

Week 4 Challenge Homework

Charges and Forces

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 sensemaking 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) What are your feelings around solving problems with symbolic algebraic arguments, as opposed to plugging numeric values in prior to performing algebraic steps? Which did you prefer at the start of your PH 201/2/3 journey? Do you have a different preference now? Do you see advantages to symbolic solutions? Advantages to algebraic solutions?

Question 1

Two balloons filled with air are tied to very light 0.5-m-long string. The loose ends of the strings are taped to the same position on a horizontal bar. When both are equally rubbed with the same material they both develop a static charge and repel each other, making an angle of 30° with respect to the vertical. If you need a quantity that is not provided, please find a source and *cite it*.

- (a) With this experiment alone can you tell what type of charge is on the balloon? Explain.
- (b) Is this a stable or unstable equilibrium?
- (c) *Estimate* the number of excess elementary charges (likely either an excess or deficit of electrons!) on each balloon. Clearly state any assumptions made in your estimation.
- (d) Use special case sensemaking to estimate the number of charges needed for the balloons to each make an angle of 90° with the vertical. Explain using the relationships (equations) between angle and charge you found in part (c). You'll want to use a symbolic solution to part (c) to help you here. A useful tactic is to show what happens to the charge as the angle approaches 90° . Make sure to include a prediction and qualitative explanation, then compare that with the result of the mathematical relationship.
- Note: this might also be considered covariational sensemaking, or both methods in conjunction, since we are reasoning using an equation/relationship between quantities.*
- (e) If a small, charged sphere is placed in the middle of the two balloons and the angle between them doubles, *estimate* the number of excess elementary charges on the sphere, again being sure to state any assumptions used in your calculation.

