|  |  |
| --- | --- |
| **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 |  | *Data Booklet Equations:* |
| Work | W | Joules [J] |  | $$W=Fs cosθ$$ |
| Power | P | Watts [W] |  | $$E\_{k}=\frac{1}{2}mv^{2}$$ |
| Kinetic Energy | Ek | J |  | $$E\_{p}=\frac{1}{2}k∆x^{2}$$ |
| Elastic Potential Energy | Ep | J |  | $$∆E\_{p}=mg∆h$$ |
| Gravitational Potential Energy | ΔEp | J |  | $$power=Fv$$ |
| Spring Constant | k | N m-1 |  |  |
| Spring Stretch | Δx | m |  |  |

## Types of Energy

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

## Conservation of Energy

|  |
| --- |
| Total Energy Before = Total Energy After |

## Work-Energy Theorem

|  |
| --- |
| Work 🡪 Energy Energy 🡪 Work$Fs=\frac{1}{2}mv^{2}$ $\frac{1}{2}mv^{2}=Fs$ |

## Calculating Work

|  |  |
| --- | --- |
| Constant force at an angle:$$W=Fs\cos(θ)$$ |  |
| 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:$$Power= Force × Velocity=Fv$$ |

## Units

|  |  |  |  |
| --- | --- | --- | --- |
|  | 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

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Variable Symbol | Unit |  | *Data Booklet Equations:* |
| Momentum | p | kg m s-1 |  | $$p=mv$$ |
| Mass | m | kg |  | $$F=\frac{∆p}{∆t}$$ |
| Velocity | v | m s-1 |  |
| Time | t | s |  | $$E\_{K}=\frac{p^{2}}{2m}$$ |
| Kinetic Energy | EK | J |  |
| Impulse | Impulse | N s or kg m s-1 |  | $$Impulse=F∆t=∆p$$ |

## Conservation of Energy Problems

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

## 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

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

## Impulse-Momentum Equation

|  |
| --- |
| $$F∆t=∆p=m∆v=mv-mu$$ |

## 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 = FΔt or Impulse = FΔt |