PHYS 121: Homework #08

April 3, 2024

Physics 121: Spring 2024: Week 11 Reading assignment:

REQUIRED: ***Physics 121 Online Class Notes*** **Cycle 2, Chapter 13+ and Cycle 3, Chapters 5++ through 7++ posted on the Canvas website, as follows:**

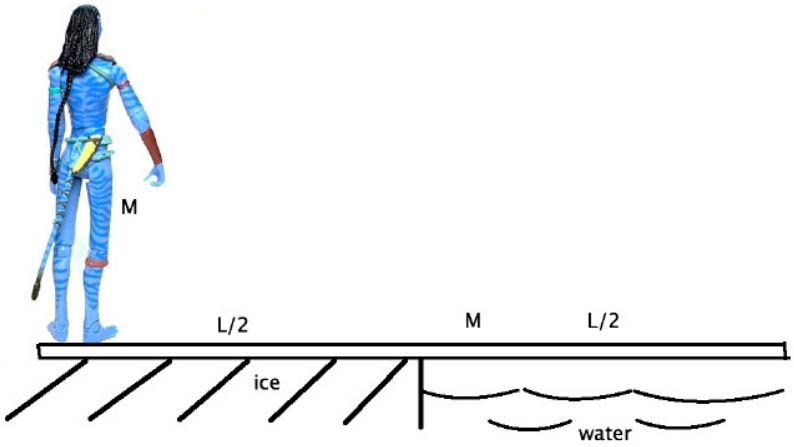
- **Chapter 05++**: Tug-of-war should make sense now.
- **Read Chapter 06++**: This is a short and simple but important little chapter. It's basically a check to make sure you can break forces into components easily by now.
- **Read Chapter 07++**: Finally we get to talk about the coefficient of static friction.

This Homework is due TUESDAY, April 9 at 11 PM and must be submitted online as a PDF file via Canvas.

Homework continues next page....

Problem 1: This is an Important Conceptual Question

Problem 11-7
Neytiri is standing on the end of a long thin uniform board of length L. *Half of the board including the end where Neytiri is standing rests on very slippery ice with the other half over open water, as shown. Lucky for our calculations, the board and Neytiri have the same mass* M *!* ☺



a) Find the x *coordinate, relative to the ice, of the overall CM of Neytiri and the board. Define* x = 0 *at her end, and* x = L *at the other end.*

b) If Neytiri walks all the way to the other end, will she fall into the water? Give your reasoning.

c) Suppose Neytiri moves at a speed v ***relative to the ice****, while she is walking to the right as described in part (b) from her original end position. What is the CM velocity?*

d) How fast is the board moving relative to the ice and in what direction, if Neytiri is moving at speed v to the right?

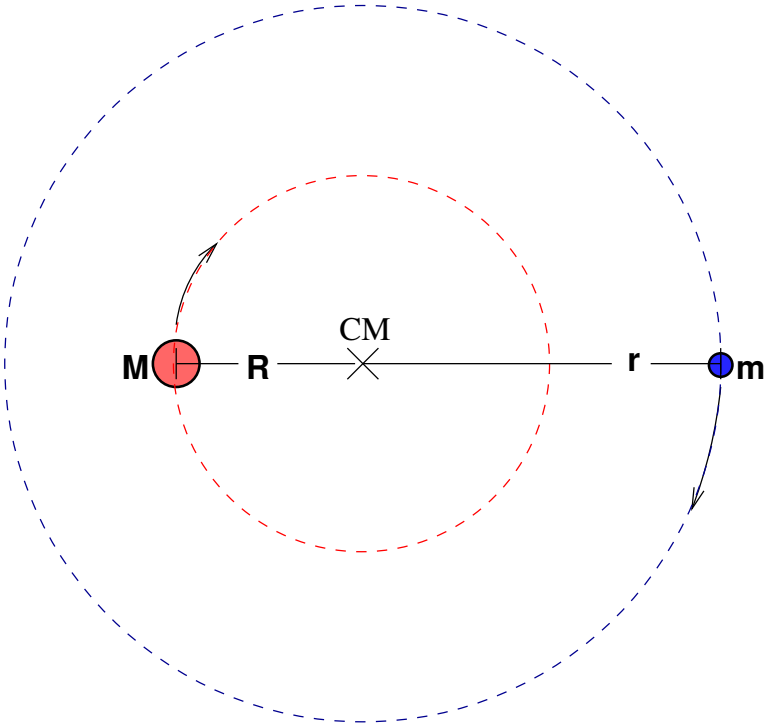
See next page for important hints on this problem.

