

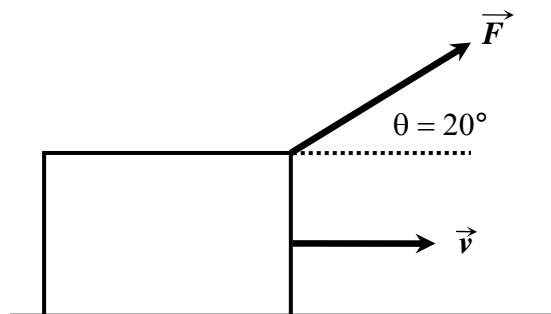
INSTRUCTIONS: Write your NAME and LECTURE SECTION (I: Ruchti, II: Hildreth) on the front of the blue exam booklet. The exam is closed book, and you may have only pens/pencils and a calculator (no stored equations or programs and no graphing). Show all of your work in the blue book. For problems II-V, an answer alone is worth very little credit, even if it is correct – so show how you get it.

Suggestions: Draw a diagram when possible, circle or box your final answers, and cross out parts which you do not want us to consider.

I. Multiple Choice Questions (4 points each) Please write the letter corresponding to your answer for each question in the grid stamped on the first *inside* page of your blue book. No partial credit is given for these questions.

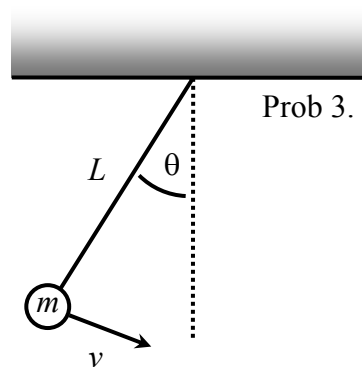
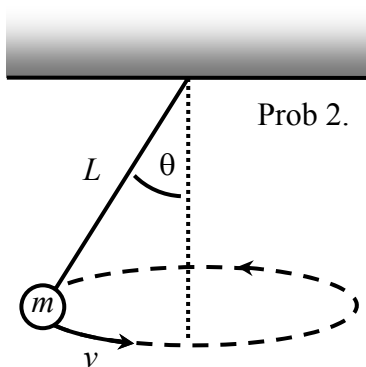
1. A block is dragged by a Force of magnitude $F = 10 \text{ N}$ across a horizontal surface at a constant velocity of $v = 3 \text{ m/sec}$ as shown in the figure. The power delivered by the force F to the block is:

- (a) 30W (b) 28.2W (c) 10.3W (d) 9.4W (e) 3.4W



2. A conical pendulum of mass m and length L makes an angle θ with respect to the vertical, as shown below. The magnitude of the velocity of the pendulum only depends upon:

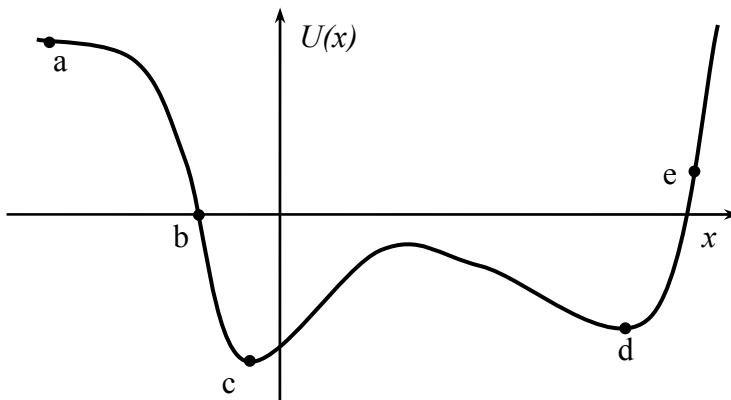
- (a) L, g, θ (b) m, L, g, θ (c) m, L, θ (d) L, θ (e) none of these



3. A simple pendulum of mass m and length L is pulled to the side through an angle θ and released from rest as shown above. The square of the velocity of the pendulum (v^2) when it reaches its lowest point (when $\theta = 0$) is given by:

