- Solutions -

Name ______________________

AP Physics

CH 8. Conservation of Energy
Homework (Halliday, Resnick, Walker)

QUESTIONS

3. You drop an object and observe that it bounces to half its original height. What conclusions can you draw? What if it bounces to 1.5 times its original height?

$y = h$

$y = 0$

$W^{NC} = \Delta KE + \Delta PE$

If ball bounces to ½ its original height than energy is not conserved and Friction/(other non-conservative forces) have acted on the ball to remove ½ the initial Energy

$PE_i = mgh$

$PE_f = \frac{1}{2} mgh$

If ball bounces to 1.5 times its original height energy has been added to the system.

$PE_i = mgh$

$PE_f = 1.5\, mgh$

4. When an elevator descends from the top of a building and stops at the ground floor, what becomes of the energy that had been potential energy?

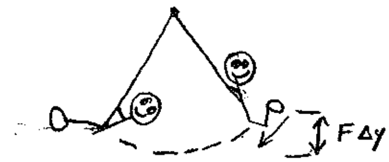
$W_{\substack{done\\net}} = \Delta KE = 0$ if start and finishes with $v=0$

$\therefore \quad W^{NC} = \cancel{\Delta KE}^{0} + \Delta PE$

Since the energy did not go back into the elevator as kinetic energy it must have been dissipated as heat energy through friction

$W^{NC} = mg\overset{0}{y_f} - mg\overset{h}{y_i} = -mgh$

13. Explain, using work and energy ideas, how you can pump a swing to make it go higher. If the swing is initially at rest, can you get it going by pumping it?



$W^{NC} = \Delta KE + \Delta PE$

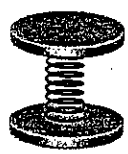
with no friction

$KE_f + PE_f = KE_i + PE_i$

By swinging your feet (pump) gravity is acting on a mass doing work on the system adding kinetic energy to the system each consecutive swing. If no energy is lost through friction, this energy remains in the system and becomes gravitational potential energy at the top of the swing, thereby increasing the height, h, each consecutive swing.

Yes.

14. Two disks are connected by a stiff spring (Fig. 8-20). Can you press the upper disk down far enough so that when it is released it will spring back and raise the lower disk off the table? Can mechanical energy be conserved in such a case?



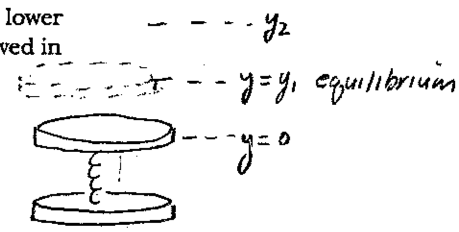


FIGURE 8-20 Question 14.

Yes it can if the spring constant k is large enough and the spring is compressed enough. If the potential energy of the spring $-\frac{1}{2}ky_1^2$ is larger than mgy_1 at the springs equilibrium the top mass will pull the spring upward past the equilibrium point. This stretching will exert an upward force on the bottom mass. If the upward stretching results in a force $ky_2 > mg$ the bottom mass will lift off the ground.

In real life no; energy would be lost because of the spring not being perfectly elastic and drag forces due to air.

17. A spring is compressed by tying its ends together tightly. It is then placed in acid and dissolves. What happens to its stored potential energy?

When the string dissolves the spring unstretches and pushes on the acid solution molecules mixing them. The additional kinetic energy of the acid molecules would result in a higher temperature measurement of the acid solution. The potential energy of the spring would become kinetic and thermal energy in the solution.

EXERCISES & PROBLEMS

SECTION 8-3 DETERMINING THE POTENTIAL ENERGY

1E. A certain spring stores 25 J of potential energy when it is compressed by 7.5 cm. What is the spring constant?
8.9×10^3 N/m

$$U(x)_{spring} = \frac{1}{2} k x^2$$

$$25\,J = \frac{1}{2} k (.075m)^2$$

$$\boxed{k = 8.9 \times 10^3\ N/m}$$

3E. You drop a 2.0-kg textbook to a friend who stands on the ground, which is 10 m below (Fig. 8-21). (a) If the potential energy is taken as being zero at ground level, then what is the potential energy of the book when you release it? (b) What is its kinetic energy just before your friend catches it in her outstretched hands, which are 1.5 m above the ground level? (c) How fast is the book moving as it is caught?

a.) 200 J b.) 170 J c.) 13 m/s

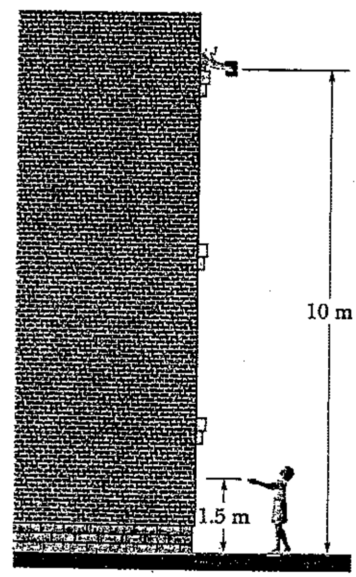


FIGURE 8-21 Exercise 3.

$$\cancel{W}^{NC} \rightarrow 0 \text{ No drag / friction}$$

$$W^{NC} = \Delta KE + \Delta PE$$

$$\therefore \quad KE_i + PE_i = KE_f + PE_f$$

a.) $PE^i_{gravity} = mgy = 2kg(9.8\frac{m}{s^2})(10m)$

$$= \boxed{196\ J}$$

b.) $\cancel{KE_i}^{\,0 \text{ at rest}} + PE_i = KE_f + PE_f$

$$196\ J = KE_f + 2(9.8)(1.5m)$$

$$196\ J = KE_f + 29.4\ J$$

$$\boxed{KE_f = 167\ J}$$

c.) $KE_f = 167\ J = \frac{1}{2}(2kg)\, v^2 \Rightarrow \boxed{v = 12.9\ m/s}$

7E. A frictionless roller-coaster car tops the first hill in Fig. 8-23 with speed v_0. What is its speed at (a) point A, (b) point B, and (c) point C? (d) How high will it go on the last hill, which is too high for it to cross?

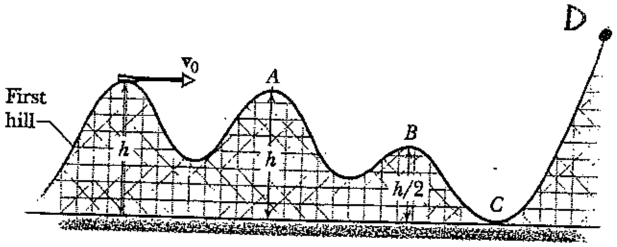


FIGURE 8-23 Exercise 7.

In General
no frictionless

$$W^{NC} = \Delta KE + \Delta PE$$

$$\therefore\ KE_i + PE_i = KE_f + PE_f$$

a.) $KE_0 + PE_0 = KE_A + PE_A$

$$\frac{1}{2}\cancel{m}v_0^2 + \cancel{m}gy_0 = \frac{1}{2}\cancel{m}v_A^2 + \cancel{m}gy_A$$

$$\frac{1}{2}v_0^2 + gh = \frac{1}{2}v_A^2 + gh \Rightarrow \frac{1}{2}v_0^2 = \frac{1}{2}v_A^2 \quad \therefore \boxed{v_0 = v_A}$$

b.) $KE_0 + PE_0 = KE_B + PE_B$

$$\frac{1}{2}\cancel{m}v_0^2 + \cancel{m}gh = \frac{1}{2}\cancel{m}v_B^2 + \cancel{m}g\frac{h}{2}$$

$$v_0^2 + 2gh = v_B^2 + gh$$

$$v_B^2 = v_0^2 + gh$$

$$\boxed{v_B = \sqrt{v_0^2 + gh}}$$

c.) $KE_0 + PE_0 = KE_c + PE_c$ because $mgy = mg(0)$

$$\frac{1}{2}\cancel{m}v_0^2 + \cancel{m}gh = \frac{1}{2}\cancel{m}v_c^2 + 0$$

$$v_0^2 + 2gh = v_c^2$$

$$\therefore \boxed{v_c = \sqrt{v_0^2 + 2gh}}$$

d.) $KE_0 + PE_0 = KE_D + PE_D$

$$\frac{1}{2}mv_0^2 + mgh = 0 + mgy_D$$

$v = 0$ at highest pt.

