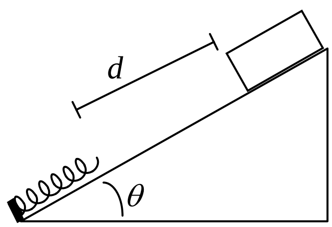
Quiz 8 Physics 201

NAME: ____________________

DO YOUR OWN WORK and SHOW ALL OF IT!

1) A block with a mass of 450 grams is free to slide down an inclined plane without friction. The plane is inclined at an angle of 36.87° above horizontal. Before it is released (from rest) it is a distance *d* of 1.7 meters away from the end of a spring with spring constant 120 N/m. Since there is no friction, the block will compress the spring and then the spring will send it flying back up the ramp.



Helpful Hint: It may be worth your time to think about the easiest way to solve these.

a) When the block is as low as it will go on the ramp (when the compression of the spring is a maximum) what is the distance that the spring is compressed past the equilibrium point?

The block stops when the spring is at maximum compression, so kinetic energy is zero. The kinetic energy is also zero when it is released from rest. There is no friction, so the loss of gravitational potential energy is made up by an increase in elastic potential energy. Let x be the distance of compression of the spring.

$$\Delta U_{grav} = -mg\,(d+x)\sin\theta \qquad \Delta U_{elastic} = \frac{1}{2}k\,x^2 \qquad \frac{1}{2}k\,x^2 - mg\,(d+x)\sin\theta = 0$$

$$x = \frac{1}{k}\left[mg\sin\theta \pm \sqrt{(mg\sin\theta)^2 + 2\,k\,mg\,d\sin\theta}\right] = \frac{mg\sin\theta}{k}\left[1 \pm \sqrt{1+\left(\frac{2\,k\,d}{mg\sin\theta}\right)}\right]$$

$$= \frac{(4.5\,N)(0.6)}{(120\,N/m)}\left[1 \pm \sqrt{1+\left(\frac{2(120\,N/m)(1.7\,m)}{(4.5\,N)(0.6)}\right)}\right] = 0.30\,m$$

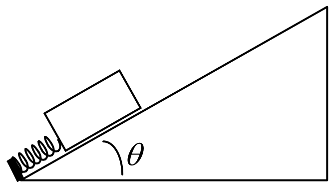
b) When the block is on the way back up the ramp, how fast is it going at the moment it loses contact with the spring?

Here the loss of gravitational potential energy is made up by kinetic energy.

$$\Delta U_{grav} = -mg\,(d)\sin\theta \qquad \Delta K = \frac{1}{2}m\,v^2$$

$$\frac{1}{2}m\,v^2 - mg\,(d)\sin\theta = 0 \qquad v = \sqrt{2\,g\,d\sin\theta} = \sqrt{20.4\,m^2/s^2} = 4.5\,m/s$$

2) The same block (with the same mass) is on an identical ramp (same degree of incline) but this time the coefficient of friction between the ramp and the block is 0.250 (assume the same coefficient of friction for kinetic and static friction). The block starts at the bottom of the ramp with the spring (same spring constant *k*) compressed 21 cm past the equilibrium point.



a) When the block is released, the spring shoves it up the ramp. How far along the ramp will the block go before stopping? (You don't need to worry about whether it will come back down or not. We are only interested in the distance that it travels on its first trip up the ramp.)

The work done by kinetic friction reduces the final amount of energy available to the block so the energy originally stored in the spring is equal to the increase in gravitational potential energy plus the work done by friction. Acceleration is parallel to the plane of the incline, so

$N - mg\cos\theta = 0 \qquad f = \mu N = \mu\, mg\cos\theta$

Work done by friction $= (\mu\, mg\cos\theta)(\Delta x)$

Increase in $U_{grav} = mg\,\Delta h = mg\,(\Delta x\sin\theta)$

$$\frac{1}{2}k\,(0.21\,m)^2 = mg\,(\Delta x\sin\theta) + (\mu\, mg\cos\theta)(\Delta x)$$

$$\Delta x = \frac{(0.5)\,k\,(0.21\,m)^2}{mg\,(\sin\theta + \mu\cos\theta)} = 0.735\,m = 73.5\,cm = 52.5\,cm \text{ away from the spring.}$$

b) Based on your answer to part a, how much energy is "lost" as heat while the block slides up the ramp? (If you did not get an answer for part a, please guess some distance and label it with the word GUESS for the purposes of solving part b.)

Two ways to do it: Let your "GUESS" be Δx *(which should be 0.735 m).*

1. *The heat is equal to the work done by friction*
2. *The heat is the "missing" energy at the end of the experiment.*

Method #1:
$$\begin{cases} Heat = f\,\Delta x = \mu N\,\Delta x = \mu\, mg\cos\theta\,\Delta x \\ \quad = 0.250\,(4.5\,N)(0.80)(0.735\,m) \approx 0.66\,J \end{cases}$$

Method #2:
$$\begin{cases} Heat = U_i - U_f = \tfrac{1}{2}k\,(0.21\,m)^2 - mg\,(0.735\,m)(\sin\theta) \\ \quad = 2.646\,J - 1.985\,J \approx 0.66\,J \end{cases}$$