Mechanics 1 – Kinematics

Revision Aid

Are you ready?

This revision booklet should be completed alongside the accompanying presentation. The aim of this revision booklet is;

- to summarise key notes and examples
- supply hints and tips from examiners, and,
- provide an opportunity to practise past exam papers.

What is Kinematics?

Kinematics is the study of objects in motion.

In Mechanics 1 we consider only the simplest motion where acceleration is constant and objects move in a straight line.

What does it look like?

Typical exam questions might include an object being thrown up into the air such that the only forces acting on the object are its weight, and acceleration can be taken as 9.8 m/s^2 acting downwards. In such questions you may be asked to find the time taken between various points of the motion, the maximum height achieved or the speed when it lands on the ground etc.

Other questions might compare the motion of two objects travelling in a horizontal plane, such as cars or trains. You might be asked to sketch a speed-time graph of the motion or interpret a speed-time graph that is provided. You could then calculate the acceleration, speed and time for various parts of the motion.

Want more help?

You should aim to spend a minimum of one hour working through this revision booklet. If after completing the booklet you have any questions or areas of uncertainty you can find more help and resources by;

- Asking your teacher for a larger selection of past exam questions to test yourself
- Using the online resources available at www.mymaths.co.uk (login and password details available with your teacher)
- Reading and working through your Alpha Workbook
- Asking another Mechanics 1 student for help

Formulae

There are five constant acceleration formulae to remember. They are not given in the exam paper of formula booklet so you will need to commit them to memory.

$$v = u + at$$

$$v^2 = u^2 + 2as$$

$$s = \left(\frac{u+v}{2}\right)t$$

$$s = ut + \frac{1}{2}at^2$$

$$s = vt - \frac{1}{2}at^2$$

s	u	v	a	t	formula
✗	✓	✓	✓	✓	$v = u + at$
✓	✓	✓	✓	✗	$v^2 = u^2 + 2as$
✓	✓	✓	✗	✓	$s = \left(\frac{u+v}{2}\right)t$
✓	✓	✗	✓	✓	$s = ut + \frac{1}{2}at^2$
✓	✗	✓	✓	✓	$s = vt - \frac{1}{2}at^2$

We can find any of the $suvat$ values, provided we know at least 3 of the other variables or can work them out from the question.

Q1 – Vertical motion

June 2008, Q2

At time $t = 0$, a particle is projected vertically upwards with speed u ms^{-1} from a point 10 m above the ground. At time T seconds, the particle hits the ground with speed 17.5 ms^{-1}. Find

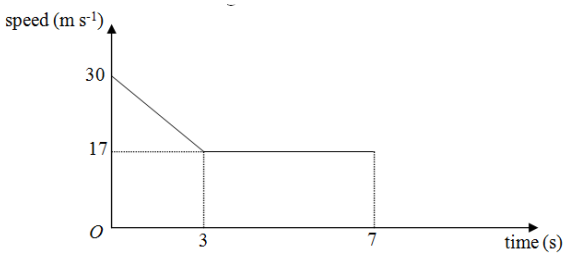
(*a*) the value of u, **(3)**

(*b*) the value of T. **(4)**

Write the examiners top tip in your own words:

Q2 – Interpret a speed-time graph

June 2001, Q3



A car of mass 1200 kg moves along a straight horizontal road. In order to obey a speed restriction, the brakes of the car are applied for 3 s, reducing the car's speed from 30 m s^{-1} to 17 m s^{-1}. The brakes are then released and the car continues at a constant speed of 17 m s^{-1} for a further 4 s. Figure 2 shows a sketch of the speed-time graph of the car during the 7 s interval. The graph consists of two straight line segments.

(*a*) Find the total distance moved by the car during this 7 s interval. **(4)**

(*b*) Explain briefly how the speed-time graph shows that, when the brakes are applied, the car experiences a constant retarding force. **(2)**

(*c*) Find the magnitude of this retarding force. **(3)**

Write the examiners top tip in your own words:

Q3 – Sketch a speed-time graph

June 2007, Q4

A car is moving along a straight horizontal road. At time $t = 0$, the car passes a point A with speed 25 m s^{-1}. The car moves with constant speed 25 m s^{-1} until $t = 10$ s. The car then decelerates uniformly for 8 s. At time $t = 18$ s, the speed of the car is V m s^{-1} and this speed is maintained until the car reaches the point B at time $t = 30$ s.

(*a*) Sketch a speed–time graph to show the motion of the car from A to B. **(3)**

Given that $AB = 526$ m, find

(*b*) the value of V, **(5)**

(*c*) the deceleration of the car between $t = 10$ s and $t = 18$ s. **(3)**

Write the examiners top tip in your own words:

Test yourself

Q1 – Vertical motion. January 2008, Q2.

