Tutorial

The meaning of speed

I. Recording motion with a tapper

Physics is, to a large extent, the study of the motion of objects. There are any number of ways to record the motion of a cart. One simple method is to attach a ribbon of paper so that it drags behind the cart and through a tapping device; the tapper leaves dots as it taps the ribbon at a constant rate. Your TA has one of these devices for you to examine.

To begin this tutorial, each person in your group will need a ruler and at least one segment of paper ribbon from the staff. All the paper segments were generated using the same tapping device. Please don't write on or fold the paper segments – other classes need to use the same ones.

A. Compare your paper segment with those of your partners. What kind of motion does each represent?

1. How does the time taken to generate one of the short segments compare to the time to generate one of the long ones? How can you tell?

2. Arrange the paper segments in order by speed. How do you know how to arrange them?

B. Suppose the tapper that made the dots strikes the ribbon every $1/40^{th}$ of a second.

1. How far did the object that generated your paper segment move in: $1/40^{th}$ of a second? $2/40^{th}$ of a second? $3/40^{th}$ of a second?

2. Predict how far the object would move in:

   i. 1 second

   ii. $1/80^{th}$ of a second

   Why are these *predictions,* rather than just calculations? That is, what assumption(s) do you use to make them?

3. Determine the speed of the object that generated each of your paper segments (in cm/s). Write the speed on a small sticky note and attach it to the paper segment.

II. Interpreting ratios

Physics, admittedly, often involves a lot of calculations. But calculations are no use unless we know what the result of the calculation means. An *interpretation* of a calculated number is a statement that tells you what the number means physically. For example, if 500 g of sand were spread evenly over a 10 cm^2 area, and interpretation of the number 50 would be "the number of grams of sand on each square centimeter."

A. Give an interpretation of the speed of the object that generated your paper segment. (If you have trouble, you might try starting your interpretation with "The speed is the number of …".)

☆ *Check your interpretation with an instructor before you proceed.*

B. A model train moving with constant speed travels 60 cm for every 1.5 s that elapses.

1. Is there a name that is commonly given to the quantity represented by the number 40? (40 = 60/1.5) If so, what is the name?

2. Interpret the number 40 for this situation.

3. Interpretations can be useful for calculating, as well as for understanding. Use your interpretation (instead of setting up and solving an equation) to figure out the distance the train moves in 2.5 s.

C. A model train moving with constant speed travels 60 cm for every 1.5 s that elapses.

1. Is there a name that is commonly given to the quantity represented by the number 0.025? (0.025= 1.5/60) If so, what is the name?

2. Interpret the number 0.025 for this situation. (You should be able to do this whether or not you identified a name for this number.)

3. Use your interpretation (not an equation) to figure out the time it takes the train to move 90 cm.

III. Longer ribbons

A. In the space below, sketch a possible paper segment resulting from motion with varying speed. What motion is taking place for the segment that you sketch?

B. Your TA has a long paper ribbon that was generated by the same tapper that generated your paper segment. Bring your paper segment to the TA and follow the instructions for this activity.

C. Suppose your paper segment was in fact part of a longer ribbon that represented varying speed. Look back at your *interpretation* of the speed for your paper segment (part II.A). Would that interpretation be valid for the entire motion that generated your segment? Why or why not?

1. If necessary, propose a new interpretation of the speed represented on your segment so that it applies even when the overall motion varies.

2. What name is given to a speed that is interpreted in this way? (The interpretation is more important than the name, so if you don't happen to know this particular vocabulary word, you can just ask and your TA will tell it to you.)

D. Suppose you selected two widely separated dots on the TA's long ribbon. Imagine measuring the distance between those two dots and dividing that by the time it took the object to move between the dots.

1. What would be an interpretation of that number?

2. What would be the name of that number? (Again, if you don't know, just ask.)

☆ *Consult an instructor before you proceed.*

IV. What to take away from this tutorial (at any speed)

In each tutorial, we will alert you to what's important for you to take away from it. We will try to particularly emphasize things that might help in any of your science courses (not only physics). In this tutorial, the two most important "exportable" ideas are *interpretations* and *awareness of assumptions.*

A. Interpretations, as you know by now, are statements that tell you what a calculated number means. Which of the following best represents your attitude about interpretations of calculated numbers? (There's no right or wrong answer to this question; please express your honest opinion and discuss it with your partners. The point is to identify the role of interpretations *for you.*)

   i. Most calculated numbers won't have any interpretation. There are just a few, like speed, that have a meaning worth paying attention to.

   ii. If a number is worth calculating it's probably because it tells you something about the physical situation, in which you should interpret it to check that it makes sense.

   iii. Lots of physics numbers probably have interpretations, but you shouldn't spend your time trying to figure them out if that's not part of the assignment.

B. During this tutorial, you made some assumptions. For example, you probably took it for granted (at least to begin with) that the motion represented on your paper segment represented the overall motion of the object. Which of the following best represents your attitude about assumptions? Again, there's no right or wrong answer to this question; please discuss your opinion frankly with your partners.

   i. Ideally, you don't assume anything. Everything should be completely spelled out.

   ii. You are always assuming things, often without even realizing it. You can't eliminate assumptions, and it's pointless to try.

   iii. You can't eliminate assumptions, but you should try to be aware of what ones you're making, so that you can check later if they're really valid.

   iv. You can't eliminate assumptions, and you should try to be aware of what ones you're making because they might help you account for counterintuitive results.

☆ *Share your group's opinions with a TA before you go.*