MODELLING IN MECHANICS

KEY WORDS & DEFINITIONS

1. **Model** – A mathematical system which enables a problem to be solved
2. **Light** – Has negligible mass
3. **Static** – Not moving
4. **Rigid** – Doesn't bend
5. **Thin** – Has negligible thickness
6. **Smooth** – Has a surface that results in no friction between itself and an object
7. **Rough** – Has a surface that requires frictional forces between itself and an object to be considered
8. **Particle** – Dimensions are negligible, so mass or object is at a point. Rotational forces and air resistance can be ignored.
9. **Rod** – A long, thin, straight object. Mass is along a line that is rigid.
10. **Lamina** – A thin 2-dimensional surface with mass distributed evenly across its flat surface.
11. **Uniform Body** – Mass is distributed evenly, so acts at the centre of mass.
12. **Light string** – Has negligible mass and equal tension at both ends.
13. **Inextensible string** – A string that does not stretch so that connected objects can move with the same acceleration if the string is taut.
14. **Wire** – A rigid, thin length of metal.
15. **Smooth and Light Pulley** – A pulley that has no mass and results in tension being equal on either side.
16. **Bead** – A particle with a hole in it which can freely move along a wire or string, resulting in equal tension either side of the bead.
17. **Peg** – A supporting object that is dimensionless and fixed but may be rough or smooth.
18. **Air Resistance** – The resistance force as experienced as on object moves through the air, which is often modelled as negligible.
19. **Gravity** – The force of attraction between objects.
20. **Earth's Gravity** – Assumed to apply to all objects with mass. Acts uniformly and vertically downwards with a value of $9.8 m/s^2$
21. **Scalar** – A quantity which has magnitude only – distance, speed, time, mass. Always positive.
22. **Vector** – A quantity which has magnitude and direction – displacement, velocity, acceleration, force, weight. Can be described using column or i j notation. Can be positive or negative.

Distance is the magnitude of the displacement vector

Speed is the magnitude of the velocity vector

SI BASE UNITS

Quantity	Mass	Length/ Displacement	Time	Speed/ Velocity	Acceleration	Weight/ Force
Symbol	kg	m	s	ms^{-1}	ms^{-2}	N (= $kgms^{-2}$)

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CONSTANT ACCELERATION

KEY WORDS & DEFINITIONS

1. **Velocity**
   The rate of change of displacement
2. **Acceleration**
   The rate of change of velocity

SUVAT EQUATIONS

For motion in a straight line with constant acceleration:

$v = u + at$	s – displacement
$v^2 = u^2 + 2as$	u – initial velocity
$s = ut + \frac{1}{2}at^2$	v – final velocity
$s = vt - \frac{1}{2}at^2$	a – acceleration
$s = \frac{1}{2}(u+v)t$	t - time

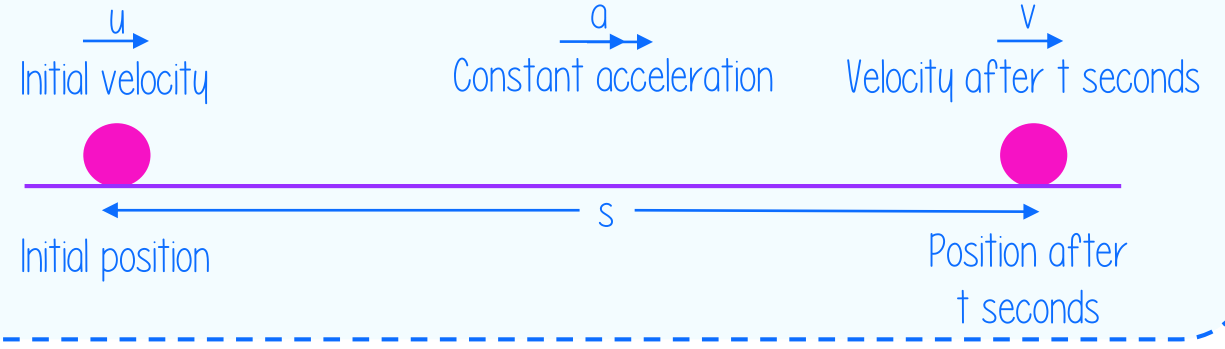
To derive the SUVAT equations:

- Find the gradient of a velocity time graph labelled with u, v, t
- Find the area underneath the velocity-time graph
- Use these two equations to replace each variable at a time to derive the other three equations.

WHAT DO I NEED TO KNOW

1. The gradient on a displacement-time graph = velocity
2. If a displacement-time graph is a straight line then the velocity is constant.
3. The gradient on a velocity-time graph = acceleration
4. If a velocity-time graph is a straight line then the acceleration is constant.
5. The area between a velocity-time graph and the time axis = Distance travelled
6. Average Speed = $\frac{\text{Total Distance Travelled}}{\text{Total Time Taken}}$
7. Average velocity = $\frac{\text{Displacement From Start Point}}{\text{Total Time Taken}}$
8. Acceleration due to gravity = $9.8 m/s^2$
9. Acceleration due to gravity does not depend on the mass of the object.
10. The degree of accuracy in your answers must be consistent with the values given in the question. I.e. if $g = 10 m/s^2$ in the question, your answer should also be given to 1 sig. fig.

