Calculating Energy

IB PHYSICS | ENERGY & MOMENTUM

Energy Calculations

Sub-topic 2.3 – Work, energy and power

$W = Fs\cos\theta$

$E_K = \frac{1}{2}mv^2$ **Kinetic Energy (KE)**

$E_P = \frac{1}{2}k\Delta x^2$

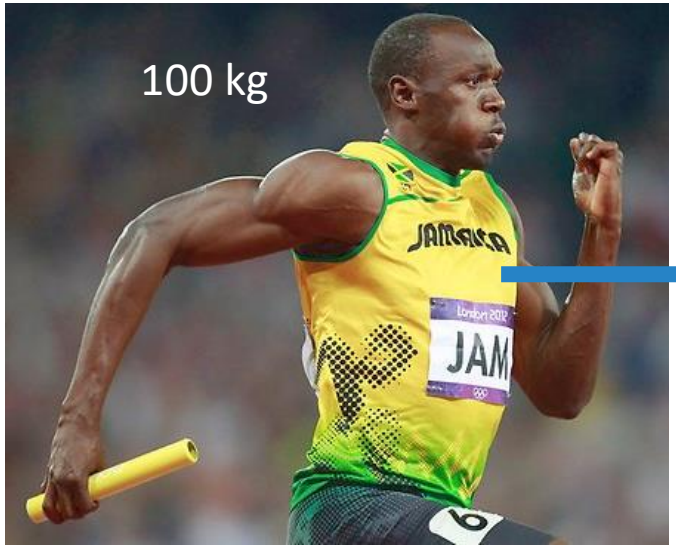
$\Delta E_P = mg\Delta h$ **Potential Energy (PE)**

$\text{power} = Fv$

$$\text{Efficiency} = \frac{\text{useful work out}}{\text{total work in}}$$

$$= \frac{\text{useful power out}}{\text{total power in}}$$

Who has more energy??

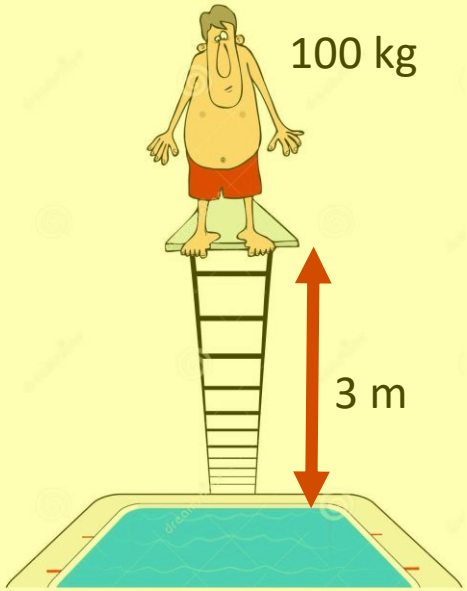


7.67 m/s

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

$$= \frac{1}{2}(100)(7.67)^2$$

$$= \mathbf{2941\ J}$$



$$PE = mgh$$

$$= (100)(9.81)(3)$$

$$= \mathbf{2943\ J}$$

Understanding Relationships

$E_K = \frac{1}{2}mv^2$ **Kinetic Energy (KE)**

$\Delta E_P = mg\Delta h$ **Potential Energy (PE)**

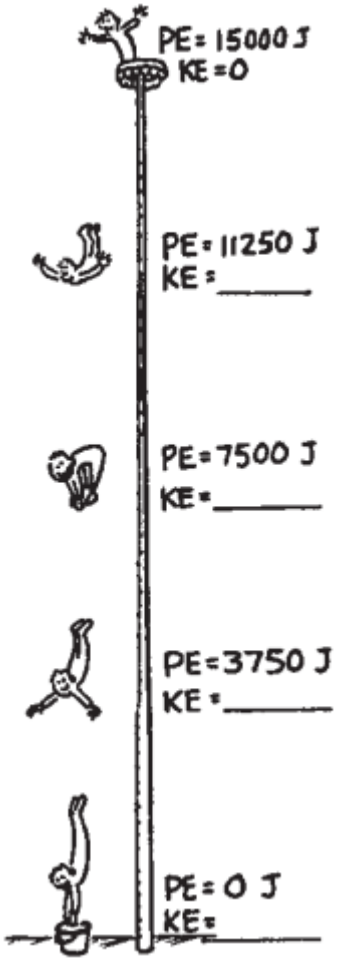
How does PE change when you triple the height?

3 times PE

How does KE change when you triple the velocity?

