COMPILATION: units 2 & 3: motion maps

Date: Wed, 8 Sep 1999
From: Brenda Royce

In fall 1998 Elaine Carson wrote:
> > We just did 1st quarter exams. Several of the students said they are learning
> > a lot more this way. I have about 5 kids that still can't write an equation
> > for a straight line and associate it with a motion. Any suggestions? Every
> > one of these is the kind of kid who is quiet in group work and doesn't ask
> > questions when they get lost.

This struck a chord with me. I had a very difficult time getting my students to understand a motion map, and to some degree what a position-time graph meant. This semester I tried building a physical motion map and x-t graph using my constant velocity carts and small markers out on the tennis court (the baselines form a handy axis system). I first ran two buggies (one at a time) up one sideline and had the kids drop plastic cups next to the buggy at even time intervals (I've done it with a stopwatch and by simply clapping in even time -- find your musician in the group). The resulting array of cups makes a very nice motion map. We then drew this on a whiteboard and discussed the need for information on direction of motion, added velocity vectors, and we had a motion map for each buggy that everyone understood.

The next step was to line up several students armed with marker cups along the baseline (t-axis) marked with 1sec times, one student on each time mark. Now the buggy was run along the sideline (x-axis) again while the students on the baseline (t-axis) walked parallel to the x-axis at the same pace as the buggy. When their time was called out by the time keeper, they dropped their marker on the court to show how far the buggy went at that time. We got a pretty linear x-t graph out of it, almost identical to their buggy lab graph.

We spent some time discussing the meaning of a point on the graph and contrasted it with where the actual path of the buggy was (along the sideline). A quick reference to the tennis court graph usually gets the confused back on track when they insist the motion of an object is along the line of an x-t graph and that objects change direction when speed changes.

READ BRENDA'S UPDATE BELOW!

Date: Thu, 9 Sep 1999
From: Richard J. McNamara

One other suggestion: Have you tried doing motion analysis with a cam-corder and a VCR? Just videotape a constant velocity cart moving across a table. Then put the tape in the VCR. Put an overhead transparency on the screen and tape it in place.Start to play back the tape and then hit the PAUSE button. Mark the location of the car on the transparency. Use the frame advance button to step through the tape two or four or five frames and once again mark the location of the car. Advance it the same number of frames and mark the car's location again. Keep repeating this process until you have enough points, then turn of the TV and VCR. Transfer the transparency to an overhead and you have the position dots for the motion map.

I like this method because I can use it again with the paradigm lab for accelerated motion. With the position dots for the accelerating object it's very easy to see that the spacing is growing or shrinking.

Date: Sun, 10 Sep 2000
From: Vonnie Hicks <VMHicks@AOL.COM>
Subject: Tennis courts and motion maps

On 9/99 Brenda Royce described an exercise using students walking on a tennis court to generate live motion maps so as to make better sense to her students. I like the activity, although have limited access to the tennis courts at the time when I need them. She also mentioned using hand-claps as timing tics for dropping markers.

I have been doing a similar thing without benefit of quite the same level of whole-body involvement but reasonable success. I have students "dot" with markers next to moving carts along tracks, either on the white melamine tracks with dry erase markers, or on rolled out adding machine paper with most any marker. The paper or the track marks can be turned into a motion map fairly easily, and even repositioned vertically to become the position axis of a bulletin-board graph.

I generally do the lab after working with pendula, and assign as a last extension to the pendulum exercise a challenge to predict the length of a pendulum with a period of one second, then construct same. Using such a pendulum, students can learn to clap at each end of the pendulum's swing so that claps can be regulated to 0.5 second intervals (takes a little practice for students rhythmically challenged, but learning curve is not too steep). Creating a time number line ("straightening out the clock scale") can complete the bulletin board graph an allow for discussion of meaning of plotted point (where the cart was, and when it was there) and the meaning of the rest of the points in a best-fit straight line (all the places and times the cart passed through that we did not have opportunity to mark).

Incidentally, with students who have a little experience with dotting and clapping, I have gotten data to fit the best-fit straight lines in Graphical Analysis better than than most stopwatch data.

The advantage of this over the tennis court is that it can also easily adapt to accelerated motion on a tilted track, and it can work with a large variety of moving objects, from actual carts to ball bearings rolling in grooves.

