Physics 1A: Mechanics

Winter 2016

Discussion: Week 4

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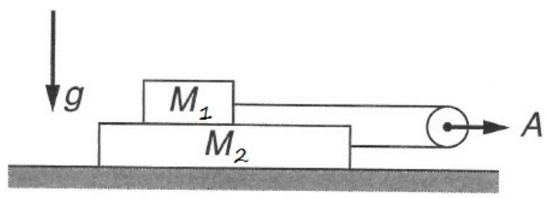
Office hours: Mondays, Tuesdays, Wednesdays 4-7 p.m. *by appointment!*

(Alternatively, just e-mail me your questions.)

Problem 1

Mass M_1 slides on top of mass M_2 as shown. Assume $M_2 > M_1$. The two blocks are pulled from rest by a massless rope passing over a massless pulley. The pulley is accelerated at rate A. Block M_2 slides on a table without friction, but there is a constant friction force f between M_1 and M_2 due to their relative motion. Find the tension in the rope.

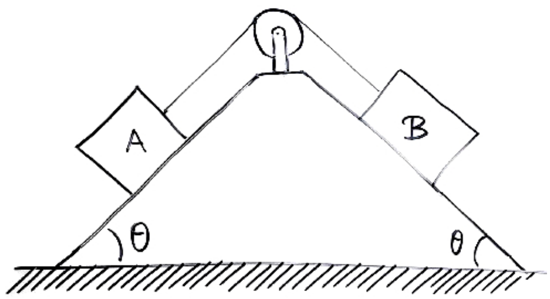


Problem 2

Blocks A and B of mass M_A and M_B are joined by a cable of constant length and negligible mass. They are placed on two sides of a frictionless, triangular block with sides sloping at an angle θ as shown. The cable is threaded over a massless pulley.

a) What is the tension in the cable?

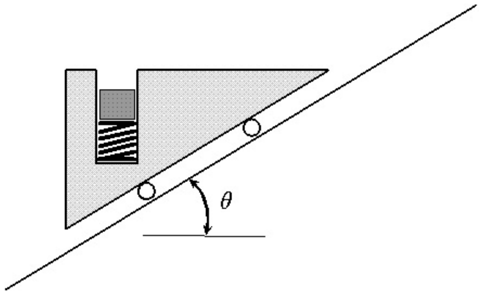
b) Imagine the whole system in question is in an elevator moving upwards with acceleration a_0. What is the tension in the cable now?



Problem 3

Even if you haven't learned about springs yet, do not worry! The only thing you need to know about springs in this problem is that the force that the spring exerts is given by $\vec{\boldsymbol{F}} = -k\vec{\boldsymbol{x}}$*, where* k *is a constant. The minus sign means that the spring acts opposite to the direction of its displacement: if you squeeze the spring, it will act against the squeezing, and if you try to elongate a spring, it will act against that too. You know that from an everyday experience!*

A piston is placed on top of a spring inside a wedge-shaped block fitted with small rollers so that it can roll down an inclined plane, as shown. When the block is at rest the spring is compressed x_1 from it's equilibrium position, but when the block is rolling down the plane the spring is compressed only $x_2 < x_1$. What is the inclination angle of the plane? (Neglect friction.)



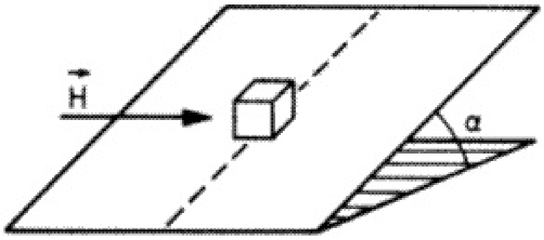
Hint: Assume some masses both for the piston on the spring and the block, but bear in mind that you don't know them and that in the end the solution should not depend on them. Pssst: it sounds more complicated than it is, so don't panic!

Problem 4

A packet of weight W rests on a rough inclined plane that makes an angle α with the horizontal.

a) If the coefficient of static friction $\mu = 2\tan\alpha$, find the least horizontal force $H_{\min}$, acting transverse to the slope of the plane that will cause the particle to move.

b) In what direction will it go?



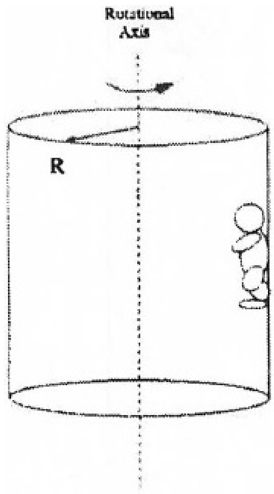
Hint: note that the friction acts along the plane of the incline, not only along the direction of the force H.

Problem 5

This is a Corbin midterm problem.

The Spin-Out (also known informally as the "barf-barrel" [LOL - AW]) was a large, vertically oriented, cylindrical amusement part ride. As riders stood against the curved wall facing inward, the cylinder would begin to rotate. At some point, the floor would drop out and the riders, stuck to the wall, would be suspended over a floor-less void.

For our purposes, take the radius of the chamber to be R, the mass of the rider under consideration to be m, and the static and kinetic coefficients of friction between the rider and the wall of the cylinder to be μ_s and μ_k, respectively.



a) For reasons of liability [not to mention basic human decency - AW], the operators must wait until the passengers are actually "stuck" to the wall before removing the floor. How fast must the walls be moving (tangential speed) before the floor can be pulled out from under the riders?

b) Evaluate your answer to part a) in the limits $\mu \to 0$ and $\mu \to \infty$ (where μ is whatever the relevant coefficient of friction is) and explain the results.

