I know Mike knows how to do it. Right?
know how to do it. And I know Romina knows how to do it over here along with Jeff and Magda certainly. Because they’ve done it. So, so why don’t you uh work on this for a while? And let’s uh, let’s see, let’s take about a half an hour or so and see what you think. How about it?

4 R5 This is really quite short brief thing that we’re just going to finish in a half an hour and be done and move away from the cat.

5 Brian Are we gonna start a new problem today?

6 R5 Um, I think Dr. Maher has something that she wants to finish up with you. And then…

7 0:14:00 R4 It could be, it could be something neat like how many donuts could you eat in five minutes.

8 Brian If it’s something like that

9 Magda It’s a probability problem.

10 R5 I think that’s what she’s going to do.

11 Romina I can’t do probability. Probability is off limits.

12 Ankur Everything is off limits.

13 Romina Today it’s off limits.

14 R5 It has been so wonderful…

15 Romina Don’t ruin it! (laughter)

16 R5 …no, one of the things that has really impressed me is that I’ve watched you guys and the entire group is that you persevere. You don’t give up and you don’t quit, and that’s really an impressive quality. So… (Table goes briefly to small talk.)

17 0:15:20 Romina Couldn’t we divide…

18 Brian You can’t do it.

19 Magda I don’t think you can.

20 Romina Yeah you can.

21 Brian Cat doesn’t cat doesn’t travel at a constant rate.

22 Romina But you have the velocity at each time interval.

23 Jeff At every single time interval?
Ankur Like the velocities that we’ve got.

Romina If in the time intervals the only data I had were the cat, I had on the cat,

Magda Can’t you do it the backwards way?

Romina Yeah, like…

Magda Like take the speed and multiply it by the time…

Romina Take the speed.

Magda Here, where’s, where’s your data? (Brian and Jeff are loud) Can I see your data? (Aquisha joins the group) We got a problem.

Romina We got a problem?

Magda It’s same but it’s different. (to Aquisha) It’s your calculator, you have to open it.

Romina You want me to go into apps right?

Aquisha You guys all …your new calculator?

Magda Because you have to transfer all your data

(Brian and Jeff make other conversation difficult to hear. Audio is also low.)

Magda So what is it?

Romina I don’t have the velocities. Oh, yeah I do.

Romina Ten point oh three one, and then three times point oh three one and add em all up together.

Magda Yup you can do it.

Romina You can do four each, divided by point oh three one and then add them all together. Should we do it?

Magda Sure. Yeah

Romina You divide them I’ll write this down. Hold on, hold on. What day is this?

Magda You don’t even need to because it’s going to be the same so why…

Brian Today is the nineteenth.

Magda …divide. There’s no point. There’s no point. If the velocity’s forty, the distance is going to be one point two five because we are multiplying by point oh three one.

Romina Where are you getting one point two five at? That?
Oh, that’s the distance.

So we have a distance.

Yeah.

So I can just add up…

The way to do it is to take these speeds and multiply by that and you get the distance.

I hope we do this right. And what did we get, what, what’s our total here? One thirty one?

Uh, huh.

(To an approaching R7) We’re done.

Oh. Maybe you can tell me what you did?

We’ll keep you updated here.

Ok.

Our velocities, each of the indivi, individual velocities, multiply by point three one, point oh three one and we get a running distance. But we already did that.

If you take the velocity and multiply it by point three one?

Point oh three one. I’m having trouble. And then you get your velocities just add them all up and it’ll tell you how far the cat went.

Yeah, huh. So what’s it…, Show me one example.

Go Magda.

Now which velocity is this?

What? Ok, say, hold on. Let me clear everything. Say it again, the first interval?

First interval?

Yeah ,and the velocity, forty point three two times point oh three one and you get one point two four nine, which is one point two five distance. Then if you wanted the second one you just do the same thing and you add the previous one to find out the total distance traveled.

Uh, huh. Did you get what they were saying (to another Researcher)?

I was trying to write here so… what is the first thing you do?
Romina: That’s uh, our speed.

R9: What you got before. Then it’s time, and you get when you multiply them?

Romina: Distance he traveled at that time.

R9: Does it match up? With what you had?

Romina: Yup. That’s how we did it. How we did it before.

R7: You did it before. Another time.

Romina: Yeah we did it before with our uh velocities just to figure it out.

R7: Uh, huh. What was the problem that you had done before? It wasn’t here is what you were saying.

Romina: No it was in, it was last week we did it.

R7: Uh, huh

Romina: When we were um, what were we trying to do? I don’t know, I think it was when we were just adding them up I think. We did it, we did it that realized what we did.

R7: Oh, I see.

Romina: We didn’t screw up on it or anything, we just realized what we did.

R7: Uh, huh

Romina: So we just remembered.

R7: Uh, huh. So, so..

Romina: We’re doing like the speed

Magda: We’re just doing the same thing.

Romina: Yeah, like how, your speed is per second and you multiply by how many seconds

Magda: Well I’m just guessing because you go (reaching for paper) can I use this?

Romina: Yeah go ahead.

Magda: So it’s distance divided by time equals like the velocity. So you’re just kind of doing v times t equals d. (too soft to be audible) We’re just multiplying by like t.

R7: So if you want to know the distance from, from eleven to twelve, what would you have to do?

Magda: Um, take the frame eleven
Uh, huh.

Well you do, We have it in two frames. So that would be our ten

So what, what frame do you want?

Eleven to, between eleven and twelve.

(inaudible)

so we add, it went seven point five

Because you take the velocity divided by point oh three one. Or multiply it by point oh three one. Two four point nine three five times point oh three one. Seven point four nine. Seven point five.

Again you want to know from frame one to frame twelve

You would have to add up, you would figure out for each frame and just add them up.

Yeah.

Because it’s always, the speeds always changing so it’s like you do it one thing at a time.

Uh huh. Do the others agree with your, what you’ve done?

Yeah they agree. Yeah, they buy it.

They buy in without analyzing?

You guy, you guys. You agree with us? You agree with us?

You agree? A hundred percent?

I wasn’t paying attention.

That was the point.

Jeff, do you agree?

Can you explain it to me?

Ok what we did was we just took velocity times point oh three one in each block and we added them together.

We did that way before…

Ass hole moves.

Move on to another project. Gas mileage on the car.
R7 (To R4) Maybe we could, you want them to write it up?

R4 Yup. Always keep transparencies handy.

R7 Uh, Romina and Magda, and everyone else who might be present. Why don’t you write up what you’ve done.

Jeff Who has their eyes open.

Romina Ok

R7 Explain what you’ve done and why. (Small talk)

Romina What should we do?

Magda Do that explanation.

