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?

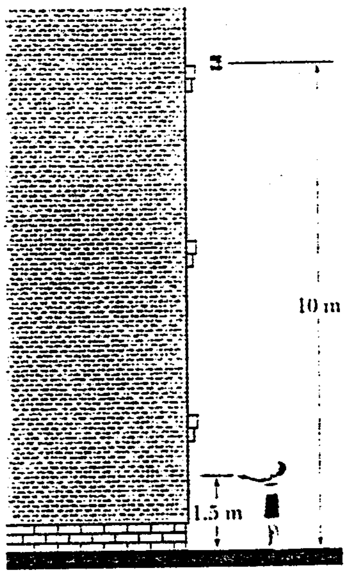


FIGURE 8-21 Exercise 3.

6E. An ice flake is released from the edge of a hemispherical frictionless bowl whose radius is 22 cm (Fig. 8-22). How fast is the ice moving at the bottom of the bowl?

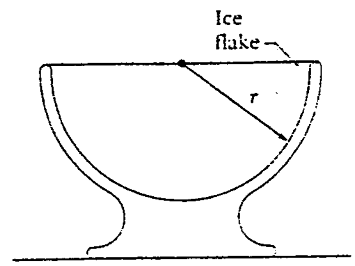


FIGURE 8-22 Exercise 6.

8E. A runaway truck with failed brakes is moving downgrade at 80 mi/h. Fortunately, there is an emergency escape ramp near the bottom of the hill. The inclination of the ramp is 15° (see Fig. 8-24). What minimum length must it have to make certain of bringing the truck to rest, at least momentarily? Real escape ramps are often covered with a thick layer of sand or gravel. Why?

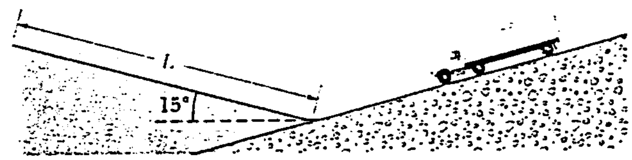
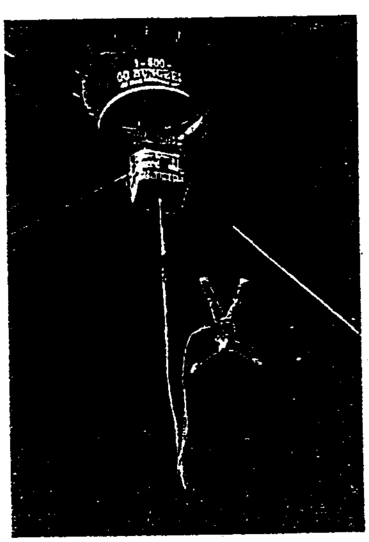


FIGURE 8-24 Exercise 8.

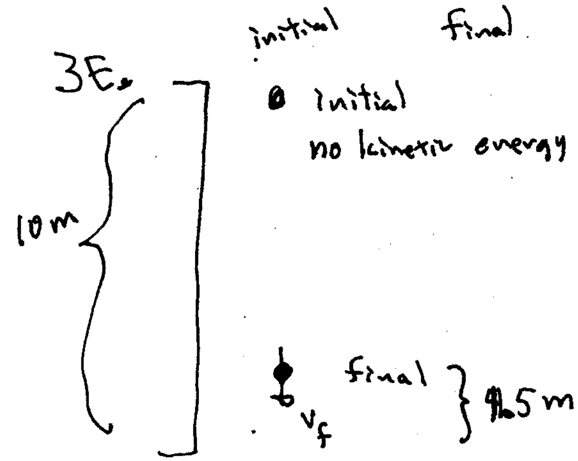
49. In the dangerous sport of bungee jumping, a student jumps from a balloon with a specially designed elastic cord attached to his ankles, as shown in the photograph. The unstretched length of the cord is 25.0 m, the student weighs 700 N, and the balloon is 36.0 m above the surface of a river below. Calculate the required force constant of the cord if the student is to stop safely 4.00 m above the river.



Bungee jumping (Problem 49). *(Gamma)*

30. How much energy is required to move a 1000-kg mass from the Earth's surface to an altitude twice the Earth's radius?

3E.