ALWAYS DRAW A SKETCH!



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FORCES & MOTION

KEY WORDS & DEFINITIONS

1. Resultant Force
The result of resolving forces on an object in a particular direction.

2. Weight
The force due to gravity acting on an object

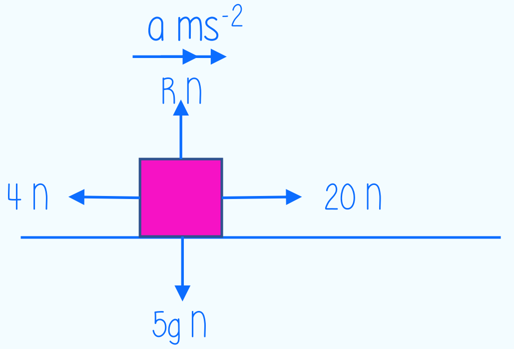
NEWTON'S LAWS OF MOTION

Newton's First Law of Motion
Objects in equilibrium will not accelerate. An object will only accelerate (or decelerate) if an unbalanced force acts on the object.

Newton's Second Law of Motion
The acceleration of an object depends on the overall net force acting on the object and the object's mass.

Newton's Third Law of Motion
For every action there is an equal and opposite reaction.

ALWAYS DRAW A DIAGRAM!



FORMULAE

Formula of Newton's Second Law of Motion

$$F = ma$$

Formula to calculate the weight of an object

$$W = mg$$

WHAT DO I NEED TO KNOW

1. To resolve forces given as vectors add the vectors

   If 2 forces $(p\mathbf{i} + q\mathbf{j})$ N and $(r\mathbf{i} + s\mathbf{j})$ N are acting on a particle, the resultant force will b $((p + r)\mathbf{i} + (q + s)\mathbf{j})$ N

2. To solve problems involving connected particles moving in the same straight line consider the particles as a single unit, moving as one.

   Particles need to remain in contact or be connected by an inextensible rod or string to be considered a single particle

3. To solve problems involving connected particles that are not moving in the same straight line consider the particles, and the forces acting on them, separately.

   Particles need to be considered separately in order to find the tension in any string between them

4. The tension in an inextensible string passing over a smooth pulley is the same on both sides

   You cannot treat a system involving a pulley as a single particle as the particles are moving in different directions

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VARIABLE ACCELERATION

KEY WORDS & DEFINITIONS

1. **Velocity**
   The rate of change of displacement

2. **Acceleration**
   The rate of change of velocity

FORMULAE

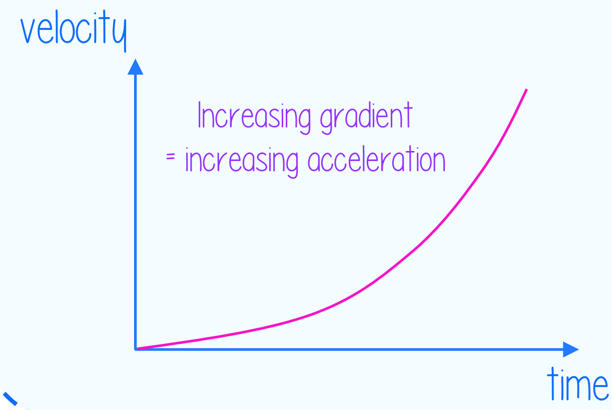
Velocity, if displacement is a function of time:

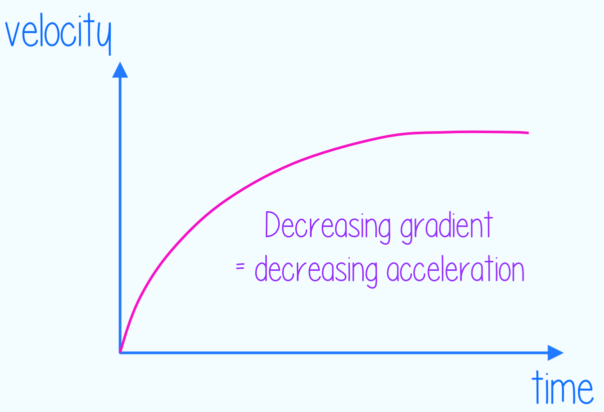
$$v = \frac{\mathrm{d}s}{\mathrm{d}t}$$

Acceleration, if velocity is a function of time

$$a = \frac{\mathrm{d}v}{\mathrm{d}t} = \frac{\mathrm{d}^2s}{\mathrm{d}t^2}$$

VELOCITY TIME GRAPHS





WHAT DO I NEED TO KNOW

1. The area under a velocity time graph represents the displacement
2. Integration is the reverse process to differentiation
3. Differentiate displacement with respect to time to get velocity
4. Differentiate velocity with respect to time to get acceleration
5. Integrate acceleration with respect to time to get velocity

$$\int (a)\,\mathrm{d}t = v$$

6. Integrate velocity with respect to time to get displacement

$$\int (v)\,\mathrm{d}t = s$$

7. The suvat equations can only be used when the acceleration is constant

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