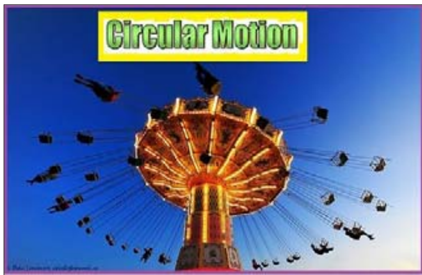


Unit 3: Circular Motion, Work and Energy

3.8 Mechanical Energy

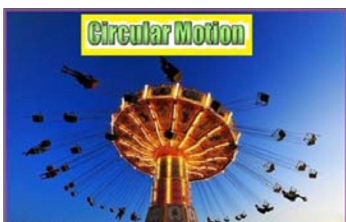
Mechanical Energy - the sum of all energies acting on a given system (ie. a skydiver has potential and kinetic energies at any given time in the air)

Since mechanical energy is the sum of all energies and work is the change in energy, we could say:

The Work-Energy Theorem

$$W = \Delta E_k + \Delta E_p$$

$E_{k_f} - E_{k_i}$



Ex.) A farmer is hauling feed and he lifts a 9.00 kg bucket up 5.00 m of rope. This takes a force of 150 N upwards.

a) What work does the farmer do on the feed? $W = Fd = (150)(5.00) = \boxed{750\,J}$

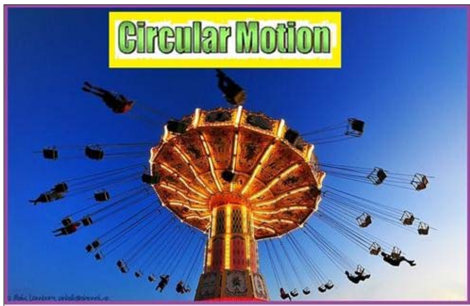
b) What is the change in PE of the feed?

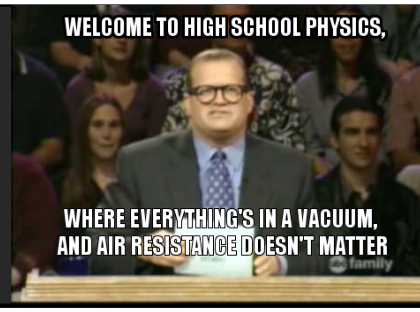
c) What is the change in KE of the feed?

b) $\Delta E_p = E_{p_f} - E_{p_i} = mgh_f - 0 = (9.00)(9.81)(5.00) - 0$
$= \boxed{441\,J}$

c) $W = \Delta E_k + \Delta E_p$
$750 = \Delta E_k + 441$

$\boxed{\Delta E_k = 309\,J}$





Ex.) A 150 kg sled and rider are pushed up a hill with a vertical height of 6.53 m. The initial velocity of the rider is 2.50 m/s and the final velocity of the rider is 5.80 m/s.What amount of work is needed to push the sled up the hill?

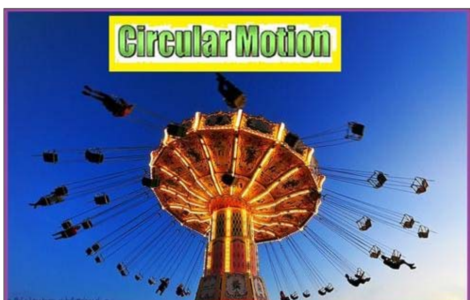
$$W = \Delta E_k + \Delta E_p$$

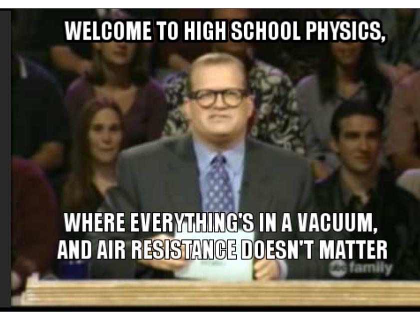
$$W = (E_{kf} - E_{ki}) + (E_{pf} - E_{pi})$$

$$= \left(\frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2\right) + (mgh_f - mgh_i)$$

$$= \left((1/2)(150)(5.8)^2 - (1/2)(150)(2.5)^2\right) + \left((150)(9.81)(6.53) - 0\right)$$

$$= \boxed{1.17 \times 10^4 \text{ J}}$$





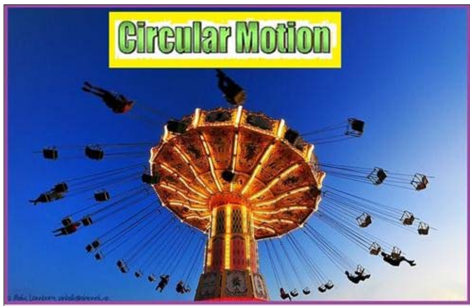
Ex.) A 450 kg care package for soldiers is dropped from an airplane and reaches a velocity of 35 m/s at 350 m. What is the $\underbrace{\text{mechanical energy}}_{\text{total energy.}}$ of the package? (Hint: pick appropriate units of energy)