Total Initial Energy = Total Final Energy

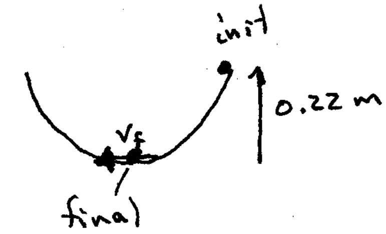
$$\frac{1}{2}m\underbrace{\cancel{v_i^2}}_{0} + mg\underbrace{y_i}_{10m} = \frac{1}{2}mv_f^2 + mg\underbrace{y_f}_{1.5m}$$

$$\cancel{m}gy_i = \frac{1}{2}\cancel{m}v_f^2 + \cancel{m}gy_f$$

$$(9.8)(10) = \frac{1}{2}v_f^2 + (9.8)(1.5)$$

$$v_f = 1.29 \text{ m/s}$$

6E.



Tot Init Mech Energy = Tot Final Mech Energy

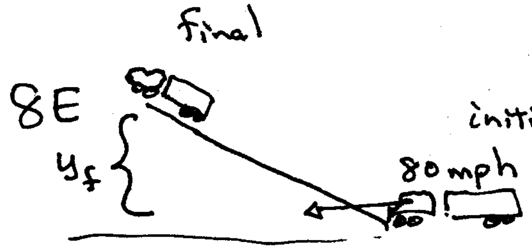
$$\frac{1}{2}m\underbrace{\cancel{v_i^2}}_{0} + mg\underbrace{y_i}_{0.22m} = \frac{1}{2}mv_f^2 + mg\overbrace{\cancel{y_f}}^{0}$$

$$\cancel{m}gy_i = \frac{1}{2}\cancel{m}v_f^2$$

$$(9.8)(0.22) = \frac{1}{2}v_f^2$$

$$v_f = 2.08 \text{ m/s}$$

8E



Tot Init Mech Energy = Total Final Mech Energy

$$\frac{1}{2}mv_i^2 + mg\cancel{y_i} = \frac{1}{2}m\cancel{v_f^2} + mgy_f$$

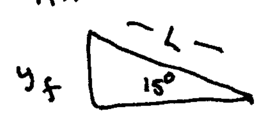
$v_i = 35.7$, $y_i = 0$, $v_f = 0$, $y_f = ?$

$$\frac{1}{2}\cancel{m}v_i^2 = \cancel{m}gy_f$$

$$\frac{1}{2}(35.7)^2 = (9.8)\,y_f$$

$$y_f = 65.0 \text{ m}$$

We were actually asked for the length of the hill



$$y_f = L \sin 15°$$

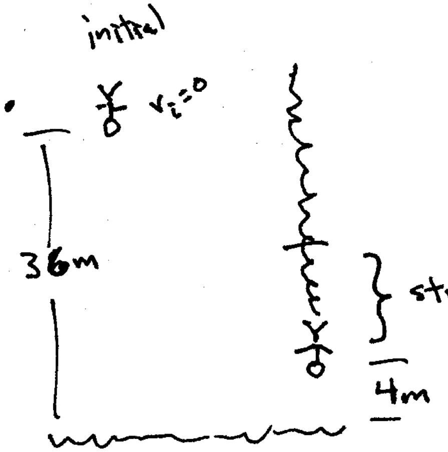
$$65.0 = L \sin 15°$$

$$L = 251 \text{ m}$$

Putting gravel or sand makes a humongous frictional force. This wastes the initial mechanical energy and therefore the stopping distance is much less

$$\left(\begin{array}{c}\text{Tot Init}\\ \text{Mech Energy}\end{array}\right) - \left(\begin{array}{c}\text{Energy Lost}\\ \text{to friction}\end{array}\right) = \left(\begin{array}{c}\text{Total Final}\\ \text{Mech E}\end{array}\right)$$

49.



