

Kinematics

A Level Maths · Knowledge organiser

KEY DEFINITIONS

Displacement

Distance in a given direction from a starting point.

Velocity

Rate of change of displacement: speed with a direction.

Acceleration

Rate of change of velocity.

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The five constant-acceleration equations linking s , u , v , a and t .

KEY FORMULAS

B = given in the exam (formula booklet or list); learn the rest.

Constant acceleration **B** $v = u + at$, $s = ut + \frac{1}{2}at^2$, $s = vt - \frac{1}{2}at^2$,
 $s = \frac{1}{2}(u + v)t$, $v^2 = u^2 + 2as$

... in vectors **B** $\mathbf{v} = \mathbf{u} + \mathbf{a}t$, $\mathbf{r} = \mathbf{u}t + \frac{1}{2}\mathbf{a}t^2$

Variable acceleration $v = \frac{dr}{dt}$, $a = \frac{dv}{dt} = \frac{d^2r}{dt^2}$, $r = \int v dt$, $v = \int a dt$

Projectiles (speed U , angle α) $x = Ut \cos \alpha$, $y = Ut \sin \alpha - \frac{1}{2}gt^2$

Speed = $|v|$; velocity-time graph: gradient = acceleration, area = displacement

YOU SHOULD BE ABLE TO...

- Build simple mechanics models by stating assumptions such as treating an object as a particle, a string as light and inextensible and a surface as smooth.
- Solve multi-stage constant acceleration problems, such as a car that accelerates then travels at constant speed, by linking the stages through shared quantities.
- Differentiate displacement to find velocity and velocity to find acceleration when motion is given as a function of time, and interpret the results.
- Model horizontal projection, such as a ball rolled off a table, treating the horizontal and vertical motion separately with constant velocity and constant acceleration.
- Derive and use general formulae for projectile motion, such as the range and the equation of the trajectory, and use them to find launch angles.
- Differentiate and integrate vectors with respect to time, such as finding velocity from $\mathbf{r} = 3t^2 \mathbf{i} + (4t - t^3) \mathbf{j}$, using initial conditions.

WORKED EXAMPLE

A car starts from rest and accelerates at 2 m s^{-2} for 5 s. Find its speed and the distance travelled.

1. $v = u + at = 0 + 2 \times 5$

2. $s = ut + \frac{1}{2}at^2 = 0 + \frac{1}{2} \times 2 \times 25$

Answer: $v = 10 \text{ m s}^{-1}$ and $s = 25 \text{ m}$

COMMON MISTAKES

- ✗ Mechanics: too many significant figures after using $g = 9.8$
- ✗ Area under a v - t graph read as acceleration
- ✗ Distance vs displacement
- ✗ Sign convention changed mid-question