<u>Work</u>:

1) A student holds a 15 kg bowling ball 1.5 m above the ground for 15 s. How much work is done on the ball?

No change in energy $\therefore W = \Delta E = 0\,J$

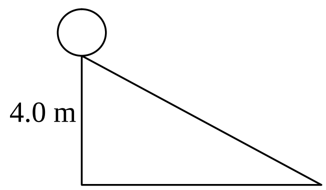
2) A block of wood is pushed at a constant velocity with a force of 25.0 N. How far did it travel if 100.0 J of work are done on it?

$W = Fd \quad d = \frac{W}{F} = \frac{100.0\,J}{25.0\,N} = 4.00\,m$

3) A 2.0 kg textbook is picked up off the floor and placed on a 0.95 m high desk. How much work is down on the book?

$W = mg\Delta h = (2.0\,kg)(9.80\,m/s^2)(0.95\,m) = 19\,J$

4) A 5.0 kg ball rolls down a ramp as shown.
How much work is done on the ball?

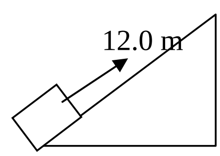


$W = \Delta E_p = E_{pf} - E_{pi}$

$= mgh_f - mgh_i$

$= 0 - 196 \quad = -2.0 \times 10^2\,J$

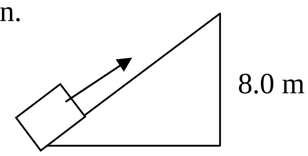
5) A 5.0 kg block of wood is pushed up a ramp as shown.
If a force of 16.0 N is needed to push it up the ramp at a constant velocity, how much work is done in the block?



$W = Fd = (16.0\,N)(12.0\,m)$

$= 192\,J$

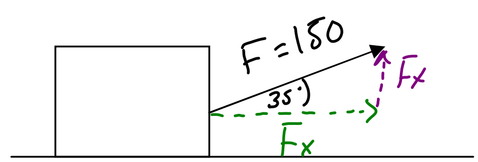
6) A 5.0 kg block of wood is pushed up a frictionless ramp as shown.
How much work is done on the block?



$W = \Delta E_p = mg\Delta h = (5.0\,kg)(9.80\,m/s^2)(8.0\,m)$

$= 4.0 \times 10^2\,J$

7) A box is pulled along a horizontal surface at a constant velocity. The tension in the rope is 150 N and the rope makes an angle of 35 ^{0} with the floor. How much work is done on the box if it is dragged 18 m?



$\cos 35° = \frac{F_x}{150}$

$F_x = 150 \cos 35 = 122.9\,N$

$W = F_x d$

$= (122.9)(18) = 2200\,J$

8) A 1200 kg car traveling at 60.0 km/h hits the brakes and comes to a stop in 32 m. How much work is done on the car?

$\div 3.6 = 16.67\,m/s$

$W = F_f d$

$= -1.7 \times 10^5\,J$

↑ because the car is losing energy!

$v = 0$

$v_0 = 16.67$

$a =$

$d = 32\,m$

$t =$

$a = \frac{v^2 - v_0^2}{2d}$

$= -4.342\,m/s^2$

$F_{net} = F_f = ma = 5210\,N$

Shortcut!

$W = \Delta E_K$

$= E_{kf} - E_{ki}$

$= 0 - \frac{1}{2}mv^2$

$= -1.7 \times 10^5\,J$

Potential Energy:

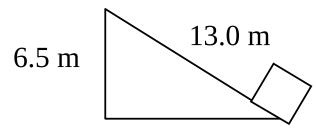
1) How much potential energy does a 12.0 kg bowling ball have if it is sitting on a 0.50 m high chair?

$E_p = mgh = (12.0\,kg)(9.80\,m/s^2)(0.50\,m) = 59\,J$

2) A 7.5 kg bowling ball sits on a 1.10 m desk. If a student lifts the ball 0.90 m above the desk, how much potential energy does it have with respect to the desk?

$E_p = mgh = (7.5\,kg)(9.80\,m/s^2)(0.90\,m) = 66\,J$

3) A 5.0 kg bock is pushed up a ramp as shown.
How much potential energy does it have when it reaches the top?



$E_p = mgh = 290\,J$

4) If the ramp in question #3 is frictionless, how much force is required to push the block up the ramp (think work!)?

$W = Fd = \Delta E_p \qquad F = \frac{E_p}{d} = \frac{294\,J}{13.0\,m} = 23\,N$

Kinetic Energy:

1) How much kinetic energy does a 50.0 g bullet traveling at 365 m/s have?

