Please check the examination details below before entering your candidate information

| Candidate surname | Other names |
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| | |

**Pearson Edexcel Level 3 GCE**

Centre Number | Candidate Number

**Paper reference** **8MA0/22**

# Mathematics

## Advanced Subsidiary
## PAPER 22: Mechanics

**You must have:**
Mathematical Formulae and Statistical Tables (Green), 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.
- 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.

## 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.*

## 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.
- Good luck with your examination.

*Turn over*

**1.** At time $t = 0$, a small stone is thrown vertically upwards with speed $14.7\,\mathrm{m\,s^{-1}}$ 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 $T$,

**(2)**

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

**(4)**

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

**(1)**

a) $t=0$ $t=T$

$u=14.7 \uparrow (A) \downarrow$

$s=0$
$u=14.7$
$v=$
$a=-g$
$t=T$

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

$0=14.7T-\frac{g}{2}T^2$ (1)

$0=T(14.7-4.9T)$

$T=0$ or $14.7-4.9T=0$

$T=\frac{14.7}{4.9}=3$

$\therefore T=3$ (1)

b) separate distances going up and going down:

up:
$s=s_1$
$u=14.7$
$v=0$
$a=-g$
$t=1.5$

" $s=\frac{u+v}{2}t$ "

$s_1=\frac{14.7+0}{2}\times 1.5$ (1)

$s_1=11.025$

down:
$s=s_2$
$u=0$
$v=$
$a=g$
$t=2.5$

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

$s_2=0+\frac{1}{2}g(2.5)^2$ (1)

$s_2=30.625$

(1)

Total distance $=s_1+s_2=11.025+30.625=41.65\text{m}=42\text{m}$ (2sf) (1)

c) account for dimensions of the stone (1)



P 6 6 8 0 7 A 0 2 1 2

**Question 1 continued**

**(Total for Question 1 is 7 marks)**

**2.** A particle $P$ moves along a straight line.

At time $t$ seconds, the velocity $v\,\text{m}\,\text{s}^{-1}$ of $P$ is modelled as

$$v = 10t - t^2 - k \qquad t \geqslant 0$$

where $k$ is a constant.

(a) Find the acceleration of $P$ at time $t$ seconds.

**(2)**

The particle $P$ is instantaneously at rest when $t = 6$

(b) Find the other value of $t$ when $P$ is instantaneously at rest.

**(4)**

(c) Find the total distance travelled by $P$ in the interval $0 \leqslant t \leqslant 6$

**(4)**

a) $a = \frac{dv}{dt}$ $\quad v = 10t - t^2 - k$

$\frac{dv}{dt} = 10 - 2t$ (2)

b) instantaneously at rest when $v = 0$

$\therefore v = 0$ when $t = 6$

$0 = 10(6) - (6)^2 - k$

$0 = 60 - 36 - k$

$k = 24$ (1)

$v = 10t - t^2 - 24$ ↓ set $v = 0$

$0 = 10t - t^2 - 24$

$0 = t^2 - 10t + 24$ (1)

$= (t-6)(t-4)$ (1)

$\therefore t = 6$ already found or $t = 4$ (1)

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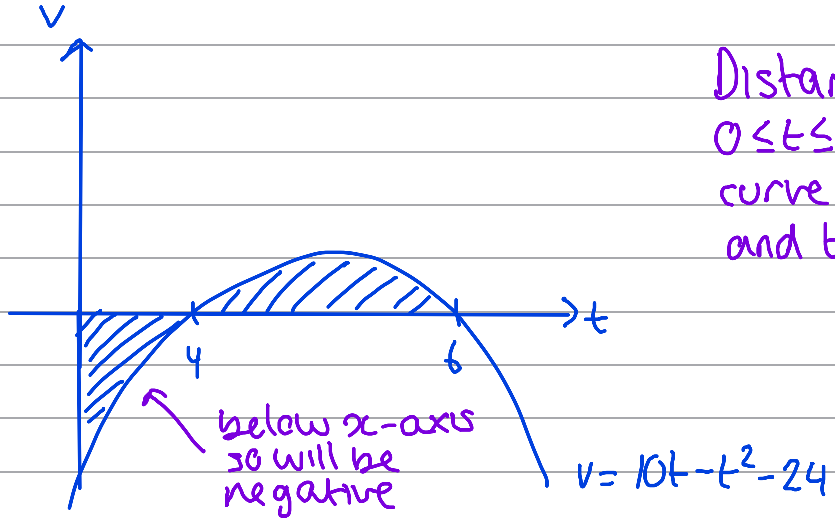
**Question 2 continued**

c)