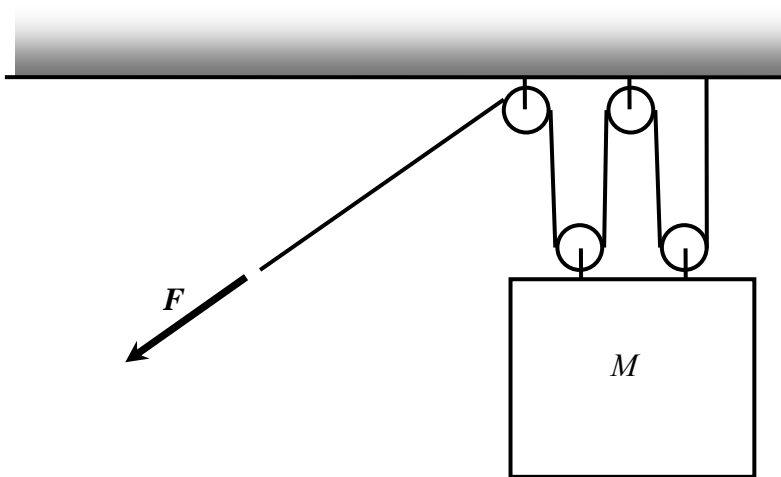
- (a) $2gL$ (b) $2gL \cos \theta$ (c) $2gL (1 - \cos \theta)$ (d) $2gL (1 - \sin \theta)$ (e) none of these

4. The graph below shows the potential energy of a system as a function of position along the x axis. At which point does the force F_x have its largest *negative* value?



5. You lift a block of mass M a vertical distance h with the pulley arrangement shown below. How much work would you do by pulling on the rope during this activity? Assume the tension in the rope is uniform throughout the system.

- (a) Mgh (b) $Mgh/2$ (c) $Mgh/3$ (d) $Mgh/4$ (e) $Mgh/5$

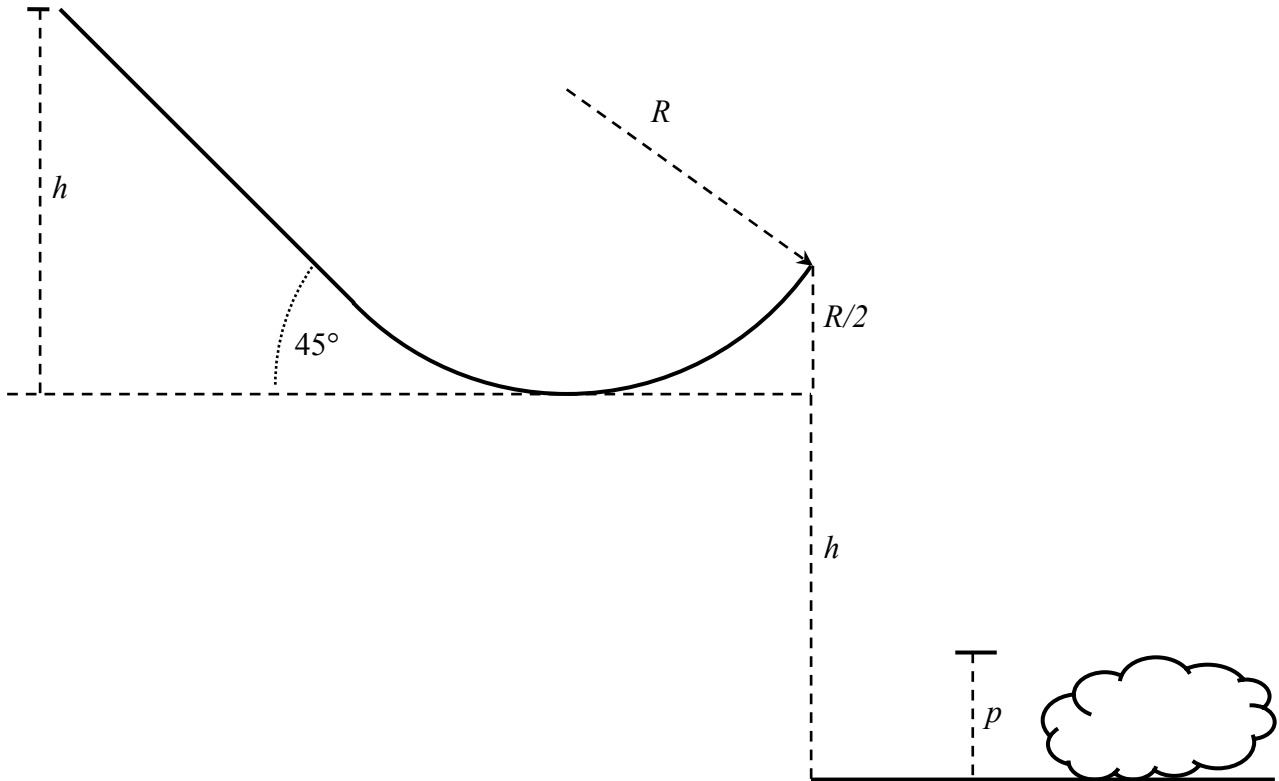


Problems (20 points each)