$E_k = \frac{1}{2}mv^2 = \frac{1}{2}(0.0500\,kg)(365\,m/s)^2 = 3.33\times10^3\,J$

2) If a 78 kg cheetah is running at a speed of 120 km/h, how much kinetic energy does it have?

$E_k = \frac{1}{2}mv^2 = \frac{1}{2}(78\,kg)(33.3\,m/s)^2 = 43000\,J$

3) A 3.91 N baseball has 775 J of kinetic energy. How fast is it moving?

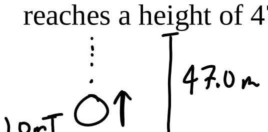
$F_g = mg \quad m = \frac{F_g}{g} = \frac{3.91\,N}{9.80\,m/s^2} = 0.399\,kg \qquad E_k = \frac{1}{2}mv^2 \quad v = \sqrt{\frac{2E_k}{m}} = \sqrt{\frac{2(775)}{0.399}} = 62\,m/s$

4) A 0.425 kg water balloon is dropped from the top of a school gymnasium onto some unsuspecting physics students (those were the days…). If the gym is 8.50 m high how much kinetic energy does it have just before it hits the ground?

$E_{kf} = E_{pi} = mgh = (0.425)(9.80)(8.50) = 35\,J$

Law of Conservation of Energy: (Use Law of Con of En OR ELSE!!!!)

1) A 0.85 kg soccer ball is booted straight up in the air. If it left the soccer player's foot at a height of 1.0 m and reaches a height of 47.0 m, what was its kinetic energy immediately after it was kicked?



$E_{ki} = E_{pf} = mgh_f = (0.85\,kg)(9.80\,m/s^2)(46.0\,m) = 380\,J$ ← assuming initial $h = 0$

2) What was the speed of the ball in question #1 when it had reached a height of 24.0 m?

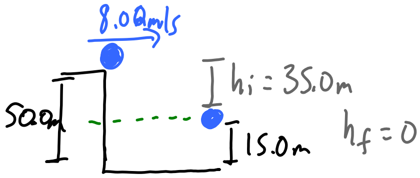
$E_{ki} = E_{kf} + E_{pf} \qquad E_{kf} = E_{ki} - E_{pf} \qquad \frac{1}{2}mv_f^2 = E_{ki} - mgh_f \qquad v_f = \sqrt{\frac{2(E_{ki} - mgh_f)}{m}} = 21\,m/s$

3) A 0.575 kg smurf is thrown straight down from a 10.0 m high toadstool. If his final speed is 18.0 m/s, how fast was he traveling initially?

$E_{ki} + E_{pi} = E_{kf}$

$\frac{1}{2}mv_i^2 + mgh_i = \frac{1}{2}mv_f^2$

$v_i = \sqrt{v_f^2 - 2gh_i} = \sqrt{(18.0)^2 - 2(9.80)(10.0)} = 11\,m/s$

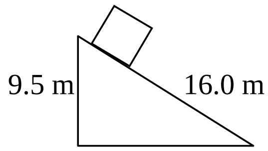


$$E_{Ki} + E_{pi} = E_{Kf} + E_{pf}^{\,0}$$
$$E_{Kf} = E_{Ki} + E_{pi} = \tfrac{1}{2}mv_i^2 + mgh_i$$

4) Another 0.575 kg smurf (there are 99 of them…) is now thrown horizontally from a 50.0 m cliff at 8.00 m/s. how much kinetic energy does it have when it is 15.0 m from the ground?

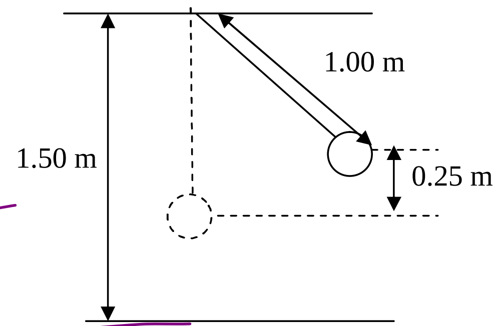
$$= \tfrac{1}{2}(0.575\,kg)(8.00\,m/s)^2 + (0.575\,kg)(9.80\,m/s^2)(35.0\,m)$$
$$= 215\,J$$

5) A box slides down a frictionless ramp as shown.
How fast is it traveling at the bottom?



$$E_{pi} = E_{Kf} \qquad v = \sqrt{2gh_i} = 14\,m/s$$
$$mgh = \tfrac{1}{2}mv^2$$

6) A pendulum if pulled aside as shown.
The pendulum bob has a mass of 0.500 kg.
If the pendulum is released from this point how fast will it be moving when it returns to the equilibrium point?



