PHYSICS 131 EXAM 2 6 March 2001

INSTRUCTIONS: Write your name on the front of the blue exam booklet. The exam is closed book, and you may have only a pen/pencil 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.

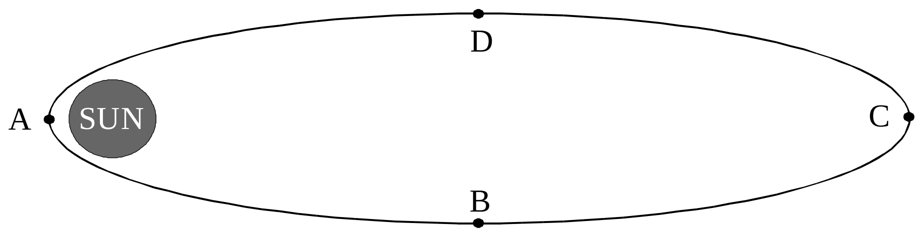
Suggestions: Draw a diagram when possible, circle or box your final answers, and cross out parts which you do not want us to consider.

In all problems neglect the effects of air resistance.

I. *Multiple Choice Questions* (4 points each).

1. The gravitational force exerted on a comet is attractive, so the comet's potential energy is greater the further it is from the sun. The comet moves in a very elliptical orbit, as indicated by the diagram. At which point on its orbit does the comet move with the largest speed?

A. A B. B C. C D. D E. B and D



2. If power P is required to lift a box a height of 10 meters at a constant speed of 3 m/s, how much power is necessary to lift the same box a height of 20 meters at a constant speed of 9 m/s?

A. P B. $2P$ C. $3P$ D. $6P$ E. $3P/2$

3. Which of the following forces is NOT conservative? (Hint: make a sketch of each F.)

A. $\vec{F} = xy\hat{i}$ B. $\vec{F} = e^{x^2}\hat{i}$ C. $\vec{F} = km/x^2\hat{i}$ D. $\vec{F} = \frac{1}{2}ky^3\hat{j}$
E. $\vec{F} = 5\hat{i} + 6\hat{j}$

4. A 3.0 kg block slides along a wooden floor with initial velocity 3.0 m/s. It stops in a distance of 11.0 meters due to kinetic friction between it and the floor. The coefficient of kinetic friction between the block and the floor is

A. 1.20 B. 0.041 C. 0.33 D. 0.102 E. 0.082

5. A hoist lifts a piano straight up off the ground with increasing speed (so it is going faster and faster the higher it gets). During the first 1m of the lift, what ***could*** the values of the work W_G done by gravity and the work W_H done by the hoist be?

A. $W_H = 7$ J, $W_G = 7$ J B. $W_H = 6$ J, $W_G = 3$ J C. $W_H = 2$ J, $W_G = -4$ J
D. $W_H = 8$ J, $W_G = -8$ J E. $W_H = 4$ J, $W_G = -3$ J

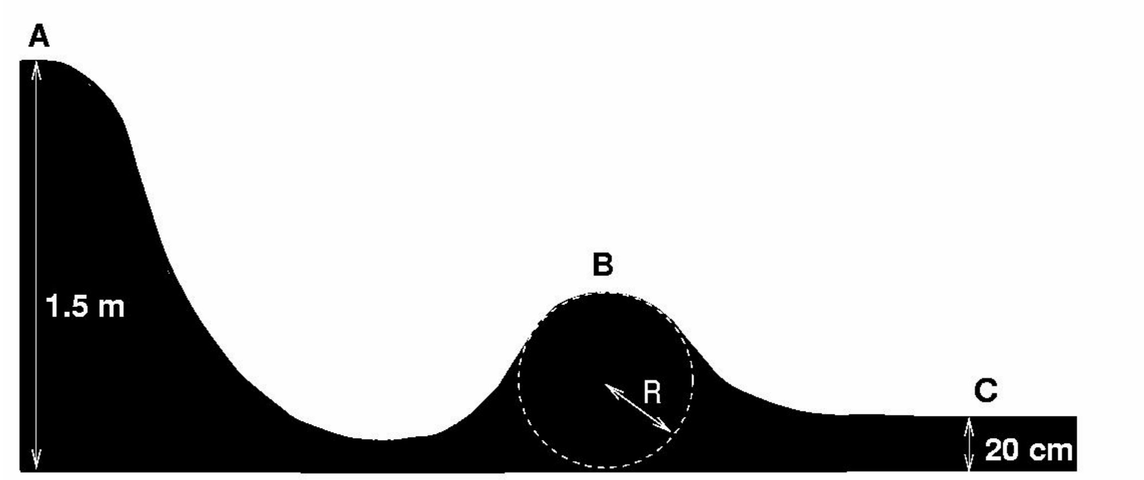
II. Eve slides along the track shown in the figure below. She starts from rest at point *A*, which is 1.5 m above the ground. At point *B*, where 30% of Eve's initial potential energy has been consumed by friction, she has a velocity just such that she barely loses contact with the track.