A firework rocket starts from rest at ground level and moves vertically. In the first 3 s of its motion, the rocket rises 27 m. The rocket is modelled as a particle moving with constant acceleration a m s^{-2}. Find

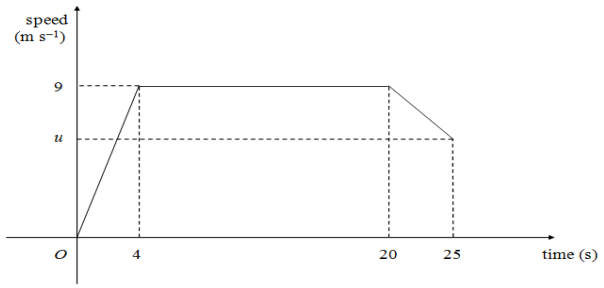
(a) the value of a **(2)**

(b) the speed of the rocket 3 s after it has left the ground **(2)**

After 3 s, the rocket burns out. The motion of the rocket is now modelled as that of a particle moving freely under gravity.

(c) Find the height of the rocket above the ground 5 s after it has left the ground **(4)**

Q2 – Interpret a *speed*-time graph. January 2005, Q3



A sprinter runs a race of 200 m. Her total time for running the race is 25 s. Figure 2 is a sketch of the speed-time graph for the motion of the sprinter. She starts from rest and accelerates uniformly to a speed of 9 m s^{-1} in 4 s. The speed of 9 m s^{-1} is maintained for 16 s and she then decelerates uniformly to a speed of u m s^{-1} at the end of the race. Calculate

(*a*) the distance covered by the sprinter in the first 20 s of the race **(2)**

(*b*) the value of u **(4)**

(*c*) the deceleration of the sprinter in the last 5 s of the race **(3)**

Q3 – Sketch a *speed*-time graph. January 2001, Q6

A parachutist drops from a helicopter H and falls vertically from rest towards the ground. Her parachute opens 2 s after she leaves H and her speed then reduces to 4 m s^{-1}. For the first 2 s her motion is modelled as that of a particle falling freely under gravity. For the next 5 s the model is motion with constant deceleration, so that her speed is 4 m s^{-1} at the end of this period. For the rest of the time before she reaches the ground, the model is motion with constant speed of 4 m s^{-1}.

(*a*) Sketch a speed-time graph to illustrate her motion from H to the ground **(3)**

(*b*) Find her speed when the parachute opens. **(2)**

A safety rule states that the helicopter must be high enough to allow the parachute to open and for the speed of a parachutist to reduce to 4 m s^{-1} before reaching the ground. Using the assumptions made in the above model,

(*c*) find the minimum height of H for which the woman can make a drop without breaking this safety rule. **(5)**

Given that H is 125 m above the ground when the woman starts her drop,

(*d*) find the total time taken for her to reach the ground. **(4)**

(*e*) State one way in which the model could be refined to make it more realistic. **(1)**

Jan 08, Q2
a) 6 (m/s)
b) 18 (m/s)
c) 43.4 or 43 (m)

Jan 05, Q3
a) 162 (m)
b) 6.2 (m/s)
c) 0.56 (m/s^2)

Jan 01, Q6
a) correct shape, 2,4,7 on axes
b) 19.6 (m/s) c) 78.6 (m)
d) 18.6 (s) e) air resistance

Spot the mistake!

January 2002, Q3

Look at the question and solution below. Can you find the mistake? Can you correct the work?

A racing car moves with constant acceleration along a straight horizontal road. It passes the point *O* with speed 12 m s^{-1}. It passes the point *A* 4 s later with speed 60 m s^{-1}.

(*a*) Show that the acceleration of the car is 12 m s^{-2}. **(2)**

(*b*) Find the distance *OA*. **(3)**

The point *B* is the mid-point of *OA*.

(*c*) Find, to 3 significant figures, the speed of the car when it passes *B*. **(3)**

(a) ~~S~~

u = 12
V = 60
a = ?
t = 4

$v = u + at$

$60 = 12 + 4a$

$48 = 4a$

$a = \frac{48}{4} = 12$

$a = 12 m/s^2$

(b) S = ?
u = 12
V = 60
a = 12
~~t~~ = 4

$v^2 = u^2 + 2as$

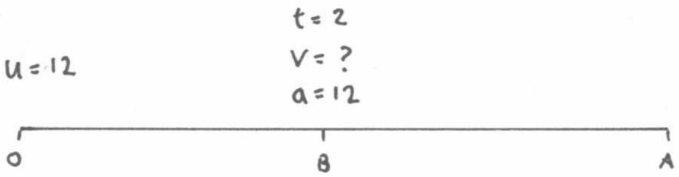
$60^2 = 12^2 + 2 \times 12 \times s$

$3600 = 144 + 24s$

$3456 = 24s$

$s = \frac{3456}{24} = 144$

$s = 144m$



(c) ~~S~~

u = 12
V = ?
a = 12
t = 2

$v = u + at$

$? = 12 + 12 \times 2$

$? = 12 + 24$

$v = 36 m/s$