Recitation Questions

15 February

Two very small cats, Fifi and Tali, are sitting on a smooth table when the table begins to tip. Fifi has a mass of m_f kg and Tali has a mass of m_t kg.[1]

The coefficients of friction between the kitties and the table are the following (Tali is slightly fuzzier). Their masses are also given (measured by their owner a few days ago); it's up to you to determine if they matter

	Fifi	Tali
μ_k	0.4	0.3
μ_s	0.5	0.4
mass (kg)	3.4	3.6

As the angle θ between the table and the horizontal becomes larger and larger, eventually the cats will slide off the table.[2]

Remember two things about friction for this problem:

1. If two things are *already sliding* past one another, the force of kinetic friction between them is equal to $\mu_k F_N$ in whatever direction opposes that motion;
2. If two things are *not sliding*, the force of static friction is *however big it needs to be* in order to stop them from sliding, up to a *maximum* of $\mu_s F_N$.

a) Draw a cartoon of the problem, and choose a coordinate system. Recall what you learned last recitation about choosing coordinate systems that make your life easy.

[1] This problem was inspired by the joke: "Q: Two kittens are sitting on a roof. Which one slides off first? A: The one with the smallest mew."

[2] They will land on their feet, since they are graceful cats. Their brother Pierre is a klutz and would land on his head, which is why we're not using him for this problem. But he's cute.

b) Draw a force diagram for the cat. Make it nice and large, since you'll need to do trigonometry to decompose the weight force into components.

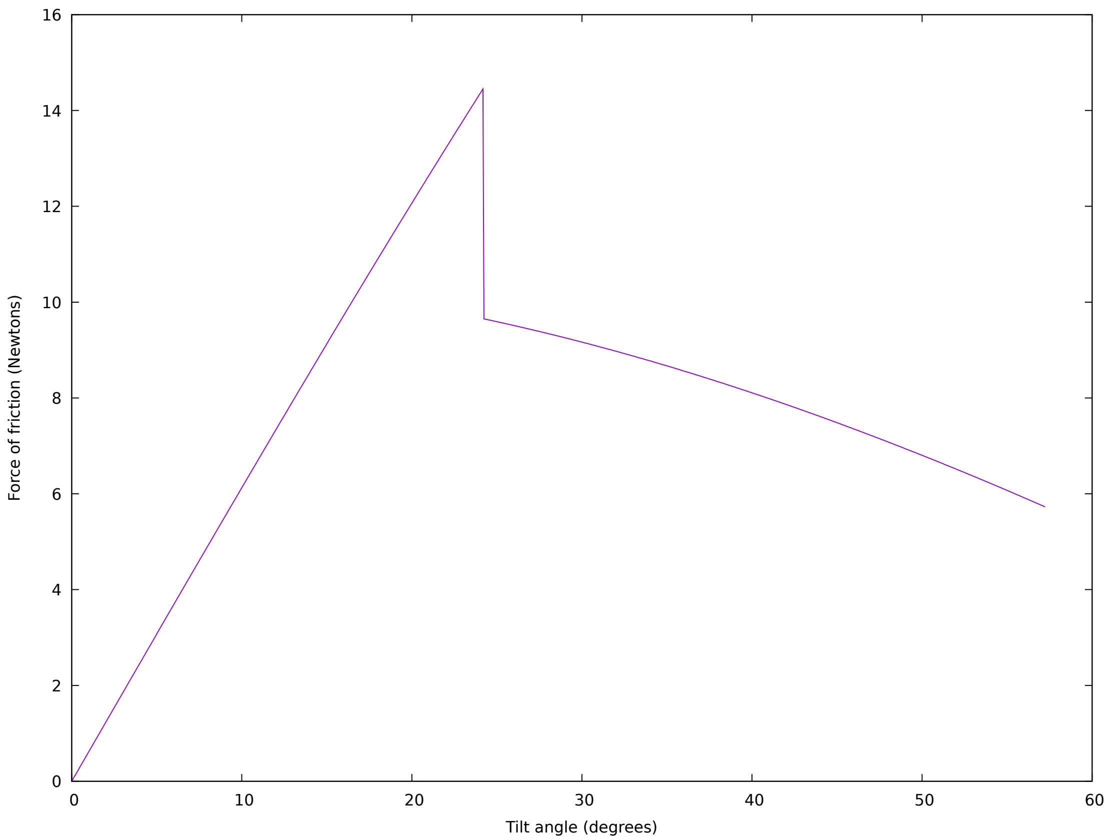
c) Decompose the weight force into components. Do this as always: draw a right triangle with the weight force as its hypotenuse, and with its legs aligned with your coordinate system. Then, figure out which angle in the right triangle is the same as θ. (Do this on your diagram above.)

d) Write down Newton's second law $\sum F = ma$ in both $x-$ and $y-$directions.

e) Right before the cat begins to slide off the table, what is true about the frictional force on them? Use this mathematical condition to solve for the angle θ at which each cat begins to slip off the table.

f) Right after Fifi begins to slide, what will her acceleration be? What will Tali's be?

g) Here is a graph of the frictional force (whether static or kinetic) vs. tilt angle. Interpret as many of its features as you can; call your TA and/or coach over to join your conversation.



Rum[3], Ohana's larger dog, is harnessed to a sled carrying Quanta, her smaller dog.[4]

Rum has mass m_R and coefficient of static friction μ_s; Quanta and her sled have mass m_Q and coefficient of kinetic friction μ_k. (Remember that traction is just a special kind of static friction, and so the maximum traction force that Rum can exert is also equal to $\mu_s F_N$.)

Rum is trying to pull Quanta and her sled up a hill sloping up at an angle θ at a constant speed. In this problem, you'll solve for the steepest hill that they can climb.

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

b) Draw a force diagram for each dog.

[3]Pronounced "room". He's adorable.
[4]She's also adorable.

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

d) This will result in four equations. Plug in things that you know. (What do you know about their accelerations?) This will result in four equations with four unknowns. What is true about the traction force on Rum when he's climbing the steepest hill that he can? Underneath each equation, identify the physical meaning of each term (i.e. "component of Quanta's weight parallel to the slope").

e) Discuss how you'd do the algebra to solve these equations; if you have time, work on doing so.