How Fast Can Things Go?

Reference: Heinemann Physics 12 4th Edition Chapters 5 – 7 Pages 147 – 269

M.1 VECTORS AND SCALARS

M.1.1 Scalars

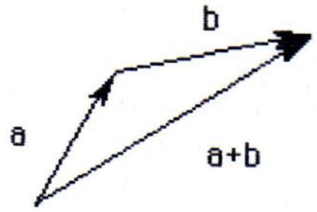
A scalar is a quantity which has only a size. e.g. temperature, time, mass

M.1.2 Vectors

A vector is a quantity which has both a size and a direction.
e.g. displacement, velocity, acceleration, force
34 m north, 3 ms^{-1} west, 6ms^{-2} south, 12 N north 10° west
To distinguish the scalar F from the vector F we write vectors in one of two ways. **F** and $\vec{F}$ are the vector F.
We represent a vector by an arrow, as such 
where the size or magnitude of the vector is represented by the length of the arrow and the direction is the direction in which the arrow points.

M.1.2.1 Addition of Vectors

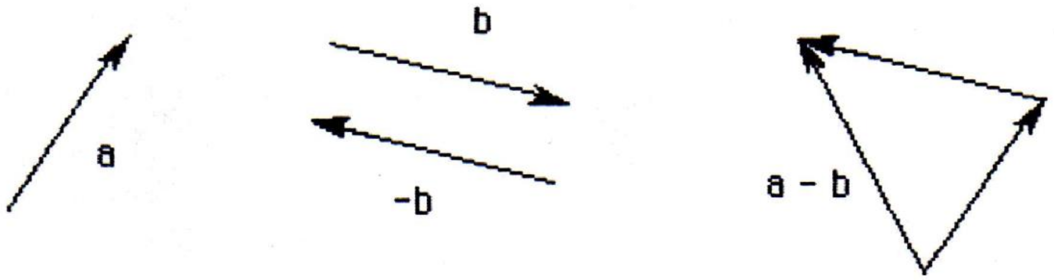
If we have two vectors a and b, to add them we put the vectors head to tail and the result of the addition is the vector drawn from the starting point to the finishing point.



M.1.2.2 Subtraction of Vectors

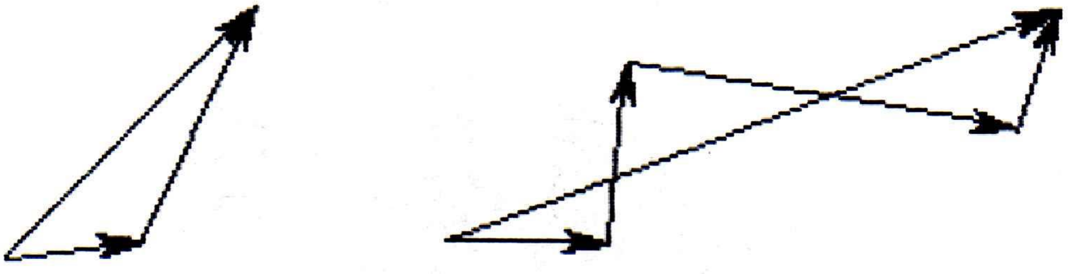
Vector subtraction is easiest to do if you think of it in terms of addition.
Consider a - b which can be expressed as a + (-b). -b means the same magnitude, but opposite direction.

Example. Find a -b



M.1.2.3 Vector Resolutes

Just as two vectors can be added to give another. A vector can be split into two or more other vectors. These are called components or resolutes.
Example



M.2 KINEMATICS

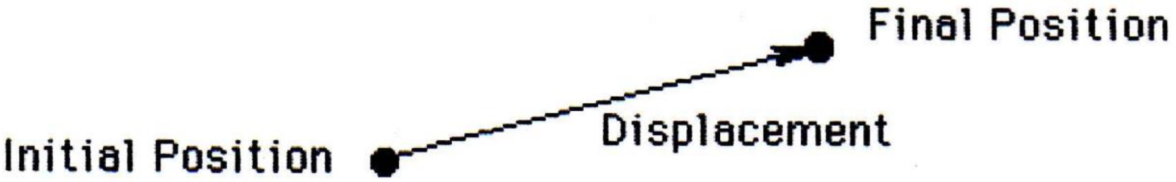
Kinematics is the study of the motion of objects. This involves a study of position, displacement, velocity, acceleration and time.

M.2.1 Position

The position of an object tells us where the object is situated. The symbol is x and the unit is metres (m).

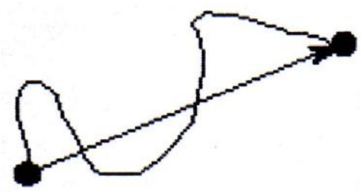
M.2.2 Displacement

The displacement of an object is the change in its position and the direction of that change.
Example



Note: The displacement is independent of how you got there, the distance travelled or the path taken.

Example



The mathematical way of writing "change of" is to use the symbol Δ (delta).
Thus change of position = Δx
Since displacement has a magnitude and a direction it is a vector and is written as $\Delta\vec{x}$ or $\vec{s}$.
The unit is metres.

M.2.3 Velocity

Velocity is a quantity which tells us how fast an object is travelling and also the direction of travel. Thus velocity is a vector and is denoted by $\vec{v}$.
The magnitude part of velocity is called speed and is denoted by v.
The velocity of an object is calculated by using the displacement and the time taken.

Thus $$v = \frac{\Delta x}{\Delta t} = \frac{x_2 - x_1}{\Delta t}$$

This equation tells us the average velocity over the time Δt.
The units of velocity are metres per second, written as ms^{-1}

M.2.4 Acceleration

Acceleration is a quantity which tells us about the change in velocity of an object and is a vector. Acceleration is defined as the change in velocity over time.

Thus $$a = \frac{\Delta v}{\Delta t} = \frac{v_2 - v_1}{\Delta t}$$

The units of acceleration are ms^{-2}.

M.2.5 Graphs of x, v, a and t

These were dealt with in detail in unit 2. The following is just a summary.

The gradient of an x-t graph is the velocity.

The gradient of an v-t graph is the acceleration.

The area under an a-t graph is equal to (Δv) the change in velocity (speed). To be able to find the actual velocity at any time, we need to know the velocity at one point in time. Usually the initial or final.

The area under an v-t graph is equal to (Δx) the change in position. To be able to find the actual position at any time we need to know the position at one point in time. Usually the initial or final.

The type of information that can be determined from different graphs is summarised in the following table.

Graph type → / Found from	x - t	v - t	a – t
Direct reading	'x' at any 't' 't' at any 'x'	'v' at any 't' 't' at any 'v'	'a' at any 't' 't' at any 'a'
Gradient	Instantaneous velocity at any point. V_{av} between any two points	Instantaneous 'a' Average 'a'	Meaningless
Area under graph	Meaningless	Δx	Δv

The gradient at a particular time is determined by drawing a tangent line to the curve at that point, and then determining the gradient of the tangent line.

Constant Acceleration

Consider the following series of graphs. These illustrate the relationships mentioned in the table above. Notice that the velocity – time graph is the gradient of the displacement – time graph, and the acceleration – time graph is the gradient of the velocity – time graph.