UNIT 2 - KINEMATICS

Equations of Motion

Displacement (s) is the overall distance travelled from the starting position of the object. It includes a direction as well as the distance, and so it is a vector quantity.

- Displacement-time graphs show the change in displacement over time, and the gradient of these graphs represents velocity.

Distance is a scalar quantity that describes the amount of ground an object has covered.

Speed is a scalar quantity that describes the distance travelled per unit time.

- Distance and speed can be represented by distance-time graphs and speed-time graphs. Unlike displacement and velocity, speed and distance can never be negative because they are scalar quantities.

Velocity (v) is the rate of change of displacement and is a vector quantity. The formula for velocity is $\Delta s / \Delta t$.

- Velocity-time graphs represent the change in velocity over time. The gradient of these graphs is the acceleration and the area underneath the line is displacement.
- Instantaneous velocity is the velocity of an object at a specific time and can be found from a displacement-time graph by drawing a tangent to the graph at the specific time and then calculating the gradient.

Acceleration (a) is the rate of change of velocity and its formula is $\Delta v / \Delta t$.

- Acceleration time graphs show the change in velocity over a period of time, and the area under the line is the change in velocity.

Uniform acceleration is when the acceleration of an object is constant.

- To calculate uniform acceleration equations, we can look at this velocity-time graph of a uniformly accelerating object.
  - The area under the line is <u>displacement</u>:
    s = area of rectangle + area of triangle
    $s = ut \div \frac{1}{2}(v - u)$
    $s = ut \div vt/2 - ut/2$
    $s = t \times (u + v)/2$
  - The gradient of the velocity-time graph is the <u>acceleration</u>:
    $a = (v - u) \div t$
    $v = u + at^2$
  - Substitute the acceleration equation into the displacement equation:
    $s = ut + \frac{1}{2}at^2$
  - The final equation can be found by substituting the ($v = u + at$) equation into the displacement equation and rearranging it to get:
    $t = (v - u) / a$
    ...Substitute this equation into the displacement equation to get:
    $v2 = u^2 + 2as$

To summarize, when an object is moving at a uniform acceleration, you can use the following formulas:

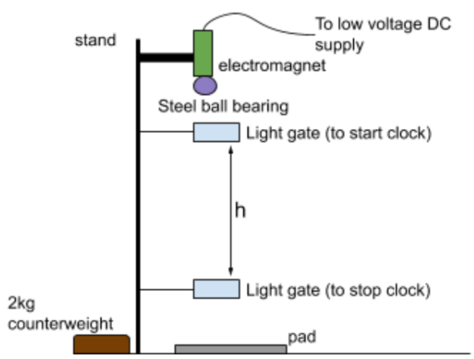
$v = u + at$	$s = t \times (u + v)/2$	$s = ut + (at^2/2)$	$v^2 = u^2 + 2as$

Where s = displacement, u = initial velocity, v = final velocity, a = acceleration, & t = time

When an object is moving at a constant velocity in one direction, and experiences a uniform acceleration in the perpendicular direction, it will follow a parabolic path.

∟ At first, the object only experiences a horizontal velocity (v_x), however as time goes on, its vertical velocity (v_y) increases due to the uniform acceleration, causing the object to change direction. As the time passed increases, the degree by which the direction has changed increases, as shown by the parabolic shape.

<u>Acceleration due to gravity</u>



The acceleration due to gravity or, g, can be found experimentally using the apparatus shown.

- The position of the lower light gate should be 0.75 meters above the pad (this is h, the height)

1) Turn on the electroball magnet and attach the ball bearing. Switch off the electromagnet and then record the time taken (t) for the steel ball bearing to fall between the light gates.
2) For each trial, reduce the height of the lower light gate by 0.05 until it reaches a height of 0.25 meters above the pad.
3) Repeat the experiment to find the mean values of t for each value of h.

The displacement of the ball bearing (s) will be h. Its initial velocity (u) will be 0, and its acceleration will be g:

$$h = \frac{1}{2}gt^2 \text{ or } 2h = gt^2$$

Therefore, if you plot the graph of 2h against the mean of t^2, the gradient will be g.