Hints on Problem 1: Ask yourself these questions:

- What is the **system** here? (getting the right answer depends on this choice!)
- Is the system **isolated**? (yes, it is.)
- Does the system **remain isolated**? (yes, it does.)
- Before Neytiri moves at all, what is the x-position of the board? (Hint: these two answers are incorrect: $x_{board} = 0$ and $x_{board} = L$.)
- Before Neytiri moves at all, what is x_{cm} corresponding to the position of the Center-of-Mass of the system? (Hint: use the Definition of Center-of-Mass.)
- Before Neytiri moves at all, what is v_{cm} corresponding to the velocity of the Center-of-Mass of the system?
- If the system remains **isolated** what does this tell you about how the velocity of the center-of-mass of the system will change?
- What does this tell you about the how the position of the center-of-mass will change?
- Consider this question. If Neytiri steps one centimeter to the right, how far will the board move and in what direction? How do you know this must be true? (Yes, the board moves! The board **must** move to ensure that your answers to the above questions remain true.)

Problem 2: Universal Gravity (from a previous final exam):

Consider two stars, each in its own *circular* orbit around a common Center-of-Mass (CM) point as show:



Suppose the masses of the two stars M and m are *given*. The radii of each of the two orbits is indicated by R and r. Assume that the radius r is *given* but the radius R is *not* given.

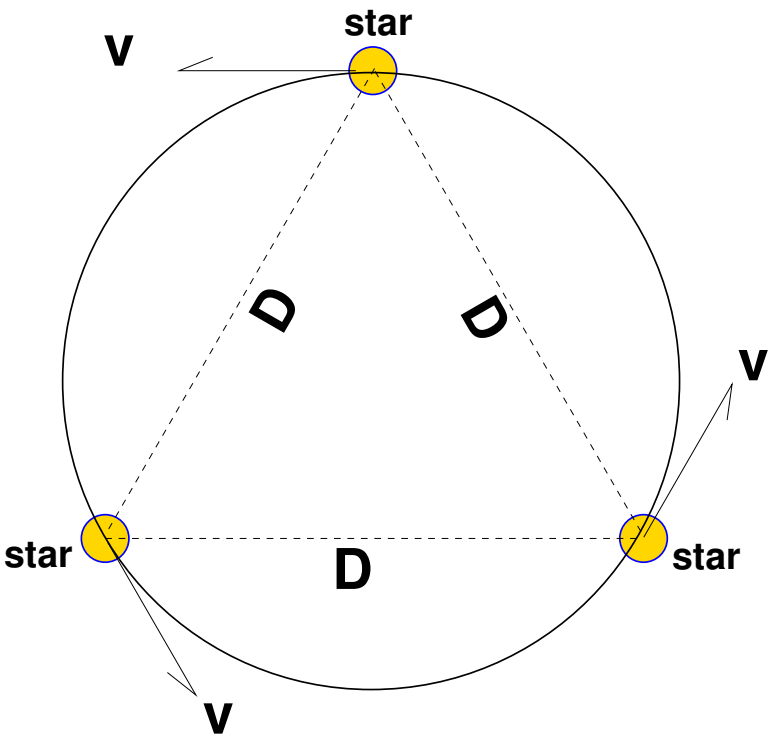
Calculate the magnitude of the linear velocity v_m of the star with mass m (on the right) in terms of the two given masses and the radius r. Explain your work.

Important: For this problem, you need to set up a step-by-step process and explain each step. You will be graded on both your answer and on your explanation of your method. You must explain your work in terms of Physics Concepts.

Hint: It may be helpful to *define* the (fixed!) Center-of-mass point as the origin (corresponding to "position zero") with the right star at a positive position and the left star at a negative position, and then use the Definition of Center-of-Mass to calculate the ratio R/r in terms of the given masses. Then use this result together with Newton's Second Law to find an expression for the velocity of the particular star.

Problem 3: A Special Triple Star System

This problem was on the final exam for Fall 2012. You need to apply Newton's Second Law.



Consider a very special arrangement of three stars place in orbit about each other as shown in the figure above. Each star has given mass m and each star is positioned on the three corners of an equilateral triangle so that the distance between any two stars is given as D – the length of one side of the triangle. All three stars travel along a circular orbit of radius $= \frac{\sqrt{3}D}{3}$ in accordance with geometry.

Calculate the *speed* v of any of the three stars in orbit. Given your answer in terms of the given parameters. Explain your work. Some possibly useful relations:

- $\sin 30^\circ = \frac{1}{2}$
- $\cos 30^\circ = \frac{\sqrt{3}}{2}$
- $\sin 60^\circ = \frac{\sqrt{3}}{2}$
- $\cos 60^\circ = \frac{1}{2}$