A. Draw the free−body diagrams for the child at points *A* and *B*.

B. What is Eve's velocity at point *B*?

C. How large is the radius *R*?

D. What is Eve's speed at point *C*, which is 20 cm above the ground, if the frictional force is negligibly small beyond point *B*? *(Hint: you don't need to do parts B and C to do this part.)*

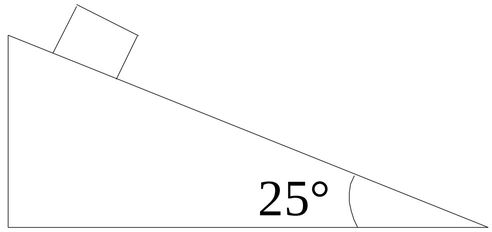


III. A 2 kg block slides down a 25° frictionless inclined plane in 5 s. Starting from the same height, an identical block slides down a 25° friction−full inclined plane in 15 s.

A. For each block, calculate the component of the block's acceleration along the inclined plane. For second block, leave answer in terms of μ_k.

B. Calculate the coefficient of kinetic friction, μ_k, of the second incline.

C. Calculate the work done by friction on the second block. *(If you couldn't get an answer for part B, express the work in terms of* μ_k*, the distance travelled by the block, and its mass.)*



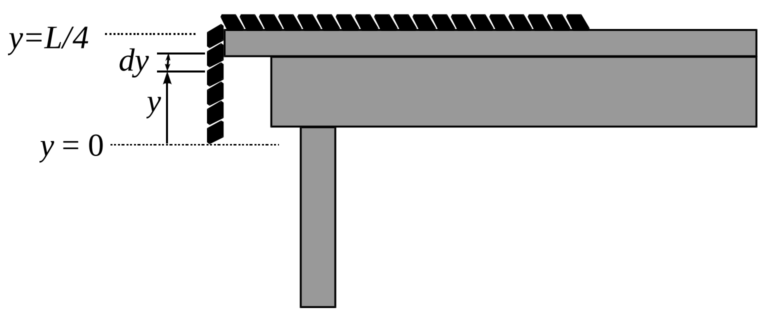
IV. A uniform rope of mass M and length L lies on a table. One fourth of its length hangs over the edge.

A. Assuming that this is the maximum length of rope that could hang over the side of the table without slipping, find the coefficient of static friction μ_s between the rope and the table.

For the next two parts, assume that there is NO kinetic friction, *i.e.*, $\mu_k = 0$. If you like, you can define a mass density per unit length, $\lambda = M/L$.

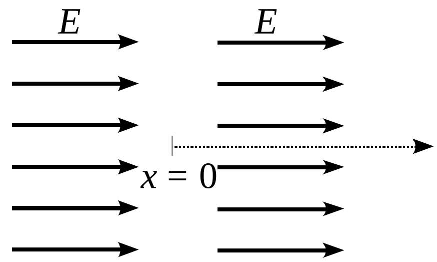
B. Find the work required to move an infinitesimal length dy of rope from a height y above the end of the rope to the table top, if the rope moves at constant velocity. *(Hint: you're always pulling against gravity.)*

C. How much work is required to pull all of the rope back up onto the table? Assume that the rope's final position is at rest, on the table.

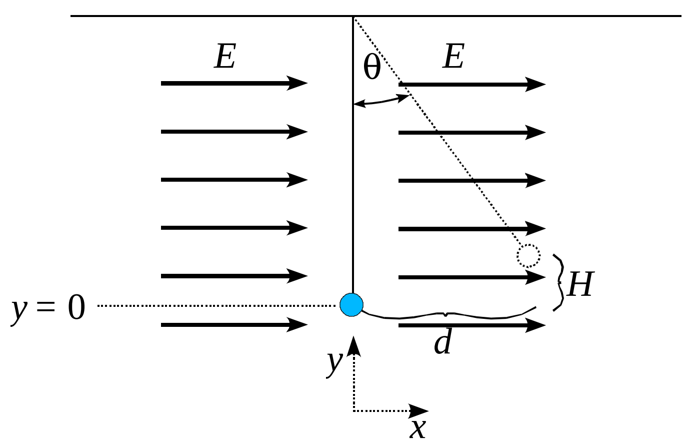


V. A particle carrying an electric charge Q placed in an electric field $\boldsymbol{E}$ feels a force proportional to its charge, given by $\vec{F} = Q\vec{E}$.

A. A particle of mass m and charge Q ($Q > 0$) is placed in a *constant* electric field oriented along the x axis, $\vec{E} = E\hat{\boldsymbol{i}}$. Find the particle's potential energy as a function of the displacement from $x = 0$. (Take x to increase along the direction of $\boldsymbol{E}$) [Hint: rotate your paper clockwise by 90 degrees and "think gravity".]



This same particle is attached to a string and suspended from the ceiling while still being enveloped in the *constant* electric field $\boldsymbol{E}$. The particle is released from rest while the string is vertical, from the origin of your coordinate system (*i.e.*, from $x = 0$, $y = 0$). The coordinate axes on the figure have been displaced for clarity.



B. Take $y = 0$ to be the point of zero gravitational potential energy, and $x = 0$ to be the point of zero electric potential energy. What is the total energy of the system before the particle is released?

C. Under the influence of gravity and the electric field, the particle swings out from the vertical and begins oscillating about its new equilibrium position. If the oscillations take the particle from $(x,y)=(0,0)$ to $(x,y)=(d, H)$, use *conservation of energy* to find H/d. (Just to be clear: (d,H) is the point at which the particle reverses its course and begins swinging back towards the origin.)