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Candidate surname					Other names									
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Wednesday 22 May 2019														
Morning							Paper Reference 8MA0-22							
Mathematics Advanced Subsidiary Paper 22: Mechanics														
You must have: Mathematical Formulae and Statistical Tables, calculator												Total Marks		

Candidates may use any calculator allowed by Pearson regulations. Calculators must not have the facility for symbolic algebra manipulation, differentiation and integration, or have retrievable mathematical formulae stored in them.

Instructions

- Use **black** ink or ball-point pen.
- If pencil is used for diagrams/sketches/graphs it must be dark (HB or B).
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions and ensure that your answers to parts of questions are clearly labelled.
- Answer the questions in the spaces provided
– *there may be more space than you need.*
- You should show sufficient working to make your methods clear. Answers without working may not gain full credit.
- Answers should be given to three significant figures unless otherwise stated.

Information

- A booklet 'Mathematical Formulae and Statistical Tables' is provided.
- The total mark for this part of the examination is 30. There are 3 questions.
- The marks for **each** question are shown in brackets
– *use this as a guide as to how much time to spend on each question.*
- Unless otherwise indicated, wherever a value of g is required, take $g = 9.8 \text{ m s}^{-2}$ and give your answer to either 2 significant figures or 3 significant figures.

Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ►

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Answer ALL questions. Write your answers in the spaces provided.

1. At time $t = 0$, a parachutist falls vertically from rest from a helicopter which is hovering at a height of 550 m above horizontal ground.

The parachutist, who is modelled as a particle, falls for 3 seconds before her parachute opens.

While she is falling, and before her parachute opens, she is modelled as falling freely under gravity.

The acceleration due to gravity is modelled as being 10 ms^{-2} .

- (a) Using this model, find the speed of the parachutist at the instant her parachute opens. (1)

When her parachute is open, the parachutist continues to fall vertically.

Immediately after her parachute opens, she decelerates at 12 ms^{-2} for 2 seconds before reaching a constant speed and she reaches the ground with this speed.

The total time taken by the parachutist to fall the 550 m from the helicopter to the ground is T seconds.

- (b) Sketch a speed-time graph for the motion of the parachutist for $0 \leq t \leq T$. (2)
- (c) Find, to the nearest whole number, the value of T . (5)

In a refinement of the model of the motion of the parachutist, the effect of air resistance is included before her parachute opens and this refined model is now used to find a new value of T .

- (d) How would this new value of T compare with the value found, using the initial model, in part (c)? (1)
- (e) Suggest one further refinement to the model, apart from air resistance, to make the model more realistic. (1)

$$\begin{aligned} a/ \quad v &= u + at \\ &= 0 + 10(3) \\ &= \underline{\underline{30 \text{ ms}^{-1}}} \end{aligned}$$

$$\begin{aligned} b/ \quad \text{At 3 seconds } & 30 \text{ ms}^{-1} \\ \text{At 5 seconds } & 6 \text{ m s}^{-1} \quad [30 - 2(12) = 6] \end{aligned}$$



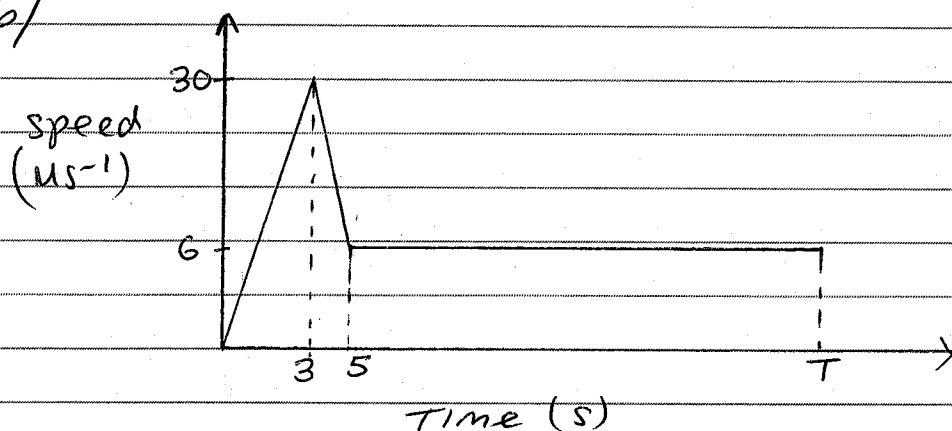
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Question 1 continued

b/



c/ Area under graph = 550

$$\frac{1}{2}(3)(30) + \frac{1}{2}(6+30) \times 2 + (T-5)6 = 550$$

$$81 + 6T - 30 = 550$$

$$6T = 499$$

$$T = 83.16$$

$$= \underline{\underline{83}}$$

d/ T would increase

e/ A more accurate value of g could be used



2.

