HW #2 - Due Friday, September 6, at 9am

Remember that you must show and explain all of your work, and all numbers that should have units must have them clearly stated! If you don't show work and indicate units the problem will be marked **wrong**! Make sure that you answer every question that I pose to you!

As always, feel free to collaborate, but be sure to only do so in a way that helps you learn and is in agreement with the Honor Code. If you are simply copying, then you are cheating, risking your academic career, and setting yourself up for failure on the exam (it's not worth it!). Check out the syllabus for guidelines, and **always credit your collaborators**!

You should already have the skills to be working on most of these problems, although we will practice some skills with graphs and acceleration more on Wednesday, 9/4. Start working immediately on the ones about material we have covered, and save the others for when we cover them (e.g., you might want to save the last one until after you do the reading that is due on Wednesday, 9/4).

Many of the short conceptual questions on this homework can be answered in only a few words, but make sure that you are clear and precise!

1. **Practice with units and average speed.** So far we've seen how to calculate average speeds, and we did some unit conversions on our math review homework. Let's practice those skills again.

   (a) Suppose you measure the length of your hair one day, and you find that it is 6.5 cm long. When you next measure it 3.7 months later, you find that it is 11.0 cm long. What is the average speed at which your hair shoots out of your head in cm/month?

   (b) We will try to always use units that are part of the International System of Units (SI units, for short), along with versions of those units that use standard metric prefixes (like *kilo-*, etc). The most basic SI unit of speed is m/s. Convert your answer from part (a) to m/s and express the answer using scientific notation, showing your work as always.

   (c) The two tectonic plates[1] that meet in the middle of the Pacific Ocean at the place known as the East Pacific Rise are moving away from each other at a rate of about 15 meters per each 100 years. By converting this speed to m/s and comparing it to your answer from part (b), determine what happens faster: continents drifting under the Pacific Ocean or hair shooting out of your head? Are they dramatically different, or are they comparable? (Aside: Different tectonic plates are presently moving at different speeds. This happens to be one of the faster ones.)

2. Apolline has decided to go watch a Roller Derby match. She leaves in her car, but shortly after leaving home, she realizes that her wallet isn't in her pocket like usual. She pulls over and looks around the car before heading back home to look there. She finds it at home and leaves for the Roller Derby again, this time making it to her destination. Apolline's position as a function of time is plotted in Figure 1. Use it to answer the next several questions.

   (a) Between what two points on the graph was Apolline driving back home and how do you know?

   (b) Between what two points on the graph was Apolline's car moving fastest and at what speed was she traveling?

   (c) Thinking back to how you calculated average speed for bowling balls in class, what was Apolline's average speed between Point D and Point G on the graph?

   (d) In physics, we often use the word **displacement** is a quite specific way. Explain in your own words the difference between *displacement* and *total distance traveled*.

[1] Tectonic plates are the massive, irregularly shaped slab of solid rock that make up the Earth's crust, moving around over time. Check it out: `https://en.wikipedia.org/wiki/Plate_tectonics`

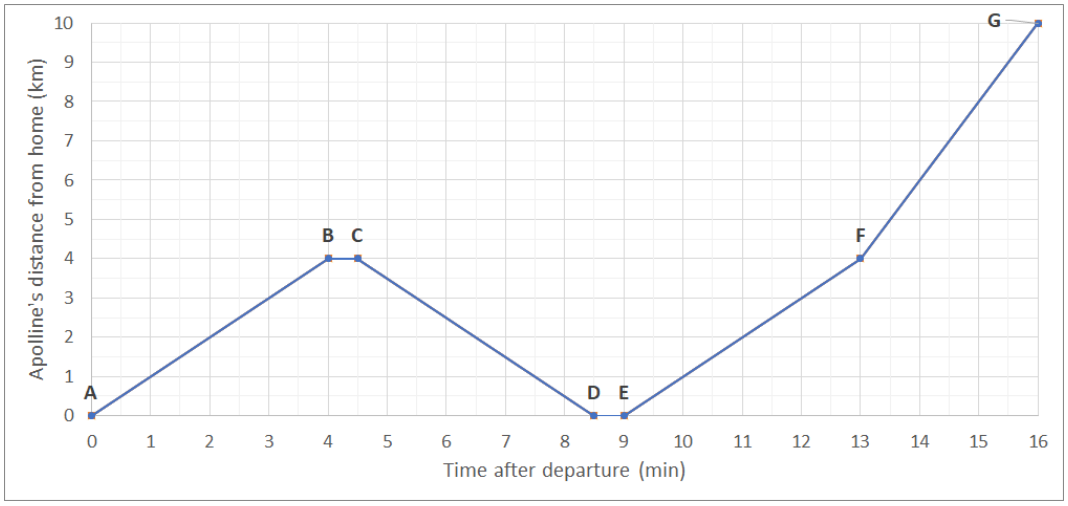

Figure 1: A graph of Apolline's motion.

