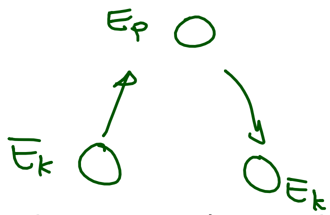
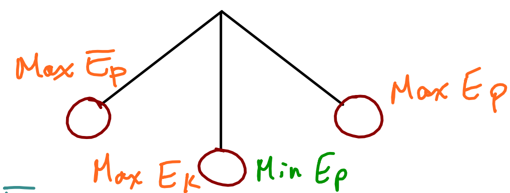
4.7 Conservation of Energy

Skate park simulation

Law of Conservation of Energy: Energy can neither be created nor destroyed, only changed from one form to another.

Imagine a ball being thrown up into the air... or a pendulum as it swings





As the mass travels upwards, E_k is converted into E_p. As the mass falls down, E_p is converted into E_k.

When only conservative forces work on an object, E_p converts entirely into E_k and vice versa. When forces like friction are at work then energy is not conserved and some energy is converted into other forms like heat, sound or light energy.

The Law of Conservation of Energy

$E_{initial} = E_{final}$

$E_{k_i} + E_{p_i} = E_{k_f} + E_{p_f} \rightarrow \boxed{\frac{1}{2}mv_i^2 + mgh_i = \frac{1}{2}mv_f^2 + mgh_f}$

ex. While jumping over the Great Wall of China, skateboarder Danny Way (82 kg), needs to leave the ramp travelling at 78 km/h $\div 3.6 = 21.\overline{6}$ m/s

a) How much potential energy does he need to start with?

$\cancel{E_{k_i}}^{0} + E_{p_i} = E_{k_f} + \cancel{E_{p_f}}^{0}$

$E_{p_i} = \frac{1}{2}mv_f^2$

$= \frac{1}{2}(82\text{ kg})(21.\overline{6}\text{ m/s})^2$

$= 19247\text{ J}$

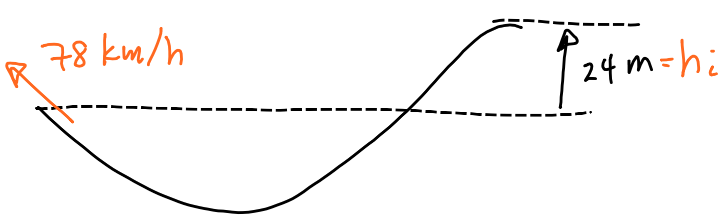
$\boxed{E_{p_i} = 19\,000\text{ J}}$

or 19 kJ

b)What minimum height of ramp should he use?

$\frac{E_{p_i}}{mg} = \frac{\cancel{mg}h_i}{\cancel{mg}} \Rightarrow h_i = \frac{19247\text{ J}}{(82\text{ kg})(9.8\text{ m/s}^2)}$

$\boxed{h_i = 24\text{ m}}$



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ex. In 2014, Renaud Lavillenie broke the 19-year old pole vault record by jumping 6.16 m high. What was his take-off velocity if his centre of mass was already 1.05 m above the ground when he took off and to clear the bar his centre of mass was raised to 6.16 m?

$$E_{p_i} + E_{k_i} = E_{p_f} + \cancel{E_{k_f}}^{\,0}$$

$$\frac{\cancel{m}gh_i}{\cancel{m}} + \frac{\frac{1}{2}\cancel{m}v_i^2}{\cancel{m}} = \frac{\cancel{m}gh_f}{\cancel{m}}$$

since mass is constant, divide it off

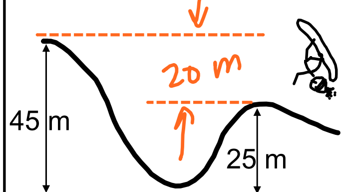
$$(2)\tfrac{1}{2}v_i^2 = (gh_f - gh_i)2$$

$$\sqrt{v_i^2} = \sqrt{2g(h_f - h_i)}$$

$$v_i = \sqrt{2(9.8)(6.16 - 1.05)}$$

$$v_i = 10.0 \text{ m/s}$$

ex. A 65 kg snowboarder starts at rest and travels down a gully and up the other side as shown. Find her speed at the top of the other side. → no friction



Since we are really only loosing 20 m of height..

$$E_{p_i} = E_{k_f}$$

$$\cancel{m}gh_i = \tfrac{1}{2}\cancel{m}v_f^2$$

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

$$v = \sqrt{2(9.8)(20\text{ m})}$$

$$v = 20.\text{ m/s}$$

$$v = 2.0 \times 10^1 \text{ m/s}$$

We can determine the coefficient of friction easily now using the conservation of energy.

ex. Mr. Grottoli's snowmobile travels at 6.2 m/s when he applies the brakes. He skids 24 m and comes to a stop. All of his kinetic energy is converted into work done on the snowmobile by friction.

$$E_k = E_{friction}$$ ← energy lost to friction

NB we are looking μ

$$\tfrac{1}{2}mv^2 = F_f\Delta d$$

$$\tfrac{1}{2}mv^2 = \mu F_n \Delta d \quad (F_n = F_g)$$

$$\frac{\frac{1}{2}\cancel{m}v^2}{g\Delta d} = \frac{\mu \cancel{m}\cancel{g}\cancel{\Delta d}}{\cancel{g\Delta d}} \Rightarrow \mu = \frac{\frac{1}{2}(6.2)^2}{(9.8)(24)}$$

$$= 0.082$$

practice: handout - Conservation of Energy #1-11