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| **Forces** | IB Physics Content Guide |

# Big Ideas

* Many forces acting on an object can be simplified down into one net force
* Acceleration is zero when net force is zero (could mean stopped or constant velocity)
* If you have the acceleration of an object, you can find the net force causing that acceleration and vice versa
* Force of friction is related to the normal reaction force
* For objects on a sloped surface, the weight must be broken down into its perpendicular and parallel component

# Content Objectives

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| 1 – Newton’s First Law and Free Body Diagrams |  |
| I can define a force (with proper units) in terms of the interaction between two objects |  |  |  |
| I can describe Newton’s first law |  |  |  |
| I can calculate the net force on an object |  |  |  |
| I can calculate an unknown force for an object in equilibrium |  |  |  |

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| 2 – Newton’s Second Law |  |
| I can describe Newton’s second law in terms of momentum |  |  |  |
| I can calculate force given mass and acceleration and calculate acceleration given force and mass |  |  |  |
| I can combine Newton’s second law with the kinematic equations to solve force/motion problems |  |  |  |
| I can explain the connection between constant velocity and balanced forces |  |  |  |

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| 3 – Weight, Normal Reaction, and Tension |  |
| I can calculate the weight of an object |  |  |  |
| I can describe the difference between mass and weight |  |  |  |
| I can use a diagram to identify the direction of tension and normal reaction forces |  |  |  |
| I can draw a free body diagram with weight, normal reaction force, friction, and any other forces |  |  |  |

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| 4 – Calculating Friction |  |
| I can calculate the force of friction when given the reaction force and coefficient of friction |  |  |  |
| I can quantitatively compare surfaces based on their coefficients of friction |  |  |  |
| I can calculate the acceleration of an object with friction based on the external force and mass |  |  |  |

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| 5 – Air Resistance |  |
| I can describe the factors that affect air resistance and how the resistance changes with velocity |  |  |  |
| I can define Terminal Velocity in terms of net force |  |  |  |
| I can graph the change in position and velocity for an object falling with air resistance  |  |  |  |

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| 6 – Forces on a Ramp |  |
| I can calculate parallel and perpendicular components of the force due to gravity on a ramp |  |  |  |
| I can calculate the force of friction required to keep an object in equilibrium |  |  |  |
| I can calculate the acceleration of an object with known mass on a ramp of known angle and friction |  |  |  |
| I can calculate parallel and perpendicular components of the force due to gravity on a ramp |  |  |  |

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| **Forces** | Shelving Guide |

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| Name of Force | Variable | Description/Important Properties | Equation |
| Weight | Fg | Force of gravity on an object with mass | Fg = mg |
| Tension | FT | Always pulls in the same direction as the rope or chain providing the tension |  |
| Normal Reaction | R | Always perpendicular to a surface |  |
| Friction | Ff | Always opposes the motion of an object | Ff = μR |
| Air Resistance | Fair | Increases with surface area and velocity |  |

If an object has a net force of zero its motion is either:

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| Not moving (velocity = 0 m s-1) | or | Moving at a constant velocity |

## Newton’s Laws

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| Newton’sFirst Law | An object at rest remains at rest and an object in motion remains in motion until and unless an external force acts upon it (Unbalanced force). |
| Newton’sSecond Law | The rate of change of momentum of an object is proportional to the resultant force acting on the body and is in the same direction. (F = ma) |
| Newton’sThird Law | All forces occur in pairs. Every action has an equal and opposite reaction |
| **Data Booklet** **Equations:** |  | Variable Symbol | Unit |
| Force | F | N |
| $$F=ma$$ | Mass | m | kg |
| $$F\_{f}\leq μ\_{s}R$$ | Acceleration | a | m s-1 |
| $$F\_{f}=μ\_{d}R$$ | Normal Reaction Force | R | N |
|  | Coefficient of Kinetic Friction | μd | -- |
|  | Coefficient of Static Friction | μs | -- |

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| Terminal Velocity | The maximum velocity a falling body can achieve. This occurs when the force of air resistance is equal and opposite to the weight and Fnet = 0 N. |
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| Sliding to a Stop | Constant Velocity |
| Icon  Description automatically generated | A picture containing text, clock  Description automatically generated |
| Fnet = Ff | Fnet = 0 N | Fpull = Ff |

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|  | Forces on a Ramp |
|  | Equilibrium |  | Accelerating |
| R | F⊥ | R | F⊥ |
| Ff | F∥ | Ff | μR |
| F⊥ | Fg cosθ | Fnet | 0 N | Fnet | F∥ - Ff |
| F∥ | Fg sinθ | a | 0 m s-1 | a | Fnet / m |