$$\boxed{y_D = \frac{v_0^2}{2g} + h}$$

11E. Figure 8-25 shows an 8.00-kg stone resting on a spring. The spring is compressed 10.0 cm by the stone. (a) What is the spring constant? (b) The stone is pushed down an additional 30.0 cm and released. What is the potential energy of the compressed spring just before that release? (c) How high above the release position will the stone rise?

a.) 7.84 N/cm
b.) 62.7 J
c.) $y = .8m$

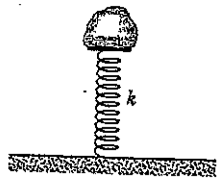
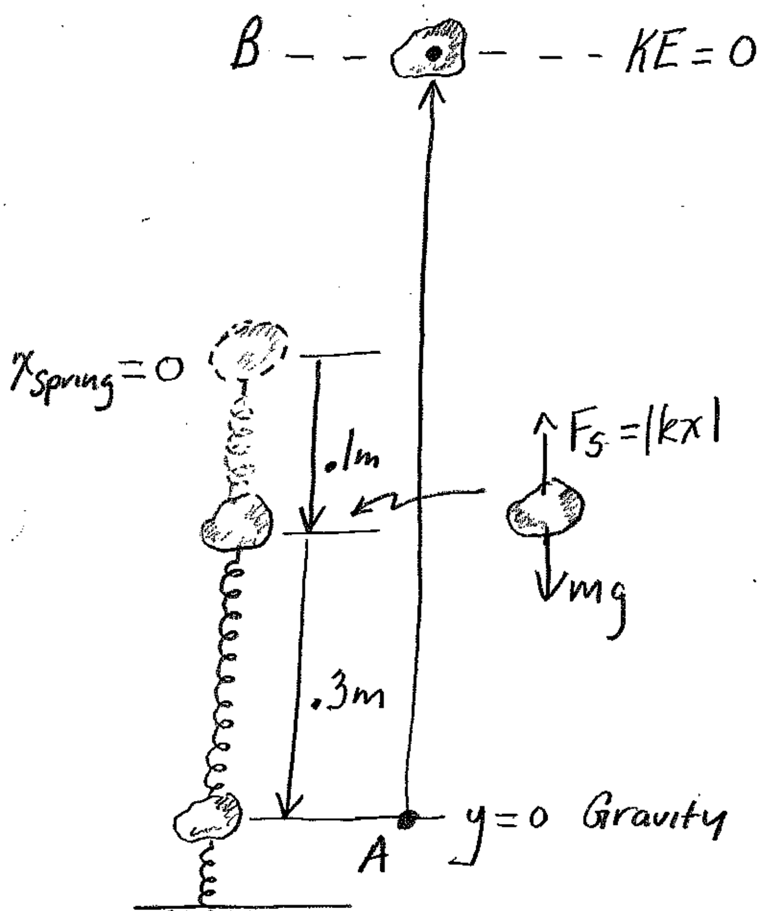


FIGURE 8-25 Exercise 11.



$KE = 0 \quad PE_s = 0 \quad PE_g = mgy$

$K(.1) = 8(9.8)$

$\boxed{k = 784 \frac{N}{m}}$

$y = 0$ Gravity $\Rightarrow KE = 0 \quad PE_s = \frac{1}{2}kx^2 = \frac{1}{2}(784)(.4)^2$

$PE_s = \boxed{62.72 J}$

$PE_g = mgy = 0$

c.) From $A \rightarrow B$

$(\cancel{KE}^{0} + PE)_A = (\cancel{KE}^{0} + PE)_B$ ⇐ No Friction

$PE_s + \cancel{PE_g}^{0} = \cancel{PE_s}^{0} + PE_g$

$62.72 J = mgy = 8(9.8)y \quad \boxed{y = .8m}$

* Can you calculate v at $y = .3m$ Answer: $v = 2.97$ m/s

13E. A ball with mass m is attached to the end of a very light rod with length L and negligible mass. The other end of the rod is pivoted so that the ball can move in a vertical circle. The rod is held in the horizontal position shown in Fig. 8-26 and then given just enough of a downward push so that the ball swings down and around and just reaches the vertically upward position, having zero speed there. (a) What is the change in potential energy of the ball? (b) What initial speed was given to the ball?

a.) mgL
b.) $v = \sqrt{2gL}$

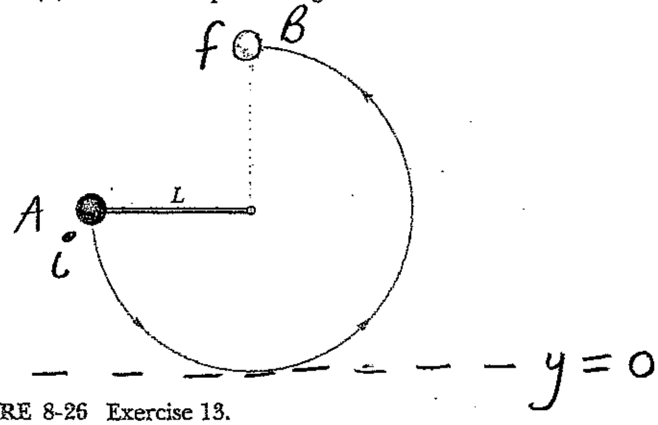


FIGURE 8-26 Exercise 13.

a.) $\Delta PE = PE_f - PE_i$

$= mgy_f - mgy_i$

$= mg(2L) - mg(L)$

$= \boxed{mgL}$

b.) No Friction

$(\cancel{KE_f}^{\,0} + PE_f) = (KE_i + PE_i)$

$mg(2L) = \frac{1}{2}mv_i^2 + mgL$

$gL = \frac{1}{2}v_i^2$

$\boxed{v_i = \sqrt{2gL}}$

16P. A 2.0-kg block is placed against a spring on a frictionless 30° incline (Fig. 8-29). The spring, whose spring constant is 19.6 N/cm, is compressed 20 cm and then released. How far along the incline does it send the block?

4m

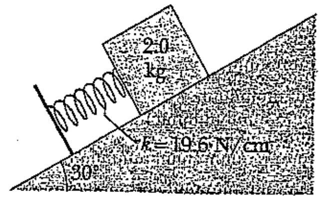
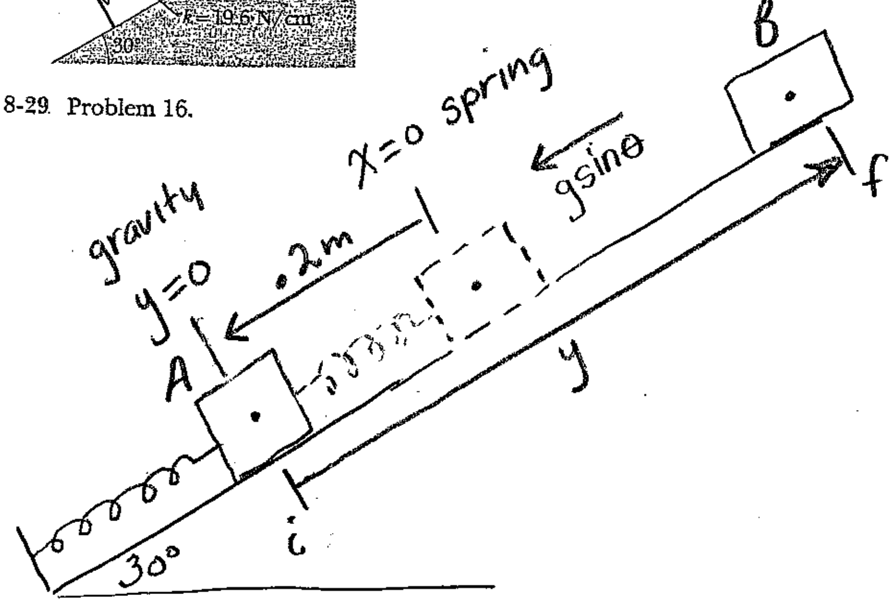


