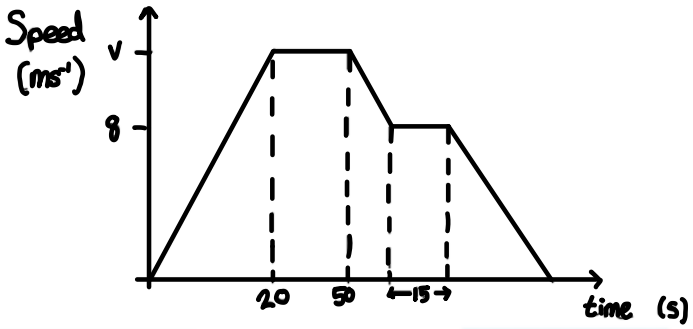
Exam Questions – SUVAT (Mechanics Chapter 8 and 9)

Q1.

A car starts from rest and moves with constant acceleration along a straight horizontal road. The car reaches a speed of V m s^{-1} in 20 seconds. It moves at constant speed V m s^{-1} for the next 30 seconds, then moves with constant deceleration $\frac{1}{2}$ m s^{-2} until it has speed 8 m s^{-1}. It moves at speed 8 m s^{-1} for the next 15 seconds and then moves with constant deceleration $\frac{1}{3}$ m s^{-2} until it comes to rest.

(a) Sketch, in the space below, a speed-time graph for this journey.



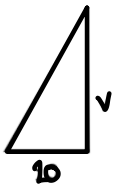
(3)

In the first 20 seconds of this journey the car travels 140 m.

Find

(b) the value of V,

area under graph for first 20s = 140m



$\frac{20 \times V}{2} = 140$

$10V = 140$

$V = 14 ms^{-1}$

(2)

(c) the total time for this journey,

At 50 seconds

$s =$
$u = 14$
$v = 8$
$a = -\frac{1}{2}$
$t = x$

$v = u + at$
$8 = 14 - \frac{1}{2}x$
$\frac{1}{2}x = 14 - 8$
$\frac{1}{2}x = 6$
$x = 12s$

Last section of Journey

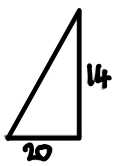
$s =$
$u = 8$
$v = 0$
$a = -\frac{1}{3}$
$t = x$

$v = u + at$
$0 = 8 - \frac{1}{3}x$
$\frac{1}{3}x = 8$
$x = 24s$

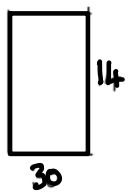
$50 + 12 + 15 + 24$
$= 101$ seconds

(4)

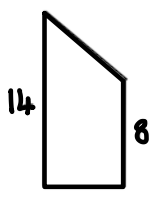
(d) the total distance travelled by the car.



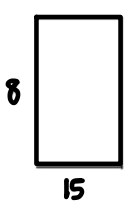
$\frac{20 \times 14}{2} = 140m$



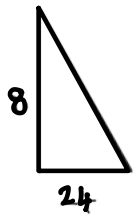
$30 \times 14 = 420m$



$\frac{14 + 8}{2} \times 12$
$= 11 \times 12$
$= 132m$



$15 \times 8 = 120m$



$\frac{8 \times 24}{2} = 96m$

$140 + 420 + 132 + 120 + 96$
$= 908 m$

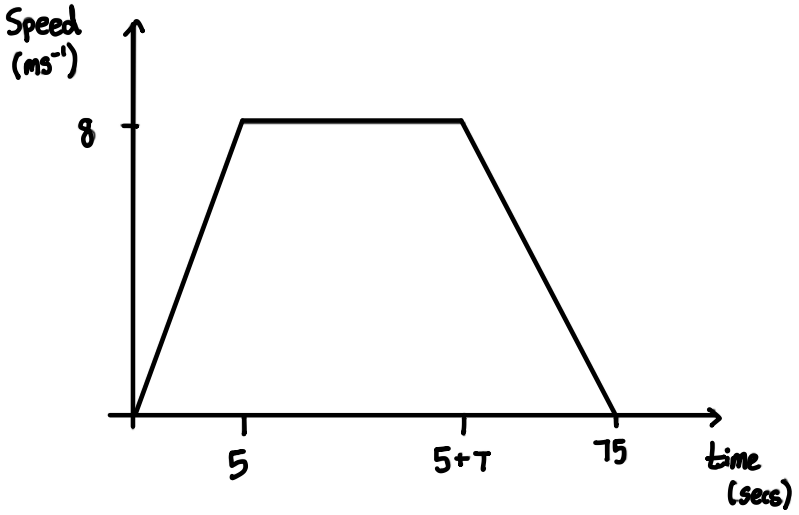
(4)

