Chapter 9 - Mechanics

Constant Acceleration

Chapter Overview

1. Displacement-Time Graphs

2. Velocity-Time Graphs

3. Constant Acceleration Formulae (SUVAT)

4. Vertical Motion Under Gravity

Topics	What students need to learn:		
		Content	Guidance
7 **Kinematics**	7.1	Understand and use the language of kinematics: position; displacement; distance travelled; velocity; speed; acceleration.	
	7.2	Understand, use and interpret graphs in kinematics for motion in a straight line: displacement against time and interpretation of gradient; velocity against time and interpretation of gradient and area under the graph.	Derivation may use knowledge of Sections 7.2 and/or 7.4 Understand and use *suvat* formulae for constant acceleration in 2D.
7 **Kinematics** *continued*	7.3	Understand, use and derive the formulae for constant acceleration for motion in a straight line.	Derivation may use knowledge of sections 7.2 and/or 7.4 Understand and use *suvat* formulae for constant acceleration in 2D.
	7.4	Use calculus in kinematics for motion in a straight line: $$v = \frac{dr}{dt}, \quad a = \frac{dv}{dt} = \frac{d^2r}{dt^2}$$ $$r = \int v \; dt, \; v = \int a \; dt$$	The level of calculus required will be consistent with that in Sections 7 and 8 in Paper 1.

1. Displacement-Time Graphs

Describe the motion of each object:
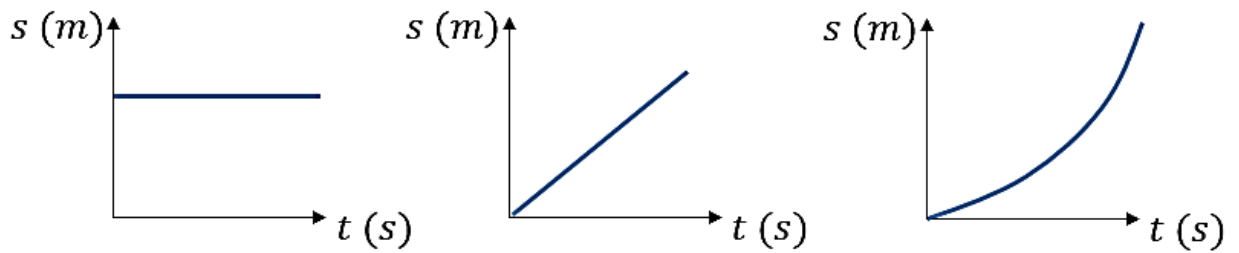
Velocity is the rate of change of displacement
(i.e. gradient of displacement-time graph)

Average Velocity = _____

Average Speed = _____
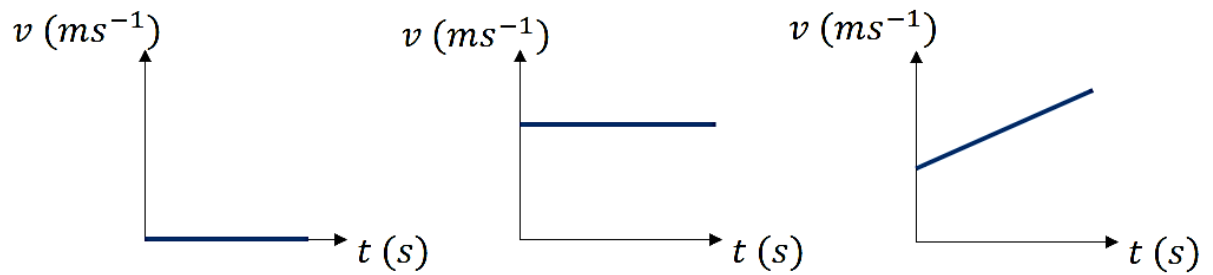

Example *(Exercise 9A Question 2)*

Khalid drives from his home to a hotel. He drives for $2\frac{1}{2}$ hours at an average velocity of 60 km h^{-1}. He then stops for lunch before continuing to his hotel. The diagram shows a displacement–time graph for Khalid's journey.

a Work out the displacement of the hotel from Khalid's home.

b Work out Khalid's average velocity for his whole journey.