Distance travelled $0 \le t \le 6$ = area under curve between t = 0 and t = 6

$$= -\int_0^4 (10t - t^2 - 24)\,dt + \int_4^6 (10t - t^2 - 24)\,dt \quad (1)$$

$$= -\left[5t^2 - \frac{1}{3}t^3 - 24t\right]_0^4 + \left[5t^2 - \frac{1}{3}t^3 - 24t\right]_4^6 \quad (1)\ (1)$$

$$= -\left(-\frac{112}{3} - 0\right) + \left(-36 + \frac{112}{3}\right)$$

$$= \frac{116}{3}\ \text{m} \quad (1)$$

**Question 2 continued**

**Question 2 continued**

**(Total for Question 2 is 10 marks)**

**3.**

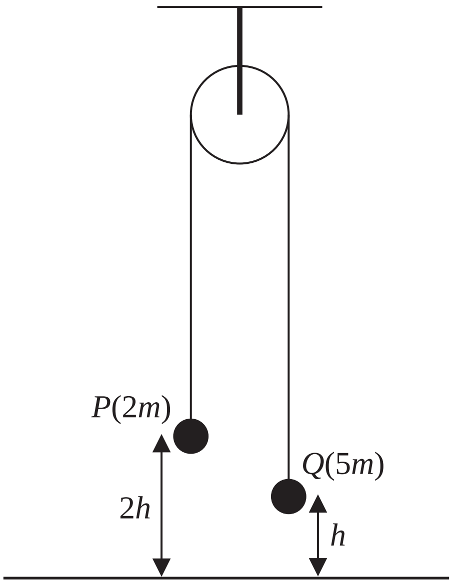



**Figure 1**

A ball $P$ of mass $2m$ is attached to one end of a string.

The other end of the string is attached to a ball $Q$ of mass $5m$.

The string passes over a fixed pulley.

The system is held at rest with the balls hanging freely and the string taut.

The hanging parts of the string are vertical with $P$ at a height $2h$ above horizontal ground and with $Q$ at a height $h$ above the ground, as shown in Figure 1.

The system is released from rest.

In the subsequent motion, $Q$ does not rebound when it hits the ground and $P$ does not hit the pulley.

The balls are modelled as particles.

The string is modelled as being light and inextensible.

The pulley is modelled as being small and smooth.

Air resistance is modelled as being negligible.

Using this model,

(a) (i) write down an equation of motion for $P$,

(ii) write down an equation of motion for $Q$,

**(4)**

(b) find, in terms of $h$ only, the height above the ground at which $P$ first comes to instantaneous rest.

**(7)**

(c) State one limitation of modelling the balls as particles that could affect your answer to part (b).

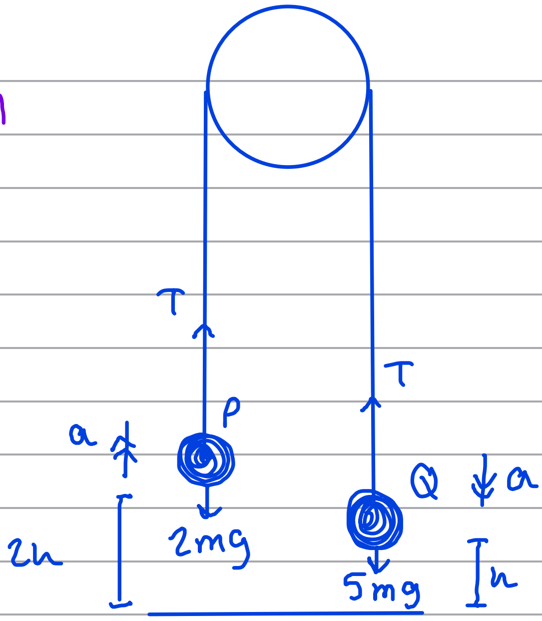
**(1)**

In reality, the string will not be inextensible.

(d) State how this would affect the accelerations of the particles.

**(1)**

**Question 3 continued**




a) (i) Always resolve in the direction of acceleration, using F = ma.

For P, R(↑): $T - 2mg = 2ma$ ①

②

(ii)

For Q, R(↓): $5mg - T = 5ma$ ②

②

b) can solve ① and ② simultaneously to find acceleration

① + ②: $T - 2mg + 5mg - T = 2ma + 5ma$ ①

$3mg = 7ma$

$a = \frac{3}{7}g$ ①

When Q hits ground it has moved down h, so P has moved up h. ∴ when Q hits ground P is 3h above ground. When Q hits ground, string goes slack (no more tension) so P moves freely under gravity.

speed at which Q hits ground:

$s = h$
$u = 0$
$v = v$
$a = \frac{3g}{7}$
$t =$

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

$v^2 = 0 + 2 \times \frac{3g}{7} \times h$

$v^2 = 8.4h$ ①

$v = \sqrt{8.4h}$

distance P moves after Q hits:

$s = H$
$u = \sqrt{8.4h}$
$v = 0$
$a = -g$
$t =$

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

$0 = 8.4h - 2Hg$ ①

$H = \frac{3h}{7}$ ①

speed of P = speed of Q while string is taut.

①

total distance above ground of P $= 3h + \frac{3h}{7} = \frac{24h}{7}$ ①

**Question 3 continued**

c) Q will not fall exactly h metres (1)

d) the accelerations of the balls would not have equal magnitude. (1)

**Question 3 continued**

**Question 3 continued**

**(Total for Question 3 is 13 marks)**

**TOTAL FOR MECHANICS IS 30 MARKS**