(Total 13 marks)

Q2.

An athlete runs along a straight road. She starts from rest and moves with constant acceleration for 5 seconds, reaching a speed of 8 m s^{-1}. This speed is then maintained for *T* seconds. She then decelerates at a constant rate until she stops. She has run a total of 500 m in 75 s.

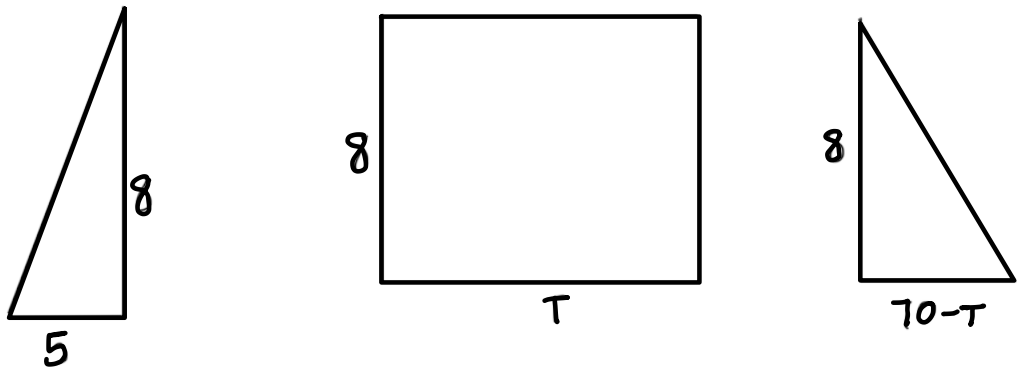
(a) In the space below, sketch a speed-time graph to illustrate the motion of the athlete.



(b) Calculate the value of *T*.

(3)

$75 - (5 + T)$
$= 70 - T$



Total distance = 500m

$$\frac{8 \times 5}{2} + 8T + \frac{8(70-T)}{2} = 500$$

$$20 + 8T + 4(70-T) = 500$$

$$8T + 280 - 4T = 480$$

$$4T = 200$$

$$T = 50 \text{ secs}$$

(5)

(Total 8 marks)

Q3.

A particle P is projected vertically upwards from a point A with speed u m s^{-1}. The point A is 17.5 m above horizontal ground. The particle P moves freely under gravity until it reaches the ground with speed 28 m s^{-1}.

(a) Show that $u = 21$

(start to end)

$s = -17.5$
$u = u$
$v = -28$
$a = -9.8$
t

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

$(-28)^2 = u^2 + 2 \times -9.8 \times -17.5$

$784 = u^2 + 343$

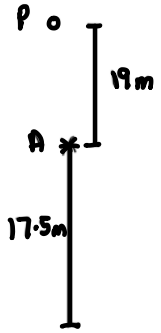
$441 = u^2$

$u = 21 \text{ ms}^{-1}$

(3)

At time t seconds after projection, P is 19 m above A.

(b) Find the possible values of t.



(start to 19m above A)

$s = 19$
$u = 21$
v
$a = -9.8$
$t = t$

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

$19 = 21t + \frac{1}{2}(-9.8)t^2$

$0 = -4.9t^2 + 21t - 19$

$0 = 4.9t^2 - 21t + 19$

$t = \frac{21 \pm \sqrt{21^2 - 4 \times 4.9 \times 19}}{2 \times 4.9}$

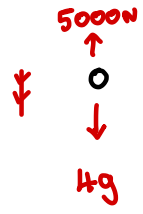
$t = 2.99\text{s}$ or $t = 1.30\text{s}$

(5)

Forces Chapter 10

The ground is soft and, after P reaches the ground, P sinks vertically downwards into the ground before coming to rest. The mass of P is 4 kg and the ground is assumed to exert a constant resistive force of magnitude 5000 N on P.

