Physics 1A notes

Mechanics

Motion along a straight line – in one direction

Kinematics: describes motion whilst ignoring the agents that caused that motion

Right: positive x direction

Left: negative

Up: positive

Down: negative

Displacement: change in position during some time interval - measured in $\Delta x \equiv x_f - x_i$ metres

Distance: length of a path followed by a particle

kinematic equations - constant acceleration

① $V_f = V_0 + at$

② $x_f = x_0 + \frac{1}{2}(V_0 + V_f)t$

③ $x_f = x_0 + V_{x0}t + \frac{1}{2}at^2$

④ $V_f^2 = V_i^2 + 2a(x_f - x_0)$

constant velocity → $a=0$

$x_f = x_0 + V_x t$

Vector: quantities which need both magnitude (size or numerical value) and direction → use + or – signs to describe them

Scalar: quantities which are described by magnitude only

Average velocity: rate at which displacement occurs – dimensions are length/time – m/s, slope/gradient of line-position time graph

$$v_{x,avg} \equiv \frac{\Delta x}{\Delta t} = \frac{x_f - x_i}{\Delta t}$$

– can be positive, negative or zero

Average speed: scalar, no direction – distance/time – positive number

Instantaneous velocity: slope of the tangent on the time-position graph

$$v_x = \lim_{\Delta t \to 0} \frac{\Delta x}{\Delta t} = \frac{dx}{dt}$$

Instantaneous speed: magnitude of instantaneous velocity – no direction

Average acceleration: rate of change of velocity – dimensions: L/T² – m/s² – positive or negative

$$a_{x,avg} \equiv \frac{\Delta v_x}{\Delta t} = \frac{v_{xf} - v_{xi}}{t_f - t_i}$$

Instantaneous acceleration: tangent of velocity-time graph

$$a_x = \lim_{\Delta t \to 0} \frac{\Delta v_x}{\Delta t} = \frac{dv_x}{dt} = \frac{d^2 x}{dt^2}$$

When an object's velocity and acceleration are in the same direction, the object is speeding up

When an object's velocity and acceleration are in the opposite direction, the object is slowing down

Constant velocity – acceleration equals 0

Freely falling objects: any object moving freely under the influence of gravity alone. It does not depend upon the initial motion of the object. If an object is dropped, thrown upwards or thrown downwards it still has a constant acceleration.

Magnitude of free fall acceleration: g= 9.80 m/s^2 - positive value if being thrusted upwards, negative value if being thrusted downwards

Vectors

Cartesian: (x, y, z)

Polar: (r, α)

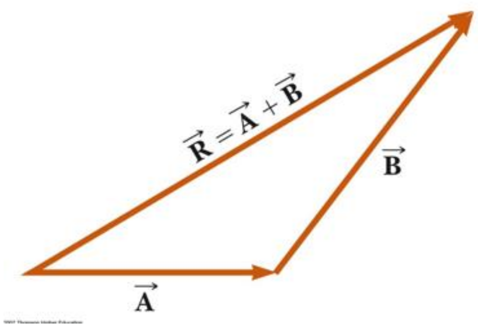
Two vectors are equal if they have the same magnitude and direction → therefore are parallel

Notation for vectors: **A** (bold), or A → arrow on top

Magnitude: *A* italics, or absolute values with arrow → has physics units and is always positive

Adding vectors graphically:

1) Choose a scale
2) Draw the first vector **A** with the appropriate length and in the direction specified
3) Draw the next vector with the appropriate length and direction, whose origin is the end of vector **A**
4) Draw the resultant: from the origin of A to the end of the last vector
5) Measure the resultant **R** and its angle

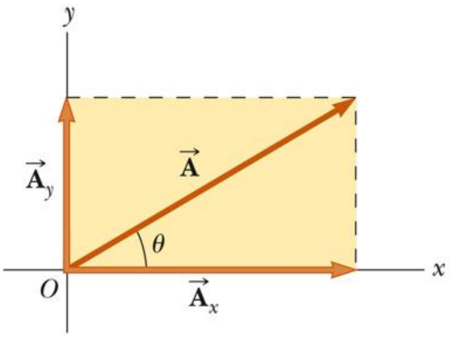


Commutative law of addition: when adding two vectors, the sum is independent of the order of addition → it doesn't matter what order you add the vectors in

When adding vectors, all vectors must have the same units and be of the same type of quantity e.g. both velocity

Component method of adding vectors

Any vector can be completely described by its components – rectangular x and y components

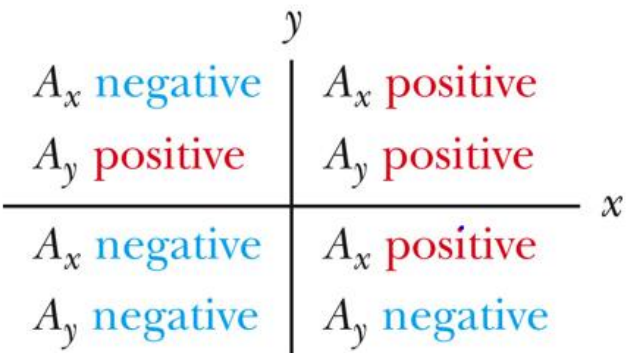


The components of **A** are **Ax** and **Ay** – scalars

$$A_x = A\cos\theta \qquad A = \sqrt{A_x^2 + A_y^2}$$

$$A_y = A\sin\theta \qquad \theta = \tan^{-1}\frac{A_y}{A_x}$$

The signs of the components will depend on the angle



Unit vector: a dimensionless vector with a magnitude of exactly 1 – used to specify a direction. The symbols **i** (x-axis), **j** (y-axis) and **k** (z-axis) represent unit vectors

3-Dimensional extension

$$R = \sqrt{R_x^2 + R_y^2 + R_z^2} \qquad \theta = \cos^{-1}\frac{R_x}{R}$$

Producing an acceleration

How can we produce an acceleration?

- Changing the magnitude of the velocity
- Changing the direction of the velocity

Motion in two directions can be modelled as two independent motions in each of the two perpendicular directions associated with the x and y axes. Any influence in the y direction does not affect the motion in the x direction.

Projectile motion

Projectile motion: when an object moves in both the x and y directions simultaneously

What assumptions are made with projectile motion?

- The free-fall acceleration is constant over the range of motion. It is directed downwards
- The effect of air friction is negligible