FIGURE 8-29. Problem 16.



$$(\cancel{KE}^{0} + PE)_A = (\cancel{KE}^{0} + PE)_B$$

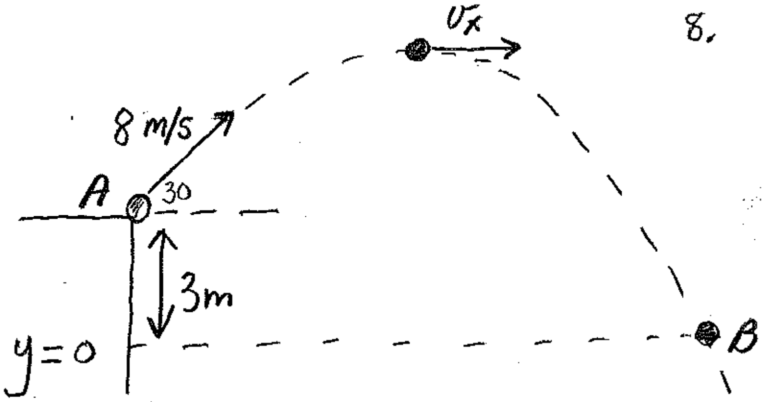
$$\frac{1}{2}kx^2 = mg'y \quad w/ \quad g' = g\sin\theta$$

$$\frac{1}{2}(1960)(.2)^2 = 2(9.8 \sin 30^\circ)\, y$$

$$\boxed{y = 4m}$$

19P. A 50-g ball is thrown from a window with an initial velocity of 8.0 m/s at an angle of 30° above the horizontal. Using energy methods determine (a) the kinetic energy of the ball at the top of its flight and (b) its speed when it is 3.0 m below the window. Does the answer to (b) depend on either (c) the mass of the ball or (d) the initial angle?

a.) 1.2 J b.) 11 m/s



$v_x = 8\cos 30^\circ = 6.93$ m/s

a.) $KE_{Top} = \frac{1}{2}(.05)(6.93)^2 = \boxed{1.2\text{ J}}$

b.) $(KE + PE)_A = (KE + \cancel{PE}^{\,0})_B$

$\frac{1}{2}(.05)8^2 + (.05)(9.8)(3) = \frac{1}{2}(.05)v_B^2$

$1.6 + 1.47 = .025\,v^2$

$\boxed{v = 11.1\text{ m/s}}$

c.) v_f at B does not depend on mass or angle. Just v_i and h

23P. The string in Fig. 8-31 is $L = 120$ cm long, and the distance d to the fixed peg P is 75 cm. When the ball is released from rest in the position shown, it will swing along the dashed arc. How fast will it be going (a) when it reaches the lowest point in its swing and (b) when it reaches its highest point, after the string catches on the peg? a.) 4.8 m/s² b.) 2.4 m/s²

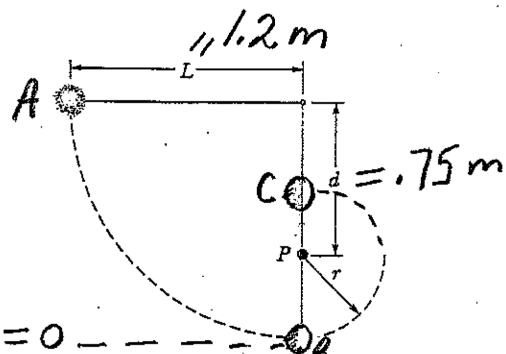


FIGURE 8-31 Problems 23 and 32.

$r = 1.2 - .75$
$= .45$ m

a.) $(\cancel{KE}^{\,0} + PE)_A = (KE + \cancel{PE}^{\,0})_B$

$mgL = \frac{1}{2}mv_B^2$

$9.8(1.2) = \frac{1}{2}v_B^2$

$\boxed{v_B = 4.85\text{ m/s}}$

b.) $(\cancel{KE}^{\,0} + PE)_A = (KE + PE)_C$

$mgL = \frac{1}{2}mv_c^2 + mg(2r)$

$9.8(1.2) = \frac{1}{2}v_c^2 + 9.8(2)(.45)$

$v_c^2 = 5.88$ $\boxed{v_c = 2.42\text{ m/s}}$

25P. A 2.0-kg block is dropped from a height of 40 cm onto a spring of spring constant $k = 1960$ N/m (Fig. 8-32). Find the maximum distance the spring is compressed.

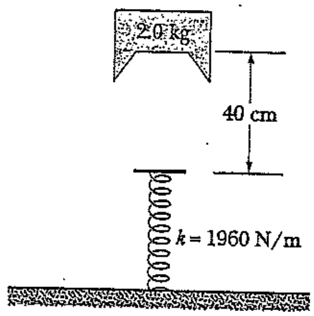
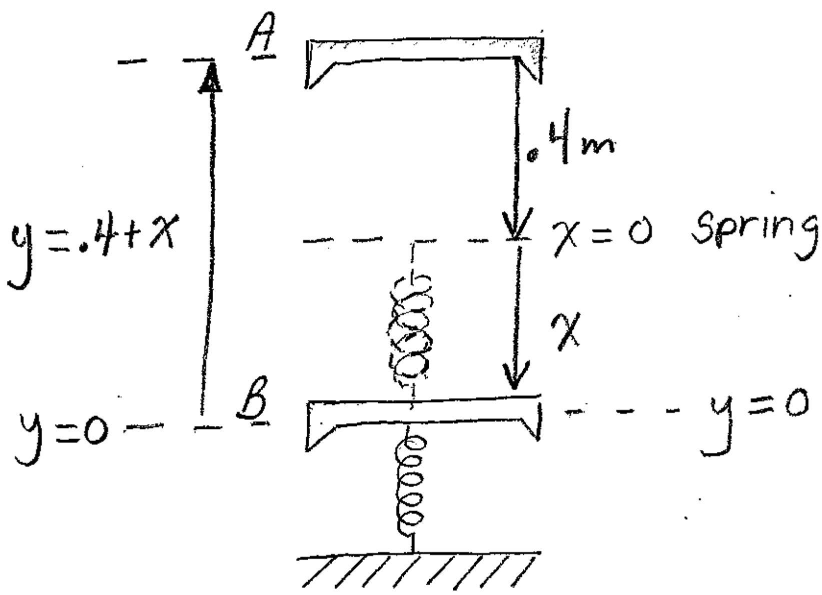


FIGURE 8-32 Problem 25.

.1 m



$$(\cancel{KE}^{\,0} + PE)_A = (\cancel{KE}^{\,0} + PE)_B$$

$$mgy = \frac{1}{2}kx^2$$

$$mg(.4+x) = \frac{1}{2}kx^2$$

$$2(9.8)[.4+x] = \frac{1}{2}(1960)x^2$$

$$7.84 + 19.6x = 980x^2$$

$$980x^2 - 19.6x - 7.84 = 0$$

$$\boxed{x = .1} \text{ or } -.08$$

29P. A 20-kg object is acted on by a force given by $F = -3.0x - 5.0x^2$, where F is in newtons if x is in meters. As the force causes the object to move, assume that the object's mechanical energy is conserved. Also assume that the potential energy U of the object is zero at $x = 0$. (a) What is the potential energy of the object at $x = 2.0$ m? (b) If the object has a velocity of 4.0 m/s in the negative x direction when it is at $x = 5.0$ m, what is its speed as it passes through the origin? (c) Next assume that the potential energy of the object is -8.0 J at $x = 0$, and reanswer parts (a) and (b).

a.) 19 J b.) 6.4 m/s c.) 11 J d.) 6.4 m/s

$$\Delta U = -\int F(x)\,dx = -(\text{Area})$$

$$F(x) = -\frac{dU}{dx} = -(\text{slope})$$

of tangents

a.) $\Delta U = -\int(-3x - 5x^2)\,dx$

$$U(x) - U_i = \frac{3x^2}{2} + \frac{5x^3}{3}$$

$$\boxed{U(x) = \frac{3x^2}{2} + \frac{5x^3}{3} + U_i}$$

$$U(2) = \frac{3(2)^2}{2} + \frac{5(2)^2}{2} + 0 = \boxed{19.3\text{ J}}$$

b.) $(KE + PE)_{x=5} = (KE + PE)_{x=0}$

$$\frac{1}{2}(20)(4)^2 + \left[\frac{3}{2}5^2 + \frac{5}{3}5^3\right] = \frac{1}{2}(20)v^2 + 0$$

