Recitation Questions
5 March

A 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. However, I want you to do it two different ways, using two different coordinate systems. 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.

As usual, you will approach this problem in three steps: 1) draw a cartoon and a force diagram, 2) construct Newton's laws of motion in each direction, 3) do algebra and find what you need to find.

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 $\vec{a}$.

First, solve the problem using the conventional coordinate system, where x is horizontal and y is vertical.

Now you will solve the problem again using a rotated coordinate system, where x is the direction parallel to the hill and y is the direction perpendicular to it. Again:

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

b) Draw a force diagram for the penguin.

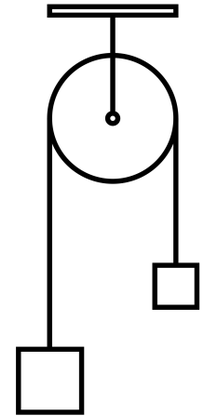
c) Write down Newton's second law in both directions – that is, $\sum F_x = ma_x$ and $\sum F_y = ma_y$. If you have any forces that don't lie along the x or y directions, use trigonometry to break them into components. This will require some thought: you will need to figure out the components of the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