**Displacement and velocity**

The *second* is the unit of time.

The *metre* is the unit of distance.

***Speed* is the rate of change of distance with respect to time.**

The unit of speed is the metre per second (m s-1 or m/s)

***Displacement* is distance in a given direction**

***Velocity* is the rate of change of *displacement* with respect to time**

The unit of velocity is the metre per second (ms-1, or m/s).

**Distance–Time Graphs (for an object travelling at constant velocity)**

If you plot a graph of *Distance* (on the y-axis) against *Time* (on the x-axis), the slope of the graph will be the speed of the object.

**Acceleration**

**Acceleration is the rate of change of velocity with respect to time\*.**

The unit of acceleration is the metre per second squared (m s-2, or m/s2 ).

**Equations of Motion**

**v = u + at**

**s = ut + ½ at2**

**v2 = u2 + 2as**

*v* = final velocity

*u* = initial velocity

*a* = acceleration

*s*= displacement (not distance)

*t* = time

**Velocity – Time graphs** (for an object travelling with constant acceleration)

If a graph is drawn of Velocity (y-axis) against Time (x-axis), the slope of the graph is the acceleration of the object.

**Note that the area under the graph corresponds to the distance travelled.**

**Derivation of the Three Equations of Motion**

***To Derive v = u + at***

**** ⇒ *v* = *u* + *at*

***To Derive s = ut + ½ at2***

Vaverage =  But v = u + at ⇒ Vaverage = 

Vaverage = **** ⇒ s = Vaverage(t) ⇒ s = **** (t)

⇒ s = ut + ½ at2

***To Derive v2 = u2 + 2as***

v = u + at ⇒ v2 = u2 + 2uat + (at)2 {multiply out both sides}

We can rewrite this as *v2 = u2 + 2a(ut + ½ at2)* {because *2a(ut + ½ at2)* = 2uat + (at)2}

Now sub in *s = ut + ½ at2* ⇒ *v2 = u2 + 2as*

**Vectors and Scalars**

**A Scalar Quantity is one which has *magnitude* only.** Examples: length, area, energy, time.

**A Vector Quantity is one which has both *magnitude* and direction.** Examples: displacement, acceleration, force.

Vectors can be represented on a diagram by an arrow, where the vector is in the same direction as the quantity it is representing.

**Resolving a vector into two perpendicular Components**

You have just seen that two perpendicular vectors can be added together to form a resultant.

Well let’s say we started off with the resultant. Would we be able to get back the two original vectors?

First we need to remember that for a right-angled triangle:

Sin θ = Opposite/Hypothenuse, therefore Opposite = Hypothenuse x Sin θ {Opp = H Sin θ}

Cos θ = Adjacent/Hypothenuse, therefore Adjacent = Hypothenuse x Cos θ {Adj = H Cos θ}

**Example**

Consider a velocity vector representing a velocity of 50 ms-1, travelling at an angle of 600 to the horizontal:

The Opposite is equal to H Sin θ, which in this case = 50 Cos 600 = 43 ms-1.

The Adjacent is equal to H Cos θ, which in this case = 50 Sin 600 = 25 ms-1.

**Experiment: To find the Resultant of Two Forces**



1. Attach three Newton Balances to a knot in a piece of thread.
2. Adjust the size and direction of the three forces until the knot in the thread remains at rest.
3. Read the forces and note the angles.
4. The resultant of any two of the forces can now be shown to be equal to the magnitude and direction of the third force.

**Force**

**A Force is anything which can cause an object to accelerate.**

The unit of force is the *Newton* (N).

**A force of 1 N gives a mass of 1 kg an acceleration of 1 m s-2.**

**What is mass?**

**The Mass of an object is a measure of its *Inertia****.*

(The inertia of an object in turn is a measure of how difficult it is to accelerate it.)

The unit of mass is the ***kilogram* (kg).**

**Relationship between Force, Mass and Acceleration**

**F = ma**

**Force = mass** × **acceleration**

**Friction**

**Friction** is a force which opposes the relative motion between two objects.

**Examples of Friction:** Brakes, Walking, Air Resistance

**Momentum**

**Momentum = Mass × Velocity**

**ρ = mv**

The unit of Momentum is the *kilogram metre per second* (kg m s-1)

**The Principle of Conservation of Momentum**

states that in any collision between two objects, the total momentum before impact equals total momentum after impact, *provided no external forces act on the system*.

(If you forget the bit in italics you lose half marks!)

**m1u1 + m2u2 = m1v1 + m2v2**

In symbols

Note that if the two objects stick together after collision,

**m1 u1 + m2 u2 = (m1 + m2)v3**

there is only one final velocity, and the above equation becomes

**Areas where the principle of conservation of momentum applies**

Collisions (ball games), acceleration of aircraft, jet aircraft

**Newton’s Laws of Motion**

1. **Newton’s First Law of Motion** states that every object will remain in a state of rest or travelling with a constant velocity unless an external force acts on it.
2. **Newton’s Second Law of Motion** states that the rate of change of an object’s momentum is directly proportional to the force which caused it, and takes place in the direction of the force.
3. **Newton’s Third Law of Motion\*** states that when body A exerts a force on body B, B exerts a force equal in magnitude but opposite in direction on A.

**Applications of Newton’s laws of motion**: Seat belts / Rocket travel / Ball games

**Work and Energy**

**Work is defined as the product of Force × Displacement.**

**W = F × s**

Work = Force displacement

**The unit of work is the Joule (J).**

**Energy is the ability to do work.**

Because work is a form of energy it follows that **the unit of energy is also the Joule.**

**The change in the energy of an object is equal to the work done on the object**

**Different Forms of Energy**

**Kinetic Energy** is energy an object has due to its motion.

**EK = ½ mv2**

Formula for Kinetic Energy:

**Potential Energy i**s the energy an object has due to its position in a force field.

 **EP = mgh**

The formula for Potential Energy:

**Any time work is done energy is transferred**

**The Principle of Conservation of Energy**

states that energy cannot be created or destroyed but can only be converted from one form to another.

Loss in Potential Energy = Gain in Kinetic Energy for a freely falling object.

Power

**Power** is the rate at which work is done.