FREQUENTLY ASKED QUESTIONS

February 3, 2015

Content Questions

Can you explain the homework problem about maximizing the mass of sand?

This was problem 6-21. The idea is to use Newton's Laws to find some equations that relate the mass of the sand to the angle at which the string is just barely not breaking (for which the tension is $T_{\max}$). You apply the "force how-to" to set up the equations, then solve for m as a function of θ (with all the other quantities known, and $T = T_{\max}$). Then to find to find the maximum m as a function of θ (and the value of $\theta = \theta_{\max}$ which maximizes $m(\theta)$), you differentiate $m(\theta)$ with respect to θ and set it equal to zero, i.e., $\frac{dm}{d\theta} = 0$. Then you solve for $\theta_{\max}$ and plug it back in to $m(\theta)$ to find $m_{\max}$.

I hope this procedure for finding extremum values of functions is familiar to you from calculus— it's extremely useful and we'll be using it again.

Can you explain how tension works?

When you pull on a rope, assuming the rope is massless (i.e., is of negligible mass) and doesn't stretch or contract, the tension is the force transmitted by the rope. If you imagine any little piece of the rope, by Newton's third law, if it pulls on its righthand neighbor with force T, that neighbor piece is pulling on it with a force equal in magnitude and opposite in direction. So for a piece anywhere in the rope, you can think of it as exerting and feeling a force T in either direction.

From a practical point of view for doing problems (and which is also a reasonable approximation for real life), when you have a massless rope, you can assume the tension is equal in magnitude everywhere in the rope.

Can you explain the two-block problem discussed in lecture? There was friction between the two blocks and the ground and the block has zero friction. What is the maximum force on the bottom so block A wouldn't move? How to analyze this problem?

I guess this is on p. 37 of lecture 6. This is an example which can be done by the Force How-To. First, decide what system to consider. Take the top block and draw a FBD. What are the forces on it? Answer: gravity mg down, normal force N_1 up, and friction force to the right (the bottom block is "trying to" drag the top block along to the right). The maximum friction force before slipping is $f_{s\text{max}} = \mu_s N_1$. Since there's no vertical acceleration, $N_1 = mg$. So $f_{s\text{max}} = \mu_s mg$.

Now take the bottom block and draw the FBD. In the vertical direction, we have Mg down, N_2 up, and also N_1 down (force *on* M from m is equal and opposite to force N_1 *on* m from M)— but it turns out this particular equation isn't needed. In the horizontal direction, there's F to the right and f_s to the left— remember by the third law, frictional force due to M on m is equal and opposite to frictional force due to m on M. So, just at slipping, in the horizontal direction we write Newton's second law as $F - f_{s\text{max}} = ma$, where a is the horizontal acceleration. Although we can substitute for $f_{s\text{max}}$, we still don't know a.

But we can still consider one more system: the two blocks together (at the time they are moving together and the top block is just about to slip) can be considered a system. The only horizontal force on the system is F. (We don't consider friction, because it's an *internal* force to the two-block system.) The total mass is $m + M$. So we can write $F = (m + M)a$ for the second law in the horizontal direction. This equation together with the one above can be solved for F.

The key to this problem to carefully consider what the "system" is, and only the forces *on* the system, for each case.

What's the difference between terminal and laminar velocity?

Terminal velocity is the maximum velocity reached by an object falling in a fluid (for example, the maximum velocity you attain when falling out of a plane). The drag force, which depends on the velocity, prevents continued acceleration; acceleration tends to zero in the presence of drag, so velocity tends to a constant value.

"Laminar velocity" isn't really a specific term, but *laminar flow* refers to smooth flow of a liquid. In contrast, *turbulent flow* happens when there are jiggles and eddies. The drag force is different in the laminar and turbulent cases, and hence the terminal velocity is different according to whether the flow of the fluid around the object is laminar or turbulent.

Can you explain why pulling the string down $2x$ raises the pulley x?

With a pulley in the configuration of problem 7-25, if you pull the rope down a distance d, the total length of rope looping down from the left-hand pulley and then up on the right becomes shorter by d. This shortening will be divided equally between the left and the right ropes of the pulley with the mass — so that pulley moves up by $d/2$.

How is energy transformed between spring force, gravity and kinetic energy?

Be careful to distinguish between the concepts of force and energy. Energy can get transformed between kinetic energy form, and various kinds of potential energy forms. So far we've seen gravitational and spring potential energy. When you compress or extend a spring from its equilibrium position, it stores potential energy. If you're squeezing the spring with your muscle, the energy comes from food you ate; if a block falls on a spring as in today's homework problem, the energy comes from the kinetic energy of the block and gravitational potential energy. (*How* this happens is a different question, without a very simple answer— for the purpose of this course, think of the flow of energy as a model describing our world very well, in which conservation of energy is a fundamental rule.)

An important concept is that energy is always conserved in the universe, although it may be lost from a system via friction, heat, etc. (we'll be covering more about this later in the course).

Can you explain the meaning of $v\vec{v}$?

A vector can in general be written $\vec{a} = a\hat{a}$, where $\hat{a}$ is a unit vector (has unit length) in the direction of $\vec{a}$, and a is the magnitude of the vector. So a vector $v\vec{v}$ can be written $vv\hat{v} = v^2\hat{v}$: it therefore has magnitude v^2.

In the quiz, was the scale accelerating or was the system? Why was there an upward force, besides tension that didn't matter? Or was saying "There is an upward force" a bad hint?

In part c, the whole system is moving down together with acceleration a. The upward force on the system (acting on the *scale*) is *given* in the problem. "There is an upward force" is not a hint— it's telling you that there's an upward force you need to include in your analysis of the problem.

This is another problem that can be approached with the how-to. First consider the mass: what are the forces *on* it? Answer: a normal force N upwards from the scale, and gravity mg. Now consider the scale: what are the forces *on* it? Answer: a normal force N downwards from the mass, gravity Mg, and the given force F upwards.

Then parts b and c can be done by applying Newton's second law to each system. In part b, acceleration is 0. In part c, acceleration is a downwards. By writing down the second law equations, you should get enough equations to solve for the unknown F.