Week 5 Challenge Homework

Free Body Diagrams and Newton's 2nd Law

Submission Details | Submit a digital copy (PDF, jpg, etc.) to Canvas. 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.

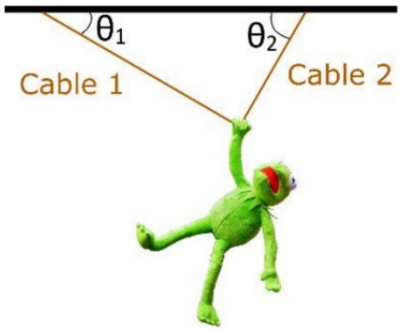
Review your solution to the Week 3 Challenge Homework. If you do not have a copy of it anymore, you can find it on Canvas or Gradescope, under the Week 3 Challenge Homework assignment. Also, review the solution which has been posted to the BoxSand solutions archive (click here for a link) a few days after the assignment is due.

(a) With a classmate, discuss the sensemaking techniques we have used in class, in recitation, and in our challenge homework so far this term. Which of the techniques on the boxsand sensemaking page have we used? In PH 201, we will focus mostly on *sign*, *units/dimensions*, and *related quantities* sensemaking, but we will see a few others. In which of these sensemaking techniques are you most confident? What questions do you have about sensemaking? Where could you find the answers to those questions? Does your classmate agree/disagree/share the same questions?

(b) Using the rubric and guidelines provided here and in the solutions archive (click here for link), grade your own solution to the Week 4 Challenge Homework submission. What areas of improvement do you see?

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

Question 1:



A chandelier with mass m is attached to the ceiling of a large concert hall by two cables. Cable 1 has tension T_1 and makes an angle of θ_1 with the ceiling. Cable 2 has tension T_2 and makes an angle of θ_2 with the ceiling.

(a) Evaluative sensemaking usually involves making a prediction for some aspect of your solution, explaining that prediction, then comparing your prediction with your solution. We will do the first piece of this now, using *sign* sensemaking. Make a prediction for the sign of the x-components of T_1 and T_2. Explain your prediction using any combination of words, algebra, diagrams, etc.

(b) We are also going to use *related quantities* sensemaking for this question. Make a prediction for the relationship between the magnitudes of the x-components of the tensions, then explain that prediction.

(c) Find an expression for T_1, the tension in cable 1, that does not depend on T_2. Express your answer in terms of some, or all of the variables m, θ_1, θ_2, and the magnitude of the acceleration due to gravity g.

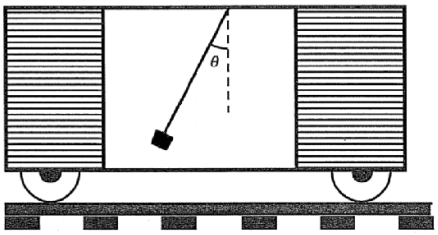
(d) Find a similar expression for the tension in cable 2, T_2, which does not depend on T_1.

(e) Complete your *sign* sensemaking by checking your results for parts (c) and (d) with your prediction in part (a). Make sure to briefly explain your comparison. Writing "they match" isn't enough.

(f) Complete your *related quantities* sensemaking by checking your results for parts (c) and (d) with your prediction in part (b). Make sure to briefly explain your comparison. Writing "they match" isn't enough.

(hint: Now that you have tried sign and related quantities sensemaking a few times, the prompts will start to be a little less descriptive and you will need to fill in some blanks. Looking back at previous sensemaking prompts may help.)

Question 2:



A rope is loosely fastened, (i.e. it can swing back and forth) to the ceiling of a railway car. When a block of unknown mass is hung from the rope and the car maintains a constant acceleration, the rope is oriented at an angle of 6° as shown in the figure. All of the following questions refer to the time when the car is accelerating and the rope is maintaining a constant angle with respect to the vertical.

(a) What must the direction of the acceleration of the car be? Explain.

(b) What is the direction of the velocity? Explain.

(c) Find the acceleration of the railway car.

(hint: find a symbolic expression for the magnitude of the acceleration before plugging in numbers)
(hint 2: when you don't know what the value of a quantity is, give it a name / variable)

(d) Use the *proportionality* (also known as *covariation*) sensemaking technique to check your symbolic expression for the acceleration in part (c) by answering the following prompts:

- Should the angle of the rope increase or decrease as the acceleration increases? Explain what you would expect the relationship between acceleration and angle to be and why.
- In your symbolic solution, if the acceleration increases, what happens to the angle of the rope? (assume all other variables stay the same)
- Compare your predicted relationship to the relationship that your symbolic solution presents. Are they the same? Explain briefly.