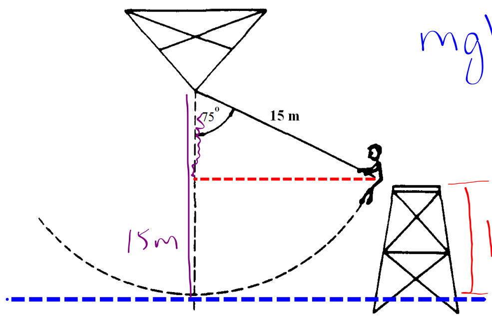
8. A daredevil student jumps off a platform as shown. Determine the speed of the student at the lowest point in the swing.



$$mgh_{Top} + \frac{1}{2}mv_{Top}^2 = mgh_B + \frac{1}{2}mv_B^2$$

$$V = \sqrt{2gh}$$

$$h = 15m - 15m\cos 75^\circ$$

Work and Energy

Demo 1	Demo 2	Demo 3	Demo 4

Was energy created in each of the demos above? Explain.

No – external force transferred energy to the system by doing work on it

Work-Energy Theorem:

Work done by external force is equal to the change in total energy of the system.

Formula: $W = \Delta E$

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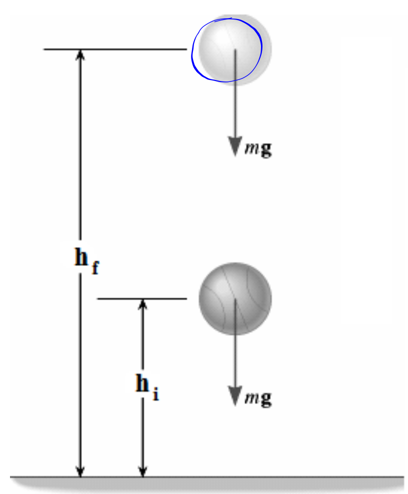
I. Gravitational Potential Energy

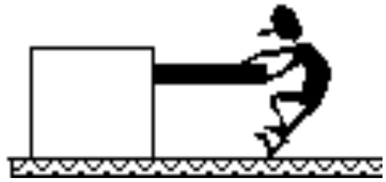
$W = F \cdot d \cdot \cos\theta$

$= (mg)\Delta h$

$= \Delta PE_g$



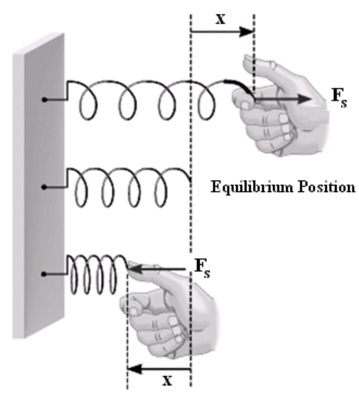
II. Kinetic Energy



$$W = F \cdot d\cos\theta$$
$$= (ma)d$$
$$= m\left(\frac{v_f^2 - v_0^2}{2}\right)$$
$$= \frac{1}{2}mv_f^2 - \frac{1}{2}mv_0^2$$
$$= \Delta \frac{1}{2}mv^2$$

$$v_f^2 = v_0^2 + 2ad$$

III. Elastic Potential Energy



$$W = F_{Avg} \cdot d\cos\theta$$
$$= \left(\frac{kx}{2}\right)x$$
$$= \frac{1}{2}kx^2$$
$$= \Delta PE_s$$

1. A 25 kilogram object is accelerated from rest to a speed of 12 meters per second by a force of 65 newtons. How much work is done by the force?

$d \rightarrow$ $V_f^2 = V_0^2 + 2ad$

$m \cdot a \cdot d$

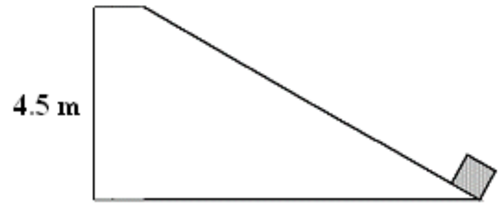
$F \cdot d$

$W = \Delta KE$

$= \frac{1}{2} m v^2$

$= 1800 J$

2. A 5.0 kilogram block slides from rest down a hill with a rough surface. When it reaches the bottom, it has 150 J of kinetic energy. How much work was done overcoming friction as it slid?



$W = \Delta E$

$5\,kg \cdot 10\,m/s^2 \cdot 4.5\,m$

$mgh = \frac{1}{2}mv^2 + Q$

$225\,J = 150\,J + \underline{75\,J}$

$F_{g\parallel} \cdot d + F_f \cdot d = 150\,J$

$225\,J \quad (-75\,J)$

75 J lost to friction

−75 J work by friction

3. A 3.0 kg ball is dropped from a height of 10. m. How fast is it going when it hits the ground? Assume an average air resistance force of 20. N acts on the ball as it falls.