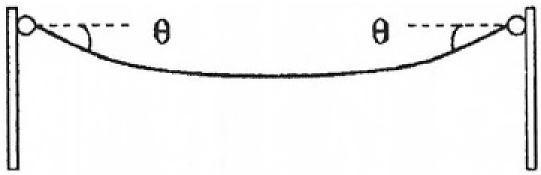
c) The floor has been pulled out from our rider and he is stuck to the wall. How large is the force of friction acting on him? Does it depend on his weight? Should he be worried (assuming weight might be an issue)? Explain.

d) Now suppose something goes wrong and the cylinder slows to a tangential speed v (less than the threshold value required to keep passengers safe). If our rider is initially at rest with respect to the cylinder wall, how long does it take him to slide down a vertical distance d (with respect to the wall)?

Problem 6

This is a Corbin midterm problem - back then he included one textbook problem in his midterm. He NEVER does it now, but this problem still shows you what he's interested in.

Most problems directed at introductory mechanics class assume that ropes, cords or cables have so little mass compared to the other objects in the problem that one can safely ignore their mass. However, if the rope is the *only* object in the problem, then clearly one cannot ignore its mass. Suppose you have a clothesline attached to two poles. The clothesline has a mass M, and each end makes an angle θ with the horizontal.



a) What is the tension at the ends of the clothesline?

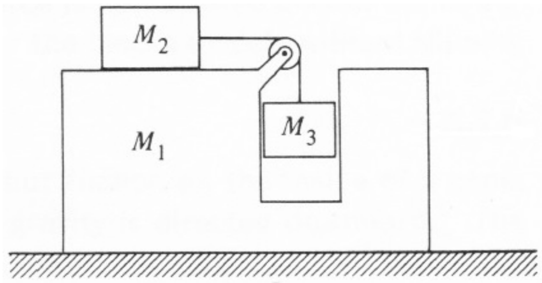
b) What is the tension at the lowest point?

c) Why can't we have $\theta = 0$?

d) Discuss your results for parts a) and b) in the limit $\theta \to \frac{\pi}{2}$.

Problem 7

Determine the acceleration of mass M_1 relative to the ground in the following machine. All surfaces are frictionless and the pulley and rope are massless.



Problem 8

This is a Corbin final problem.

On the planet Xergon the force of gravity is not $\vec{\boldsymbol{F}} = -g\hat{\boldsymbol{j}}$, instead it is $\vec{\boldsymbol{F}} = -gy\hat{\boldsymbol{j}}$, where g is a constant.

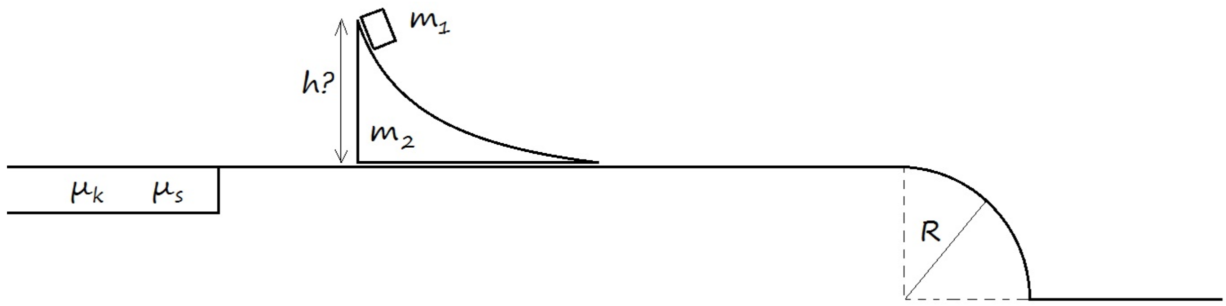
a) Write and solve the equation of motion for the position (as a function of time) of an object shot upwards with velocity $\vec{\boldsymbol{v}} = v_0\hat{\boldsymbol{j}}$ at $t = 0$ and solve for the motion. The object goes up, reverses direction and hits the ground much as it does in the gravitation field of the Earth, however $y(t)$ is different.

b) How much time will it take for the object to hit the ground?

c) If the initial velocity is $\vec{\boldsymbol{v}} = v_{0x}\hat{\boldsymbol{x}} + v_{0y}\hat{\boldsymbol{y}}$, $v_0 = \sqrt{v_{0x}^2 + v_{0y}^2}$, what is the equation of the r of the mass as a function of x and the angle θ with respect to the x-axis?

Problem 9

This is a Corbin midterm problem.



Consider the picture shown above. A block of mass m_1 sits on a ramp of mass m_2 sits on a ramp of mass m_2; the ramp, in turn, sits on a frictionless horizontal table. The right end of the table joins smoothly to a rounded surface of radius R (frictionless) and the left end of the table meets up with a long horizontal surface described by friction coefficients μ_s and μ_k.

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a) Assuming that the block proceeds towards the right after reaching the horizontal surface, find the speed at which it must travel so that it shoots off the table without ever touching the cylindrical surface.

b) In order to reach the speed calculated in the previous part, how high up on the ramp must the block start (that is, what is the vertical distance h, shown in the picture)?

c) What happens to your answers to the first two parts if $m_1 \gg m_2$? Explain.

d) Once the ramp encounters the patch of friction, how far will it slide before coming to rest?

Problem 10

This is a homework problem.

The gravitational pull of the earth on an object is inversely proportional to the square of the distance of the object from the center of the earth. At the earth's surface this force is equal to the object's normal weight mg, where $g = 9.8 \left[\frac{\mathrm{m}}{\mathrm{s}^2}\right]$, and at large distances, the force is zero. If a 20,000-kg asteroid (*use symbols first!*) falls to earth from a very great distance away, what will be its minimum speed as it strikes the earth's surface, and how much kinetic energy will it impart to our planet? You can ignore the effects of the earth's atmosphere. How does this energy compare to the energy of a nuclear bomb in 1945?