Energy & Momentum IB Physics Content Guide

Big Ideas

- The total energy of a closed system must be constant
- Energy is neither created nor destroyed, it just changes form
- Work is done when a force is applied to an object and the object moves in the same direction as the applied force
- The total momentum of an isolated system is always constant
- The force on an object when speeding up or slowing down can be affected by changing the time for the force
- The impulse of a collision is equal to the change in momentum

Content Objectives

1 – Energy

I can use evidence (speed, stretch, height) to describe and calculate all types of energy present.			
I can describe and calculate kinetic energy			
I can describe and calculate gravitational potential energy			
I can explain the implications of the conservation of energy			
I can 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			

2 – Work and Power

I can define and calculate the property of work			
I can identify situations where there is motion but no work being done			
I can calculate work when the force is at an angle to the direction of the motion			
I can equate work done on a system to the change in energy of an open system.			
I can use the work-energy theorem to solve for an unknown			
I can calculate power from work or velocity			

3 – Elastic Potential

I can derive a 'Joule' and 'Watt' from the fundamental units kg, m, and s.			
I can use Hooke's Law to calculate the elastic force at a given displacement			
I can use area under the curve to calculate the work of a variable force			
I can describe and calculate elastic potential energy			

4 – Conservation of Momentum

I can define and calculate momentum			
I can calculate "before" and "after" momentums for multiple objects			
I can use the conservation of momentum to solve for missing variables in linear collisions			
I can describe the process required for explosion, hit and bounce, and hit and stick scenarios			
I can describe the difference between elastic and non-elastic collisions			
I can describe how energy is not always conserved within a system			
I can calculate the amount of energy retained in a non-elastic collision			

5 – Momentum and Impulse

I can describe the meaning of impulse and how it is related to momentum change			
I can use impulse and momentum to solve for an unknown in a collision problem			
I can conceptually describe how to decrease the force experienced in a collision			
I can determine the impulse of a collision from a force vs time graph			

Energy & Momentum Shelving Guide

	Variable Symbol	Unit
Work	W	Joules [J]
Power	P	Watts [W]
Kinetic Energy	E_k	J
Elastic Potential Energy	E_p	J
Gravitational Potential Energy	ΔE_p	J
Spring Constant	k	N m^{-1}
Spring Stretch	Δx	m

Data Booklet Equations:

$$W = Fs\cos\theta$$

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

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

$$\Delta E_p = mg\Delta h$$

$$\text{power} = Fv$$

Types of Energy

Kinetic Energy	Elastic Potential Energy	Gravitational Potential Energy
$\frac{1}{2}mv^2$	$\frac{1}{2}k\Delta x^2$	$mg\Delta h$

Conservation of Energy

Total Energy Before = Total Energy After

Work-Energy Theorem

Work → Energy

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

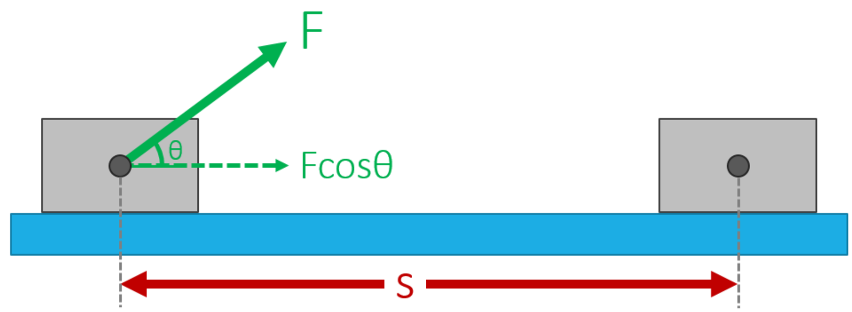
Energy → Work

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

Calculating Work

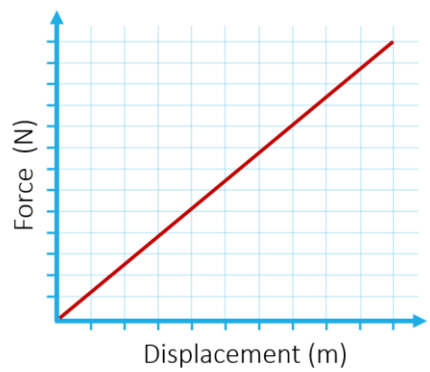
Constant force at an angle:

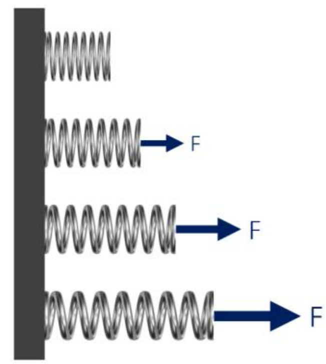
$$W = Fs\cos\theta$$



Varying Force:

Area under the curve





Examples of no work being done for an object in motion:

