Week 8 Challenge Homework

2-D Conservation of Momentum, Work and Kinetic Energy

Submission Details | Submit a digital copy (PDF, jpg, etc.) to Canvas. Include solutions to the metacognitive exercise and each question. Please use the interface to associate each page of your submission with the assignment. It makes grading much easier. Please clearly indicate which question is being solved. If data is needed to complete a problem, be sure to cite the source you've acquired your data from. Typed work will not receive credit. See the course website for further details.

Group Submissions | You may submit a group collaboration to Canvas. Add each group member to the submission. Each group member should contribute to the work. Clearly indicate which part of the submission is written by each member (color or labels are preferable).

Sensemaking | You will be asked to apply sensemaking in some problems. More information about sense-making can be found on the BoxSand Sensemaking page, which is linked on the Canvas homepage.

Metacognitive Exercise

Each week will feature a metacognitive exercise, followed by one or two challenge problems to solve. The metacognitive exercise will usually ask you to reflect on your solution to the previous week's challenge problems.

Review your solution to the Week 7 Challenge Homework. If you do not have a copy of it anymore, you can find it on Canvas or Gradescope, under the Week 7 Challenge Homework assignment. Also, review the solution which has been posted to the BoxSand solutions archive (click here for a link) a few days after the assignment is due.

Note: only 2 – 5 sentences are expected for each part of this exercise. Though you are welcome to write more if you would like.

(a) How did your predicted grading for the week 7 challenge homework (from the week 7 metacognitive exercise) compare with the grading from your grader? What are your thoughts around any of the differences? Do they make sense in retrospect?
(b) The week 7 prompt was a different style of prompt. What are your feelings about this style of prompt? Did you enjoy it? Were there aspects that were more challenging or more accessible?
(c) What physical representations did you create in solving the week 7 challenge homework? How were they useful in solving and/or communicating your solution to the question?

Question 1:

An evil doer has stolen the unstable atomic nuclear mass ($\mathbf{17.017 \times 10^{-27}\ kg}$) from the unstable nuclear mass facility. While waiting at a stop light the unthinkable happens (actually, quite expected and predictable up to a probability) and the mass disintegrates into three particles. One of the particles, of mass $\mathbf{5.00 \times 10^{-27}\ kg}$, moves in the y-direction with a speed of $\mathbf{6.00 \times 10^{6}\ \frac{m}{s}}$. Another particle, of mass $\mathbf{8.40 \times 10^{-27}\ kg}$, moves in the x-direction with a speed of $\mathbf{4.00 \times 10^{6}\ \frac{m}{s}}$.

(a) Start your *Sign* sensemaking by making a prediction for the signs of the x- and y-components of the velocity of the third particle. Explain this prediction using any combination of words, diagrams (hint: physical representation), graphs, etc.
(b) Find the magnitude and direction of the velocity of the third particle.
(c) Finish your *Sign* sensemaking by comparing your predicted and found signs for the components of the velocity of the third particle.

Question 2:

In the school cafeteria, a trouble-making child blows a **12.0 g** spitball through a **25.0 cm** straw. The force (**F**) in Newtons, of his breath as a function of the distance along the straw (**x**) in meters, can be modeled as a linearly decreasing function for the first half of the straw then a constant force through the rest of the straw. The force decreases by half along the first half of the straw. Assume there is negligible friction, and that the straw is held horizontally.

(a) Sketch a plot of the force of his breath as a function of position along the straw, labeling the force at $\mathbf{x = 0}$ as $\mathbf{F_0}$.
(b) If the spitball begins from rest and leaves the straw with a speed of $\mathbf{16\ m/s}$, how much work is done on the spitball?
(c) What is the maximum force $\mathbf{F_0}$, that acts on the spitball? (hint for part d: find a symbolic solution to part (c) before plugging in numerical values)
(d) Use *Proportionality* (also known as *Covariation*) sensemaking to analyze your answer to part (c) by answering the following prompts.
   - Would you expect the maximum force, $\mathbf{F_0}$, to increase or decrease if the length of the straw were smaller, but the amount of work done on the spitball stayed the same?
   - Explain your above prediction using any combination of words, diagrams, algebra, etc.
   - Finally, compare your prediction with a calculation (following along the lines of your original calculation) assuming the length of the straw is now ½ of the original length.