PQ 4

2012 Term 1 Week 5

Q1

A racing car starts from rest and accelerates uniformly in a straight line at 12 m s^{-2} for 5 s. Calculate the **final velocity** of the car.

$u = 0$ m s^{-1} (rest)

$a = 12$ m s^{-2}

$t = 5$ s

$v = ?$

$v = u + at$

$v = 0 + (12 \times 5)$

$v = 0 + 60$

$v = \underline{60 \text{ m s}}^{-1}$ (in direction of acceleration)

$v = u + at$

Q2

A speedboat travels 400 m in a straight line when it accelerates uniformly from 2.5 m s^{-1} in 10 s. Calculate the acceleration of the speedboat.

s = 400 m

u = 2.5 m s^{-1}

t = 10 s

a = ?

$$s = ut + 1/2at^2$$

$s = ut + 1/2at^2$

$400 = (2.5 \times 10) + (0.5 \times a \times 10^2)$

$400 = 25 + 50a$

$50a = 400 - 25 = 375$

$a = 375/50 =$ $\underline{7.5 \text{ m s}}^{-2}$ (in direction of original velocity)

Q3

A rocket is travelling through outer space with uniform velocity. It then accelerates at 2.5 m s^{-2} in a straight line in the original direction, reaching 100 m s^{-1} after travelling 1 875 m. Calculate the rocket's **initial velocity**?

$a = 2.5\ m\ s^{-2}$

$v = 100\ m\ s^{-1}$

$s = 1\ 875\ m$

$u = ?$

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

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

$100^2 = u^2 + (2 \times 2.5 \times 1\ 875)$

$10\ 000 = u^2 + 9\ 375$

$u^2 = 10\ 000 - 9\ 375 = 625$

$u = \sqrt{625} = \underline{25\ m\ s}^{-1}$ (in direction of acceleration)

Q4

A car, travelling in a straight line, decelerates uniformly at 2 m s^{-2} from 25 m s^{-1} for 3 s. Calculate the car's velocity after the 3 s.

$a = -2$ m s^{-2}

$u = 25$ m s^{-1}

$t = 3$ s

$v = ?$

$$v = u + at$$

$v = u + at$

$v = 25 + (-2 \times 3)$

$v = 25 + (-6)$

$v = \underline{19 \text{ m s}}^{-1}$ (in direction of original velocity)

Q5

A greyhound is running at 6 m s^{-1}. It decelerates uniformly in a straight line at 0.5 m s^{-2} for 3 s. Calculate the **displacement** of the greyhound while it was decelerating.

$u = 6$ m s^{-1}

$a = -0.5$ m s^{-2}

$t = 3$ s

$s = ?$

$s = ut + 1/2at^2$

$s = (6 \times 3) + (0.5 \times -0.5 \times 3^2)$

$s = 18 + (-2.25)$

$s =$ <u>15.75 m</u> (in direction of original velocity)

$s = ut + 1/2at^2$

Q6

A curling stone leaves a player's hand at 5 m s^{-1} and decelerates uniformly at 0.75 m s^{-2} in a straight line for 16.5 m until it strikes another stationary stone. Calculate the **velocity** of the decelerating curling stone at the instant it strikes the stationary one.

$u = 5\ m\ s^{-1}$

$a = -0.75\ m\ s^{-2}$

$s = 16.5\ m$

$v = ?$

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

$v^2 = 5^2 + (2 \times -0.75 \times 16.5)$

$v^2 = 25 + (-24.75)$

$v^2 = 0.25$

$v =\ /0.25 = \underline{0.5\ m\ s}^{-1}$ (in direction of original velocity)

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

Q7

A firework rocket is launched vertically upwards from the ground at 49 m s^{-1}.

(a) What will be the velocity of the rocket at its maximum height?

(b) Calculate:

(i) the time taken for the rocket to reach its maximum height;

(ii) the maximum height.

$u = 49$ m s^{-1}

$a = -9.8$ m s^{-2}

$t = ?$

$s = ?$

(a) At maximum height, $v = 0$ m s^{-1}

(b)(i) $v = u + at$

$0 = 49 + (-9.8 \times t)$

$0 = 49 - 9.8\,t$

$9.8\,t = 49$

$t = 49/9.8 = $ 5 s.

(ii) $s = ut + 1/2at^2$

$s = (49 \times 5) + (0.5 \times -9.8 \times 5^2)$

$s = 245 + (-122.5)$

$s = $ 122.5 m

(i.e., 122.5 m upwards, so height = 122.5 m)

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

$0^2 = 49^2 + (2 \times -9.8 \times s)$

$0 = 2401 + (-19.6\,s)$

$19.6\,s = 2401$

$s = 2401/19.6 = $ 122.5 m

(i.e., 122.5 m upwards, so height = 122.5 m)

Q8

A long-range artillery shell is fired from level ground with a velocity of 500 m s^{-1} at an angle of 30° to the horizontal. Determine:

(a) the greatest **height** the shell reaches;

(b) the **time** taken to reach that height;

(c) the **total time** the shell is in the air;

(d) the **horizontal distance** the shell travels (i.e., its **range**).

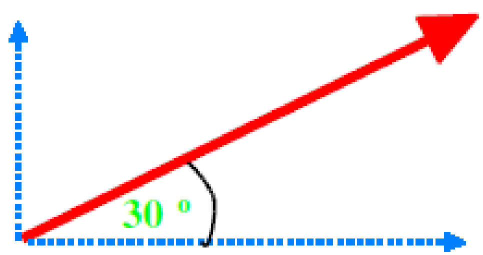
First, resolve the velocity into its horizontal and vertical components:

Vertical component of velocity

= 500 sin 30°

= 500 x 0.5

= 250 m s^{-1}.



Horizontal component of velocity

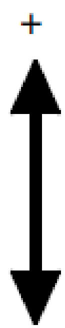
= 500 cos 30°

= 500 x 0.866

= 433 m s^{-1}.

Q8 continued

(a)



v at highest point = 0

gravitational acceleration = $-9.8\ m\ s^{-2}$

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

$0^2 = 250^2 + (2 \times -9.8 \times s)$

$0 = 62\,500 - 19.6\,s$

$19.6\,s = 62\,500$

$s = 62\,500/19.6 =$ **<u>3 189 m</u>** (to nearest metre).

Q8 continued

(b) $v = u + at$

$0 = 250 + (-9.8 \times t)$

$0 = 250 - 9.8\,t$

$9.8\,t = 250$

$t = 250/9.8 =$ **25.5 s**

(c) Total time shell is in air = 2 x 25.5 s = **51 s**

(d) $s_h = v_h t$

$= 433 \times 51$

= **22 083 m right**