Displacement (km) vs Time (hours)

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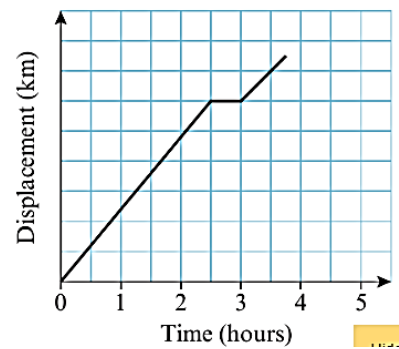
2. Velocity-Time Graphs

Describe the motion of each object:

$v\ (ms^{-1})$ $v\ (ms^{-1})$ $v\ (ms^{-1})$

$t\ (s)$ $t\ (s)$ $t\ (s)$


Acceleration the rate of change of velocity
(i.e. <u>gradient</u> of velocity-time graph)

The **area** under a velocity-time graph gives the **distance travelled.**

Example

The velocity-time graph shown is for a body which starts from rest, accelerates uniformly to a velocity of 8ms^{-1} in 2 seconds, maintains that velocity for a further 5 seconds then decelerates uniformly to rest. The entire journey takes 11 seconds. Find:

a) The acceleration of the body during the initial part of the motion
b) The deceleration of the body during the final part of the motion
c) The total distance travelled by the body
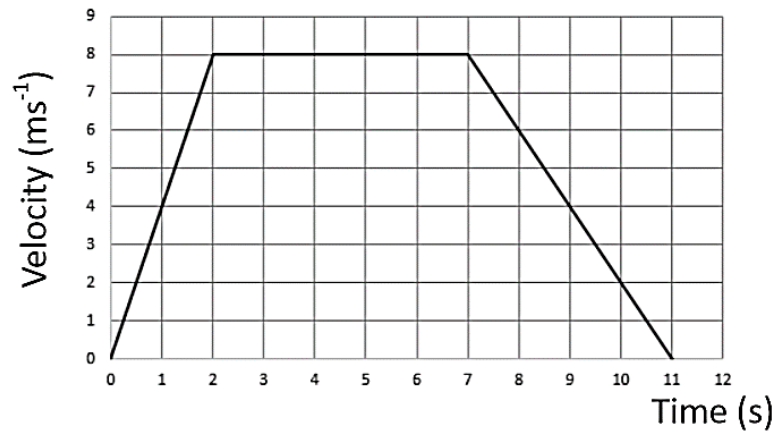
Algebraic Example

A particle moves along a straight line. The particle accelerates uniformly from rest to a velocity of 8 ms^{-1} in T seconds. The particle then travels at a constant velocity of 8 ms^{-1} for $5T$ seconds. The particle then decelerates uniformly to rest in a further 40 s.

(a) Sketch a velocity-time graph to illustrate the motion of the particle.

Give then the total displacement of the particle is 600m.

(b) find the value of T.

Test Your Understanding *(EdExcel M1 May 2013 Q5)*

A car is travelling along a straight horizontal road. The car takes 120 s to travel between two sets of traffic lights which are 2145 m apart. The car starts from rest at the first set of traffic lights and moves with constant acceleration for 30 s until its speed is 22 m s⁻¹. The car maintains this speed for T seconds. The car then moves with constant deceleration, coming to rest at the second set of traffic lights.

(a) Sketch, in the space below, a speed-time graph for the motion of the car between the two sets of traffic lights.

(2)

(b) Find the value of T.

(3)

A motorcycle leaves the first set of traffic lights 10 s after the car has left the first set of traffic lights. The motorcycle moves from rest with constant acceleration, a m s⁻², and passes the car at the point A which is 990 m from the first set of traffic lights. When the motorcycle passes the car, the car is moving with speed 22 m s⁻¹.

(c) Find the time it takes for the motorcycle to move from the first set of traffic lights to the point A.

(4)

(d) Find the value of a.

(2)