3.2.3 In Class or Homework Exercise

1. A 120 g tennis ball is travelling at 135 km/h. What is its kinetic energy?

$$m = 120g = 0.12kg \qquad E_k = \tfrac{1}{2}mv^2$$
$$v = 135km/h = 37.5m/s \qquad = \tfrac{1}{2}(0.12)(37.5)^2$$
$$E_k = ? \qquad = \boxed{84J}$$

2. How much work must be done to stop a 1200 *kg* car travelling at 110 *km/h*?

$$m = 1200kg$$
$$v_i = 110km/h = 30.6m/s$$
$$v_f = 0$$
$$W_{net} = ?$$

$$\begin{aligned} W_{net} &= \Delta E_k \\ &= E_{kf} - E_{ki} \\ &= 0 - \tfrac{1}{2}mv_i^2 \\ &= 0 - \tfrac{1}{2}(1200)(30.6)^2 \\ &= \boxed{-5.6\times10^5 J} \end{aligned}$$

3. A small cart with a mass of 250 g is accelerated from rest to a velocity of 2.0 m/s along a level track. Calculate the force that was exerted on the cart over a distance of 10.0 cm in order to cause this change in speed.

$$m = 250g = 0.25kg$$
$$v_i = 0$$
$$v_f = 2.0m/s$$
$$\Delta d = 10.0cm = 0.100m$$
$$F_p = ?$$

$$\begin{aligned} W_{net} &= \Delta E_k \\ &= E_{kf} - E_{ki} \\ &= \tfrac{1}{2}mv_f^2 - 0 \\ &= \tfrac{1}{2}(0.25)(2.0)^2 \\ &= 0.50J \end{aligned}$$

$$\begin{aligned} W_{net} &= F_{net}\Delta d \\ 0.50 &= F_{net}(0.100) \\ F_{net} &= \boxed{5.0N} \end{aligned}$$

The net force applied to the cart was 5.0 N; in the absence of any friction, this must be the force exerted on the cart.

4. If the speed of a car is tripled, by what factor will the minimum braking distance be increased, assuming all else is the same?

Since we know that $W_{net} = \Delta E_k$,

$$\begin{aligned} W_{net} &= \Delta E_k \\ F_{net}\Delta d &= 0 - \tfrac{1}{2}mv_i^2 \\ \Delta d &= -\frac{m}{2F_{net}}v_i^2 \end{aligned}$$

Since $\Delta d \propto v_i^2$, tripling the initial speed of the car will result in a stopping distance 9 times greater.

5. A 125 g arrow is fired from a bow whose string exerts an average force of 110 N on the arrow over a distance of 95 cm. What is the speed of the arrow as it leaves the bow?

$m = 125g = 0.125kg$

$F_{net} = 110N$

$\Delta d = 95cm = 0.95m$

$v_f = ?$

$$W_{net} = F_{net}\Delta d \cos\theta$$
$$= (110)(0.95)\cos 0°$$
$$= 104.5J$$

$$W_{net} = \Delta E_k$$
$$W_{net} = \tfrac{1}{2}mv_f^2 - 0$$
$$104.5 = \tfrac{1}{2}(0.125)v_f^2$$
$$v_f = \boxed{41m/s}$$

6. Peter does 225 *J* of work in pushing a 13.5 *kg* block along a horizontal surface from rest.

   a. If the surface is frictionless, what is the final speed of the block?

   $W_p = 225J$

   $m = 13.5kg$

   $v_i = 0$

   $v_f = ?$

   Since the surface is frictionless, the work done by Peter is also the net work.

   $$W_{net} = \Delta E_k$$
   $$225 = \tfrac{1}{2}mv_f^2 - 0$$
   $$225 = \tfrac{1}{2}(13.5)v_f^2$$
   $$v_f = \boxed{5.77m/s}$$

   b. If the block only reaches a speed of 4.0 *m*/*s*, how much work was done by friction?

   $W_p = 225J$

   $m = 13.5kg$

   $v_i = 0$

   $v_f = 4.0m/s$

   $W_f = ?$

   Since we know the initial and final speeds of the block, we can find the net work done on the block.

$$W_{net} = \Delta E_k$$
$$= \tfrac{1}{2} m v_f^2 - 0$$
$$= \tfrac{1}{2}(13.5)(4.0)^2$$
$$W_{net} = 108 J$$

Since Peter did 225 J of work, but only 108 J actually resulted in an increase in kinetic energy, 117 J of energy were lost to friction:

$$W_{net} = W_p + W_f$$
$$108 = 225 + W_f$$
$$W_f = \boxed{-117 J}$$

7. A person does work, W, on a ball when he pitches it. How much work would he have to do to pitch the ball three times as fast?
   Since $W = \Delta E_k$ and $v_i = 0$,
   $$W = \tfrac{1}{2} m v_f^2 - 0$$
   $$= \tfrac{1}{2} m v_f^2$$

   Since $W \propto v_f^2$, it would require 9 times as much work in order to pitch the ball 3 times as fast.