Brian I think we need to put tape on these things. This tape is getting pretty old (referring to the table)

Magda And give like a couple of examples.

Aquisha Is your calculator on?

Magda Yeah this is yours. Are your batteries in? (Romina continues to write. Aquisha continues to set up her calculator. Brian and Jeff continue to talk off topic.)

Romina Magda do you want me to ???

Magda No that looks good.

Romina Then you add them all up (as she is writing)

R7 Let me ask you guys another question. Suppose you wanted to find the distance the cat moved in frame three, four, five, and frame eleven.

Romina You’d, you’d, you’d start it at five, at point three two one and point three two five, and just start there and end at eleven. (Inaudible. Small talk about the shore, what they did on Friday, as Romina is completing the transparency. Magda is explaining to Aquisha what they did on Friday. R4 comes to the table and talks to Romina. Much of the conversation is too low to be heard over other conversation at the table.)

R4 How far did it go?

Romina A hundred thirty one centimeters.

R4 What?

Romina One hundred thirty one point three two centimeters.
Now…

We already did that, we did a lot.

Oh you did?

Yeah.

Now was that from your measurements? Or the calculations with velocities.

Um, this all (indicating the first column in her notebook) is from the calculations for velocity.

Oh it is?

(Inaudible) but when you do it matches up.

Let’s see, does this, is this, this a running total right?

Yeah.

so that would be the distance between frame one and frame two (reaching in front of Romina to point at the data in the first column)

So let’s see, at frame four the ??? should be the same, is that true?

Did you do fifty three point five centimeters yet? I just want to check the data.

Yeah, yeah it is

So I’m still very curious as to whether or not it did that. Continue your process…

Oh, you want us to figure it out? I’ll do that.

I’m curious. I’d just like to know.

We got, these are like from, he just wants to know like this, like this…, and they’d have to add up wouldn’t they?

They’d have to add up because we got these numbers (indicating the numbers at the bottom of the notebook page) but doing that with all these numbers, you know. You know what I’m saying?

Because we got, we got this number by using that number..

Yeah

That number by using that number…

And we added all the numbers previous to that so…, when these numbers that we got, that’s how we got
I have another question for this table. (Question is too low to be audible) (Romina works on calculator asking Magda questions, but Magda is not paying attention. Eventually Romina gives up also.)

What I think, what what might work well, looking at things is to have this group go (indicating Matt’s table), then this group (indicating Table 1), and then this group (Mike’s table).

We’re going first?

Second.

You want to go first (to Romina)

I’ll go first, I don’t care.

Sounds good to me.

Ok, you like that better?

Yeah.

You like that better than we’ll do that. Now there may be some some differences, I don’t know. I’m interested to see what happens here. And if you want to bring up a calculator to do something with that, show some graphs or something that’s fine too. So let’s take a look at what each other has done here uh. First of all, what do you think about the claim of this other student? I thought that would be a good way to start.

Not ours, what the person on the sheet said.

What the person on the sheet said.

I think it’s a good claim.

Shelley thinks its ok. Go for it Romina

We, well that that’s what we used to get our uh velocity (pointing to d,t,v equations on transparency) in our chart. Like when we made big long chart. So we just do some simple math there, d equals velocity times time, that’s because, and we just did that. We just took our velocities and the point oh three one interval and we got our distance. Like you can see it, seconds cross each other out (pointing to work on
transparency) and then you get a distance in centimeters. Like you just take the centimeters per second and multiplying by how many seconds you went so..., that’s where you get your distance from. And then if you add all your distances up you can get like how far they traveled.

177 056:44 R4 Ok, so help me on frame one on that first line and tell me. Just go through that with, for me.

178 Romina Ok well our velocity is forty point three two centimeters per second. And if you multiply that by the point oh three one interval you get one point two five centimeters. That’s how far it traveled in distance.

179 R4 When?

180 Romina From frame one to two.

181 R4 Ahh. And then two to three…

182 Romina It went one point two five centimeters again. And if you just add them up you can get like a running total. If you just wanted like a certain spot you could do that too.

183 R4 How would that, how does that look, how does that look on the graph? I know you have a graph there. I was just wondering how…

184 Romina We, um we graphed distance, no we graphed yeah we graphed time and running distance. No we graphed time and the running distance, (attaching calculator to projector) and the graph its simple you know. That is time (indicatin x axis) and that’s our distance. It’s just like, it’s just shows like the cats walking first and it’s covering like less distance (indicating first eight points) then as soon as it starts running it covers more distance (indicating rising points). Where’d he go? There he is (giggle).

185 R4 Is that graph….

186 Romina That’s just distance vs time.

187 R4 …from the cat.

188 Romina We think it’s what we did. But we’re having a lot of trouble defining these things though. We could be wrong. Questions, comments? Simple to the point.

189 R4 So are you supporting this claim?

190 0:58:42 Romina Yeah, ok you guys are next.
R4: Ok, I’m gonna, I would like to step back out of the questioning role here, uh you know let you all carry this.

Romina: You guys have no questions? You’re with me a hundred percent.

R6: What was the total distance?

Romina: Total distance? Um, you just, whatever distance you want from like frame one to twenty four, you just add up all these numbers (indicating transparency which is no longer projected), do you want me to put it back up?

R6: Yeah. And what did you get for that?

Romina: Uh, it’s a hundred, we have a hundred thirty one point like one six seven I think. Their total. And, and like we used that when Aquisha did hers like (to Aquisha) when you did your part. Like remember, do you, do know what I’m talking about? Aquisha did her like graphing the lines and then she just measured it, and then she kept on like…, she just drew how far the cat moved in each one. She measured it, she had a hundred and thirty. So we were so close that’s what we used for our, our like that big raft rail we had on the floor.

R12: In the first frame one two, and then you get velocity, how you got those numbers. The velocity.

Romina: Velocity is um, those are numbers we calculated when we had uh, when we, like this was with this equation (pointing to the transparency top left – off screen), when we measured the distance and divided by point oh three one – by the time. And then we…, those are our calculated velocities.

R12: forty point thirty two is uh, you divide, what did you divide

Romina: Um, the distance at like

R12: Which distance?

Romina: Um from frame to frame, how far like the nose traveled.

R12: In that case it’s from frame one to frame two?

Romina: Uh, huh

R12: And then you divide by

Romina: point oh, three one. By time.
And that one point twenty five is, what is that?

That’s the, the distance it went from frame one to two.

Is that the result of dividing forty thirty two by point zero thirty one?

Yes.

Does it match the actual measurements that you have in the chart?

Yeah, that’s exactly what we had. (pause) Ok, anyone else?