(c) Find the vertical distance that P sinks into the ground before coming to rest.



$F = ma$

$4g - 5000 = 4a$

$-4960.8 = 4a$

$a = -1240.2 \text{ ms}^{-2}$

(after hits floor)

$s = x$
$u = 28$
$v = 0$
$a = -1240.2$
t

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

$0^2 = 28^2 + 2 \times -1240.2 \times x$

$2480.4x = 784$

$x = 0.316\text{m}$

(4)

(Total 12 marks)

Q4.

A small stone is projected vertically upwards with speed 39.2 m s^{-1} from a point O.

The stone is modelled as a particle moving freely under gravity from when it is projected until it hits the ground 10 s later.

Using the model, find

(a) the height of O above the ground,

(Start until end)

+ ↑

$s = -x$

$u = 39.2$

$v =$

$a = -9.8$

$t = 10$

↑ O, x

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

$-x = 39.2 \times 10 + \frac{1}{2} \times -9.8 \times 10^2$

$-x = -98$

$x = 98$ m

(3)

(b) the total length of time for which the speed of the stone is less than or equal to 24.5 m s^{-1}

+ ↑

Start until speed $24.5 ms^{-1}$

$s =$

$u = 39.2$

$v = 24.5$

$a = -9.8$

$t = x$

$v = u + at$

$24.5 = 39.2 + -9.8x$

$9.8x = 14.7$

$x = 1.5$

Start until going down with speed $24.5 ms^{-1}$

+ ↑

s

$u = 39.2$

$v = -24.5$

$a = -9.8$

$t = x$

$v = u + at$

$-24.5 = 39.2 - 9.8x$

$9.8x = 63.7$

$x = 6.5$

time less $= 6.5 - 1.5$

$= 5$ seconds

(3)

(c) State one refinement that could be made to the model that would make your answer to part (a) more accurate.

We could include air resistance, as this would mean the acceleration would be lower.

(1)

(Total for question = 7 marks)

Q5.

At time $t = 0$, a small stone is thrown vertically upwards with speed 14.7 m s^{-1} from a point A.

At time $t = T$ seconds, the stone passes through A, moving downwards.

The stone is modelled as a particle moving freely under gravity throughout its motion.

Using the model,

(a) find the value of T,

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

+ ↑

Start until back at A

$s = 0$

$u = 14.7$

$v =$

$a = -9.8$

$t = x$

$0 = 14.7x + \frac{1}{2} \times -9.8 \times x^2$

$0 = 14.7x - 4.9x^2$

$0 = x(14.7 - 4.9x)$

$x = 0$ or $14.7 - 4.9x = 0$

$14.7 = 4.9x$

$x = 3$ //

(2)

(b) find the total distance travelled by the stone in the first 4 seconds of its motion.

Distance travelled in 3 secs

+ ↑ Max distance from A

$s = x$

$u = 14.7$

$v = 0$

$a = -9.8$

t

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

$0 = 14.7^2 + 2 \times -9.8 \times x$

$19.6x = 14.7^2$

$x = 11.025$

$11.025 \times 2 = 22.05$ m

up to 4 seconds

+ ↑

$s = -x$

$u = 14.7$

v

$a = -9.8$

$t = 4$

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

$-x = 14.7 \times 4 + \frac{1}{2} \times -9.8 \times 4^2$

$-x = -19.6$

$x = 19.6$m

Total distance

$= 22.05 + 19.6$

$= 41.65$m

$= 41.7$m (3 sf) //

(4)

(c) State one refinement that could be made to the model, apart from air resistance, that would make the model more realistic.

Taking into account the dimensions of the stone,

(1)

(Total for question = 7 marks)