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Date: Mon, 25 Sep 2000
From: Jim Schmitt <jschmitt@ECASD.K12.WI.US>

After my first year of modeling, I was very frustrated with my students' ability to produce and interpret motion maps. This year I have found what seems to be a better initial experience for them. I videotape a student walking across the front of the room. I ask her/him to walk forward, stop for a split second and then walk backwards - keeping her/his head still the entire time. When I play the tape, I hook the VCR up to a video projection system so that the image of the student is huge on the front board (you can do this on a TV with overhead markers, but it's not as impressive). Then, I play the tape back frame-by-frame. I put a dot on the board where the student is in each frame (you can, of course, do this every 3rd, 10th, etc.. frame, as long as it is in even intervals). The dot goes on the same part of the body (I usually pick the nose...they think that's really funny!). As we progress forwards, the concept of a dot at each time interval comes as no problem.

The cool part is when the person stops. Where does the dot go? Without fail, they say it should either go above or below (I coax the "above" solution when both are given) because otherwise you won't see it over the top of the previous dot.

What about each successive dot standing still? Keep going above. Then, when the body goes the other direction, the dots move the other way.

What about arrows? They have no problem with this, either, both with direction and length. Actually, while we did this with the constant velocity unit, the arrows changed length due to the reality that humans cannot stop instantaneously...previewing the acceleration maps we will soon be making.

I was amazed at how easily this method worked at explaining this tool of depicting models. Finally, when students "forget" how to make the maps, you just remind them of when we tracked someone's nose in class!

Date: Tue, 26 Sep 2000
From: Bill Jameson <bjameson@MAIL.DEFOREST.K12.WI.US>

When I have my students (9th graders) do their constant-velocity lab with toy cars, I ask them to mark the position of the car with a penny. Each second, they place a penny beside the front (or back) end of the car. After 6 or more seconds, they stop the car and measure the position of each penny relative to the starting place.

I started doing this because they had too much trouble recording the position in real time. One week later, I realized that the pennies neatly laid out a motion map. Now I use that example to help them understand motion maps.

BRENDA'S UPDATE, and more!

Date: Fri, 24 Aug 2001
From: Brenda Royce <brroyce@MEDIAONE.NET>
Subject: motion maps and graphs

It was interesting to be reminded of some great ideas for getting motion maps across to students. I realized I should also update my comments from 2 years ago on the tennis court motion map/x-t graph. That part of the curriculum landed in late August or late January, not the most conducive weather for student attention outside, so I have made modifications that have been effective.

I set up a meter stick number line (with both + and - directions) and have them observe a person walking (or battery car, or ....) and drop cups at even claps to develop the motion map, just like on the tennis court, and then have them draw a picture of this along the top of their WBs. We can collect more than 1 pattern of motion and then move inside at this time if weather demands. In discussion, we add vectors and relate it the original motion.

Then I have them rotate their WB so the x-axis of the motion map is directed upward like the position axis of an x-t graph and add a time axis to the right at x=0. We discuss what that axis means, and then copy the dots at the same x value over each position's time value on the t axis.

We then discuss how these two are related and I ask (more than once) where on the graph the person/buggy was actually moving until they realize the motion is ONLY along the x-axis.

I am now having them draw their motion maps along the x-axis of the graph (when we are using both). It just drives home that the x-axis is 'where the action is'.

Once this is understood, graphs can be translated into motion maps by choosing equal time intervals and copying the positions into a motion map on the left of the x-axis. This makes the motion maps more quantitatively correct, especially for accelerating objects where the students do not readily visualize the pattern of changing position change at successive 1-second intervals.

Later, graph matching with a motion detector makes it kinesthetically understood. I have also used a Guess the Graph activity where students walk off their 'secret' graph or motion map along a class-designated axis and the class figures out which graph/map from a 'menu' on the overhead is correct.

Date: Mon, 27 Aug 2001
From: Nina Daye <dayen@OHS.ORANGE.K12.NC.US>

You can use the pull off stickers that are found in many office supply stores to mark the place of various objects. This is a nice lead-in as well to motion maps.

Date: Wed, 5 Sep 2001
From: John Barrer <forcejb@YAHOO.COM>

One of my students came up with a creative way to present instantaneous reversal on a motion map. Rather than erasing one of the two dots, he made a single large elliptical dot which ended the + travel and also began the - travel.

Date: Sun, 30 Sep 2001
From: Charles Rhodes <Crhodes@AP.NET>
Subject: Beyond motion maps.

During a whiteboard session with the usual motion maps, one group included an Emotion Map. They created this expression of their inner being by replacing the dots with smiley faces. The faces were rich symbolic representations of complex feelings as they have changed over recent days. The class sat in awe and then delight as they realized the depth of the humanity these three friends were sharing with all of us.

We learn as we teach. I am thankful for these young people teaching me again that I can be much more to them than a physics teacher, if I am willing to listen to what is really in them and to accompany them as they try to make sense of the world. Teaching physics demands so much, how can there be time to do more? The answer is in other questions I put to myself. If I do not accompany them, who will? If not now, then when?