Let’s. Let’s have a look at the information from the next group. Maybe everyone’s waiting until their presentation to uh bring these questions up. (Shelley goes up to the projector and displays their calculator screen)

We have um, basically the same thing. Um these are all the distances, the times, the velocities (indicating different columns from left to right on the board. And we didn’t get a chance to write it out yet. But it’s basically just the same thing, where it’s um v equals dt. And if you want to be cumulative you could just add em all up.

What, again, what are you adding up Shelley? I need to be really clear on this.

Um, distances, because that’s what the student is looking for right?

So what, C 5 is…?

That’s the velocities.

Those are ok, so those are what are what are in this, in this instance given, right?

Yeah.

You may have calculated them from something but, as far as this task is concerned that’s given to us right?

Uh, huh.

Ok, where are the, where are the, where are the distances that you calculated?

(Pointing to first column) There.

Now what does that distance number one represent? That first data point. The first distance.

What?
What does that first distance represent?

The first, what do you mean?

You have data, you have number one, and then C 3 it say’s one.

Yeah, that’s um the distance that, the how much the cat moved from frame one to frame ten (two?).

Ok, so one to two, two to three. Ok. How far did you go all together?

You would just have to add them up. What is it like…

Did you do that?

Same as Romina’s. Comes out, should come out around a hundred thirty two I think. That’s what our distance was at the end.

Is that what you had measured?

Yeah, it comes out around a hundred thirty two. They’re like a hundred thirty one point six six seven or something?

I think in actuality it’s supposed to be like a hundred and thirty, so real close.

Yeah. I mean it’s there. It’s off one or two I mean it’s not…. for what we’re doing here, for what it says we do, it’s not that big of a difference.

Could you plot your velocity’s there real quick?

Oh, jeez. A little help somebody.

C 5, didn’t we do C 5 and C 6?

What’s C 6 though?

I don’t know, I don’t have C 6. Velocities and what? Just velocities? Velocities was C 5. Distances, distances, velocity and time was..

What do you want velocity graphed against?

Time

Oh, time so…, time’s…

C 4

C 4? (Shelley makes changes to her calculator and graphs what she has done) there are points up the y axis and a beginning of a quartic function)
That parabola probably shouldn’t be there. Whatever that is.

Yeah

Well no, because the time’s at point oh three one intervals, that’s what is looks like. If you do it when you add it all up then it’ll go out on the line. Point oh three one, point oh six two…

So you have everything stacked on top of point oh three one.

There. (laughter) (Shelley has projected the intended (?) graph)

So could you relate your calculations in any way to this, to this graph? (pause)

He asked you a question.

Like what do you mean?

I’m looking at this graph and I’m wondering, the calculations that you did to determine distance, is there a way that you could see that on this graph?

It’s just…, the distance is just the velocity divided by the, the velocity times the time. So I mean, I don’t know if you could see the distance on there really. That’s just, that’s just the two pieces of data we’re using. The velocity times the time. The distance is what you get when you multiply those two.

Ok. Anything else you need, want to say?

I don’t think so, it’s basically the same as Romina’s group did. I think.

Ok. So you support the claim as well, right?

Yes.

We’ve got two votes for the claim. (Small pause as the last group goes to the front)

Alright. Umm, don’t worry about the numbers because ours were, they were our original ones that are all messed up. But lets say you take any given velocity right, in order to find the distances for each one you have to multiply by point oh three one, right? And then add them up like everybody’s doing, right? Does that kinda look like uh, that (pointing to a line of numbers at the bottom of the screen). You know the velocity times that, you know, everybody sees it (pointing to the column of numbers and then the row at the bottom). And you could factor out the point oh
three one, gets that. I’m just making the answer, same thing you’re doing. Add the velocities up and divide it by point oh three one. That’s all you gotta do. And there’s kind of a proof why and…, that’s all folks.

265  R7    Mike, your, the numbers that you have at the top are of velocities?
266    Mike    Yeah
267  R7    Between frames?
268    Mike    Yeah.
269  R7    So the first one is a velocity between two frames.
270    Mike    I don’t remember, I just took, I picked any four on the list. But let’s say this was like seventeen eighteen, nineteen…, it would work. I mean, I’m not, I’m not, I’m not you know, using this as you know, I don’t have a total or anything like that. I’m just using this as a method of uh, of figuring it out. If you gave me correct numbers, those aren’t correct numbers. If you gave me correct velocities this way would work. Just add the velocities together, divide by the time.
271  R7    I don’t see where you’re dividing by time.
272    Mike    I multiplied by time (quickly and emphatically). Multiplied…
273    R4    So if you were to put you know, units on those things. What would, what would they mean Mike? That would help me.
274  1:09:12    Mike    The unit the velocities are in?
275    R4    Uh, huh.
276    Mike    That’s in uh meters per, seconds.
277    R4    Meters?
278    Mike    Me, uh, decimeters I don’t know.
279    Matt    Centimeters it’s gotta be.
280    Mike    No, because then it’s gonna be three hundred centimeters.
281    Matt    There are three hundred centimeters at the end.
282    Mike    Is it?
283    Matt    Yeah
Mike: Alright then I guess.

Magda: Yeah

Mike: Alright, well when originally tried to find the distance between just two frames, you would multiply it by the velocity, um, time. Right? Then you get a distance for those two frames right?

R12: Ok.

Mike: Then you add those distances together. Right?

R12: Ok.

Mike: So, on the bottom you see each one, each one of these things is a distance. Here’s your velocity and your time. And when you look at that, you can factor out the point oh three one.

R12: Ohhh.

Mike: See you take em out, factor it out of all four of them. And basically what you’re left with is the velocities all added together. Times point oh three one.

R12: Ohh, I see. I see.

Mike: Questions?

R4: Ok. There were, there, there were ah, I think a couple of questions from some folks still on, on what Shelley what you put on there. I wonder if you would be willing to let us take a look at that again. Would that be ok? You have a, I notice you have an overhead. Is there...?

Shelley: No, no that’s, we were wrong.

R4: That’s, that isn’t congruent with what you’re saying?
304 1:11:10 Mike No that was something we were doing before and we realized that that’s got totally nothing to do with anything. (Shelley goes up).

305 Shelley Do you want the graph or just the numbers?

306 R4 I think the numbers, the table was what was of some interest. (Shelley displays the calculator table again) What I’m curious of does everyone understand what this table, or these tables are?


308 Shelley Oh, sorry.

309 R6 Could I ask you a question Shelley? You, you prepared a completely different transparency then this. What happened with that?

310 Shelley We realized it was wrong. So..

311 Matt That was the total time, the total distances. It wasn’t anything between frames. Like it wasn’t what we thought it was, er anything like that. So…, just leave that alone.

312 R6 So you, so you’re back to time and velocities and distances between frames.

313 Matt Yeah. We’re back to this. Yeah.

314 1:12:14 R4 Would it be useful for us to see that earlier work jus to see what got discounted, and, and, why?

