

Week 3 Challenge Homework

Rotational Conserved Quantities and Microscopic Model of Gasses

Submit a digital copy (PDF, jpg, etc.) to gradescope.com. Please use the Gradescope interface to associate each page of your submission with the corresponding question number! It makes grading much easier.

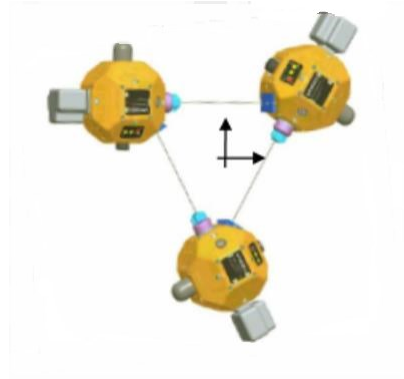
Every page should be labeled on the top left with the question number and there should be only be one solution per page. If a solution takes more than one page, be sure to label that it is a continuation of the previous page's solution. If data is needed to complete a problem, be sure to cite the source you've acquired your data from. See the course website for further details.

You will be asked to apply sense-making in some problems. Use the list below as a reference to the different sense-making techniques. More information about sense-making can be found on the BoxSand menu under Math Tools => [Sense-making](#).

- *Sign*: Check the **sign** of each quantity makes sense.
- *Dimensionality*: Check the **dimensionality** and units of each quantity makes sense.
- *Order of Magnitude*: Check the **order of magnitude** of the final answer and other important quantities is within a factor of 10 of what you think it should be.
- *Graphical Analysis*: Use a **graph** to see if the behavior of a solution makes sense.
- *Proportionality*: Using a symbolic solution, check the behavior of the answer when you change a given quantity on which it is dependent. Does the answer vary **proportionally** to what you expect?
- *Special Cases*: Check the behavior of a derived equation in limiting (**special**) cases makes sense, e.g. as x goes to 90 degrees in $\sin(x)$.
- *Self-consistency*: Check derived equations, functions, or values, are **self-consistent**, e.g. check that the slope of a derived position plot matches the values of the given velocity plot
- *Known Values*: Compare given or derived quantities with common well **known values**.
- *Related Quantities*: Compare the relative magnitude of two **related quantities**.

Question 1:

A space station consists of three modules, connected to form an equilateral triangle of side length 82.0 m. 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 is $g/2$.



- What is the angular momentum of the system?
- If the modules are pulled closer what should happen to the rotational rate? Explain.
- Determine the distance between the modules which would give an effective acceleration of gravity equal to g .
- Use the Proportionality sensemaking technique to evaluate whether the effective acceleration of gravity changes as expected with a change in the distance between modules. Hint: compare the problem statement and your answer to part (c) with your answer to part (b).

Question 2:

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

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