3^2 → 9 times KE

Conservation of Mechanical Energy



Total Energy Before = Total Energy After

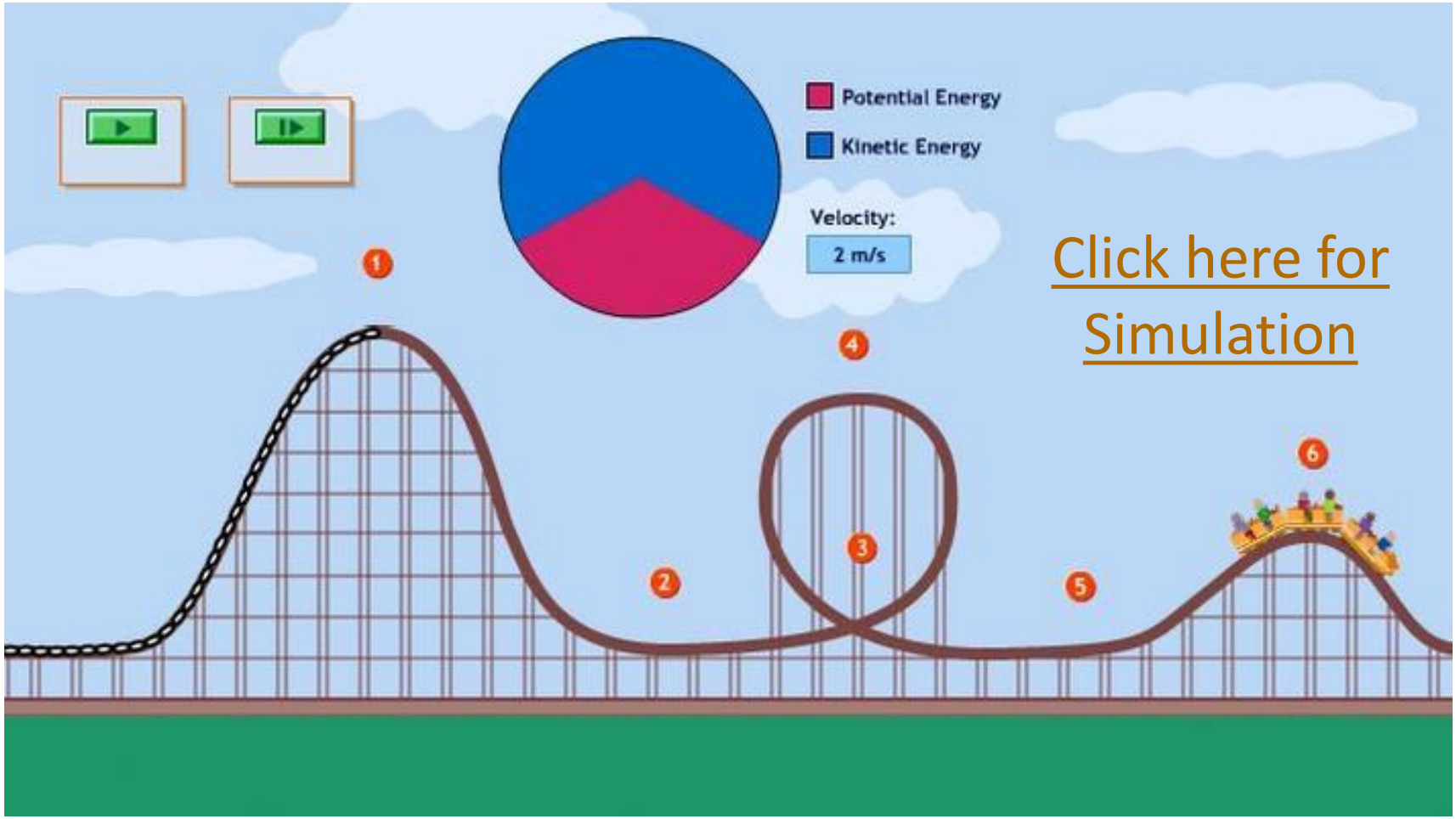
3750 J

7500 J

11250 J

15000 J

Conservation of Energy



Click here for Simulation

Conservation of Energy

A 2-kg ball is released from a height of 20 m. What is its velocity when its height has decreased to 5 m?