315 Benny Let em see it.

316 Matt Alright. (Shelley removes TI projector and Mike puts on a three column transparency) Alright, it’s basically it’s, it’s the whole thing with total distance. I took the total distance, and the total time, and we came up with velocities, and we’re seeing like what we could do between frames. If we could do the total distance at the end. But I mean we can get the total distance at the end. But when you start doing the distances between all these, all these here, it doesn’t work out.

317 R4 Say more. I’m still, I’m still kinda confused.

318 Matt It’s

319 Shelley The distance numbers are right.

320 Matt Yeah but it’s just…,

321 R4 I’m confused about what your thinking was, and why it was.
Matt: It’s just easier to do it the other way where just to find, just being able to find the distances between and the total distances. Like with this to do it, you could still do it, but you’d have to take, you’d have to find the distance first of all you have to use the velocity, and the time to find this distance. And use the velocity and time to find this distance (pointing to each number in each column on the transparency as he speaks) then subtract them then you’d get your answer. But it’s too long to do it that way. You, it’s easier to do it that way. Just to find, being able to find the distances in between the frames.

R4: You all follow that?

R3: But what Matt you’re saying and I think that you’re, you’re helping me see a while ago, you’re saying that you could get the same information...

Matt: You could get the same numbers; it’s just a longer...

R3: ...out of this?

Matt: Yeah, it’s just a longer process of getting them.

R3: May I ask you just a couple of questions? I think I find this very very interesting because you really see lots of of interesting things. The numbers on the left are the...

Matt: (Pointing to the left column) These.

R3: What are they?

Matt: This is the distance as like it accumulates.

R3: Ok, and so that number one…, is the first one?

Matt: That’s how much...

R3: And if you got down to where it says five? That would be the distance from the beginning?

Matt: From the beginning to there.

R3: To the fifth one.

Matt: Yeah. And even at, even at that last one it’s one thirty two. So...

R3: Ok, that’s fine. And the times, It helps me to look at a few of them. The four on the front to the say the first five frames, we get down to where it says five point five.
Matt Uh, huh

R3 Is that right? And then in the middle, what is that?

Matt This is the time as it goes up. The time between the frames. Like this is between one and two (indicating on the board the top two numbers in the center column) two and three (indicating the second and third), three and four. As it goes up.

1:15:20 R3 Ok so that’s an accumulated…

Matt Time.

R3 Time. Ok. And over here on the right. What are those purple ones?

Matt See that, that’s where, the think…, that’s where it goes wrong. Because we’re not sure if those velocities are right. That’s supposed to be centimeters per second. But it goes, it goes up steadily

R3 Yeah

Matt And like from all our graphs, none of them really do that. And we don’t know why, it’s just…

R3 Don’t they go up and down a little? I see some there that are less than others.

Matt Those were just originally, they’re just the distance times the time, I think.

R3 From, from earlier.

R2 Wait, lets pick one. Could you walk through how it was found.

Matt It’s just, it’s…, what is it? (To Shelley). I don’t even know. We just had these numbers, in our, in the book.

1:16:30 R3 So they were, I would say that they were probably your velocities…

Matt They’re the velocities we got somehow. I don’t know how we got them. But they’re, we got them. We got the velocities somehow.

R3 Yeah.

Matt I’m not really sure how. This is our old data. And so we just put them with these and if you use the same numbers. I mean, like when you, when you go to do
this; this velocity times this time gets this distance (pointing at the numbers from right column to left column). And they all work out to be equal like, there’s no error in any of them. So…

360 R3 So you’re saying that second velocity times the second time gives you two point five?
361 1:17:14 Matt Yeah.
362 R3 I don’t understand that. Could you show me how you do that?
363 Matt It’s just, it’s just velocity times time. You multiply that number (pointing to the overhead from the machine)…
364 R3 Point oh six two.
365 Matt Yeah by this number. It’s just how you would get it. We’re trying to figure out how he would get…
366 R3 He wasn’t going that fast for the whole time.
367 Matt I, we know, and that’s why we didn’t use it originally. Because you weren’t going that fast and that’s why we threw it away.
368 R3 But it gives you the distance and time. That’s really fascinating to me.
369 Matt But the reason it does that…
370 R3 Does it? Can somebody tell me the reason that it does that?
371 Matt Well the reason it does that is because these were the…, when we originally started this is what happened. When we originally started we originally did this. So we were doing all the accumulated times and stuff. So this data comes from originally from using this number (pointing to 2.5 in the distance column (second entry)), and this number (pointing to .062 in the time column (second entry)), to get the velocity. And we never even, we never wound up using that again. So this was thrown out a while ago. We just thought maybe we did it this way…
372 1:18:26 R3 Ok, so the velocities on the thing Shelley was showing you are different from these velocities?
373 Matt Yeah
374 R3 You have certainly helped me.
375 R2 Matt I’m still wondering. Look at the second, look at the one you put a dot on. Forty point thirty two.
Matt: Yeah

R2: Now, two jumps down there’s another forty point thirty two. Would that one get multiplied by point one twenty four?

Matt: Yeah

R2: What do you get when you do that?

Matt: I would guess five.

R3: Can we do it on a calculator or something?

Matt: Yeah

Shelley: Oh, the numbers on the bottom aren’t lining up right. Angela messed up on the...(?) So we might be ‘timesing’ (her word) it by the wrong number.

R4: So this goes by the way of a new sheet Shelley?

Matt: (Putting the TI projector on the overhead) It’s forty point three two times point one two four and get 4.99968. So five. And forty point three two times point one two four is five.

R2: What about the next one? Is that 35.48?

Magda: Uh, huh. Just those numbers on the…

Shelley: On the bottom, they just don’t match up right.

Matt: (replacing the transparency for the TI) Five point five and five point five. So all the, all the numbers match up. It’s just that the velocities are wrong. They’re not…,(transparency is back up)

R2: I see. When you say the velocities are wrong. Could you explain that a little better.

Matt: The way, the way we got them well, we didn’t take, we didn’t go find them, this is an old table we had. And all we did, this was like the first try at doing the cat problem. And all we did, this was the accumulated time that we used, and this was the accumulated distance between them all. So that these velocities are the result of using these numbers.

R2: Oh, I see.

Matt: From here and here.

