PQ 5

Q1

A train, initially travelling at 10 m s^{-1} has an acceleration of 2 m s^{-2} for 4 s. What is its final velocity and how far does it travel while accelerating?

$u = 10 \text{ m s}^{-1}$

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

$t = 4 \text{ s}$

$v = u + at$

$= 10 + (2 \times 4)$

$= \mathbf{18 \text{ m s}^{-1}}$

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

$= (10 \times 4) + (\frac{1}{2} \times 2 \times 4^2)$

$= 40 + 16 = \mathbf{56 \text{ m}}$

Q2

A car, 220 m away from traffic lights, is initially travelling at 44 m s^{-1} and slows to a halt at the traffic lights. What is the deceleration?

$s = 220$ m

$u = 44$ m s^{-1}

$v = 0$ (since the car slows to a halt)

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

$$0 = 44^2 + 2 \times a \times 220$$

$$a = \frac{-(44)^2}{2 \times 220} = -4.4 \text{ m s}^{-2}$$

Q3

A stone is thrown vertically upwards with an initial velocity of 35 m s^{-1}. What is the velocity after 5 s?

u = 35 m s^{-1}

a = -9.8 m s^{-2} (gravity; negative since upwards is taken as positive)

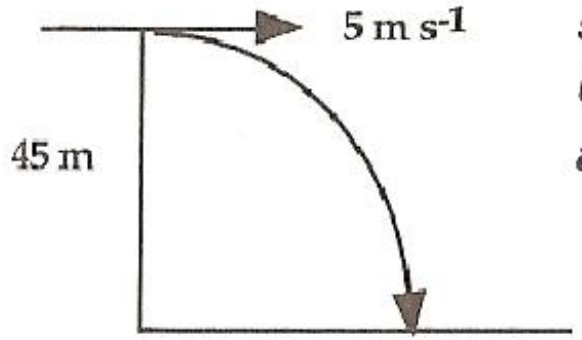
t = 5 s

$$v = u + at$$

$$= 35 + (-9.8 \times 5) = 35 - 49 = \mathbf{-14\ m\ s^{-1}}$$

Q4

A ball is kicked horizontally at 5 m s^{-1} off a 45 m high cliff. Ignoring air resistance find
(a) the time taken for the ball to land,
(b) the distance the ball lands from the foot of the cliff,
(c) the velocity just as the ball lands.



s = 45 m
u = 0 (initial vertical velocity)
a = g = 9.8 m s^{-2} (downwards taken as positive)

Using the vertical motion to find the time, choose the correct equation and complete the calculation.

$$s = ut + \frac{1}{2}at^2 \Rightarrow 45 = 0 \times t + \frac{1}{2} \times 9.8 \times t^2$$

$$\Rightarrow t^2 = \frac{45}{4.9} = 9.2 \Rightarrow t = 3.0 \text{ s}$$

Q4 continued

Use the horizontal motion to find the horizontal distance covered in this time.

$s = V_h t$ (use since constant velocity)

$s = 5 \times 3$

$= 15$ m

Using the vertical motion to find the vertical velocity at the end of the flight, choose the correct equation and complete the calculation.

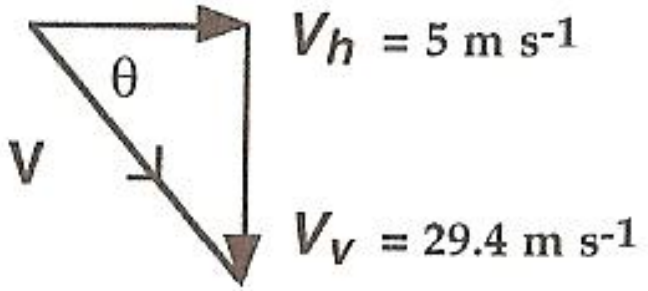
$v = u + at$

$= 0 + (9.8 \times 3)$

$= 29.4 \text{ m s}^{-1}$

Q4 continued

Combine the final horizontal and vertical components of the velocity to find the velocity.