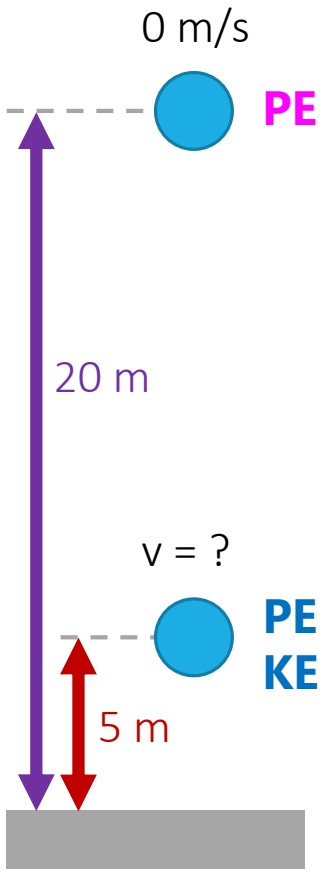
$$Initial\ Energy = Final\ Energy$$

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

$$(2)(9.81)(20) = (2)(9.81)(5) + \frac{1}{2}(2)v^2$$

$$392.4 = 98.1 + v^2$$

$$\boldsymbol{v = 17.2\ m/s}$$



Try this

The height of the building Spider-Man (a.k.a. Peter Parker, a.k.a. Tobey McGuire) starts off on is 6 stories, or 18 meters high. The height of the building he wants to swing to is 1 story, or 3 meters high. Tobey McGuire is has a mass of approximately 72 kg. Use conservation of energy to calculate his speed when his feet touch the roof of the second building

$$Initial\ Energy = Final\ Energy$$

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

$$(72)(9.81)(18) = (72)(9.81)(3) + \frac{1}{2}(72)v^2$$

$$12{,}714 = 2{,}119 + 36v^2$$

$$\boldsymbol{v = 17.2\ m/s}$$

Notice any similarities??

The final velocity is the same in each example. Same height change, mass doesn't matter!

Conservation of Energy

A 2-kg ball is released from a height of 20 m. What is its velocity when its height has decreased to 5 m?

$$PE + \cancel{KE} = PE + KE$$

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

$$(2)(9.81)(20) = (2)(9.81)(5) + \tfrac{1}{2}(2)v^2$$

$$392.4 = 98.1 + v^2$$

$$\boldsymbol{v = 17.2\ \mathrm{m/s}}$$

Try this

The height of the building Spider-Man (a.k.a. Peter Parker, a.k.a. Tobey McGuire) starts off on is 6 stories, or 18 meters high. The height of the building he wants to swing to is 1 story, or 3 meters high. Tobey McGuire is has a mass of approximately 72 kg. Use conservation of energy to calculate his speed when his feet touch the roof of the second building

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$$\boldsymbol{v = 17.2\ \mathrm{m/s}}$$

Try this

*if you aren't given the mass, you should write out the equation and the mass will cancel

What is the velocity of a marble at point A?

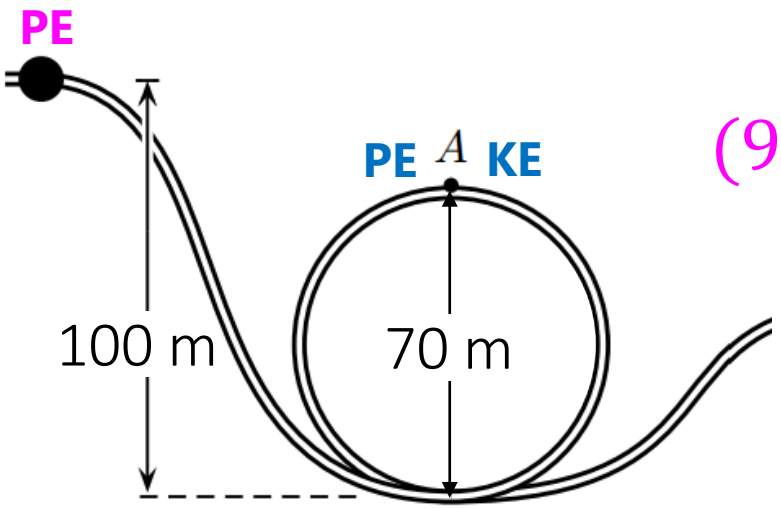
Initial Energy = Final Energy

$$PE + \cancel{KE} = PE + KE$$

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

$$(9.81)(100) = (9.81)(70) + \frac{1}{2}v^2$$

$$\boldsymbol{v = 24.3\ m/s}$$



No Mass? No Problem…

Water at the bottom of a waterfall has a velocity of 30 m/s after falling 16 meters. What is the water speed at the top?

PE
KE

$$PE + KE = \cancel{PE} + KE$$

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

$$\frac{1}{2}v^2 + (9.81)(16) = \frac{1}{2}(30)^2$$

$$\boldsymbol{v = 24.2\ \mathrm{m/s}}$$

Lesson Takeaways

- ❑ I can describe and calculate kinetic energy and gravitational potential energy
- ❑ I can explain the implications of the conservation of energy and show that the total energy in a closed system is always the same
- ❑ I can interpret a scenario and set up an equality based on the energies present at different locations
- ❑ I can use the conservation of energy to solve for an unknown energy or variable in a problem