$$E_m = E_k + E_p$$

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

$$= (1/2)(450)(35)^2 + (450)(9.81)(350)$$

$$= \boxed{1.8 \times 10^6 \text{ J}}$$

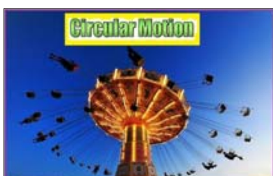


Why is mechanical energy important? Because of the big idea we have studied throughout this course...THE LAW OF CONSERVATION OF ENERGY!

In an isolated system, mechanical energy is conserved. Energy is not created or destroyed, only changed in form.

Isolated System - a system in which energy cannot enter or leave

Energy is Conserved - the total amount of energy is constant but may be in constant flux



Ex.) A frictionless roller coaster car has a mass of 200 kg and travels along a path as shown:

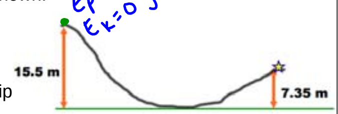
Calculate the :

a) PE at the first hill

b) KE and speed at the bottom of the dip

c) speed at the top of the second hill

$\left.\begin{matrix} E_p \text{ max} \\ E_k = 0 \end{matrix}\right\} E_m$



a) $E_p = mgh = 200 \cdot 9.81 \cdot 15.5 = \boxed{3.04 \times 10^4 \text{ J}}$

Mechanical Energy/ Total Energy to be conserved

b) $E_m = E_k + E_p$

$3.04 \times 10^4 = \frac{1}{2}mv^2 + 0$

$3.04 \times 10^4 = (\frac{1}{2})(200)v^2$

$\boxed{E_k = 3.04 \times 10^4 \text{ J}}$

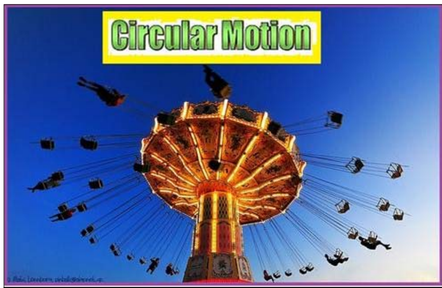
$\boxed{v = 17.4 \text{ m/s}}$

c) $E_m = E_k + E_p = \frac{1}{2}mv^2 + mgh$

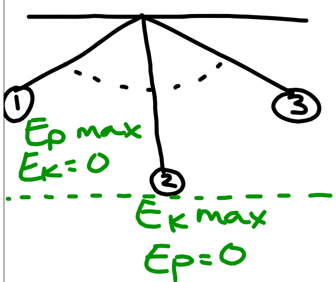
$3.04 \times 10^4 = (\frac{1}{2})(200)(v^2) + (200)(9.81)(7.35)$

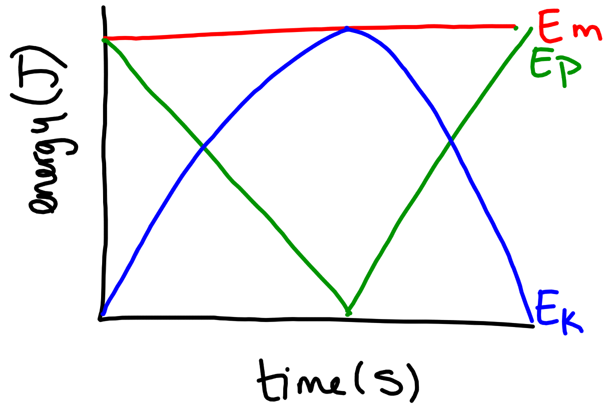
$\sqrt{\frac{15990.3}{100} = \frac{100v^2}{100}}$

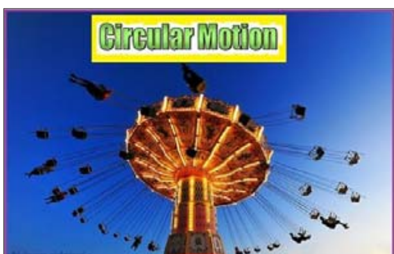
$\boxed{v = 12.6 \text{ m/s}}$



Ex.) Draw (on the same set of axes) an E_p vs. time graph and a E_k vs. time graph for an ideal pendulum swinging back and forth. Consider the starting point to be when the bob is pulled back to the side then released.







Ex.) Use two different methods to calculate the speed an object would hit the ground with if dropped from 12.0 m.