$$|V| = \sqrt{V_h + V_V} = \sqrt{25 + 864}$$

$$|V| = 29.8 \text{ m s}^{-1}$$

$$\theta = \tan^{-1}\left(\frac{29.4}{5}\right) = 80^{o}$$

Q5

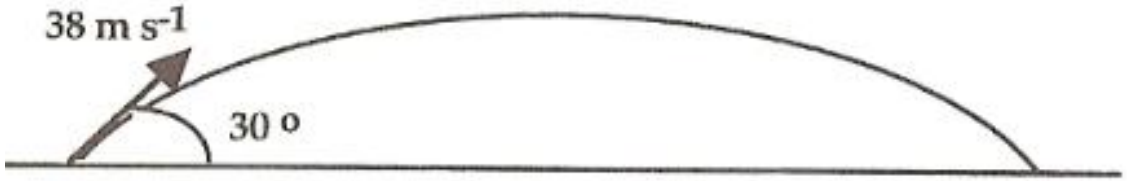
A golf ball is hit at 38 m s^{-1} at an angle of 30° to the horizontal. Find

(a) the total time of flight,

(b) the maximum height reached,

(c) the range of the golf ball.

Sketch the trajectory and calculate the horizontal and vertical components of velocity.



$V_h = V \cos\theta = 38 \cos 30 = 33 \text{ m s}^{-1}$

$V_v = V \sin\theta = 38 \sin 30 = 19 \text{ m s}^{-1}$

Q5 continued

Consider the vertical motion to find the time of flight.

$u = 19 \text{ m s}^{-1}$ (upwards taken as positive)

$v = 0$ (at the top of the flight)

$a = g = -9.8 \text{ m s}^{-2}$ (negative since g acts downwards)

$$\text{Time to top of flight} = \frac{v - u}{a} = \frac{0 - 19}{-9.8} = 1.9 \text{ s}$$

Total time of flight = 2 x time to top = **3.8 s**

Q5 continued

Use equation of motion to find height.

$$v^2 = u^2 + 2as$$
$$0 = 19^2 - 2 \times 9.8\, s$$
$$19.6\, s = 361$$
$$s = \mathbf{18.4\ m}$$

Consider horizontal motion to find range.

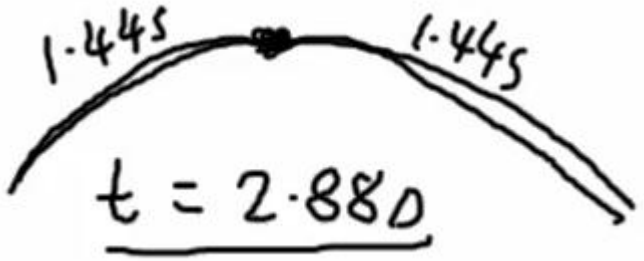
$$s = V_h t \quad \text{(use since constant velocity)}$$
$$s = 33 \times 3.8$$
$$s = \mathbf{125\ m}$$

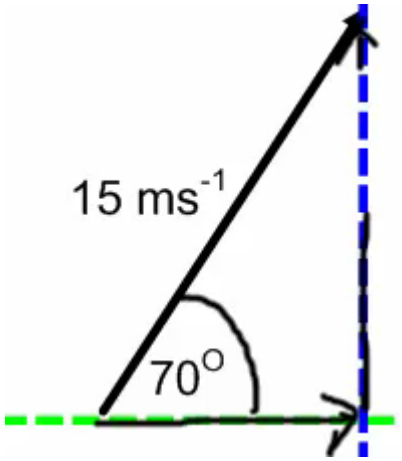
Q6

(a) Find the horizontal & vertical components

(b) Show that the golf ball is in the air for 2.87s

(c) Find the horizontal distance travelled





$v_v = 15 \times \sin 70^\circ$

$= 14.1\ ms^{-1}$

Vertical Info

- u = 14·1 ms⁻¹
- v = 0 m/s
- a = −9·8 ms⁻²
- S
- t = ?