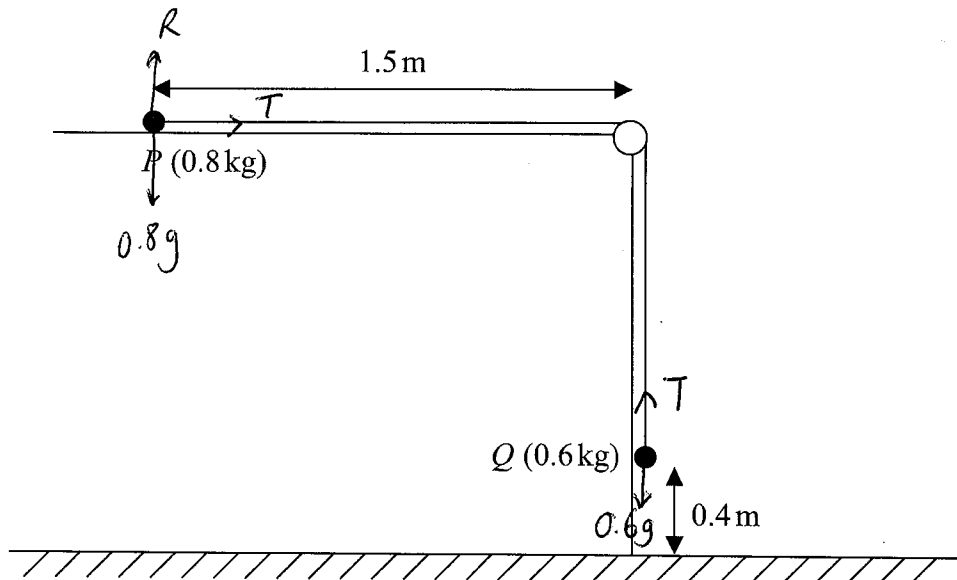


Figure 1

A small ball, P , of mass 0.8 kg , is held at rest on a smooth horizontal table and is attached to one end of a thin rope.

The rope passes over a pulley that is fixed at the edge of the table.

The other end of the rope is attached to another small ball, Q , of mass 0.6 kg , that hangs freely below the pulley.

Ball P is released from rest, with the rope taut, with P at a distance of 1.5 m from the pulley and with Q at a height of 0.4 m above the horizontal floor, as shown in Figure 1.

Ball Q descends, hits the floor and does not rebound.

The balls are modelled as particles, the rope as a light and inextensible string and the pulley as small and smooth.

possible limitations for (c)

Using this model,

- (a) show that the acceleration of Q , as it falls, is 4.2 m s^{-2} (5)
- (b) find the time taken by P to hit the pulley from the instant when P is released. (6)
- (c) State one limitation of the model that will affect the accuracy of your answer to part (a). (1)

$$\begin{aligned} \text{a) } Q: F &= ma & P: T &= 0.8a \\ 0.6g - T &= 0.6a \end{aligned}$$

$$0.6g - 0.8a = 0.6a$$

$$0.6g = 1.4a$$

$$a = \frac{0.6g}{1.4} = \underline{\underline{4.2\text{ m s}^{-2}}}$$



Question 2 continued

b/ First 0.4 m

$$\begin{aligned}s &= 0.4 \\ u &= 0 \\ v &= ? \\ a &= 4.2 \\ t &= ?\end{aligned}$$

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

$$0.4 = \frac{1}{2}(4.2)t^2$$

$$0.4 = 2.1t^2$$

$$t^2 = \frac{0.4}{2.1}$$

$$t = 0.436 \text{ s}$$

$$\begin{aligned}v &= u + at \\ &= 4.2(0.436) \\ &= 1.83 \text{ ms}^{-1}\end{aligned}$$

Next 1.1 m (constant speed)

$$\text{speed} = \frac{\text{distance}}{\text{time}}$$

$$\text{time} = \frac{\text{distance}}{\text{speed}}$$

$$\begin{aligned}&= \frac{1.1}{1.83} \\ &= 0.601 \text{ s}\end{aligned}$$

$$\text{Total time} = 0.436 + 0.601 = \underline{\underline{1.04 \text{ s}}}$$

c/ The rope may not be inextensible

(Total for Question 2 is 12 marks)



3. A particle, P , moves along a straight line such that at time t seconds, $t \geq 0$, the velocity of P , $v \text{ ms}^{-1}$, is modelled as

$$v = 12 + 4t - t^2$$

Find

- (a) the magnitude of the acceleration of P when P is at instantaneous rest, (5)
- (b) the distance travelled by P in the interval $0 \leq t \leq 3$ (3)

a) instantaneous rest when $v = 0$

$$0 = 12 + 4t - t^2$$
$$0 = (6 - t)(2 + t)$$

$$t = 6 \quad t = -2$$

6 t is greater than zero

$$a = \frac{dv}{dt} = 4 - 2t$$

$$= 4 - 2(6)$$

$$= 4 - 12$$

$$= -8$$

$$|a| = \underline{\underline{8 \text{ ms}^{-2}}}$$

b) $s = \int v \, dt$

$$s = 12t + 2t^2 - \frac{1}{3}t^3 + C$$

when $t = 3$

$$s = 12(3) + 2(3)^2 - \frac{1}{3}(3)^3$$

$$= \underline{\underline{45 \text{ m}}}$$