R2: Oh, I see. So they’re not the same as the velocities for the little intervals.
<table>
<thead>
<tr>
<th>Time</th>
<th>Name</th>
<th>Text</th>
</tr>
</thead>
<tbody>
<tr>
<td>395</td>
<td>Matt</td>
<td>They’re not. No.</td>
</tr>
<tr>
<td>396</td>
<td>R2</td>
<td>They’re velocities</td>
</tr>
<tr>
<td>397</td>
<td>Matt</td>
<td>They’re velocities from one to yeah.</td>
</tr>
<tr>
<td>398</td>
<td>R2</td>
<td>I see. You have certainly made it clear for me. Are there any other questions?</td>
</tr>
<tr>
<td>399</td>
<td>R4</td>
<td>Any other comments? Good thank you. I would like to invite Dr. Maher.</td>
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<td>400</td>
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<td>At this time on the video Dr. Maher introduces a marble task that is not a part of the catwalk.</td>
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I have two questions for you, um, well the first one, I am just curious when they brought those boxes out from third grade and what was that like.

Um, Too many memories, I don’t know….we used to, I knew it had something to do with probability cause we used we used to problems like that all the time it was just, when we were small it was just tormenting cause we did not understand anything , you don’t know probability when you’re young and now when they brought it out this time, we were glad, you know, we knew it was going to be easy for us this time ….but it just brought back all those memories from years ago when we couldn’t do it.

Did you ever see those tapes…Carolyn was saying she was going to show them

I’ve never, I think we’ve seen one but we weren’t actually doing math in it people were coloring, they showed us they thought it was funny how someone was so not amused with the problem they would start coloring their thumbs and making thumb prints and that’s the only I’ve ever seen, I’ve never seen a tape

Would you like to see it

Yes I would, it should be funny, um to see how much we have progressed too

Your tables seemed to be very quiet compared to the other tables when the boxes came out, I didn’t I mean after you got over the big surprise, did you remember the problem pretty well?

Yea I knew exactly what the problem was, it was just just it was like as soon as you take out the boxes you knew you had to guess how many of something were in there and our table and I think our table was more used to it, I think we’re more, more experienced group
and the other tables had taken a long break or hadn’t done it so we just kinda knew what we were going to do so it wasn’t even a problem for us. It didn’t even bother us.

9 2:13  R1  What was it like hearing some of the ideas from the other kids?

10 2:16  Romina  It was, you know they were some of the same ideas, we were all like, it’s that’s why we’re strange, we all had like we’ve all worked in different schools and everything but we all have the same ideas, we all approach things very similarly so it’s just funny

11 2:31  R1  I was interested in your reaction to this whole thing because if I remember right usually do like maybe an evening or an afternoon and this was like a two weeks something like that.. what was it like doing that this whole time compared to the way you normally do

12 2:52  Romina  It wasn’t as bad as I thought it would be to be honest, um usually it’s, I think its more stressful not this way the two week way period but the other way we do it because you have to come up with something by the end of that time period and usually they want like an explanation, they want an answer and everything. this we had more time to sit think about it we could of approach the problem in like several different ways we had like different graphs and we represented the problem in different ways and we like all talked about it for a long time and then we came up with the answers by ourselves and then we would like be able to share it so we got other groups ideas too. It was a lot. It was paced better and I think it was more productive too

13 3:37  R1  Was there anything you didn’t like about it?

14 3:41  Romina  Nah it was okay I mean the four hours got a little long and our attention span is very short if we are not occupied with something that is like difficult for us we are gonna lose track very easily but I think it was fine. It was pretty good. It was organized well.

15 3:57  R1  You said you know um something about um if it’s not difficult. Could you tell me more about that?

16 4:07  Romina  We, We all have very short attention spans. If it is something that seems too easy or something we can get done in a matter of two minutes then we will do it real quick. We will like we will throw an answer on a sheet and we will stop I mean the problem really has to interest us and it has to cause it usually works best when we disagree with each other cause that way we
will be like it helps so much we are the type of people that if we disagree with each other just cause we are disagreeing we will work on any problem you’ll give us we will go on and on until we figure which one of us wins kind of and if it’s not intriguing to us we won’t do it we’ll just sit around and just look at each other that what it takes.

It does not seem like you have a short attention span when you working on something that you are into.

Yeah, when we’re into something we are into something. We’ll uh we’ll give you any we will talk about it forever we will argue about it forever we will do anything that’s required, we’ll come up with anything, like we will come us with weird things too. We will keep going as far as we can with the problem if we are interested in it.

This must have been a bit of a reunion for you right?

Yea yea um. I remember working a lot with those kids and uh Matt, Milin in like uh sixth grade . just seeing them again it was just weird . yea we all got along now like I know Matt’s coming home with me, we’ve got an hour ride so it was nice we all got along well. We all remembered each other and our tendencies.

Were you surprised by how they looked and people changed a lot.

Actually no they didn’t they look a little like they have they look like they don’t have they’re they’re not as like the baby fat anymore but their the same people they they just grew up a little.

Did have you ever mean in the situation where you have not seen someone in a long like that and saw them.

Yea

What was unusual.

It is unusual. Most people your if you’re from Kenilworth you’re from Kenilworth forever you know you don’t move from that you it is such a small town we don’t a lot of people don’t move and come back if you’re gone you’re gone so this this was very unusual. I hadn’t seen them in years.

I was just curious what you though people were you were you expecting the kids you seen you knew them when you were little kids so were you expecting them to look really different or.

I was I didn’t know I was I didn’t think I was gonna
recognize either of them but I did they came and I was like Milin and Matt it wasn’t even a surprise I knew what they were going to look like I I thought I knew what they were gonna look like. They didn’t change much

29 6:42 R1 And then how bout um there was some new people to the group too that wasn’t there before what was it like

30 6:48 Romina I felt bad for them but cause we all had I mean Matt and Milin like I felt bad for them too cause we were all like we’ve been we’ve grown up together we’ve been together for years and they were kinda like the outsiders and I’m I’m not sure if the kids from New Brunswick had done this before they said they hadn’t so I it must like must have been so awkward for them they did very well but they by end of this week they were into everything they were doing they were just with us. We all we got along well

31 7:16 R1 Why do you think it might have been hard for them

32 7:17 Romina Cause they were especially the first day they were all thrown they were all separated they were all in different group the bunch of kids we all knew we we socialized a little you know and they just kinda sat there they didn’t know what was expected of them they didn’t know we were all like ready to we knew what Rutgers wanted you know so we were able to give them the answers and the discussions and they didn’t they didn’t know they wanted to talk about the problem and things like that so, until they caught onto that part they were a little lost

33 7:47 R1 Did any of them come up to you and and talk to you about was going on

34 7:53 Romina Yea, Victor did a little I think Victor did the best getting into the whole group he uh he was he was I kept on asking him yea I like pushed him along a lot throughout the thing cause when he’d go up there and presenting I would ask him questions and he hated that so much but by the end he was like it’s alright I expect questions from me he like helped me out a lot up there he was ok we got along

35 8:21 R1 Um I think to some point somebody from the outside who has never seen this set up would seem like a really strange thing. Could you do me a favor and just describe what it is like to just walk in the first day and you know see whatever they had set up for you?