Given $U = 0$ at $x = 0$

$$160 + 245.8 = 10v^2$$

$$\boxed{v = 6.37\text{ m/s}}$$

c.) Now let $U_i = -8$ J at $x = 0$

$$U(2) = \frac{3(2)^2}{2} + \frac{5(2)^2}{2} - 8 = \boxed{11.3\text{ J}}$$

d.) $(KE + PE)_{x=5} = (KE + PE)_{x=0}$

$$160 - \left[\frac{3}{2}5^2 + \frac{5}{3}5^3 - 8\right] = \frac{1}{2}(20)v^2 + (-8)$$

$$160 - [245.8 - 8] = 10v^2 - 8$$

$$\boxed{v = 6.37\text{ m/s}}$$

30P. A small block of mass m can slide along the frictionless loop-the-loop track shown in Fig. 8-35. (a) The block is released from rest at point P. What is the net force acting on it at point Q? (b) At what height above the bottom of the loop should the block be released so that it is on the verge of losing contact with the track at the top of the loop?

a.) $\sqrt{65}\,mg$ b.) $x = 5R/2$

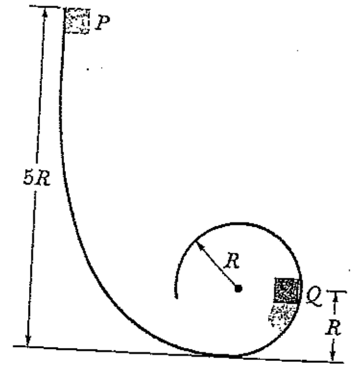


FIGURE 8-35 Problem 30.

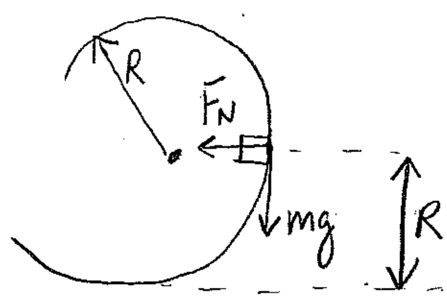
(a.) $KE_i + PE_i = KE_f + PE_f$

$$0 + mg(5R) = \frac{1}{2}\cancel{m}v^2 + \cancel{m}g(R)$$

$$8gR = v^2$$

$$\therefore F_{net} = \sqrt{\left(\frac{m(8g\cancel{R})}{\cancel{R}}\right)^2 + (mg)^2}$$

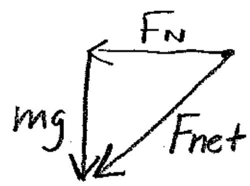
$$\boxed{F_{net} = \sqrt{65}\,mg}$$



$$\sum F_{Rad} = \frac{mv^2}{R}$$

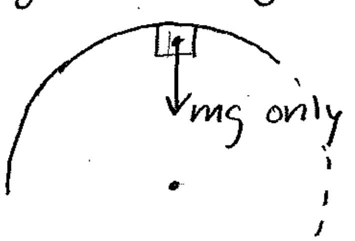
$$F_N = \frac{mv^2}{R}$$

$$F_{net} = \vec{F}_N + m\vec{g}$$



$$F_{net} = \sqrt{\left(\frac{mv^2}{R}\right)^2 + (mg)^2}$$

(b.) Verge of losing contact



mg only $F_N \to 0$

$$\therefore F_{rad} = mg = \frac{mv^2}{R}$$

Algebra ⇒ $\frac{1}{2}mv^2 = \frac{1}{2}mgR$

$$\cancel{KE_i}^{\,0} + PE_i = KE_f + PE_f$$

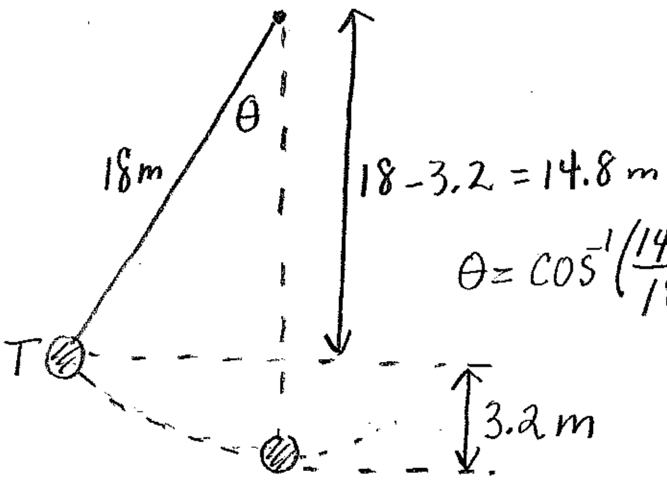
$$\cancel{m}g(h) = \overset{\frac{1}{2}mv^2}{\frac{1}{2}\cancel{m}gR} + \cancel{m}g(2R)$$

$$h = \frac{1}{2}R + 2R$$

$$\boxed{h = 2.5R}$$

31P. Tarzan, who weighs 688 N, swings from a cliff at the end of a convenient vine that is 18 m long (Fig. 8-36). From the top of the cliff to the bottom of the swing, he descends by 3.2 m. The vine will break if the force on it exceeds 950 N. Does the vine break?

$T = 933\ N$



$$\theta = \cos^{-1}\left(\frac{14.8}{18}\right) = 34.7^\circ$$

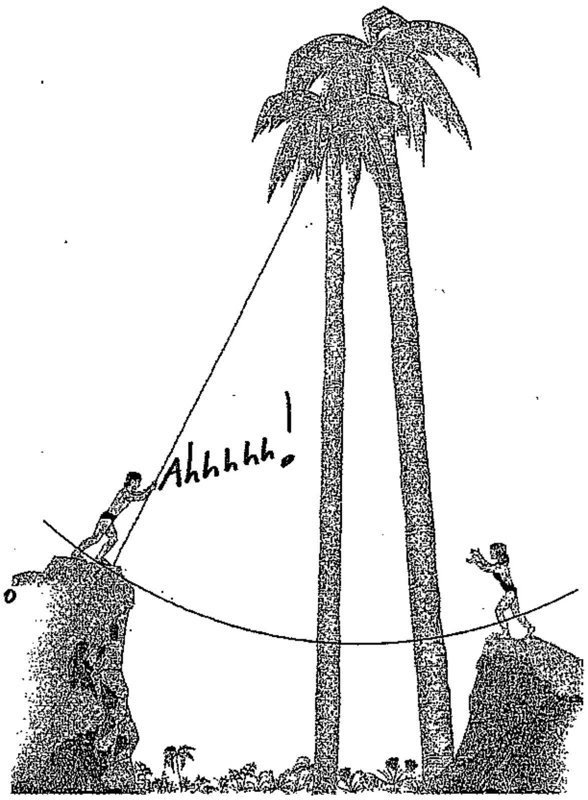
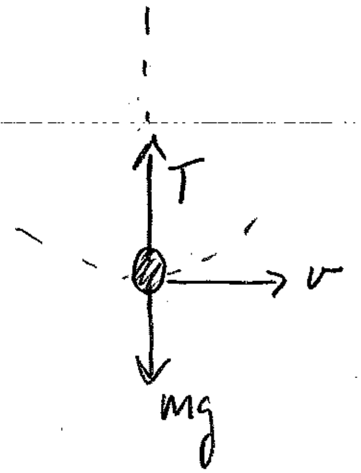


FIGURE 8-36 Problem 31.



$$\sum F_{rad} = m\frac{v^2}{r}$$

$$T - mg = m\frac{v^2}{r}$$

$$T - 688 = \frac{4403}{18}$$

$$\cancel{KE_i}^{\,0} + PE_i = KE_f + PE_f$$

$$0 + mg(3.2) = \frac{1}{2}mv^2 + 0$$

$$688(3.2) = \frac{1}{2}mv^2$$

$$2\ 688(3.2) = mv^2$$

$$4403 = mv^2$$

$$T = 688 + 244.6$$

$$\boxed{T = 932.6\ N}$$

VINE NOT BREAK!
TARZAN SAVE JANE.

