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| **Motion** | IB Physics Content Guide |

# Big Ideas

* Motion is described relative to a chosen coordinate system.
* Displacement-time, velocity-time, and accel-time graphs are connected in the representation of physical motion.
* When an object is at constant velocity, displacement-time is linear.
* When an object is at constant acceleration, displacement-time is quadratic (curved), and velocity-time is linear.
* Kinematic equations can take three of the *suvat* variables to solve for the remaining two
* Vector quantities can be combined to find resultant vectors or divided into their component parts
* X and Y motion are independent of each other for a two-dimensional projectile

# Content Objectives

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| 1 – Units |  |
| I can describe the difference between quantitative and qualitative observations |  |  |  |
| I can identify the 7 Fundamental SI units |  |  |  |
| I can define and give an example of a derived unit |  |  |  |
| I can represent fractional units with negative exponents |  |  |  |
| I can convert metric units between prefixes |  |  |  |
| I can convert fraction units and exponential units using Dimensional Analysis |  |  |  |
| I can use dimensional analysis to verify a formula |  |  |  |
| I can use dimensional analysis to determine the units for a solution |  |  |  |
| I can represent large and small numbers using scientific notation |  |  |  |
| I can compare quantities by orders of magnitude |  |  |  |

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| 2 – Displacement Graphs |  |
| I can describe the difference between distance and displacement |  |  |  |
| I can calculate distance and displacement for 1D motion |  |  |  |
| I can plot constant velocity on a displacement vs time graph |  |  |  |
| I can plot changing velocity on a displacement vs time graph |  |  |  |
| I can use a d vs t graph to identify if an object is moving in the positive/negative/speeding/slowing  |  |  |  |

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| 3 – Velocity Graphs |  |
| I can describe the difference between speed and velocity |  |  |  |
| I can compare the difference between a vector and scalar quantity |  |  |  |
| I can plot constant velocity on a velocity vs time graph |  |  |  |
| I can plot changing velocity on a velocity vs time graph |  |  |  |
| I can use a v vs t graph to identify if an object is moving in the positive/negative/speeding/slowing  |  |  |  |
| I can define acceleration in terms of velocity |  |  |  |

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| 4 – Calculating from Graphs |  |
| I can use an equation to calculate average speed/velocity |  |  |  |
| I can calculate instantaneous velocity using the slope of a displacement vs time graph |  |  |  |
| I can calculate instantaneous acceleration using the slope of a displacement vs time graph |  |  |  |
| I can calculate overall displacement using the area of a velocity vs time graph |  |  |  |

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| 5 – The Kinematic Equations |  |
| I can identify the 5 primary variables of accelerating motion (suvat) |  |  |  |
| I can identify the proper kinematic equation to use for a problem that is presented |  |  |  |
| I can rearrange to solve for the unknown variable |  |  |  |
| I can calculate for an unknown using the kinematic equations |  |  |  |

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| 6 – Free Fall |  |
| I can identify the constant acceleration due to gravity neglecting air resistance |  |  |  |
| I can interpret a free fall problem to identify hidden values and understand  |  |  |  |
| I can use the kinematic equations to solve free fall problems |  |  |  |
| I can experimentally determine the acceleration due to gravity |  |  |  |

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| 7 – Horizontal Projectiles |
| I can add and subtract vectors to find a resultant |  |  |  |
| I can calculate an angle from two components of a right triangle |  |  |  |
| I can calculate the x and y components of a vector given the magnitude and angle |  |  |  |
| I can identify hidden values for a horizontal projectile problem |  |  |  |
| I can use information about a horizontal projectile’s motion to calculate the initial velocity |  |  |  |
| I can use the x and y velocity components to calculate a projectile’s impact velocity and angle |  |  |  |

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| 8 – Projectile Motion |  |
| I can identify hidden values for a projectile launched at an angle |  |  |  |
| I can calculate the x and y components for an initial velocity at an angle |  |  |  |
| I can calculate max height for a projectile launched at angle |  |  |  |
| I can calculate distance traveled for a projectile launched at angle |  |  |  |
| I can calculate total air time for a projectile launched at angle |  |  |  |

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| **Motion** | Shelving Guide |

List the seven fundamental base units and their abbreviations:

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|  | Unit | Abbreviation |
| Length | Meter | m |
| Mass | Kilogram | kg |
| Time | Second | s |
| Electric Current | Ampere | A |
| Temperature | Kelvin | K |
| Amount of Substance | Mole | mol |
| Luminous Intensity | Candela | cd |

Metric Prefixes – List the unit prefixes in their appropriate decimal position



### Dimensional Analysis

Convert the following:

20 mi hr-1 🡪 m s-1

$$\frac{20 mi}{1 hr}×\frac{1609 m}{1 mi}×\frac{1 hr}{60 min}×\frac{1 min}{60 s}=8.9\frac{m}{s}=8.9 m s^{-1}$$

0.0007 km2 🡪 m2

$0.0007 km^{2}×\frac{1000 m}{1 km}×\frac{1000 m}{1 km}=700 m^{2}$ or $0.0007 km^{2}×\left(\frac{1000 m}{1 km}\right)^{2}=700 m^{2}$

Determine the units for Q:

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| --- | --- | --- |
| Q = mc ΔT$$Q=\left(kg\right)\left(J kg^{-1} K^{-1}\right)\left(K\right)=\frac{\left(kg\right)\left(J\right)\left(K\right)}{kg K}=J$$ | m (mass) | kg |
| c (specific heat) | J kg-1 K-1 |
| ΔT (change in temp) | K |
|  | Scalar | Vector |
| How far (m) | Distance | Displacement |
| How fast (m s-1) | Speed | Velocity |

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|  | **Displacement vs Time** | **Velocity vs Time** | **Acceleration vs Time** |
| Meaning of the Graph | Slope:Velocity | Slope:AccelerationArea under the Curve:Displacement | Area under the Curve:Velocity |
| **Constant Displacement** |  |  |  |
| **Constant Positive Velocity** |  |  |  |
| **Constant Negative Velocity** |  |  |  |
| **Constant Positive Acceleration**(speeding up) |  |  |  |
| **Constant Negative Acceleration**(slowing down) |  |  |  |

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|  | Variable Symbol | Unit |  | Kinematic Equations | s | u | v | a | t |
| Displacement | s | m |  | $$v=u+at$$ |  | **✔️** | **✔️** | **✔️** | **✔️** |
| Initial Velocity | u | m s-1 |  | $$s=ut+\frac{1}{2}at^{2}$$ | **✔️** | **✔️** |  | **✔️** | **✔️** |
| Final Velocity | v | m s-1 |  | $$v^{2}=u^{2}+2as$$ | **✔️** | **✔️** | **✔️** | **✔️** |  |
| Acceleration | a | m s-2 |  | $$s=\frac{\left(v+u\right)t}{2}$$ | **✔️** | **✔️** | **✔️** |  | **✔️** |
| Time | t | s |  |  |  |  |  |  |  |

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| Horizontal Component | $$A\_{H}=A\cos(θ)$$ |  |
| Vertical Component | $$A\_{V}=A\sin(θ)$$ |

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|  | Vertical |  |
| s |  |
| u | 0 m s-1 |
| v |  |
| a | -9.81 m s-2 |
| t |  |

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| --- | --- | --- |
|  | Vertical |  |
| s |  |
| u | u sinθ |
| v | 0 m s-1 |
| a | -9.81 m s-2 |
| t |  |