36 8:36 Romina The first day was so intimidating it was I had expected like the usual Dr. Maher and Gina they’re like always
there and they’re like we’re we’re like acquaintances. We are like we get along well and all that but the first you walked in their was like three tables and you’re all separated and there was not cameras than we had expected and there was like a special camera for each table and and so many people there were so many adults there that we hadn’t expected we thought it was only going to be like three maybe but then there was like twenty and they were so they were hanging on every word we said we had two note takers each like to each table that was so scary because like you had to do something you couldn’t sit there for four hours and not do a thing but everyone’s waiting so so it was scary

37 9:21 R1 Usually when you do this there are also people sitting around watching how was this different

38 9:29 Romina Well the thing with when we do it after school sessions we are in a room and we have a camera man but usually the adults leave and they’re not they’re not there and they leave they used to not do it but recently bringing random people in one by one but we never we were never hit by all of them at the same time

39 9:49 R1 Does that affect how you work I mean

40 9:52 Romina It’s pressure but we all work we all work very well under pressure we just we’re more productive under pressure any way so I guess it was it was a good idea just make us do something

41 10:15 Romina You know what else was different about this just to continue when when we were people were just brought in new people we were able to talk about things we had done that we knew well and we were able to just explain to them you know we thought we knew what we were talking about and knew the answers already we were worked on the problem like prior to them being there so that was easy just explain to them but this time they were new problems at us and actually watching us work which is very different

42 10:44 R1 Could you describe the cat problem for us if somebody hadn’t seen it? What’s that about?

43 10:50 Romina Okay, it’s about how a cat someone took pictures of a cat in .031 seconds like intervals we just had to see how far the cat moved using just a grid and 24 pictures that’s it

44 11:10 R1 That doesn’t sound like a problem

45 11:14 Romina There wasn’t much to work with. They just wanted to know they gave us twenty four pictures and they were
like here figure out how far the cat went and how fast it went that was hard we didn’t know where to start and then each line is five centimeters and we took it from there see like we didn’t that’s what they didn’t give us any information that the first hour I say we just sat going, ‘what what do they want?’ but after that it was easy we just take a ruler and do some multiplying and its fine. It wasn’t that bad

46 11:45   R1  Well what were some of the questions you had sort of had to settle with in that first hour before you could move along

47 11:50   Romina  What the problem was. How we’re gonna like they gave us little tiny pictures on one just one sheet and we were suppose to see how far the cat went and in most pictures it didn’t even look like the cat was even moving and like we could measure anything cause like our ruler was too big for the pictures and we just didn’t know how to do it we didn’t realize it was in like centimeters like we are used to miles per hour not centimeters per second we had to like establish like what our variables were and work from there.

48 12:20   R1  Do you think it was a badly framed question cause you didn’t know what to do?

49 12:25   Romina  I think they did it on purpose cause it wasn’t they just didn’t give us any information, they didn’t give us like it wasn’t structured they didn’t give us all, ‘this is what it is’ and ‘this is what we want you to figure out.’ It was just typical Rutgers. They give us something they give us like very little information about something and see what we take it to and it think we did very good we got as far as it think we could of with our knowledge.

50 12:52   R1  Where did you end up taking it to?

51 12:55   Romina  We we were able to figure out how far the cat moved and that time span, what velocity he was going out between each frame we we went in depth like how far the cat moved in like what was it doing when it was walking running we were able to make graphs to see how fast it was going at certain times and we related that to when it was walking and running.

52 13:17   R1  Yea I wasn’t there for much of this but I I I I heard that they had laid out some tape on floor could you tell me about that?

53 13:27   Romina  Yea we uh we had numbers for each time frame and we had um we uh we knew how far the cat moved and how fast it did it and well it was .031 seconds and we
knew how fast it moved in every interval, so we did we kind of multiplied that by 50 like a life like version of it and put it out in the hallway and then just to see because we were having a problem we didn’t know where the cat was accelerating if it was accelerating throughout so what we did was ran the course and saw that we had to get one place to another in 2 seconds so we had to see what we went from walking taking little steps to like running and then we were just sprinting as fast as we could reach them we were able to tell how the cat was moving.

54  14:12  R1  Why did you multiply by 50?

55  14:13  Romina  To make it so we can follow it cause the actual size of the paper layout was 130 centimeters so we couldn’t really feel it in there then we made it a little bit bigger in the library but it wasn’t you couldn’t feel the full effect because at first like in the span of two feet was the first ten intervals so you couldn’t really do it so we figured we’d multiply it by 50 so that way we would actually have to be walking from the piece we marked with tape from tape to tape we would have to be walking and then running

56  14:49  R1  What did you find out by doing this yourself in the hall?

57  14:52  Romina  Well we were they were asked cause they were really stuck on this frame ten and we didn’t know what was happening in frame ten cause they knew it was it was we ranged at cause we started at between 9 and cause we went uh we measured the time between the interval like between that time we measured the velocities we couldn’t do it for the exact frame we did it in between but we could between from 9 to 10 I could remember getting somewhere between 8 cm/sec and the 10th to 11th going 120 so something big happened there but we were missing it so what we did when we laid it out we saw like that you would have to come to like a stop and we go from a walk and coming to a pause and then you started running so then we figured out that was what the cat was doing so we were able so that what we got out of it

58  15:36  R1  If you were to describe with your hand what the cat was doing just like …

59  15:42  Romina  The cat the cat was walking like this you can’t even see it in pictures the cat walking and then it brought I think it was scared or something startled it cause someone wanted it to run for the picture sake and its
two hind legs came together and it started like a gallop so it was like a big change there from just walking from step to step and then a gallop.

60 16:09 R1 This is a very unusual kind of activity I’ve never seen anything like it. What do you think you got out of it?

61 16:19 Romina I think we see things almost at a higher level we don’t see it as just numbers and a grid we saw it like we put like variables that no one thinks of like what the cat just doesn’t just gradually walk and then running no it like something had to have happened there to make it run and then we we were able to put like real life things into it and like what can it affect it like not math like real things

62 16:56 R1 You mentioned something about real life could you go into that more cause I really could not follow it

63 16:59 Romina So like when you do math you don’t like this was our problem like we have a real big problem going from one thing to another when you do math we do math two plus two equals four - there is nothing involved and when we do like word problems we never take anything else into consideration like you take when in real life like little things like a person like just running that just doesn’t happen all of a sudden you have to be kind of gradual to it or just things like air resistance and things just friction there’s like real life situations that math doesn’t account for that we have to.

