COMPILATION: Unit 3 - inclined rail paradigm lab (ball on ramp lab)

Date: Sat, 07 Oct 2000
From: mitchell johnson <johnsonm@lvcm.com>
I see a lot of discussion on the constant acceleration labs for x vs t and v vs t, but for the last two years I have had my honors also find v vs d for the third equation. Then the slopes of their lines all have units of m/s^2 but are multiples of each other 2a, a, 1/2 a. Last year was fine for all three graphs, we use 2 m PASCO tracks; but this year the v vs d graph was linear for a lot of groups and wasn't near the 2a value for those that weren't, even though with the units I tried to convince them that it should be v^2 vs d. Has anyone had this difficulty with the v^2 graph? How did you handle it? I have not been able to determine a cause.

UPDATE FROM MITCH, the next year:
Date: Wed, 03 Oct 2001
From: mitchell johnson
Subject: Re: How did you resolve this problem last fall?
YES we solved the problem. On the position vs time squared graph it was necessary to subtract any initial time before the experiment began. Second, because the Pasco equipment uses 2 positions to calculate the instantaneous velocity, position must be taken to be a point well before the end of the track where the cart collides with the end stop. Then the v^2 vs distance comes out. The average of the v squared graph was about 10% from 2 while the average for x vs t^2 was within 5 %. Close enough to get the results.

Date: Sat, 07 Oct 2000
From: Jim Schmitt <jschmitt@ECASD.K12.WI.US>

This year I varied the ball on the ramp a bit...and got great results. I had 10 setups (3 per group):

*Air track, slight angle, with photogate
*Air track, slight angle, with photogate through LoggerPro
*Air track, slight angle, videotape (camera follows very closely, so as to pick up the scale)
*Hot Wheels Track and car, about 25, with photogate
*Hot Wheels Track and car, about 35, with photogate
*Pasco Track, slight angle, with photogate
*Ball (golf ball) on ramp, slight angle, with photogate
*Ball (steel ball) on ramp, slight angle, with photogate
*Bagel (yes, bagel, from an old TPT article) dropped free fall in front of a gridded board, videotaped
*Nerf ball dropped free fall in front of a gridded board, videotaped

All of these gave great x vs. t graphs (can't forget to use the "free point" of x=0 at t=0). What I liked is that the discussion was very rich on the differences and similarities in results. One example...aside from a great difference in slope, those who videotaped never had an intercept above 5% of the max vertical value. They didn't have to worry about being just in front of the first gate. The other groups did not always have intercepts below 5%.

One other feature is that by using a photogate, your independent variable is position, and dependent is time. When you videotape, your independent is time (because you must choose which frames you will look at), and dependent is position. This leads into a great discussion of variables and which axes they go on, and why we often prefer to use time on the horizontal axis...and how the method of collecting data can dictate independence and dependence.

Date: Sun, 8 Oct 2000
From: John Barrere <forcejb@YAHOO.COM>

Although I haven't done the math, at least part of the explanation of "linear" x vs. t results may have to do with some of the system energy showing up as rotational KE of the ball.

We got good results with HAND TIMING with a shallow (maybe 10-15 degrees) and long (8ft) ramp. I also had one class group that was able to successfully estimate g by hand timing a 3m free-fall.

Date: Sun, 8 Oct 2000
From: Thomas J Gordon <tomgordon@JUNO.COM>
Subject: Re: ball on ramp

Add a racketball ball that's filled with water. GET A NEEDLE FROM YOUR DOCTOR OR VET. Prepare the balls in her office in a bucket of water with the needle just barely inserted and in upward orientation. Squeeze and release repeatedly until no more bubbles are released by the needle. You'll probably find this ball will be the quickest down the incline (remember the soup cans?)

Date: Sat, 07 Oct 2000
From: Bob Baker <bob.baker@WORLDNET.ATT.NET>
Subject: Developing acceleration from the rail lab

When developing acceleration, it has been my experience that the students' first exposure to the concept determines their conceptual understanding. Traditionally in modeling, I have developed acceleration from the rail lab as the change in velocity as determined by the change in slope of the position-clock reading graph. This year with regular physics I developed acceleration from the motion map of the rail lab. After each group presented the rail lab, the discourse with students went as follows: T: teacher question. S: student response.

T: Can you draw a motion map of the rail lab?
S: students draw the motion maps horizontally.
T: Did the ball go horizontally on the rail or did it move horizontally and down?
S: students redraw motion maps at an angle
T: What do the dots on the motion map represent?
S: time, clock readings, position
T: What is the clock reading of the third dot?
S: students discover they must count dots, 0, 1, 2 to get two seconds for the third dot.
T: What else do the dots represent?
S: position?
T: In the rail lab, what is the position of the first dot?
S: zero
T: How do you show that on the motion map?
S: students draw an X-axis as the frame of reference for the motion map.
T: What do the arrows on the motion map represent?
S: velocity
T: Why do the arrows get longer?
S: the ball rolls faster and faster
T: Why do the dots get farther apart?
S: the ball rolls faster and faster
T: Does the first dot have an arrow?
S: some yes, some no
T: How fast was the ball traveling the instant it was let go?
S: it was not moving
T: How long should the arrow be for the first dot?
S: there should be no arrow on the first dot. (Students erase arrow on first dot.)

T: Suppose the second arrow represents 4m/s and the third arrow represents 6m/s.Write these numbers above the arrows. How long is the second arrow?
S: 2 m/s, students write a 2 above the arrow.
T: What is the difference in velocity between the second and third arrow?
S: 2 m/s
T: What is the difference in velocity between the first and second arrow?
S: 2 m/s
T: Under the second arrow starting at the dot, can you draw a new arrow that is 2 long using half an arrow head?
S: students draw the arrow.
T: What does the 2 arrow represent?
S: the change in velocity
T: Under the third arrow starting at the dot, can you draw a new arrow that is 2 long using half an arrow head?
S: students draw this arrow and an arrow under the second dot
T: What do these arrows represent?
S: the change in velocity
T: Should the first dot have an arrow like the other arrows with half an arrowhead?
S: some say yes, some say no
T: How fast is the ball moving at the first dot?
S: 0 m/s
T: How fast is the ball moving at the second dot?
S: 2 m/s
T: Was there a change in velocity?
S: yes
T: Should you draw a half arrowhead arrow at the first dot?
S: yes, students draw arrow with half arrowhead
T: What do the lengths of the half arrowhead arrows represent?
S: the change in velocity
T: How long does it take for the velocity to change 2 m/s?
S: one second
T: What do the lengths of the half arrowhead arrows represent in terms of your last two answers?
S: the change in velocity each second
T: Is there a name we could give to the change in velocity each second?
S: acceleration
T: What can we say about the acceleration of the ball based on the acceleration arrow lengths?
S: the acceleration is constant
T: Does acceleration have direction?

The discussion continues until the students are convinced that acceleration has direction.

Date: Fri, 12 Oct 2001
From: Larry Dukerich <dukerich@asu.edu>
Subject: Re: questions & questioning strategies
To: jane.jackson@asu.edu (Jane Jackson)

You wrote about the idea of using Bob Baker's Q&A session as a springboard for how we could ask good questions during a white-boarding session. I think these are OK, so long as we remind teachers that the art of the profession is in knowing when to dig deeper and when to let it go for the time being. There is no one-size-fits-all script that will magically make white-boarding come alive.