32P. In Fig. 8-31 show that, if the ball is to swing completely around the fixed peg, then $d > 3L/5$. (*Hint:* The ball must still be moving at the top of its swing. Do you see why?)

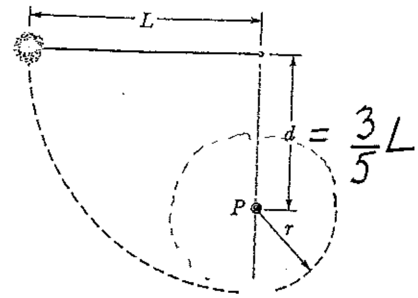


FIGURE 8-31 Problems 23 and 32.

$$\cancel{KE_i}^{\,0} + PE_i = KE_f + PE_f$$

$$mgL = \frac{1}{2}mv^2 + mg(2r)$$

$$mgL = \frac{1}{2}(mgr) + mg(2r)$$

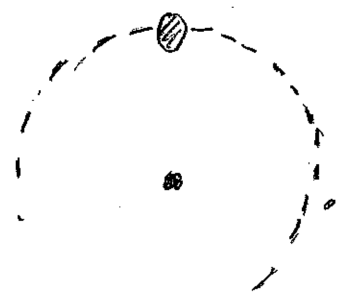
$$L = \frac{1}{2}r + 2r$$

$$L = \frac{5}{2}r$$

<u>TOP</u> - LIMITING CASE WHEN $T = 0$

AND

$\sum F_{rad} = mg$



$\therefore \; mg = m\frac{v^2}{r}$

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and $\quad d = L - r$

$$d = L - \frac{2}{5}L$$

$$\boxed{d = \frac{3}{5}L}$$

37P*. A boy is seated on the top of a hemispherical mound of ice (Fig. 8-39). He is given a very small push and starts sliding down the ice. Show that he leaves the ice at a point whose height is $2R/3$ if the ice is frictionless. (*Hint:* The normal force vanishes as he leaves the ice.)

$KE_i = 0$

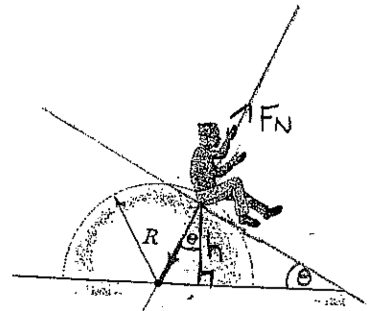
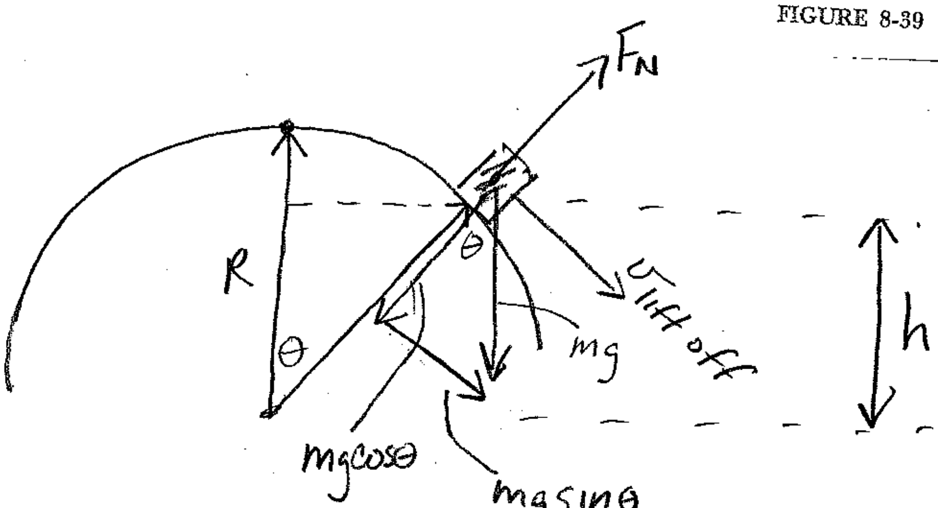


FIGURE 8-39 Problem 37.

$h = R\cos\theta$



$$\cancel{KE_i}^{\,0} + PE_i = KE_f + PE_f$$

$$mg(R) = \frac{1}{2}mv^2 + mgh$$

$$mg(R) = \frac{1}{2}(mgh) + mgh$$

$$R = \frac{3}{2}h$$

$$\boxed{h = \frac{2}{3}R}$$

$$\Sigma F_{rad} = m\frac{v^2}{r}$$

$$\cancel{F_N}^{\,0} - mg\cos\theta = m\frac{v^2}{R}$$

$$\cos\theta = \frac{h}{R}$$

$$mg\left(\frac{h}{R}\right) = m\frac{v^2}{R}$$

$$mgh = mv^2$$

Going Further

$$R\cos\theta = \frac{2}{3}R$$

$$\theta = \cos^{-1}\left(\frac{2}{3}\right)$$

$$\theta = 48.2^\circ$$

SECTION 8-5 USING A POTENTIAL ENERGY CURVE

38E. A particle moves along the x axis through a region in which its potential energy $U(x)$ varies as in Fig. 8-40. (a) Plot the force $F(x)$ that acts on the particle, using the same x axis scale as in Fig. 8-40. (b) The particle has a (constant) mechanical energy E of 4.0 J. Plot its kinetic energy $K(x)$ directly on Fig. 8-40.

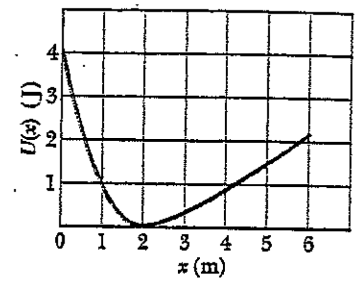
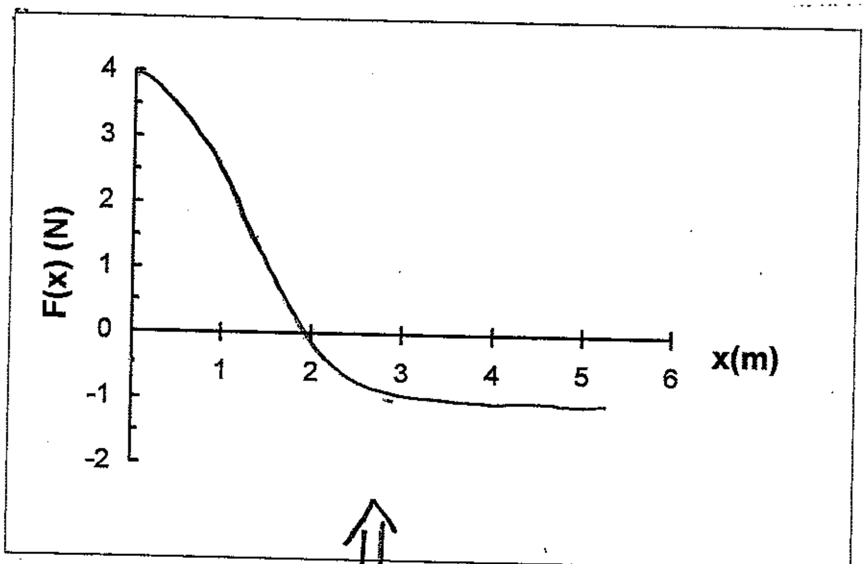
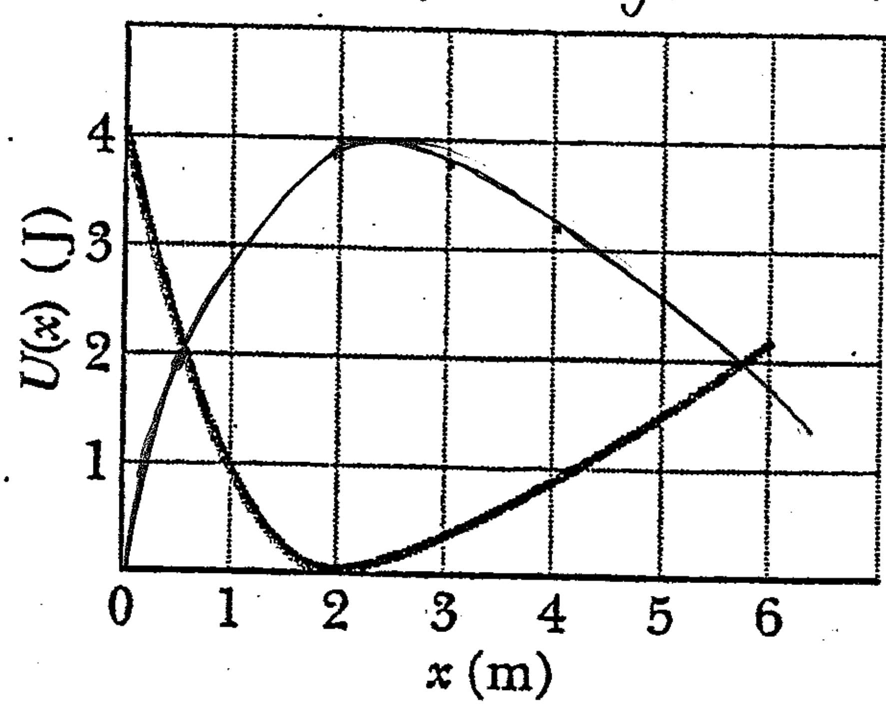


