PHYS 121: Homework #05 and Reading Assignment

February 27, 2024

This Homework is due Monday, March 6 at 11 PM and must be submitted online as a PDF file via Canvas.

Homework and Reading Assignment continues next page....

Physics 121: Spring 2024: Week 7 Reading assignment:

REQUIRED: ***Physics 121 Online Class Notes*, posted on the Canvas page, as follows:**

- **Re-Read Chapter 15:** Here we have a nice first look at the Spring Force, Hooke's Law and the concept of Simple Harmonic Motion (SHM).
- **Read Chapter 05+**: This is a pretty important chapter. We look at a chain of blocks and a massive rope. The critical issue here is that everything we do follows from Newton's Second Law. Sometimes we apply it to a single body. Other times we define a "system". Either way, it's all about the Second Law.
- **Read Chapter 06+**: Force components again. Remember this simple rule. When a force is broken into components, one of these is always the magnitude of the force times the cosine of some angle, the other is always the magnitude times the sine of the same angle. Make sure you also understand the examples of the ball on a string and the plane flying in a horizontal circle. In both of these cases the "centripetal" coordinate is horizontal, toward the center of the circle.
- **Read Chapter 07+**: Here we have another chance to look at friction. Please note that even though the concept of the coefficient of static friction is described on page 7-2, we will not be using this to solve problems until Cycle 3.
- **Read Chapter 08+**: Back to pulleys again but now we put them in more complicated arrangements. Here is the key idea: A rope always pulls. It only pulls. It cannot push. An ideal rope also always pulls with the same tension everywhere along it's length and that is true regardless of whether or not the rope itself and/or the object that the rope is pulling on are in motion. A pull is a pull is a pull.

Reading Assignment Continues....

OPTIONAL BUT RECOMMENDED: **Read** ***Physics for Scientist and Engineers*** **by Ohanian and Markert** as follows:

- **Review Chapter 5, Selected Sections as follows:**
  - **Review Sections 5.1 and 5.2** Every time I start this course I re-read these two sections.
  - **Skim Section 5.3** Now that we are thinking in 2-D and 3-D the concept of net force as a vector sum should really be sinking home.
  - **Read Section 5.4** This is good stuff. Weightlessness has nothing to do with weight and everything to do with being accelerated vertically.
  - **Skim Section 5.5** You are now well-prepared to reflect on the power and subtlety that is Newton's Third Law.
  - **Skim Section 5.6** Lots of good examples with different angle and directions here. If you are comfortable with this material, you will be in great shape for the next exam.

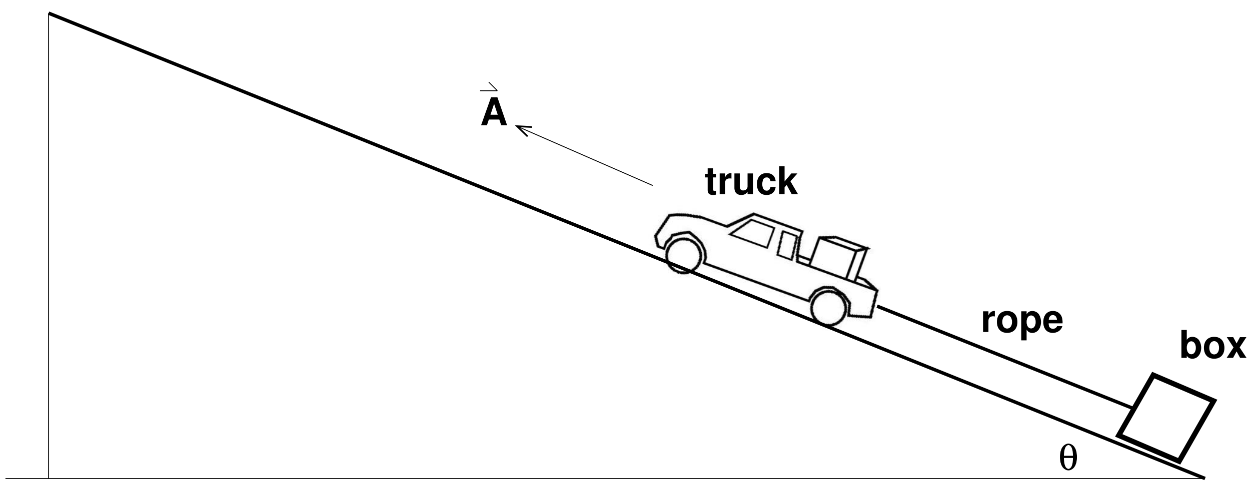
Homework continues next page....