$a = \frac{\Sigma F}{m} = \frac{mg - F_f}{m} = \_\_\_$

$mgh = \frac{1}{2}mv^2 + F_f \cdot d$

$V_f^2 = V_0^2 + 2ad$

$mgh - F_f \cdot d = \frac{1}{2}mv^2$

$V = \sqrt{\frac{mgh - F_f \cdot d}{.5\,m}}$

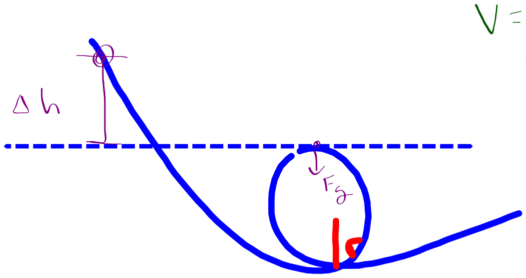
$\sqrt{\frac{3\,kg \cdot 9.8\,m/s^2 \cdot 10\,m - 20\,N \cdot 10\,m}{.5 \cdot 3\,kg}}$

4. A 5.0 kg box is sliding across a rough surface at 2.0 m/s and is brought to rest in 0.40 m. How much work is done by friction in stopping the box? Calculate the force of friction.

10 J

$\frac{1}{2}mv^2 = Q$

$F_f \cdot d$



$mg\Delta h = \frac{1}{2}mv^2$

$v = \sqrt{2g\Delta h}$

v_{min}

$\Sigma F_{in} =$

$F_g =$

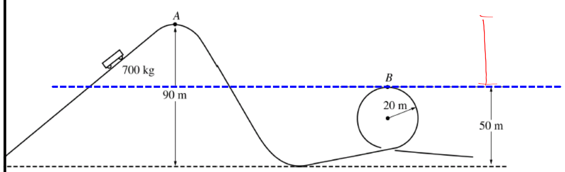
$mg = mv^2/r$

$v = \sqrt{rg}$

h_{min}

$\sqrt{2gh} = \sqrt{rg}$

Additional Problems



1. A roller coaster ride at an amusement park lifts a car of mass 700 kg to point A at a height of 90 m above the lowest point on the track, as shown above. The car starts from rest at point A, rolls with negligible friction down the incline and follows the track around a loop of radius 20 m. Point B, the highest point on the loop, is at a height of 50 m above the lowest point on the track.

a) Determine the speed of the car at the bottom of the first hill.

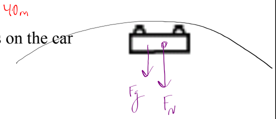
$mgh = \frac{1}{2}mv^2$

$v = \sqrt{2gh} = 42 m/s$ (h = 90 m)

b) Calculate the speed of the car at point B.

$v = \sqrt{2gh} = 28 m/s$ (h = 40 m)

c) Calculate the force the track exerts on the car when it is upside down at point B.



$\Sigma F_{in} = \frac{mv^2}{r}$

(+) (+) (+)

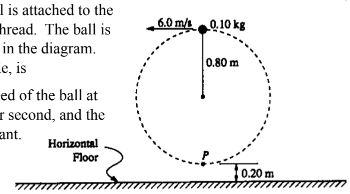
$F_N + F_g = mv^2/r$

$F_N = \frac{mv^2}{r} - mg$

$\frac{700 kg \cdot (28 m/s)^2}{20 m} - 700 kg \cdot 9.8 m/s^2$

$= 21\,000 N$

2. A 0.10-kilogram solid rubber ball is attached to the end of a 0.80-meter length of light thread. The ball is swung in a vertical circle, as shown in the diagram. Point *P*, the lowest point of the circle, is 0.20 meter above the floor. The speed of the ball at the top of the circle is 6.0 meters per second, and the total energy of the ball is kept constant.



a) Determine the total energy of the ball, using the floor as the zero point for gravitational potential energy.

3.56J

b) Determine the speed of the ball at point *P*, the lowest point of the circle.

$E_{Bottom} = mgh_B + \frac{1}{2}mv^2$ (h = .2 m)

3.56J =

c) Determine the tension in the thread at

i) the top of the circle.

3.5N

$\Sigma F_{in} = \frac{mv^2}{r}$

(+) (+) (+)

$F_T + F_g = mv^2/r$ (6 m/s)

$F_T = \frac{mv^2}{r} - mg$

ii) the bottom of the circle.

9.4N

$\Sigma F_{in} = \frac{mv^2}{r}$

(+) (-) (+)

$F_T + F_g = mv^2/r$ (8.2 m/s)

$F_T = \frac{mv^2}{r} - mg$ (-)