Edexcel GCE

Core Mathematics M1

Kinematics

(SUVAT)

Materials required for examination
Mathematical Formulae (Green)

Items included with question papers
Nil

Advice to Candidates

You must ensure that your answers to parts of questions are clearly labelled.
You must show sufficient working to make your methods clear to the Examiner. Answers without working may gain no credit.

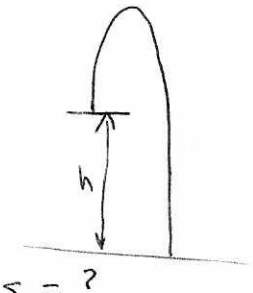
1. A stone is thrown vertically upwards with speed 16 m s^{-1} from a point h metres above the ground. The stone hits the ground 4 s later. Find

(*a*) the value of h,

(3)

(*b*) the speed of the stone as it hits the ground.

(3)



$s = ?$
$u = 16$
$v =$
$a = -9.8$
$t = 4$

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

$s = 16(4) + \frac{1}{2}(-9.8)(4)^2$

$= -14.4$

$\therefore$ $h = 14.4\text{m}$

b/ $v = u + at$

$= 16 + (-9.8)(4)$

$= 23.2\ \text{ms}^{-1}$ ~~(-)~~ ignore sign as it is speed (non vector)

2. 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)

$s = 27$
$u = 0$
$v =$
$a = ?$
$t = 3$

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

$27 = 0(3) + \frac{1}{2}(a)(3)^2$

$27 = 4.5a$

$a = 6 \text{ ms}^{-2}$

b/ $v = u + at$

$v = 0 + 6(3)$

$= 18 \text{ ms}^{-1}$

c/ After 3 seconds: $s =$
$u = 18$
$v =$
$a = -9.8$
$t = 2$

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

$s = 18(2) + \frac{1}{2}(-9.8)(2)^2$

$= 16.4 \text{ m}$

$27 + 16.4 = 43.4 \text{ m}$

3. A train moves along a straight track with constant acceleration. Three telegraph poles are set at equal intervals beside the track at points A, B and C, where $AB = 50$ m and $BC = 50$ m. The front of the train passes A with speed 22.5 m s^{-1}, and 2 s later it passes B. Find

(a) the acceleration of the train,

(3)

(b) the speed of the front of the train when it passes C,

(3)

(c) the time that elapses from the instant the front of the train passes B to the instant it passes C.

(4)

$s = 50$
$u = 22.5$
$v =$
$a = ?$
$t = 2$

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

$50 = 22.5(2) + \frac{1}{2}a(2)^2$

$50 = 45 + 2a$

$a = 2.5\ ms^{-2}$

b/ $s = 100$
$u = 22.5$
$v = ?$
$a = 2.5$
$t = ?$

$v^2 = u^2 + 2as$
$= (22.5)^2 + 2(2.5)(100)$
$= 1006.25$
$v = 31.72144385\ ms^{-1}$
$= 31.7\ ms^{-1}$ (3sf)

c/ $v = u + at$

$31.7 = 22.5 + 2.5t$

$t = 3.68857754$

$3.69 - 2 = 1.69$ seconds (3sf)

4. Three posts P, Q and R, are fixed in that order at the side of a straight horizontal road. The distance from P to Q is 45 m and the distance from Q to R is 120 m. A car is moving along the road with constant acceleration a m s^{-2}. The speed of the car, as it passes P, is u m s^{-1}. The car passes Q two seconds after passing P, and the car passes R four seconds after passing Q.

Find

(i) the value of u,

(ii) the value of a.

(7)

P to Q

$s = 45$
$u = u$
v
$a = a$
$t = 2$

P to R

$s = \cancel{120}\ 165$
$u = u$
$a = a$
$t = 6$

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

$45 = 2u + \frac{1}{2}a(2)^2$

$45 = 2u + 2a$

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

$\cancel{120}\ 165 = 6u + \frac{1}{2}a(6)^2$

$\cancel{120}\ 165 = 6u + 18a$

$\cancel{40}\ 55 = 2u + 6a$

$6a + 2u = \cancel{40}\ 55$

$2a + 2u = 45$

$4a = \cancel{55}\ 10$

$a = \cancel{1.25}\ 2.5\ ms^{-2}$

$45 = 2u + 2(\cancel{1.25}\ 2.5)$

$u = \cancel{23.75\ ms^{-1}}$

$u = 20\ ms^{-1}$

$a = 2.5 ms^{-2}$ $u = 20 ms^{-1}$

5. A ball is projected vertically upwards with speed 21 m s^{-1} from a point A, which is 1.5 m above the ground. After projection, the ball moves freely under gravity until it reaches the ground. Modelling the ball as a particle, find

(a) the greatest height above A reached by the ball,

(3)

(b) the speed of the ball as it reaches the ground,

(3)

(c) the time between the instant when the ball is projected from A and the instant when the ball reaches the ground.

(4)

To the top

$s = ?$
$u = 21$
$v = 0$
$a = -9.8$
$t =$

$v^2 = u^2 + 2as$
$0 = 21^2 + 2(-9.8)s$
$s = 22.5\text{ m}$

$22.5 + 1.5 = \underline{24\text{m}}$

b/ From the top: $s = -24$
$u = 0$
$v = ?$
$a = -9.8$
$t = .$

$v^2 = u^2 + 2as$
$v^2 = 2(-9.8)(-24)$
$v^2 = 470.4$
$v = 21.68870674$
$= 21.7\text{ ms}^{-1}$ (3sf)

c/ whole motion
$s = -1.5$
$u = 21$
$v = -21.7$
$a = -9.8$
$t = ?$

$s = ut + \frac{1}{2}at^2$
$-1.5 = 21t + \frac{1}{2}(-9.8)t^2$
$-1.5 = 21t - 4.9t^2$
$4.9t^2 - 21t - 1.5 = 0$
$t = \frac{-(-21) \pm \sqrt{(-21)^2 - 4(4.9)(-1.5)}}{2(4.9)}$
$= 4.36$ seconds (3sf)

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

(*a*) the value of u,

(3)

(*b*) the value of T.

(4)

whole motion

$s = -10$
$u = u$
$v = -17.5$
$a = -9.8$
$t =$

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

~~$-17.5 = u$~~.

$306.25 = u^2 + 196$

$110.25 = u^2$

$u = 10.5 \text{ ms}^{-1}$

b/ $v = u + at$

$-17.5 = 10.5 + -9.8t$

$t = \frac{20}{7}$ seconds