Physics 121: Spring 2024: Homework #05

11 PM Sharp, MONDAY, March 4, 2024

Important note: The homework will be graded on a scale of 0 to 15 points. **Not all problems will be graded.**

Problem 1:



A truck pulls a box up a ramp at a constant given constant acceleration A as shown above with an ideal rope. The angle of the ramp is given as θ. The wheels of the truck pull the truck up with no slipping and no sliding. The box is greased on the bottom surface so that there is a given coefficient of sliding friction between the box and the ramp of μ. The mass of the truck is given as m_t and the mass of the box is given as m_b.

a) Draw a careful Free Body Diagram for both the truck and the box. Include a proper coordinate system and be sure to indicate every force on each body. Make very sure you have each force clearly and properly labeled. At this time we expect all students use the format and notation given in this class for every FBD.

b) In terms of given parameters A, m_t, m_b, μ and θ, determine the magnitude of each and every force on both the truck and the box. Note: thee are four forces on each. Be sure you find all eight forces and express your answers in terms of the given parameters.

Problem 2. The Simple Pendulum represents a rich system for checking our understanding of forces, work, and energy. This from a previous final exam:

A pendulum is made from a bob of mass m and an ideal string of length ℓ. Suppose the bob is pulled back and released from rest at a position with the string at an angle of θ_0 relative to the vertical where θ_0 has some particular but arbitrary value less than 90 degrees. For all of these questions give your answer in terms of the given parameters m, ℓ and θ_0.

(part a) Draw a careful sketch of what is going on here.

(part b) What is the magnitude of the acceleration of the bob immediately after the bob is released? Hint: no it is not zero. Another hint. If you choose the right coordinate system this problem is relatively simple.

(part c) What is the tension on the string immediately after the bob is released? No, it is not zero. No, it is not mg. Hint: What kind of acceleration applies in the direction of the string?

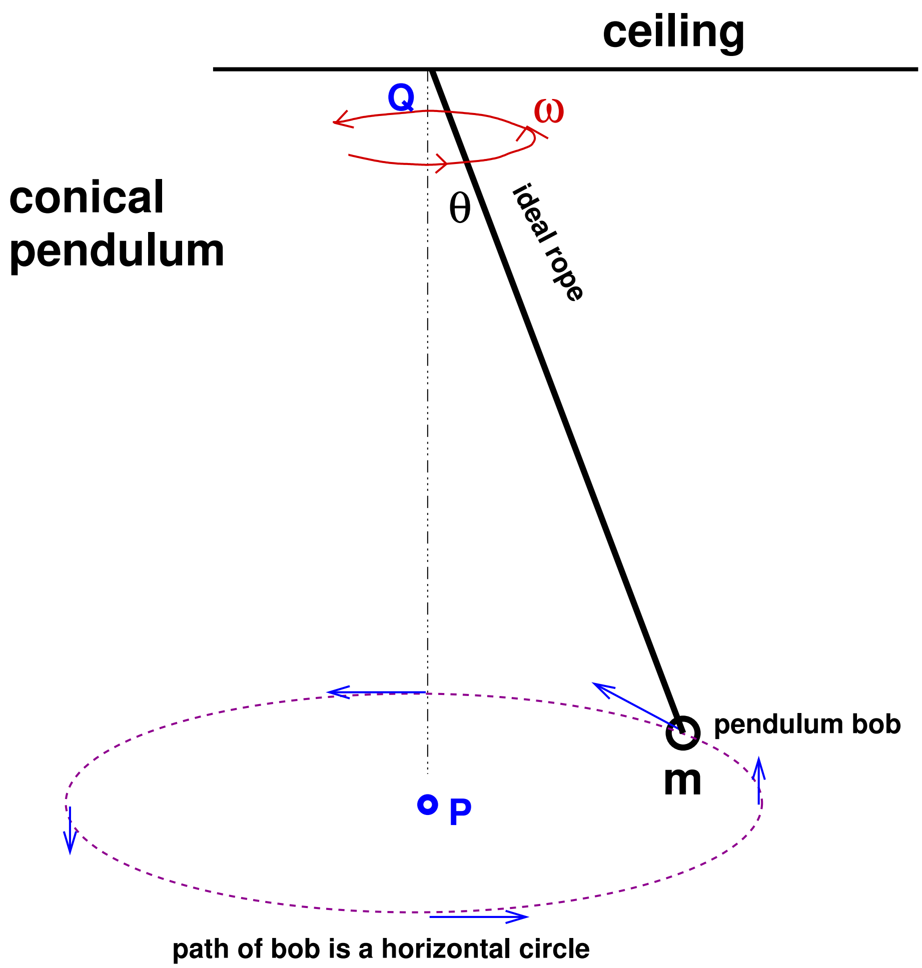
(part d) What is the Work done by the force of Tension as the bob falls from its initial position to the position corresponding to the bottom of the arc?