The bungee cord stretches 7 m

$$\boxed{\begin{array}{c}\text{weight}\\ mg = 700\end{array}}$$

In this problem, we also have energy stored in the bungee stretch

Total Init Mech E = Total Final Mech E

$$mgy_i = mgy_f + \frac{1}{2}kx^2_{stretched}$$

$$[700](36) = [700](4) + \frac{1}{2}k(7)^2$$

$$k = 914 \text{ N/m}$$

10P. In Fig. 8-33, a small block of mass m can slide along the frictionless loop-the-loop. The block is released from rest at point P, at height $h = 5R$ above the bottom of the loop. ~~How much work does the weight of the block do on the block as the block travels from point P to (a) point Q and (b) the top of the loop? If the gravitational potential energy of the block–Earth system is taken to be zero at the bottom of the loop, what is that potential energy when the block is (c) at point P, (d) at point Q, and (e) at the top of the loop?~~

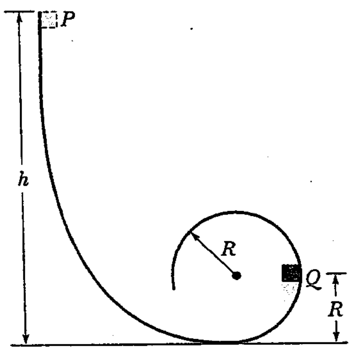


FIGURE 8-33 Problems 10 and 39.

[redacted] (a) In Problem 10, what is the *net* force acting on the block when it reaches point Q? (b) At what height h should the block be released from rest so that it is on the verge of losing contact with the track at the top of the loop? (*On the verge of losing contact* means that the normal force on the block from the track has just then become zero.)

33P. The string in Fig. 8-40 is $L = 120$ cm long, and the distance d to the fixed peg at point P is 75.0 cm. When the initially stationary ball is released with the string horizontal as shown, it will swing along the dashed arc. What is its speed when it reaches (a) its lowest point and (b) its highest point after the string catches on the peg?

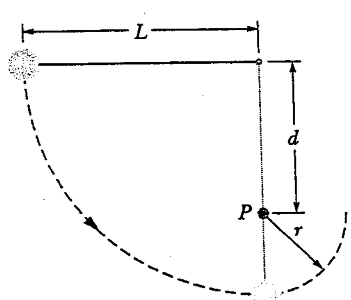


FIGURE 8-40 Problems 33 and 41.

40P. Tarzan, who weighs 688 N, swings from a cliff at the end of a convenient vine that is 18 m long (Fig. 8-44). 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. (a) Does the vine break? (b) If no, what is the greatest force on it during the swing? If yes, at what angle does it break?

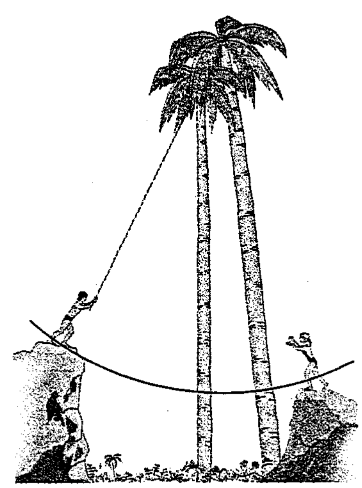
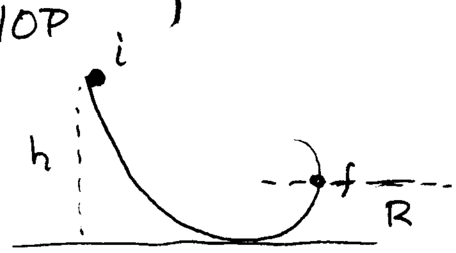


FIGURE 8-44 Problem 40.

10P

a)



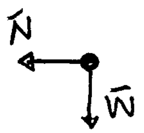
$$\begin{pmatrix}\text{Init}\\ \text{Mech}\\ E\end{pmatrix} = \begin{pmatrix}\text{Final}\\ \text{Mech}\\ E\end{pmatrix}$$

$$mgh = mg(2R) + \tfrac{1}{2}mv_f^2$$

$$\cancel{m}g\,5R = \cancel{m}g\,2R + \tfrac{1}{2}\cancel{m}v_f^2$$

$$v_f^2 = 6gR$$

Now diagram the forces at position Q



the Weight would be just mg

the Normal force is responsible for the circular motion at that location

$$m a_{rad} = \Sigma F_{rad}\text{'s}$$

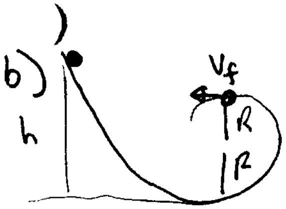
$$m\,v^2/R = N$$

$$m\,6gR/R = N$$

$$6mg = N$$

These two forces give the components of the NET FORCE

b)



$$\begin{pmatrix}\text{Init}\\ \text{Mech}\\ E\end{pmatrix} = \begin{pmatrix}\text{Final}\\ \text{Mech}\\ E\end{pmatrix}$$

$$mgh = mg(2R) + \tfrac{1}{2}mv_f^2$$

If the block is going to move in a circle, then there are constraints on the speed in the loop.

