Physics 8, Fall 2019, Homework #6.

Due at start of class on Friday, October 18, 2019

Problems marked with (*) must include your own drawing or graph representing the problem and at least one complete sentence describing your reasoning.

Remember **online response** at `positron.hep.upenn.edu/q008/?date=2019-10-18`

(Chapter 10 problems.)

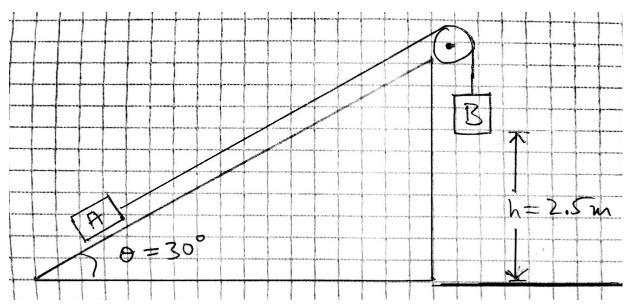
1. Three forces are exerted on a 2.00 kg block initially at rest on a slippery surface: a 100 N force directed along the x-axis, a 50.0 N force making an angle of 30.0° (counterclockwise) from the x-axis, and a 144 N force making an angle of 190° (counterclockwise) from the x-axis. (These forces are all in the horizontal plane, so gravity is irrelevant.) (a) Draw a diagram of the three forces, indicating their directions. (b) What is the vector sum of the forces acting on the block? (c) What is the work done on the block (by the vector sum of these forces) in 10.0 s? (Part c is tricky, because time is given, not displacement.)

2*. A janitor is pushing an 12 kg trashcan across a level floor at constant speed. The coefficient of friction between can and floor is 0.12. (a) If he is pushing horizontally, what is the magnitude of the force he is exerting against the can? (b) If he pushes not horizontally but rather at an angle of 35° down from the horizontal, what must be the magnitude of his pushing force to keep the can moving at constant speed?

3. A resort uses a rope to pull a 45 kg skier up a 35° slope at constant speed for 90 m. The tow rope is parallel to the ski slope. (a) Find the tension in the rope if the snow is slick enough to allow you to ignore any frictional effects. (b) How much work does the rope do on the skier? (c) Now find the tension in the rope if the coefficient of kinetic friction between snow and skis is $\mu_k = 0.20$. (d) Now how much work does the rope do on the skier?

4*. You have to specify the power output of a motor for a ski tow rope that will carry twenty passengers at a time, each having an average inertia of 55 kg. The grade of the ski slope is 29° above horizontal, and the average coefficient of kinetic friction between skis and snow is 0.15. You decide that 2.5 m/s is a safe speed to be towed up the slope. What must the minimum power output of the motor be?

5*. [This fiendishly tricky problem is adapted from a Phys150 quiz I found in the photocopier one day.] Block A, of mass $m_A = 4.0\,\text{kg}$, and block B, of mass $m_B = 8.0\,\text{kg}$, are connected by a rope and pulley whose masses are negligible, as shown below. The friction coefficients between block A and the inclined plane (inclined at angle $\theta = 30°$) are $\mu_K = 0.20$ and $\mu_S = 0.60$. Initially my hand holds block A at rest, so that the rope is taut and block B is suspended at height $h = 2.5\,\text{m}$ above the platform. I remove my hand, thus releasing the blocks from rest. (a) Draw a FBD for block A and a FBD for block B the instant after I release the blocks. (b) At what time t after release does block B reach the platform? (c) Draw a FBD for block A the instant after block B has reached the platform (so the rope is no longer taut). (d) How far from the original starting position does block A travel up the inclined plane before it stops or turns around? (The plane is very long, so you do not need to worry about block A running into the pulley.) (e) What happens to block A after it reaches its maximum altitude? Does it stop, or does it start to slide downward? (f) Draw a FBD for block A for the scenario that you consider in part (e).



6*. A 1.10 kg block on a horizontal tabletop is pushed against the free end of a spring (whose other end is attached to a wall) until the spring is compressed 0.220 m from its relaxed length. The spring constant is $k = 110$ N/m, and the coefficient of kinetic friction between block and tabletop is 0.25. When the block is released from being held against the compressed spring, how far does the block travel before coming to rest?

7. A woman applies a constant force to pull a 45.0 kg box across a floor at constant speed. She applies this force by pulling on a rope that makes an angle of 36.9° above the horizontal, and for the box-floor interface, $\mu_k = 0.12$. (a) Find the tension in the rope. (b) What is the work done by the woman as she moves the box 9.0 m?

8. The coefficient of static friction of tires on ice is about 0.10. (a) What is

the steepest driveway on which you could park under those circumstances? (b) Draw a free-body diagram for the car when it is parked (successfully) on an icy driveway that is just a tiny bit less steep than this maximum steepness. (You might want to do (b) before you do (a).)

9. A fried egg of inertia m slides (at constant speed) down a Teflon frying pan tipped at an angle θ above the horizontal. [This only works if the angle θ is just right.] (a) Draw the free-body diagram for the egg. Be sure to include friction. (b) What is the "net force" (i.e. the vector sum of forces) acting on the egg? (c) How do these answers change if the egg is instead speeding up as it slides?

10. A child rides her bicycle 1.0 block east and then $\sqrt{3} \approx 1.73$ blocks north to visit a friend. It takes her 10 minutes, and each block is 60 m long. What are (a) the magnitude of her displacement, (b) her average velocity (magnitude and direction), and (c) her average speed?

11. Calculate $\vec{C} \cdot (\vec{B} - \vec{A})$ if $\vec{A} = 3.0\hat{\imath} + 2.0\hat{\jmath}$, $\vec{B} = 1.0\hat{\imath} - 1.0\hat{\jmath}$, and $\vec{C} = 2.0\hat{\imath} + 2.0\hat{\jmath}$. Remember that there are two ways to compute a dot product—choose the easier method in a given situation: one way is $\vec{P} \cdot \vec{Q} = |\vec{P}||\vec{Q}| \cos\varphi$, where φ is the angle between vectors $\vec{P}$ and $\vec{Q}$, and the other way is $\vec{P} \cdot \vec{Q} = P_x Q_x + P_y Q_y$.

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XC1*. Optional/extra-credit. (From Chapter 10.) You have just inherited property in Vermont that would make an excellent ski resort. One of the ski slopes has a cliff on the other side of the hill, and this gives you a money-saving idea. Instead of a chair lift or motorized tow-rope, you decide to attach a pulley to the top of the cliff and then drape the tow-rope over the pulley, with one end of the rope temporarily secured at the base of the ski slope and a counterweight attached to the end that hangs over the edge of the cliff. The plan is to release the rope and pull two skiers (with the inertia for the pair kept between 100 and 200 kg) up the 400 m slope, which has an incline angle of 35°. You guess that customers get nervous if they move faster than 5.0 m/s, and you begin immediately to calculate the required properties of the counterweight. (I guess a 200 kg pair must make it up the hill, and a 100 kg pair must reach the top at final speed less than 5.0 m/s.)