(part e) What is the Work done by the Weight force as the bob falls from its initial position to the position corresponding to the bottom of the arc?

(part f) What is the maximum speed V of the bob during the swing of the pendulum?

(part g) What is the magnitude of the force of Tension on the string when the bob is at the position corresponding to the bottom of the arc? Hint: No, $T = mg$ is not the correct answer.

Problem 3: A Conical Pendulum



A "Conical Pendulum" is shown in the figure above. The bob of given mass m travels in a *horizontal circular path*. The point P indicate the point at the center of the circular path of the bob as shown. The angle of the ideal string with respect to the vertical is **constant** and given as θ. The length of the string ℓ is also given.

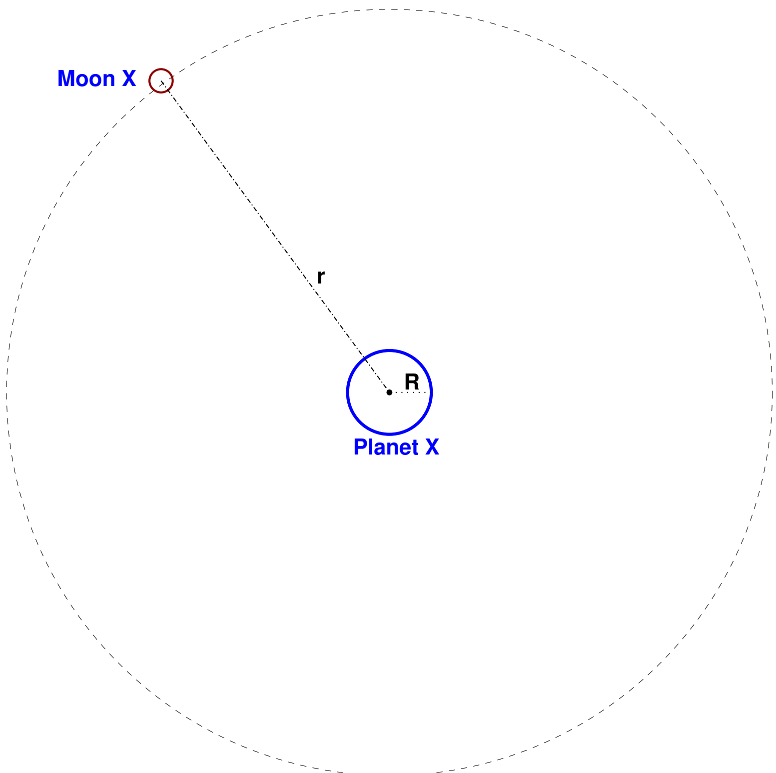
Part (a) – : Draw a careful and complete **Free-Body-Diagram** showing all of the forces on the bob. Be sure to include an appropriately labeled coordinate system.