At the top:

$$m a_{rad} = \Sigma F_{rad}\text{'s}$$

$$m\,v^2/R = N + mg$$

min speed is when $N \to 0^+$

$$m\,v^2/R = mg$$

$$v^2 = gR$$

Now back to the energy formula

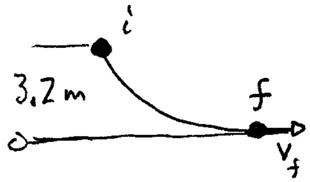
$$mgh = mg\,2R + \tfrac{1}{2}mv^2$$

$$= mg\,2R + \tfrac{1}{2}mgR$$

$$\cancel{mg}h = \cancel{mg}\,\tfrac{5}{2}R$$

$$h = \tfrac{5}{2}R$$

40P. The greatest tension in the vine will occur at the bottom of the swing.



$$\begin{pmatrix}\text{Init}\\\text{Mech}\\E\end{pmatrix} = \begin{pmatrix}\text{Final}\\\text{Mech}\\E\end{pmatrix}$$

$$\cancel{m}gy_i = \tfrac{1}{2}\cancel{m}v_f^2$$
$$9.8(3.2) = \tfrac{1}{2}v_f^2$$
$$v_f = 7.92 \text{ m/s}$$

Then to get the tension at the bottom of the swing:

$$m a_{rad} = \Sigma F_{rad}$$
$$m\frac{v^2}{R} = T - mg$$
$$70\frac{(7.92)^2}{18} = T - 688$$

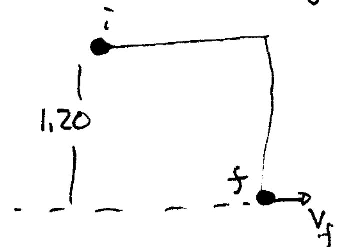
$mg = 688$
$m = 70$ kg

$$T = 932 \text{ Newtons.}$$

Therefore vine does not break.

33P

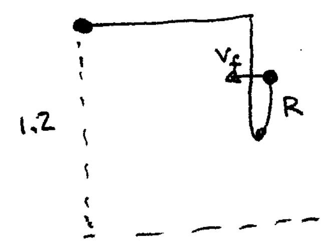
a) Compare initial position to bottom of swing.



$$\begin{pmatrix}\text{Init}\\\text{Mech}\\E\end{pmatrix} = \begin{pmatrix}\text{Final}\\\text{Mech}\\E\end{pmatrix}$$

$$\cancel{m}gy_i = \tfrac{1}{2}\cancel{m}v_f^2$$
$$9.8(1.2) = \tfrac{1}{2}v_f^2$$
$$v_f = 4.84 \text{ m/s}$$

b) Let's suppose that the ball wraps all the way around



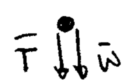
R = 0.45

$$\begin{pmatrix}\text{Tot}\\\text{Init}\\\text{Mech}\\E\end{pmatrix} = \begin{pmatrix}\text{Final}\\\text{Mech}\\E\end{pmatrix}$$

$$\cancel{m}gy_i = \cancel{m}gy_f + \tfrac{1}{2}\cancel{m}v_f^2$$
$$9.8(1.2) = 9.8(0.90) + \tfrac{1}{2}v_f^2$$
$$v_f = 2.42 \text{ m/s}$$

Now, we just assumed we could satisfy the constraints of circular motion, so we need to check if that is true.

At the top of the loop:



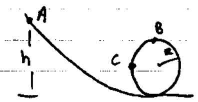
$$m a_{rad} = \Sigma F_{rad}\text{'s}$$
$$m\frac{v^2}{R} = T + mg$$

min speed is when $T \to 0$

$$\cancel{m}\frac{v^2}{R} = \cancel{m}g$$
$$v^2 = gR \rightarrow v = 2.1 \text{ m/s}$$

So we are OK!