(e) Determine Apolline's displacement and total distance traveled during the entirety of her escapade of trying to get to the Roller Derby. Which one is of larger magnitude?

(f) Can total distance traveled ever be smaller than total displacement? Explain why or why not in your own words (don't look this up - just think for a moment!).

(g) As you may recall from a past math or science class, there are two different types of numerical quantities that come up a lot in physics: scalars and vectors. After reading Section 2.1 of the OpenStax textbook, explain the main difference between the two quantities.

(h) In part (d), you defined *displacement* and *total distance traveled*. Which one of these is a scalar and which one is a vector? Explain.

(i) We have two ways of describing how fast something is moving: velocity and speed, defined in Section 2.2 of the OpenStax textbook. Which of these two quantities is a vector and which is a scalar? Describe in your own words what speed is and how it differs from velocity.

(j) What is Apolline's average **velocity** between time 0 min and time 16 min? Be sure to give both its magnitude and its direction, and don't forget units. (In this case, giving a direction is as simple as saying "toward" or "away from" her home!)

3. Suppose that the students of a physical education class are made to climb a rope that hangs from the ceiling. A particular student, Horace, does this exercise. When he starts, he moves up the rope slowly. Then, about halfway up, he suddenly picks up the pace and quickly reaches the top. After resting for a little while, he descends the rope quickly. He does this in a much faster time then it took him to ascend, and he gradually goes faster and faster as he is descending. Roughly sketch a position versus time graph that could plausibly show Horace's motion, being sure to label which axis is which and making sure to include all of the major features of the motion that I have described.

4. Look at Figure 2. It shows a position versus time graph for two objects, Object A and Object B.

(a) At $t = 1$ s, which object has a larger speed? Explain how you know.

(b) Do objects A and B ever have the same speed? If so, at what time or times? How do you know?

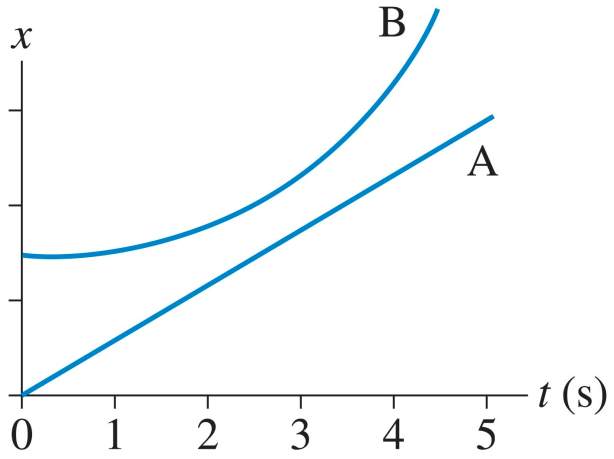

Figure 2: A graph of the motion of two objects.

5. In every day conversation, we are often sloppy with physics-related words. Let's think about how we use them a bit more.

   (a) Cars usually have a brake pedal (that makes them slow down) and an accelerator pedal (that makes them speed up). They also have steering wheels that make them turn. Recall that velocity and acceleration are vectors and thus have both a magnitude and a direction, and acceleration describes a change in velocity. In careful physics terminology, does the brake, the accelerator, the steering wheel, or more than one of these cause an acceleration of the car? Explain.

   (b) Recall that velocity and acceleration are both vectors and thus have both a magnitude and a direction. Could a moving object have an acceleration that points in the opposite direction of its velocity? Either give an example of this happening or explain why it can't.

   (c) Could a moving object have an average velocity that points in the opposite direction of its displacement that occurred during that motion? Either give an example of this happening or explain why it can't.

   (d) Could a moving object have an average acceleration that points in the opposite direction of its displacement that occurred during that motion? Either give an example of this happening or explain why it can't.

   (e) When someone says that something is "decelerating" to indicate that it is slowing down, what do they really mean in terms of how the acceleration of the object is pointing?