Part (b) – : Calculate the magnitude of the force of Tension on the string. Explain your work. Give your answer in terms of the given parameters. Hint: Apply Newton's Second Law in the vertical Component.

Part (c) – : Calculate the **angular speed** ω of the conical pendulum. Explain your work. Give your answer in terms of the given parameters. Hint: Apply Newton's Second Law in the centripetal component. Use the Rolling Constraint: $v = \omega r$ that relates the (linear) speed of an object with Uniform Circular Motion to the angular speed of rotation about the axis.

Problem 4: Planet X and it's Moon

Suppose a new planet is discovered at a great distance from the sun in deep space. The new planet is called *Planet X*. Suppose further that *Planet X* has *moon*, called *Moon X*, that orbits the planet in a circular orbit. Assume that the mass of the planet is quite large compared to the mass of the moon.



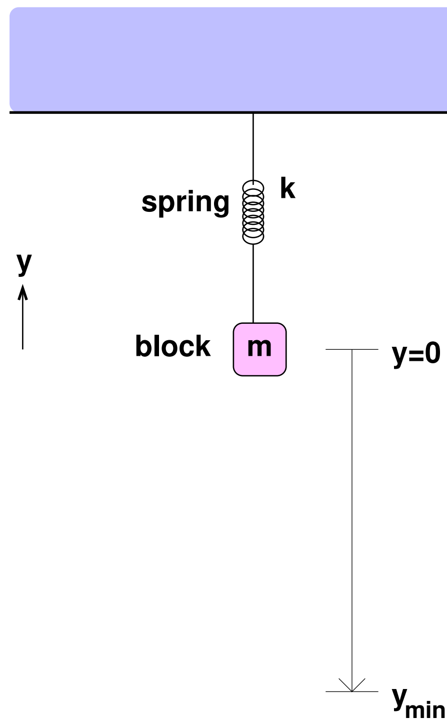
Suppose astronomers measure the radius of *Planet X* to be $R = 5.20 \times 10^5$ meters, and the orbital radius of *Moon X* to be $r = 4.61 \times 10^6$ meters, as shown. Suppose also that the orbital period of *Moon X* P is measured to be 14.32 hours. Assume that the mass of *Planet X* is known to be much larger than the mass of *Moon X*. In other words $M >> m$.

a) On the figure, draw a vector to indicate the *direction* of the gravitational force on *Moon X*. Explain how you know this.

b) In terms of the given parameters, can you calculate the mass M of *Planet X*? Here, start from First Principles assuming Uniform Circular Motion and Newton's Law of Universal Gravity. Give your answers both in terms of symbolic constants and numerically. Explain how you calculated this. Show your work.

c) Suppose you are standing on *Planet X* and you drop your mobile phone. What is the observed acceleration due to the gravity of *Planet X* on that phone? Explain your work.

Problem 5: Spring Block Drop



A block of given mass m is released at rest at a position $y = 0$ where it is connected to an ideal spring with a given spring constant k. At the release, the spring is at its equilibrium position (neither compressed nor extended). Once released, the block falls vertically and the spring stretches.

Part (a) – What is y_{min} corresponding to the minimum *position* of the block after release? Express your answer in terms of the given parameters. Explain your work. Hint: Note that y_{min} is negative.

Part (b) – What is the magnitude and direction of the acceleration of the block when the block is at the position y_{min} as calculated in Part (a)? Express your answer in terms of the given parameters. Explain your work. Hint: no, the acceleration here is not zero.

Part (c) – What is y_{max}, corresponding to the position of the block when it has maximum *speed*? Express your answer in terms of the given parameters. Explain your work. Hint: You do not need to find the actual value of the maximum speed. Also Conservation of Energy is not what you want. Instead, think about the net force on the block as a function of position.