- Pushing something that doesn't move (no displacement, no work)
- Waiter carrying a tray horizontally (force is vertical, motion is horizontal)
- Orbiting object (velocity is tangent to path, force is toward the center)

Calculating Power

In terms of work and time:

$$Power = \frac{Work}{Time}$$

In terms of force and velocity:

$$Power = Force \times Velocity = Fv$$

Units

	Standard Unit	From Equation	Fundamental SI Units
Work	J	N m	kg m^2 s^{-2}
Power	W	J s^{-1}	kg m^2 s^{-3}

Momentum

	Variable Symbol	Unit
Momentum	p	kg m s^{-1}
Mass	m	kg
Velocity	v	m s^{-1}
Time	t	s
Kinetic Energy	E_K	J
Impulse	Impulse	N s or kg m s^{-1}

Data Booklet Equations:

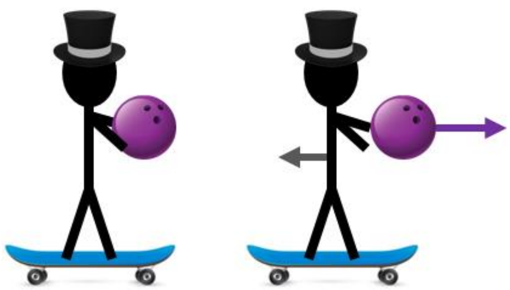
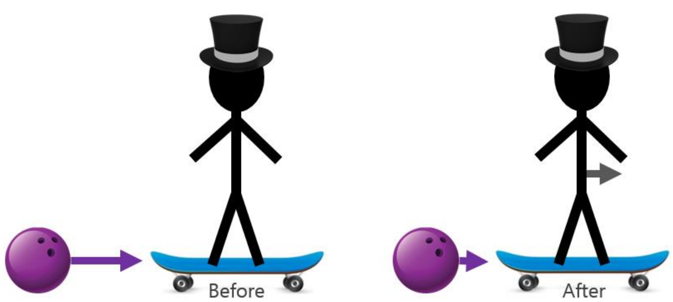
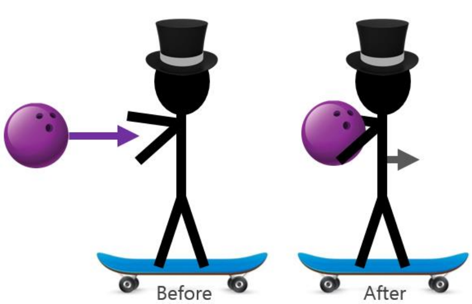
$$p = mv$$

$$F = \frac{\Delta p}{\Delta t}$$

$$E_K = \frac{p^2}{2m}$$

$$\text{Impulse} = F\Delta t = \Delta p$$

Conservation of Energy Problems

	"Explosion" $p_{AB} = p_A + p_B$
	"Hit and Bounce" $p_A + p_B = p_A + p_B$
	"Hit and Stick" $p_A + p_B = p_{AB}$

Types of Collisions

Elastic	Kinetic Energy is conserved (perfect hit and bounce) *Typically just found in particle collisions	
Inelastic	Kinetic Energy is not conserved	

Calculating Impulse

<table>
<tr><td>Constant force:

Force × Time
$F\Delta t$</td><td>
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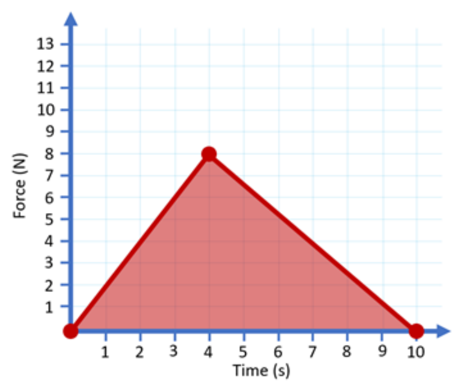
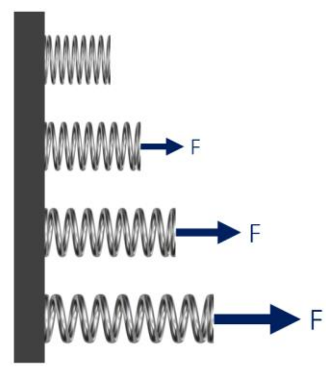
<tr><td>Varying Force:

Area under a Force vs Time Graph</td><td>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Impulse-Momentum Equation

$$F\Delta t = \Delta p = m\Delta v = mv - mu$$

Collision Safety

Explain (using impulse, force, and time) how to decrease the force acting on an object undergoing a collision:

Impulse is the same overall regardless of the impact style because the object has a set mass and impact velocity. The force can be decreased by increasing the time of the impact.

Impulse = $\mathbf{F}\Delta t$ or Impulse = $F\mathbf{\Delta t}$