Week 3 Challenge Homework

Rotational Conserved Quantities and Microscopic Model of Gasses

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 2 Challenge Homework. If you do not have a copy of it anymore, you can find it on Canvas or Gradescope, under the Week 2 Challenge Homework assignment. Also, review the solution which has been posted to the BoxSand solutions archive (click here for a link). Solutions are posted a few days after the assignment is due.

(a) The provided solution to Question 2, part (c) shows all the work in symbolic form (without numerical values plugged in). What are some reasons why a physicist might want to work out a solution symbolically?

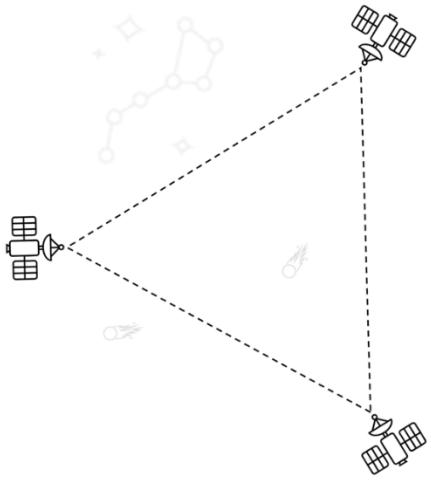
(b) How confident are you feeling about writing solutions of your own using symbolic reasoning until the last step where numbers are plugged in?

(c) As this course progresses, you will gradually be expected to show mastery of symbolic reasoning. Is it something you are already practicing? Or do you tend to solve problems by plugging values in earlier in the solution? How are you or how will you work towards developing this skill?

(d) Once you have worked through question 2 in this week's challenge homework, grade yourself using the challenge homework grading rubric. We have provided a table for the rubric here, but you might also find it useful to review the rubric and guidelines posted in the solutions archive (click here).

Category	None, attempted, developing, meets, or exceeds expectations	Reasoning (briefly)
Metacognition		
Clarity of Communication		
Earnest Attempt		
Physical Representation		
Sensemaking		

Question 1:



A space station consists of three modules, connected to form an equilateral triangle of side length 82.0 m. The space station creates "artificial gravity" by spinning around the center of the triangle. Suppose 100 people, with an average mass of 75.0 kg each, live in each capsule and the mass of the modules is negligible compared to the mass of the people. At the current rotational rate, the **effective** acceleration of gravity inside each module is g/2.

(a) What is the angular momentum of the system?

(b) If the modules shorten the connections between themselves, what should happen to the effective gravitational acceleration? Explain. (Hint 1: the angular momentum of the system will remain constant! Hint 2: finding a symbolic relationship/equation for the effective gravitational acceleration in terms of connection length may be helpful) These are the prediction and explanation pieces of the sensemaking process which will be completed in part (d).

(c) Determine the distance between the modules which would give an effective acceleration of gravity equal to g. (Hint: again, assume the angular momentum of the system is constant)

(d) Use the *Proportional Reasoning* (also known as *Covariational Reasoning*) sensemaking technique to evaluate the effective acceleration of gravity changes, by answering the following prompt.

· Complete the sensemaking process by making a comparison between your prediction in part (b) with your answer to part (c). Explain why your answer to part (c) is reasonable (or not!).

Question 2:

A helium atom falls in a vacuum chamber on Earth. The mass of a helium atom is 6.64×10^{-27} kg.

(a) From what height must it fall so that its translational kinetic energy at the bottom equals the average translational kinetic energy of a helium molecule at 300 K?

(b) Use the *Proportional Reasoning* (also known as *Covariational Reasoning*) sensemaking technique to evaluate your solution to part (a), by answering the following prompts.

i. If the temperature listed in part (a) increased, would you expect the required height to increase or decrease? (this is your prediction step to the sensemaking process)

ii. To explain your answer to the previous prompt (b.i), find a symbolic solution (an equation using symbols instead of numerical values for quantities) to the relationship between the height a helium atom must fall and the temperature.

iii. Compare your prediction (b.i) with your symbolic solution (b.ii). Does the symbolic solution match the prediction? Explain.

(c) At what temperature would the average speed of helium atoms equal the escape speed from the Earth, 1.12×10^4 m/s.

(d) Do **any** of the helium atoms in the Earth's atmosphere have this speed? Explain your answer and any consequences that may arise from it.