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| **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

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| 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 | |  |  |  |

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| 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 | |  |  |  |

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| 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 | |  |  |  |

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| 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 | |  |  |  |

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| 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 | |  |  |  |

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| **Energy & Momentum** | Shelving Guide |

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|  | Variable Symbol | Unit |  | *Data Booklet Equations:* |
| Work | W | Joules [J] |  |  |
| Power | P | Watts [W] |  |  |
| Kinetic Energy | Ek | J |  |  |
| Elastic Potential Energy | Ep | J |  |  |
| Gravitational Potential Energy | ΔEp | J |  |  |
| Spring Constant | k | N m-1 |  |  |
| Spring Stretch | Δx | m |  |  |

## Types of Energy

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| --- | --- | --- |
| Kinetic Energy | Elastic Potential Energy | Gravitational Potential Energy |
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## Conservation of Energy

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| Total Energy Before = Total Energy After |

## Work-Energy Theorem

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| Work 🡪 Energy Energy 🡪 Work |

## Calculating Work

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| Constant force at an angle: |  | |
| 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

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| In terms of work and time: | In terms of force and velocity: |

## Units

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|  | Standard Unit | From Equation | Fundamental SI Units |
| Work | J | N m | kg m2 s-2 |
| Power | W | J s-1 | kg m2 s-3 |

# Momentum

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| --- | --- | --- | --- | --- |
|  | Variable Symbol | Unit |  | *Data Booklet Equations:* |
| Momentum | p | kg m s-1 |  |  |
| Mass | m | kg |  |  |
| Velocity | v | m s-1 |  |
| Time | t | s |  |  |
| Kinetic Energy | EK | J |  |
| Impulse | Impulse | N s or kg m s-1 |  |  |

## Conservation of Energy Problems

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|  | “Explosion”  pAB = pA + pB |  |
|  | “Hit and Bounce”  pA +pB = pA + pB |  |
|  | “Hit and Stick”  pA + pB = pAB |  |

## Types of Collisions

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

## Calculating Impulse

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| Constant force: Force × Time  FΔt |  | |
| Varying Force: Area under a  Force vs Time Graph |  |  |

## Impulse-Momentum Equation

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## Collision Safety

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| 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 = FΔt or Impulse = FΔt |