Recitation Questions

5 March

Today's recitation has two problems. The first is designed to teach you how to handle objects that move on a slope. First, you will do it in the easier way, using a rotated coordinate system where x is the direction parallel to the hill and y is the direction perpendicular to it. If you have time, you will also approach it using the conventional coordinate system, where x and y are horizontal and vertical, and compare the approaches.

The second problem involves two objects that are roped together. It will teach you how to handle situations like this where two objects have accelerations that are related, but not necessarily equal.

Your recitation evaluation today will be a brief Blackboard quiz; it should take you about three minutes to complete.

These problems, like all others for the next few weeks involving Newton's second law, can be approached as follows:

1. Draw a cartoon of the situation, and draw force diagrams for all objects.
   - Choose a coordinate system (which way is x and which way is y?)
   - If you have any forces that aren't aligned with x and y, do trigonometry to find their $x-$ and $y-$components
   - Remember, only physical pushes and pulls are forces – not abstract ideas like "acceleration" or "net force"
2. Write down Newton's law of motion $\sum \vec{F} = m\vec{a}$ for each object, along each axis that is relevant
   - If your force diagrams are clear, you can read these equations straight off your diagrams
3. Substitute in things you know; solve for things you don't
   - If you have more than one object, some forces may be equal by Newton's third law; you can substitute this in
   - You may know things about the acceleration of the object in different directions, or the forces on it
   - Solve the resulting system of equations by substitution

Tux the penguin slides down a frictionless icy hill; the hill is inclined at an angle θ. In this problem, you will calculate the penguin's acceleration. First, let's do it with the rotated coordinate system – the easier approach.

Here you will need to draw *large* diagrams, since you will need to label and think carefully about your coordinate systems and vector components, drawing triangles on top of them and doing trigonometry. If you spend as much as 10-15 minutes on this step, that is okay; it is very important to get right. Please call over your TA/coach and discuss this with them.

a) Draw a cartoon of the problem, and label your coordinate system.

b) Draw a force diagram for the penguin. (Draw this one large, since you will need to construct a right triangle with one of the forces as its hypotenuse to break it into components.) Before you go onto the next page, once you and your group agree on the force diagram, copy it onto your own paper. You'll need it again.

c) Write down Newton's second law in both directions – that is, $\sum F_x = ma_x$ and $\sum F_y = ma_y$. If you have any forces that don't lie along the x or y directions, use trigonometry to break them into components.

d) This will result in two equations with three unknowns: a_x, a_y, and F_N. However, in this problem, a_x and a_y are related. What is their relation? This should reduce you to two equations and two unknowns; write them below.

e) Solve those equations to find the acceleration of the penguin. Use trigonometry to find the magnitude of $\vec{a}$.

If you have at least 35 minutes left in the recitation section, try solving the problem using the conventional coordinate system, where x is horizontal and y is vertical. Otherwise, skip ahead to the problem with the pulleys. Here, again:

a) Draw a cartoon of the problem, and label your coordinate system.

b) Draw a force diagram for the penguin. If you have any forces that don't lie along the x or y directions, use trigonometry to break them into components.

c) Write down Newton's second law in both directions – that is, $\sum F_x = ma_x$ and $\sum F_y = ma_y$.

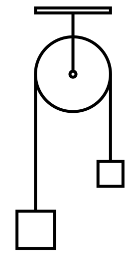
This will require some thought: you will need to figure out the components of the penguin's weight in the x and y directions. Call over your TA or coach to check your work when you are done.

d) This will result in two equations with three unknowns: a_x, a_y, and F_N. However, a little thought will tell you what one of these is. What is it? This should reduce you to two equations and two unknowns; write them below. Once you and your group agree on them, copy them onto your own paper.

e) Solve those equations to find the acceleration of the penguin.

f) Discuss the difference in the two approaches. In one, you aligned your coordinate system with gravity, and in the other, you aligned your coordinate system with the direction that you knew the penguin would accelerate in. Which was easier? Which should you adopt for future problems? Invite your TA or coach over to join your conversation.

Two weights of mass m_1 and m_2 are attached to either end of a string. This string is passed over a light frictionless pulley, as shown in the image. Clearly the heavier mass will go down and the lighter one will go up, but at what rate? In this problem, you will calculate their acceleration.



a) What do you expect the system to do if one of the masses is much heavier than the other? What do you expect if the two masses are equal?

b) Draw force diagrams for both objects. Label your choice of coordinate system separately for each object – you don't have to choose the same coordinate system for each!

c) State Newton's law for both objects. Note that their accelerations aren't necessarily the same, depending on your choice of coordinate system, so you should introduce separate variables a_1 and a_2 for both. The tension forces *are* the same.

d) Since you have two objects, you have two copies of Newton's law. However, you have three unknowns: T, a_1, and a_2. What other statement can you make about the accelerations that lets you solve the system?

e) Actually solve the system, giving values of a_1 and a_2 in terms of m_1, m_2, and g. Then, translate your expressions for a_1 and a_2 into words. (Your TA and coaches can help with this.) Does your result make sense? Does it agree with your predictions in part (a)?