$V_i = 0$

$d = 12.0\,m$

$a = 9.81\,m/s^2$

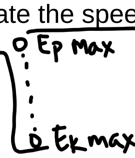
$V_f = ?$

$V_f^2 = V_i^2 + 2ad$

$V_f = \sqrt{V_i^2 + 2ad}$

$= \sqrt{0^2 + 2(9.81)(12)}$

$= \boxed{15.3\,m/s}$



$Ep_{top} = Ek_{bottom}$

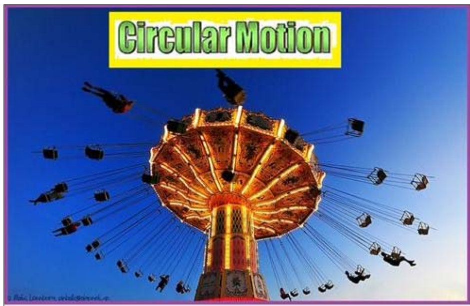
$mgh = \frac{1}{2}mv^2$

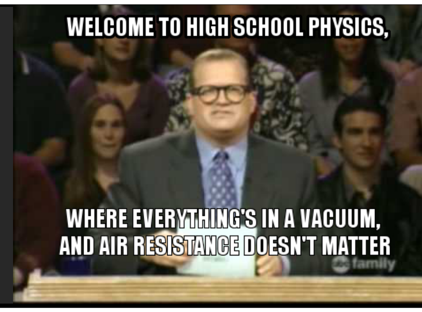
$2\cancel{m}gh = \cancel{m}v^2$

$V = \sqrt{2gh}$

$V = \sqrt{2(9.81)(12)}$

$\boxed{V = 15.3\,m/s}$





Ex.) A pendulum is dropped from the position shown 0.25 m above equilibrium. WHat is the speed of the bob as it passes through the equilibrium position?

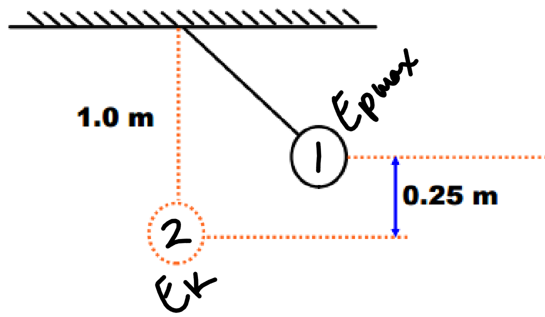
$$E_{p\,top} = E_{k\,bottom}$$

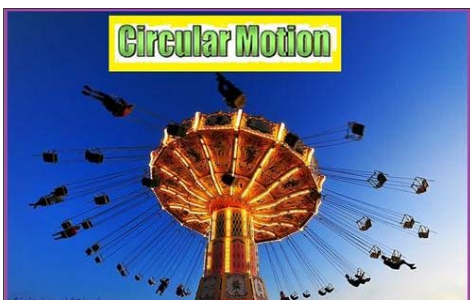
$$\cancel{m}gh = \tfrac{1}{2}\cancel{m}v^2$$

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

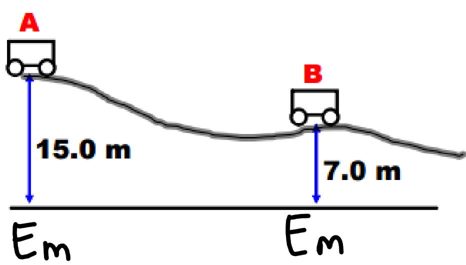
$$v = \sqrt{2(9.81)(0.25)}$$

$$\boxed{v = 2.2\ \text{m/s}}$$





Ex.) A roller coaster traveling on a frictionless track is shown. If the speed of the car at A is 3.0 m/s, what is the speed at B?



$$E_m = E_p + E_k = mgh_A + \tfrac{1}{2}mv_A^2$$

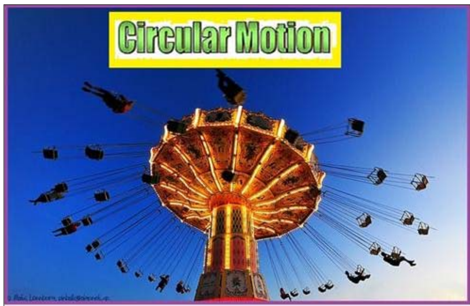
$$E_{mA} = E_{mB}$$

$$\cancel{m}gh_A + \tfrac{1}{2}\cancel{m}v_A^2 = \cancel{m}gh_B + \tfrac{1}{2}\cancel{m}v_B^2$$

$$(9.81)(15) + (\tfrac{1}{2})(3)^2 = (9.81)(7) + (\tfrac{1}{2})v_B^2$$

$$-68.67 \qquad -68.67$$

$$\boxed{v_B = 13\ \text{m/s}}$$



Questions: Pg. 310 # 6, 7, 8.

Pg. 315-316 # 1, 3, 4.

Read: Pg. 319-322.

- "Work" Booklet
- Textbook
- Handout