64 17:37 R1 And did bringing those things in sort of change how you did the math?

65 17:42 Romina It made sense of it. Like we had the numbers there but we they did not make sense to us like we didn’t understand how things could change so fast what was going on why it would change speeds so fast you do do like a real life version of it you can see what the cat’s doing you can understand and like our graphs would go up all of a sudden and fly down and but when we did we could see it was accelerating, it came to a peak and then it was slowing down like it just makes sense of all the math

66 18:20 R1 Did any of this experience in the last couple weeks you know it was pretty intense couple of weeks did any of it make you change how you’re thinking about math?

67 18:30 Romina They have been working up to this. It hasn’t been like all of a sudden it made me I was I don’t know I was very surprised by what we did this week cause they gave us very random things or just like our two problems were just pictures and that was all they were
from the picture we developed so many things like we had all these numbers and then we were able to get graphs for all these different things so it was just like pretty interesting how we came up with so much many different like point of views and areas and methods and like we had hour conversations about our math which I didn’t think was possible not a lot of people think you can talk about math but we it was just surprising what you can do and what like how controversial it could get like how many different opinions and ideas and like we all had we all knew we were working with the same things but we had so many different ideas like how to go about it so.

So that’s something you’ve been doing before with probability problems um was there anything about these problems you found especially surprising or unusual having to spend two weeks working on them

The probability problems they gave us specific numbers and they gave us ratios and they there wasn’t there really weren’t other factors in it fractions and you kept adding and multiplying fractions until you came up with something with this it was just so like random it was just like a seashell there is not much you can do with a seashell and then like we kind of had to like invent anything we kinda had to like what we had to choose what path we were going to take and what we were going to do. With other things we had we had things given to us, with this we kind of had to make up on our own we all had to agree with the other group kind of had to come up with common let’s do something standard so we all get the same thing so it was a lot more compromising too

Could you um so we can get to see it could you describe that third grade probability problem what was the problem

They put ten marbles into a box and it’s either you get a choice of two colors and they cut a hole out of the box and then when you shake the box only one - we could only see one marble and from shaking the box you have to guess how many first of all there are ten marbles in there you have to guess how many are one color and how many are the other color and you just do that by you just trial that’s all you do

So you shake the box, then a marble falls out and do you get to keep shaking it until you empty it all out

No, it’s only one at a time you shake it and the hole is
not big enough for the marble to fall it it is only big enough to see part of 1 marble to see what color it is and then you shake it and only 1 marble comes out and you shake it again and they all kind of the 10 get mixed together again and then falls out well it doesn’t fall out it come to corner

21:31 R1 Did you do it by trial and error or did you solve the problem by trial and error or is there a way of thinking about it?

21:41 Romina Well, if you do it enough times you just have to keep on doing it and recording it is just a lot of data and note taking you just keep writing down what you get until actually your going to do it 100 times and yellow came up 70 times there is probably 7 yellows in there and the 3 of the other color and you do it’s some logic but like if there is more of one color its more likely to come up and if you keep on doing it enough like if you came up if you were to the millionth you would eventually get a reasonable probably right number of how many are in there.

22:14 R1 Is it possible that you could do it a million times and get all yellows?

22:19 Romina Its possible but see when you do it more times the chance of getting say there is 1 yellow and 9 blacks for the first 10 times it’s a possibility to could get yellow 10 times but when you go up to when you do it more and more times its less likely your chances are smaller so.

22:40 R1 Some people might say you know I mean if if like you know if the yellow shows up 3 times in a row it’s more likely the yellow is going to keep showing up

22:53 Romina No I don’t… It’s like flipping a coin The first time you can flip a heads or a tail but if you do it 2 times getting tail like twice in a row is harder than just getting it once it it always like it the probability becomes like the probability of getting something in a row like a lot of times becomes less likely.

22:42 R1 Maybe you should tell me is there anything you would like to you say that we have not been asking you about this experience?

23:52 Romina I don’t I think it was a good experience over all I don’t know it just for us we don’t know why we all have very low self esteem about everything and we didn’t think we were capable we were very scared coming to this two weeks cause we thought a lot was expected from us and we were not going to be able to perform
under all the pressure but I don’t know we came out we I think we did I don’t know what do you guys think while we came and we did a lot of problem solving we did a lot of thinking like we just sat and thought for hours a day and we came up with a lot of interesting things and we were able to go in front of a large audience and just talk about our ideas and then argue our points and prove our points so I think it was a very good experience

24:37 R1 Would you feel more comfortable if people reassured you more about whether you were on the right track, not on the right track or do you feel

24:46 Romina That’s um almost I don’t know I don’t like being reassured in like the problem like I look for reassurance but if they gave it to me it’s almost like they’re like they’re treating me like a little child like you’re good keep going with that keep on going like that this is like when we do come up with something it’s so much better because we came up by ourselves without someone holding our hand and walking us through it like if they walk us through it but yea we are going to get to the right answer but if they do this they don’t know what’s going to happen what direction we are going to take so it makes it all the better.

25:18 R1 So this problem that you brought up about self esteem is really a big problem in math that especially like a lot of people feel you know they’re not good in math and whether they are good or not they should sometimes feel they’re not good I mean I mean if you were to advise a teacher on how you would build up someone’s self-esteem in math do you have any thoughts on that?

25:41 Romina It’s hard though because math is just so different I think there’s two big different areas of math: one of them is like the thinking involved and one of them is just like spitting out numbers. I know I was never good at the spitting out the number thing and everything but I was decent at the thinking about it. If they can incorporate both of those into one and so I think most kids either go on one track or the other and if they can they if the teacher has both of them in a class the kids are bound to do one or the other, like you think he can do math for the time being

26:12 R1 If you were to make um if you were talking to someone who just wasn’t familiar with what math is
maybe there is some older generation someone who
has not had the opportunities you had you know what
what how you define math I mean what is
mathematics?

87 26:34 Romina  I don’t know. It’s just so - I think it’s problem
solving. It’s taking up a lot of things into
consideration coming up with a reasonable answer to
something or solution. It’s nothing - math is just so
vague and in so many areas of something it’s
everywhere unfortunately like it’s like everywhere you
can’t get away from it - it’s everywhere you can find
and every situation you could possible think of you
always think of probability, cause and effect things
and that’s math

88 27:05 R1  I think I think a lot of people think of math as
arithmetic the number adding part and all that

89 27:11 Romina I think that’s what scares most people away from math
the fact that they think it’s just like long division or
something and its not that it’s just you have to apply it
to different things and it’s so much so…I think that if
you just open and you keep opening math up like this
for everybody eventually we are going to have a good
math background and enough to do what we can do.