$V = u + at$

$t = \frac{V-u}{a}$

$= \frac{(0-14.1)}{-9.8}$

$= 1.44s$

Horizontal info

$d = v_h \times t$

$d = 5.1 \times 2.88$

$d = 14.7m$

Q7

A car initially travelling at 10ms^{-1} accelerates at 0.5ms^{-2} for 8 seconds. Find its speed after this time interval.

$u = 10\ \text{ms}^{-1}$

$a = 0.5\ \text{ms}^{-2}$

$t = 8\ \text{s}$

$v = ?\ \text{ms}^{-1}$

$$\begin{aligned} v &= u + at \\ &= 10 + 0.5 \times 8 \\ &= 10 + 4 \\ &= 14\ \text{ms}^{-1} \end{aligned}$$

Q8

A hedgehog crossing a road has an initial speed of 0.3 ms^{-1} and accelerates uniformly at 0.04 ms^{-2}. If the hedgehog takes 10 seconds to cross the road, calculate the width of the road.

$u = 0.3 \text{ ms}^{-1}$

$a = 0.04 \text{ ms}^{-2}$

$t = 10 \text{ s}$

$s = ? \text{ m}$

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

$= 0.3 \times 10 + \frac{1}{2} \times 0.04 \times 10^2$

$= 3 + 2$

$= 5 \text{ m}$

So the width of the road is 5 metres.

Q9

A satellite has an initial speed of 500 ms^{-1}. The retro rockets are fired, causing a deceleration of 15 ms^{-2}. Calculate the distance over which the speed will fall to 200 ms^{-1}.

$u = 500 \text{ ms}^{-1}$

$a = -15 \text{ ms}^{-2}$

$v = 200 \text{ ms}^{-1}$

$s = ?$ m

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

$$2as = v^2 - u^2$$

$$s = \frac{v^2 - u^2}{2a}$$

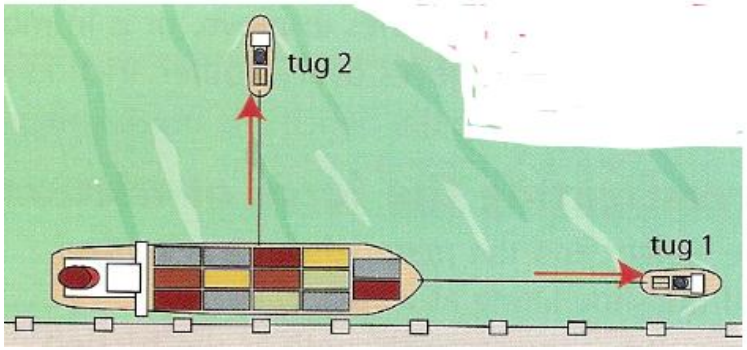
$$= \frac{200^2 - 500^2}{2 \times (-15)}$$

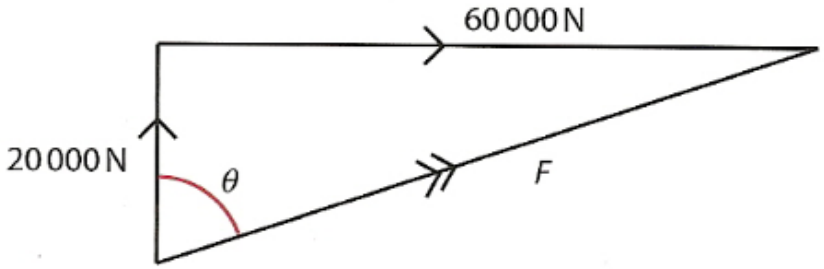
$$= 7000 \text{ m}$$

So the distance is 7 kilometres.

Q10

Two tugs pull a ship off a pier. One pulls forward with a force of 60 000 N while the other pulls sideways with a force of 20 000 N. Calculate the resultant force on the ship.





$F = \sqrt{(20\,000^2 + 60\,000^2)} = 63\,245\ \text{N}$

$\tan\theta = \text{opp} / \text{adj} = 60\,000/20\,000 = 3$

$\theta = 71.6°$