7-22 Loop-the-Loop



$R = 30$ m

a) Comparing A & B:

Tot Init E = Tot Final E

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

- but to stay on the track at B, there's a minimum speed

$\downarrow v \quad N \downarrow \downarrow mg$

(+)

$ma_{rad} = N + mg$

$m\,v^2/R = N + mg$

smallest $N \to 0^+$

$m\,v^2/R = mg$

$v^2 = gR$

$mgh = \frac{1}{2}mgR + 2\,mgR$

$\cancel{m}g\,h = \frac{5}{2}\,\cancel{m}g\,R$

$h = \frac{5}{2}R$

b) Comparing A & C:

Tot Init E = Tot Final E

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

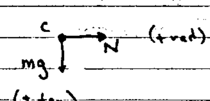
$h = 3.5\,R$

$3.5\,mgR = \frac{1}{2}mv^2 + mgR$

$2.5\,\cancel{m}gR = \frac{1}{2}\cancel{m}v^2$

$v^2 = 5gR = 5\,(9.8)\,30$

$v = 38.4$ m/s



$m\vec{a} = \Sigma \vec{F}s$

$m\,a_{rad} = N \qquad \cancel{m}a_{tan} = \cancel{m}g$

$a_{rad} = \frac{v^2}{R} = \frac{(38.4)^2}{30} = 49$ m/s²

$a_{tan} = g = 9.8$ m/s²

23P

$L = 120$ cm

$d = 75$ cm

$r = 45$ cm

a) Compare initial position to bottom of swing

Tot Init E = Tot Fin E

$\cancel{m}g\,h = \frac{1}{2}\cancel{m}v^2$

$v^2 = 2gh = 2(9.8)(1.20\text{ m})$

$v = 4.8$ m/s

b) Compare init position to over peg.

Tot Init E = Tot Final E

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

$\cancel{m}g\,(h-2r) = \frac{1}{2}\cancel{m}v^2$

$9.8\,[1.2 - 2(0.45)] = \frac{1}{2}v^2$

$v = 2.42$ m/s

Is this fast enough to be traveling in a circle at the top?

$mg \downarrow \downarrow T$

0^+ at min speed

$m\,a_{rad} = \cancel{T} + mg$

$\cancel{m}\frac{v^2}{r} = \cancel{m}g$

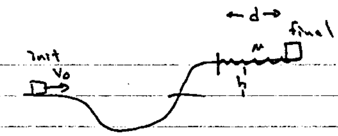
$v^2 = gr$

$= 9.8\,(0.45)$

$v = 2.1$ m/s

— Yep.

77P



$\mu = 0.60$ $h = 1.1$ m
$v_0 = 6$ m/s

$$(\text{Tot Init E}) - (\text{lost to frict}) = \text{Tot Final E}$$
$$\tfrac{1}{2}mv_0^2 - fd = mgh$$
$$\tfrac{1}{2}mv_0^2 - \mu N d = mgh$$
$$\tfrac{1}{2}\cancel{m}v_0^2 - \mu \cancel{m}g d = \cancel{m}gh$$
$$\tfrac{1}{2}(6)^2 - 0.6(9.8)d = 9.8(1.1)$$
$$0.6(9.8)d = 7.22$$
$$d = 1.22 \text{ m}$$

9P. $U = \frac{A}{r^{12}} - \frac{B}{r^6} = A r^{-12} - B r^{-6}$

a) $F = -\frac{dU}{dr} = (-)\left[-12Ar^{-13} + 6Br^{-7}\right]$
$= 12Ar^{-13} - 6Br^{-7}$

In equilibrium when $F = 0$

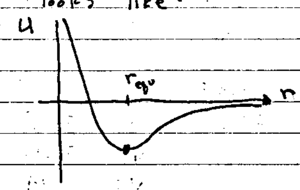
$0 = 12Ar^{-13} - 6Br^{-7}$

mult r^7 $0 = 12Ar^{-6} - 6B$

$r^6 = \frac{6B}{12A} = \frac{1}{2}\frac{B}{A}$

$r_{equ} = \left(\frac{1}{2}\frac{B}{A}\right)^{1/6}$

b) The potential looks like:



If $r < r_{equilibrium}$ $\rightarrow$ F repulsive
If $r > r_{equilibrium}$ $\rightarrow$ F attractive