FIGURE 8-40 Exercise 38.



Take negative of tangent slopes



Total Energy = 4J (KE+PE)

$$\Delta U = -\int F(x)dx \quad F(x) = -\frac{dU}{dx}$$

40P. A particle of mass 2.0 kg moves along the x axis through a region in which its potential energy $U(x)$ varies as shown in Fig. 8-41. When the particle is at $x = 2.0$ m, its velocity is -2.0 m/s. (a) What force acts on it at this position? (b) Between what limits of x does the particle move? (c) What is its speed at $x = 7.0$ m?

a.) 4.7 N b.) −3.5 J c.) 3.6 m/s

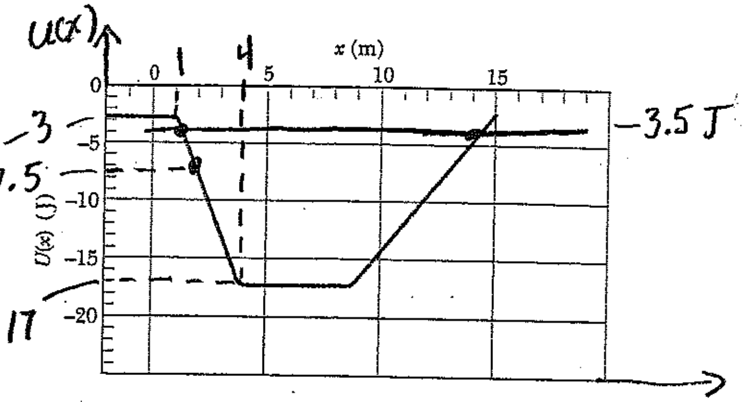


FIGURE 8-41 Problem 40.

$$a.)\ F = -\frac{dU}{dx} = -\frac{[-17-(-3)]}{4-1} = +\frac{14\,J}{3\,m} = \boxed{4.67\,N}$$

b.) At $x = 2m$ $KE = \frac{1}{2}(2)(2)^2 = 4J$

$\therefore (KE + PE)_{x=2} = 4J - 7.5J = -3.5J$

$\therefore PE_{max} = -3.5$ when $KE = 0$ and $1.5 \leq x \leq 14$

c.) No friction $\therefore$ $-3.5J = (KE + (-17J))$ at $x = 4$

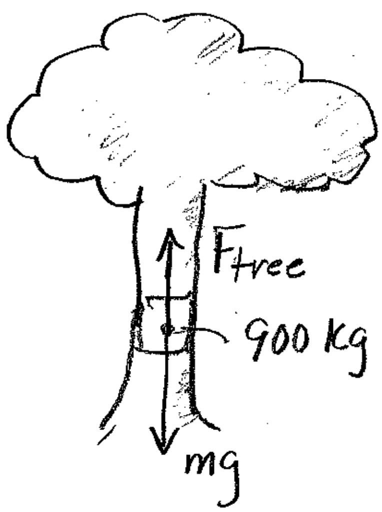
$KE = 13.5J$

$\frac{1}{2}(2)v^2 = 13.5$ $\boxed{v = 3.67\,m/s}$

SECTION 8-6 CONSERVATION OF ENERGY
SECTION 8-7 WORK DONE BY FRICTIONAL FORCES

43E. It is claimed that large trees can evaporate as much as 900 kg of water per day. (a) Evaporation takes place from the leaves. To get there, the water must be raised from the roots of the tree. Assuming the average rise of water to be 9.0 m from the ground, how much energy must be supplied per day to raise the water? (b) At what rate is the energy supplied if the evaporation is assumed to occur during 12 h of the day?

a.) 7.9×10^4 J b.) 1.8 W



$$a.)\ W_{tree} = F_{tree} \overset{\cos 0°}{\cdot} \Delta y$$

$$= (900)(9.8)\,9m$$

$$= \boxed{7.9 \times 10^4\,J}$$

$$t = 12\,hr \cdot \frac{3600\,sec}{1\,hr} = 43{,}200\,s$$

$$b.)\ P = \frac{W}{t} = \frac{7.9 \times 10^4\,J}{43{,}200\,s} = \boxed{1.83\,W}$$

$$9.8\ \frac{m}{s^2}\cdot\frac{100\ cm}{1\ m}\cdot\frac{1\ in}{2.54\ cm}\cdot\frac{1\ ft}{12\ in} = 32\ ft/s^2$$

48E. An outfielder throws a baseball with an initial speed of 120 ft/s. Just before an infielder catches the ball at the same level, its speed is reduced to 110 ft/s. By how much did air drag reduce the mechanical energy of the ball? The weight of a baseball is 9.0 oz.

$-20\ lb\cdot ft$

$$9.0\ oz\cdot\frac{1\ lb}{16\ oz} = .563\ lb$$

$$m = \frac{.563\ lb}{32\ ft/s^2} = .0176\ \frac{lb}{ft/s^2}$$

$v_i = 120\ ft/s \qquad v_f = 110\ ft/s$

$$W_{\text{done by air drag}} = \Delta KE = \frac{1}{2}\left(.0176\ \frac{lb}{\left(\frac{ft}{s^2}\right)}\right)\left[\left(110\ \frac{ft}{s}\right)^2 - \left(120\ \frac{ft}{s}\right)^2\right]$$

$$= \boxed{-20.24\ ft\cdot lb}$$

$$W_{AIR} = \Delta KE + \cancel{\Delta PE}^{\,0}$$

53E. The luxury liner *Queen Elizabeth 2* (Fig. 8-44) is powered by a diesel-electric powerplant with a maximum power of 92 MW at a cruising speed of 32.5 knots. What forward force is exerted on the ship at this highest attainable speed? (1 knot = 6076 ft/h.)