$$E_{pi} = E_{Kf} \qquad v = \sqrt{2gh_i}$$
$$mgh_i = \tfrac{1}{2}mv_f^2$$
$$= \sqrt{2(9.80\,m/s^2)(0.25\,m)} = 2.2\,m/s$$

Power and Efficiency

1) A 12.0 kg block is pushed up an 8.0 m ramp at a constant speed of 2.50 m/s with a force of 28.0 N. How much power does this require?

$$P = \frac{W}{t} = \frac{Fd}{t} = Fv = (28.0\,N)(2.50\,m/s) = 70.\,W$$

2) A 25.0 kg crate it lifted on to a 2.0 m ledge by a worker that exerts 325 W of power. How long does it take to reach the ledge?

$$P = \frac{W}{t} = \frac{\Delta E_p}{t} = \frac{mgh}{t} \qquad t = \frac{mgh}{P} = \frac{(25.0\,kg)(9.80\,m/s^2)(2.0\,m)}{325\,W}$$
$$= 1.5\,s$$

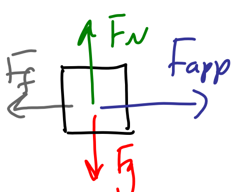
3) A 0.390 kg hockey puck is accelerated across a frictionless sheet of ice from rest to a speed of 15.0 m/s in 1.5 m. How much power is exerted on the puck?

$v = 15.0\,m/s$, $v_0 = 0$, $a = ?$, $d = 1.5\,m$, $t = ?$

$$a = \frac{v^2 - v_0^2}{2d} = 75\,m/s^2 \qquad t = \frac{v - v_0}{a} = 0.20\,s$$

$$P = \frac{W}{t} = \frac{\Delta E_K}{t} = \frac{\tfrac{1}{2}mv^2}{t} = \frac{\tfrac{1}{2}(0.390\,kg)(15.0\,m/s)^2}{0.20\,s} = \boxed{220\,W}$$

4) A 5.0 kg box is sliding across the floor at 2.00 m/s when it is accelerated to 8.00 m/s in 1.80 s. If the coefficient of friction is 0.220 how much power is required to accelerate the box?



$v = 8.00\,m/s$, $v_0 = 2.00\,m/s$, $a = ?$, $d = ?$, $t = 1.80\,s$

① $a = \frac{v - v_0}{t} = 3.333\,m/s^2$

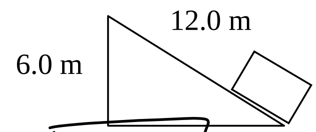
② $d = \frac{v^2 - v_0^2}{2a} = 9.00\,m$

③ $F_f = \mu F_N = \mu mg = 10.78\,N$

④ $F_{net} = F_{app} - F_f = ma \qquad F_{app} = ma + F_f = (5.0)(3.333) + 10.78 = 27.45\,N$

⑤ $P = \frac{W}{t} = \frac{F_{app}d}{t} = \frac{(27.45)(9.00)}{1.80} = \boxed{137\,W}$

5) A 7.0 kg box is pushed up the ramp shown in 3.25 s. If it requires a force of 40.0 N to push at a constant velocity, what is the efficiency of the ramp?



$W_{out} = mgh = (7.0)(9.80)(6.0)$
$= 411.6\ J$

$W_{in} = Fd = (40.0)(12.0) = 480\ J$

$Eff = \frac{W_{out}}{W_{in}} \times 100\%$
$= \frac{411.6\ J}{480\ J} \times 100\% = \boxed{86\%}$

6) A 1250 W electric motor is used to lift an 80.0 kg weight to a height of 4.0 m in 3.00 s. What is the efficiency of the motor?

1250 W → P_{in}

$P_{out} = \frac{W}{t} = \frac{\Delta E_p}{t} = \frac{mgh}{t}$
$= \frac{(80.0)(9.80)(4.0)}{3.00} = 1045\ W$

$Eff = \frac{P_{out}}{P_{in}} \times 100\%$
$= \frac{1045\ W}{1250\ W} \times 100\% = \boxed{84\%}$

7) A pulley has an efficiency of 85.0%. If 475 J are exerted to lift a 16.0 kg weight, how high is the weight lifted?

475 J → W_{in}

$Eff = \frac{W_{out}}{W_{in}} \times 100\%$

$W_{out} = \frac{Eff}{100\%} \times W_{in}$
$= \frac{85\%}{100\%} \times 475\ J$
$= 403.75\ J$

$W_{out} = \Delta E_p = mgh$

$h = \frac{W_{out}}{mg} = \frac{403.75\ J}{(16.0\ kg)(9.80\ m/s^2)}$
$= \boxed{2.57\ m}$