

# Where's the Math?

## The Role of Representations in Understanding $F=ma$

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# What kind of research do we need to make online learning in math and science more effective?

- Much research on online education has been about process: retention, facilitator role, group size, schedule etc. without attention to subject matter.
- We need to know more about the conditions necessary for people to achieve particular learning goals, i.e. the content and structure of the curriculum, the learning resources available, the pedagogical approach, the ways the content interacts with the online environment.

# A set of values about science and learning for course design

- Create a community of practice that reflects the way scientists participate in the practice of science, which include
  - Science is asking questions, hands-on experimentation, observation and a search for patterns.
  - Science relies on communicating one's findings and conclusions to the wider scientific community, with supporting evidence.
  - The goal (often unreachable) of scientific discourse is to move toward a common understanding, based on the evidence each scientist offers.

# Investigating Physics

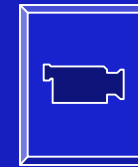
- Second course in the Lesley/TERC online master's degree in science education
- Development incorporated immediate formative feedback from (27) teachers taking the first offering
- Focuses on  $F=ma$  for 13 weeks!
- Goals:
  - A rigorous qualitative understanding of Newton's laws
  - Development of a physicist's eye, the ability to see  $F=ma$  in every instance of motion observed or experienced.
- Format:
  - Asynchronous
  - "Lightly" facilitated by physicist
  - Posts on Friday and Wednesday; students experiment, report, discuss.

# The Role of Representations

- Scientific communication goes beyond text: graphs, diagrams, tables, symbolic notations etc. (Lemke) (Note that most of these are mathematical in nature.)
- Lehrer and Schauble: Modeling is “the construction and test of representations that serve as analogues to systems in the real world”
- Scientific community involves common appropriation of representations of the physics of motion

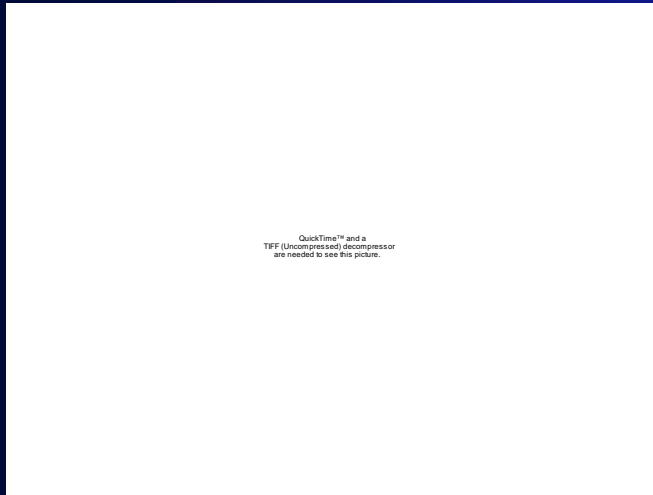
# Three representations moving from phenomenon to mathematical graph Strobe Pictures 1

- Motion shared among participants as online video:

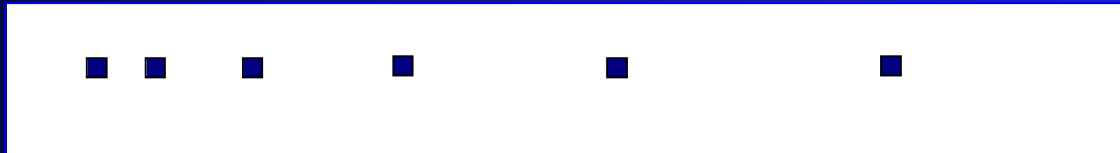


QuickTime™ and a  
Sorenson Video decompressor  
are needed to see this picture.

# Strobe Pictures 2



Closely related to video, yet extracts essential elements of motion.



# Cork Graphs 1

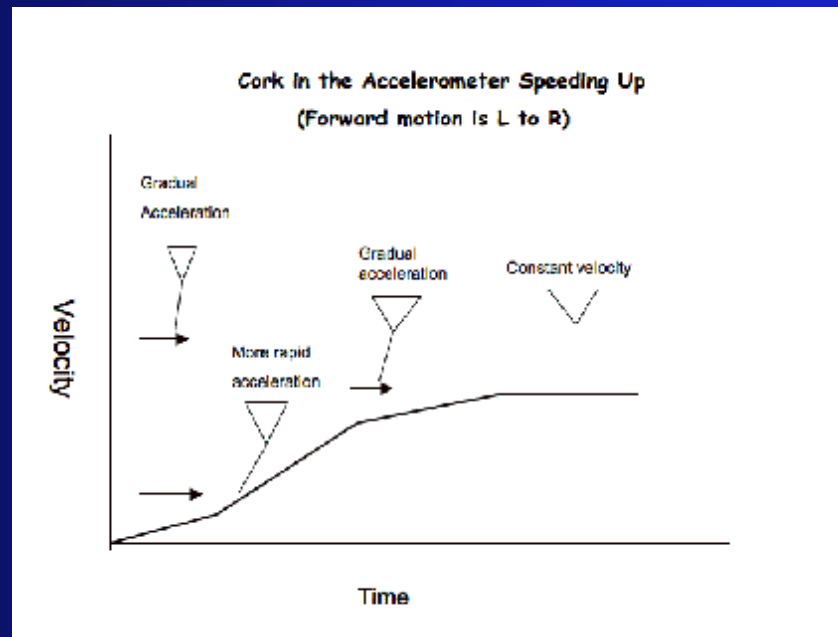
- Students built their own accelerometer:



And used it to identify acceleration

## Cork graphs 2 - PowerPoint to the “rescue”

- Cork graphs showed velocity over time with associated pictures of the way the accelerometer looked at that point in the motion. PowerPoint allowed students to annotate their graphs.



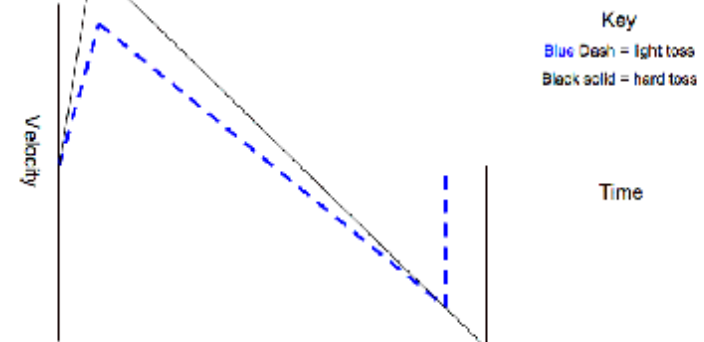
# Complex Motion Velocity Over Time Graphs

## Graph of Velocity of Ball Dropped



The graph of the ball dropping just looks like the second half of this Z-shaped graph.

## Hand Toss of Ball



# Conclusions

- Part of a scientific community is the development of a common language, including non-textual representations.
- Online course materials often include fancy graphs, video and sound, but limit students' contributions to text.
- If we value the creation of online communities of scientific inquiry, we must provide students with the ability to create representations to **think** with and to use as **evidence**.