$5.5\times10^6\ N$

$P = 92\times10^6\ W$

$$v = 32.5\ knots\cdot\frac{6076\ ft/hr}{1\ knot}\cdot\frac{12\ in}{1\ ft}\cdot\frac{2.54\ cm}{1\ in}\cdot\frac{1\ m}{100\ cm}\cdot\frac{1\ hr}{3600\ s} = 16.72\ \frac{m}{s}$$

$$P = \vec{F}\cdot\vec{v} = F v \overbrace{\cos 0°}^{1}$$

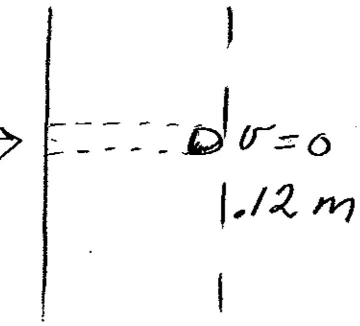
$$F = \frac{P}{v} = \frac{92\times10^6\ W}{16.72\ \frac{m}{s}} = \boxed{5.5\times10^6\ N}$$

55E. A swimmer moves through the water at an average speed of 0.22 m/s. The average drag force opposing this motion is 110 N. What average power is required of the swimmer? $24\ W$

$v = .22\ m/s \qquad F = 110\ N$

$$P = F\cdot v = \boxed{24.2\ W}$$

59E. A 30-g bullet, initially traveling 500 m/s, penetrates 12 cm into a solid wall before it stops. (a) What is the reduction in the bullet's mechanical energy? (b) Assume that the force of the wall on the bullet is constant, and calculate its value. 3.1×10^4 N



$$\overbrace{(KE_i + PE_i)}^{ME_i} \quad \overbrace{(KE_f + PE_f)}^{ME_f} \quad 500\ m/s$$

If $\Delta y = 0$ no change in PE due to gravity

Assume $y=0$ so $PE_i = PE_f = 0$

$$ME_i = KE_i = \frac{1}{2}(.03)(500)^2 = 3750\ J$$

$$ME_f = KE_f = 0$$

a.) ∴ Reduction of 3750 J

cos 180°

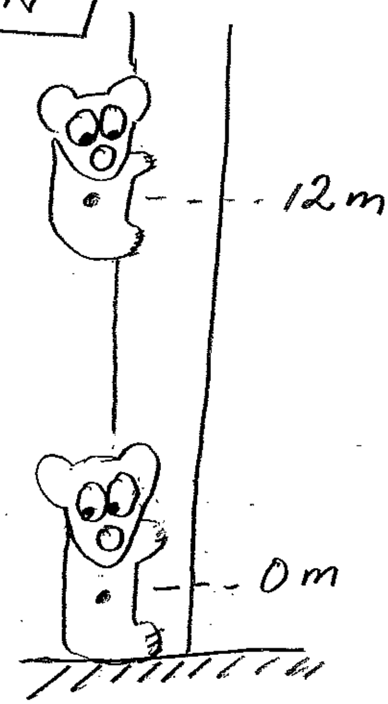
b.) $W_{fr} = -3750\ J = F_{fr} \cdot \Delta x$

$$-3750 = -F_{fr}(.12)$$

$$\boxed{F_{fr} = 3.13 \times 10^4\ N}$$

64E. A 25-kg bear slides, from rest, 12 m down a lodgepole pine tree, moving with a speed of 5.6 m/s just before hitting the ground. (a) What change occurs in the potential energy of the bear? (b) What is the kinetic energy of the bear just before hitting the ground? (c) What is the average frictional force that acts on the bear?

a.) -2.9×10^3 J b.) 3.9×10^2 J c.) 210 N



a.) $\cancel{PE_f}^{\,0} - PE_i =$

$$-mgy_i = -25(9.8)(12)$$

$$= -2.94 \times 10^3\ J$$

b.) $KE_f - \cancel{KE_i}^{\,0} =$

$$\frac{1}{2}mv^2 = \frac{1}{2}(25)(5.6)^2$$

$$= 392\ J$$

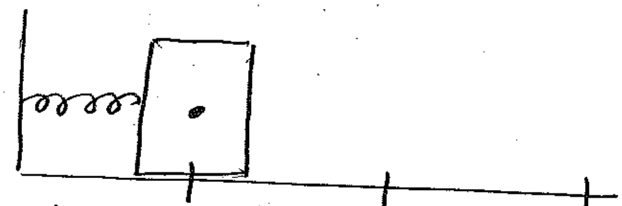
cos 180°

$$W_{fr} = \overbrace{(KE_f + \cancel{PE_f}^{\,0})}^{ME_f} - \overbrace{(\cancel{KE_i}^{\,0} + PE_i)}^{ME_i}$$

$$F_{fr} \cdot \Delta y = 392 - 2.94 \times 10^3$$

$$-F_{fr}(12) = -2548\ J \implies \boxed{F_{fr} = 212\ N}$$

67P. You push a 2.0-kg block against a horizontal spring, compressing the spring by 15 cm. When you release the block, the spring forces it to slide across a table top. It stops 75 cm from where you released it. The spring constant is 200 N/m. What is the coefficient of kinetic friction between the block and the table? $\mu_k = .15$



$$W_{fr} = \underset{\cos 180^\circ}{F_{fr}} \cdot \Delta X = (KE_f + PE_f) - (KE_i + PE_i) \qquad x = -.15 \qquad x = 0$$

$\Delta X = .75\,m$

$$-(\mu F_N)(\Delta X) = (0+0) - (0 + \tfrac{1}{2}kx^2)$$

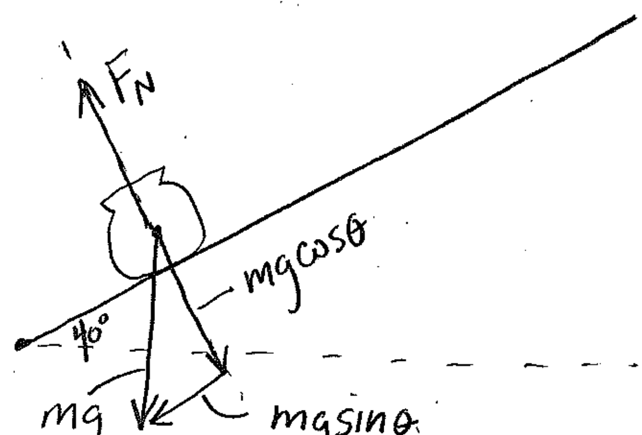
$$-\mu(19.6)(.75) = -\tfrac{1}{2}(200)(.15)^2$$

$$\mu(14.7) = 2.25$$

$$\boxed{\mu = .153}$$

$F_N = mg$
$= 2(9.8)$
$= 19.6\,N$

73P. A cookie jar is moving up a 40° incline. At a point 1.8 ft from the bottom of the incline (measured along the incline), it has a speed of 4.5 ft/s. The coefficient of kinetic friction between jar and incline is 0.15. (a) How much farther up the incline will the jar move? (b) How fast will it be going when it slides back to the bottom of the incline? a.) 5 in. b.) 8.7 ft/s



$$W_{fr} = \underset{\cos 180^\circ}{F_{fr}} \cdot \Delta X = (\cancel{KE_f}^{\,0} + PE_f) - (KE_i + \cancel{PE_i}^{\,0})$$

$$-\mu F_N \Delta X = PE_f - KE_i$$

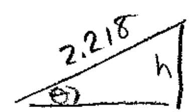
h_f $(\sin\theta\,\Delta x)$

$$-\mu(\cancel{m}g\cos\theta)\Delta X = \cancel{m}(g\sin\theta)\Delta X - \tfrac{1}{2}\cancel{m}v^2$$

$$-.15(32\cos 40^\circ)\Delta X = 32\sin 40^\circ(\Delta X) - \tfrac{1}{2}(4.5)^2$$

$$-3.63\,\Delta X = 20.57\,\Delta X - 10.125$$

$$\Delta X = .4183\,ft \cdot \frac{12\,in}{1\,ft} = \boxed{5.02\,in}$$



b.) $$-\mu F_N(.4183 + 1.8) = (KE_f + \cancel{PE_f}^{\,0}) - (\cancel{KE_i}^{\,0} + PE_i)$$

$$-\mu(\cancel{m}g\cos\theta)(2.218) = \tfrac{1}{2}\cancel{m}v^2 - \cancel{m}(g\sin\theta)(2.218)$$

$$-3.63(2.218) = \tfrac{1}{2}v^2 - 20.57(2.218)$$

$$-8.156 = .5v^2 - 45.62$$

$$\boxed{v = 8.66\,m/s}$$

76P. A 1500-kg automobile starts from rest on a horizontal road and gains a speed of 72 km/h in 30 s. (a) What is the kinetic energy of the auto at the end of the 30 s? (b) What is the average power required of the car during the 30-s interval? (c) What is the instantaneous power at the end of the 30-s interval, assuming that the acceleration was constant? a.) 3×10^5 J b.) 1×10^4 W c.) 2×10^4 W