90 27:43 R2 Um Dr. Speiser talked about how much it meant to
him how he was here for the two weeks and what he
got out of it um and how it benefitted him I want to
hear how you think it benefitted you guys you?

91 27:59 Romina I think it helped us out a lot it almost like we were
testing ourselves like we had to come up at first it
didn’t tell us half of the people in there were from
Harvard and um they were professors at like
universities like and like going in there and finding
that out it was almost like a test to see if we can
actually do it I know a lot of have been especially this
year I don’t know what happened with half of us in
there but we were already turned off by math and we
already thought we couldn’t do it and that was it our
math career was over when a lot of us had hoped to
pursue math in the future but this changes it around a
little because if we were able to go in there like
professors we were to have in years to come were like
kinda impressed by what we were doing and how we
were thinking, maybe we can do it so maybe it
changed us a lot. Changed our opinion.

92 28:54 R1 I guess one thing that I’m wondering is, you know I I
am very impressed by what you do and I’m I’m you
know I hadn’t really seen people do the kinds of things you do but I’m sure there are people who do you know but given that you’re in high school and that these are new ideas for you I’m just wondering why you’re concerned or you think maybe people may think its you’re not doing a fabulous job and

93 29:24 Romina Cause it doesn’t it doesn’t seem a lot for us. Like if you gave us like this big long test with all these problems that seems like a lot for us cause it’s either right or wrong but like when we come in here we are just sharing our ideas and like working in groups to come out with an answer like this this it’s not easier for us it’s completely different but we usually we don’t think people just expect that so when we do that like we don’t understand why that’s such a big deal for some people like we never understand like until recently we never really understood the research that is behind this whole project but we didn’t we didn’t see how us sitting in a room talking about our ideas can be interesting to someone or benefit anyone

94 30:11 R1 Well you know well if you had a job in math do you think doing let’s say somebody gave you some problem to solve they wouldn’t give you a cat probably you know but it might be something else that’s a real world problem, do you think you would know what to do with it?

95 30:31 Romina I think if you me if we all went in there and they gave us the problem and we work at it until we get somewhere until we start off in the right direction it might take us a long time but pretty much anything like things that were given to us were like this was all calculus and we pretty much have no experience in because we haven’t taken calculus yet but we were able to break it apart from what we knew we have like the basic math background but whenever we have to take it to the higher levels and like make that like use it in situations and apply it and I think we could do if we really we would have to work at it but from what we know I think we can handle it the most part.

96 31:11 R1 Well I guess I’m I’m just wondering do you think if you had a job that involved math the kinds of things you’d be doing in that job would be more like this or more like the kinds of things that maybe taught in some of the other classes like in textbooks?

97 31:30 Romina No it would definitely be like this because first of all I wouldn’t be like like finding the solution for a big
problem by myself I would a lot of other peoples they’d be like we would have to have some sort of arguing like to bring up points that maybe I don’t see that could help the solution cause it it’s gonna affect people mine 2 + 2 = 4 is not going to affect anyone on a test but when I go out in the real world and have to find like like real life situations like different variables that would affect it and people arguing will help and people would just keep talking about it and we have to find as many solutions as possible and go from there to see which ones the best solution it will definitely help this way

98 32:15  R1  <inaudible question>

99 32:25  Romina  I still don’t understand how beneficial this research is they tell us but I think we don’t think we are doing enough to help you but I think we’re showing you that maybe like the textbook way isn’t always the best way it may be it might be good to learn like we used it the first couple of years like 1st to 3rd grade you know just giving us the basics but after that if you just - people underestimate what we can do and if you can just give us problems and keep working at it it like builds us up. Makes us more. Like I am a more verbal person I can speak well and I can communicate my ideas where other people might like my same age level can’t because they never had to they don’t know their intimidated where I was kind of put on the spot and had to and it just develops your idea and maybe when we are like running the world we can come up with better solutions cause we know more and we can like we’ve practiced and we have been able to have like group thinking and solutions.

100 33:24  R1  You’ve said you had a lot people underestimate what you can do can you tell me more about it?

101 33:28  Romina  Like because we don’t always get to a right answer like the do fractions and logarithms and things like that like maybe they don’t think we are as smart as we can like as we are but if you give us like real problems like problems that actually matter not just spitting back numbers and then memorization we can apply its almost like higher level thinking like like real life solutions and we can sometimes like we can we are pretty rational people when we can come with interesting things like point of views and ideas that no one else really looks at especially for our age level they just think that we can memorize things that’s it
and if we can’t memorize things we are not that intelligent.

102 34:35  R1  By underestimating you in that way

103 34:36  Romina  We don’t we are not able to achieve if not everyone if no one else thinks we can do it why would we think we can do it um like if you’re telling the only way I can be smart is if I can memorize all the answers to the like science that wouldn’t be very I could never do that I could but it would take a lot of studying where I can be using my time for more like thinking like thinking up my own ideas connecting it where as the sine of 30 will never mean anything to me whereas but if I thought about it and could see a graph in my head and see where a point fell on a graph and what it was that would mean a lot more cause then I could I could use like that graph in other situations where the sine 30 I couldn’t I could just that is all it would be worth.

104 35:27  R2  I was just wondering.  You said that you really did not know what this research had to do with anything and um you might be able to articulate that but you’ve learned a lot through being in that class and being in this project and I’m wondering if you were if a new teacher someone who hadn’t taught before came to you and said listen Romina know more about learning math than I do how would you what should my math class look like what is the most important thing I should do for my students? What would you say?

105 36:00  Romina  I think they would have to incorporate the two maths I was talking about before I think we need a little bit of like the memorization and like this times this is this just like quick math to get by little things the SATs to get by that but then I think they have to have like have to have us able to talk in class talk about our ideas and give us like a problem about speeds and cars and let us go on for about a week or two just talking about it and experimenting with it and then once we are done with that they can show us like the easy math went in that and if we can do that we would be able to do both. We’ll be able to do our own thinking and we will be able to do the quick solving at the same time.

106 36:44  R1  I know of work you have been doing have had lot of use of calculators, what’s the point of that?

107 36:53  Romina  Our calculators are to do like the math that would take us just a little longer to do by hand and like calculator now is not just like you can add divide multiply and subtract it’s it does so much more for us like with a
calculator we were, its almost like we were making something visual for us to see something so if we input all our numbers in the calculator and it came out with this nice graph for us and then we can see like the cat was like accelerating and like decelerating we can see like almost like how to show it was almost like an exponential graph it was going up by so much that we could see that when we graphed whereas when we were just looking at the numbers if a pattern doesn’t jump out at me I won’t be able to tell but you put in on a calculator you can see it.

108  37:47  R1  Anything else? Do you have anything to add?
109  37:49  Romina  No, I’m good.
110  37:51  R1  Well thank you very much.