II. In the modern day X-Games, freestyle skiers execute hair-raising jumps after sliding down a steep hill and hitting a ramp at the bottom. Our favorite skier of mass M begins her trip down a 45-degree slope at rest, at a height h above the bottom. We will approximate the bottom of the slope as a curved path of radius R , as shown in the figure below. The ramp rises to a height $R/2$ above the lowest point of the path. Ignore the effects of friction along the snow path in this problem. (See figure on next page.)

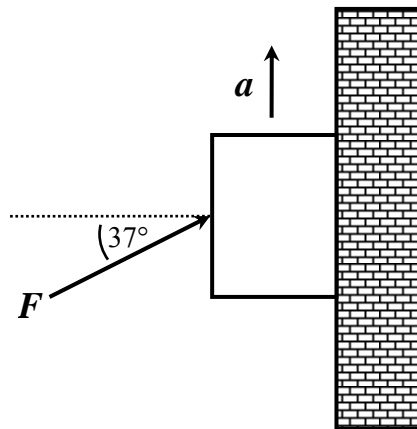
- a) Find the speed of the skier as she reaches the bottom of the slope.
- b) Draw a free-body diagram of the forces on the skier at the bottom of the slope. Find the upward force of the snow on her legs as she reaches the bottom of the slope.
- c) Find the speed of the skier as she leaves the lip of the ramp.

- d) After flying off of the ramp, the skier lands in a giant soft pile of snow of height p . The bottom of the pile of snow is a full distance h below the bottom of her launch slope. The snow breaks her fall. Find the work done by the force of the snow acting on the skier if she stops moving just as she gets to the bottom of the snow pile.



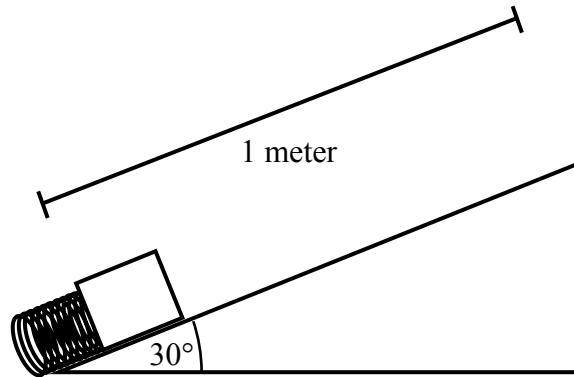
III. A block of mass $m = 0.5 \text{ kg}$ is pushed up a vertical wall by a force F of magnitude 10 N , as shown. The coefficient of kinetic friction between the block and the wall is μ_k . The block is accelerating vertically upward at a rate of 2 m/s^2 .

- Draw a free body diagram for the block.
- Find the normal force of the wall on the block (not including the frictional force).
- Find the coefficient of kinetic friction, μ_k .
- If the block moves upward 3 meters, find the net work done by all forces acting on the block.



IV. A ball of mass $m = 2 \text{ kg}$ is launched from rest up a frictionless ramp of length 1 meter by a spring launcher. The spring has total length 1 m and is fully compressed before the ball is released. The spring constant $k = 1000 \text{ N/m}$. The ramp makes an angle of 30 degrees with the horizontal.

- Find the potential energy of the ball in the starting position at the bottom of the ramp.
- Find the potential energy of the ball when it reaches the top end of the ramp.
- Find the velocity vector (\mathbf{v}) of the ball as it leaves the ramp.
- To what height *above the base of the ramp* does the ball rise after launch?



V. In a recent Ford truck commercial, a Ford F150 is swung by its front tow bars by a huge centrifuge. We will take a slightly simplified view of this problem, as shown in the figure below. The truck (which we'll treat as a point mass) has a mass of 2000 kg. The cable attached to the tow bar has a length of 5 meters. The arm of the centrifuge has a length of 10 meters. Assume that the cable attached to the tow bars is much stronger than the bars themselves.

- Once the centrifuge begins to spin, the truck swings out. Draw a free body diagram for the truck at this time.
- Write down Newton's Laws for the truck, clearly indicating your chosen coordinate axes.
- For an arbitrary angle θ , find the tension in the cable.
- If the tow bars break at a towing force of 60,000 N, what is the angle θ and the velocity of the truck at this time?