$$72\,\frac{km}{hr}\cdot\frac{1\,hr}{3600\,s}\cdot\frac{1000\,m}{1\,Km} = 20\,\frac{m}{s}$$

a.) $KE_f = \frac{1}{2}(1500)(20)^2 = \boxed{3\times10^5\ J}$

b.) $P = \frac{W}{\Delta t} = \frac{3\times10^5\,J}{30\,s} = \boxed{1\times10^4\ Watts}$

c.) $P = F\cdot v$, $F = ma$

$= (1500)(.67)(20)$

$= \boxed{20000W}$

$20\,\frac{m}{s} = \cancel{v_i}^{\,0} + a t^{\,30\ sec}$

$a = .67\ m/s^2$

78P. In the hydrogen atom, the magnitude of the force of attraction between the positively charged nucleus (a proton) and the negatively charged electron is given by

$$F = k\frac{e^2}{r^2},$$

where e is the magnitude of the charge of the electron and the proton, k is a constant, and r is the separation between electron and nucleus. Assume that the nucleus is fixed in place. Imagine that the electron, which is initially moving in a circle of radius r_1 about the nucleus, suddenly "jumps" into a circular orbit of smaller radius r_2 (Fig. 8-50). (a) Calculate the change in kinetic energy of the electron, using Newton's second law. (b) Using the relation between force and potential energy, calculate the change in potential energy of the atom. (c) By how much has the atom's total energy decreased in this process? (The missing energy is the energy of the light that the atom emits because of the electron's jump.)

a.) $\frac{1}{2}ke^2\left(\frac{1}{r_2}-\frac{1}{r_1}\right)$ b.) $ke^2\left(\frac{1}{r_1}-\frac{1}{r_2}\right)<0$

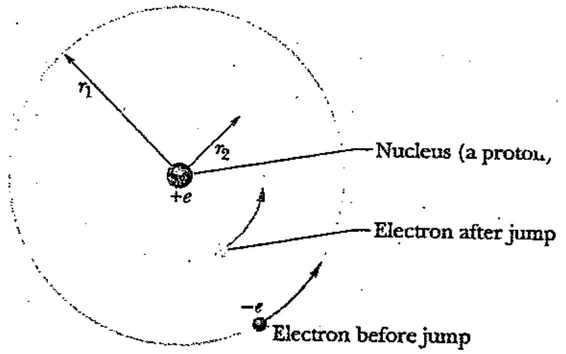


FIGURE 8-50 Problem 78.

a.) $F_{rad} = \frac{mv^2}{r} = \frac{ke^2}{r^2}$ then $v^2 = \frac{k}{m}\frac{e^2}{r}$

and $\Delta KE = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2 = \boxed{\frac{1}{2}ke^2\left(\frac{1}{r_2}-\frac{1}{r_1}\right)}$

b.) $\Delta U(x) = -\int \vec{F}(r)\cdot d\vec{r}$ cos180° F(r) in dr out

$= +\int k\frac{e^2}{r^2}dr = ke^2\int r^{-2}dr = -ke^2\left[\frac{1}{r}\right]_{r_i}^{r_f} = -ke^2\left[\frac{1}{r_f}-\frac{1}{r_i}\right]$

Note: $U(x)$ is ⊖ lost PE if $r_f < r_i$

c.) $W^{NC} = (KE_f + PE_f) - (KE_i + PE_i)$

$= \left(\frac{1}{2}\frac{ke^2}{r_2} - \frac{ke^2}{r_2}\right) - \left(\frac{1}{2}\frac{ke^2}{r_1} - \frac{ke^2}{r_1}\right)$

$= -\frac{1}{2}\frac{ke^2}{r_2} + \frac{1}{2}\frac{ke^2}{r_1}$ ⇐ Will be ⊖ since $r_2 < r_1$

81P. A small particle slides along a track with elevated ends and a flat central part, as shown in Fig. 8-52. The flat part has length L. The curved portions of the track are frictionless, but for the flat part the coefficient of kinetic friction is $\mu_k = 0.20$. The particle is released at point A,

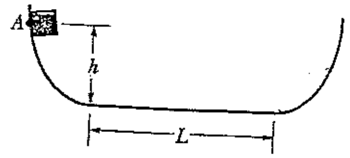


FIGURE 8-52 Problem 81.

which is a height $h = L/2$ above the flat part of the track. Where does the particle finally come to rest?

Center of the track

Total x distance it needs to travel to come to a stop

$$W^{NC} = \cancel{\Delta KE}^{0} + \Delta PE = -F_{fr}\,\Delta X$$

$$-\cancel{m}\cancel{g}\frac{L}{2} = -\mu \cancel{m}\cancel{g}\,\Delta X$$

$$\Delta X = \frac{1}{.2}\,\frac{L}{2} = \boxed{2.5\,L}$$

109. Two blocks, of masses M and $2M$ where $M = 2.0$ kg, are connected to a spring of spring constant $k = 200$ N/m that has one end fixed, as shown in Fig. 8-62. The horizontal surface and the pulley are frictionless, and the pulley is massless. The system is released from rest with the spring

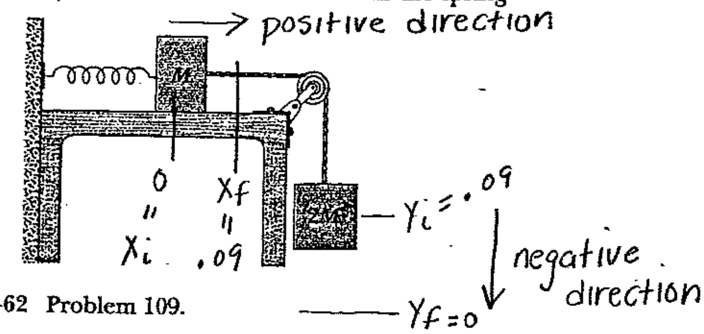


FIGURE 8-62 Problem 109.

unstretched. (a) What is the combined kinetic energy of the two masses after the hanging mass has fallen 0.090 m? (b) What is the kinetic energy of the hanging mass after it has fallen 0.090 m? (c) What maximum distance does the hanging mass fall before momentarily stopping?

a.) 2.7 J b.) 1.8 J c.) .39 m

a.) $\cancel{W^{NC}}^{\,0} = (KE_f + PE_f) - (KE_i + PE_i)$

$\cancel{KE_i}^{\,0 \text{ rest}} + PE_i = KE_f + PE_f$

$2Mgy_i + \frac{1}{2}k\cancel{x_i^2}^{\,0} = KE_f + 2Mg\cancel{y_f}^{\,0} + \frac{1}{2}kx_f^2$

$KE_f = 2Mgy_i - \frac{1}{2}kx_f^2 = 2(2)(9.8)(.09) - \frac{1}{2}(200)(.09)^2$

$= 3.528 - .81 = \boxed{2.72\text{ J}}$

b.) $KE_f = \frac{1}{2}(3M)v^2 = 2.72$ J

$= \frac{1}{2}(3)(2)v^2 = 2.72$ $\quad v^2 = .9067$ $\quad v = .952$ m/s

$KE_{2m} = \frac{1}{2}(\underbrace{2M}_{2\text{kg}})(.9067) = \boxed{1.81\text{ J}}$

or Since $KE_{Total} = KE_m + KE_{2m}$ $\Rightarrow KE_{2m} = \frac{2}{3}\underbrace{KE_{total}}_{2.72\text{ J}} = \boxed{1.81\text{ J}}$

c.) $KE_f = 0$ for max dist. $\therefore \rightarrow$ $\cancel{W_{fr}}^{\,0} = (\cancel{KE_f}^{\,0} + PE_f) - (\cancel{KE_i}^{\,0} + PE_i)$

$PE_i = PE_f$

$2Mgy_i = \frac{1}{2}kx_f^2 \Rightarrow y_i$ and x_f must have same magnitude

$39.2x - 100x^2 = 0 \quad \Rightarrow x(39.2 - 100x) = 0 \quad x = \frac{39.2}{100} = \boxed{.392\text{m}}$