Please check the examination details below before entering your candidate information

Candidate surname	Other names

Centre Number

Candidate Number

Pearson Edexcel Level 3 GCE

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 4 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.

Turn over

Q:1/1/1/

Pearson

1. The point A is 1.8 m vertically above horizontal ground.

At time $t = 0$, a small stone is projected vertically upwards with speed $U\,\text{m s}^{-1}$ from the point A.

At time $t = T$ seconds, the stone hits the ground.

The speed of the stone as it hits the ground is $10\,\text{m s}^{-1}$

In an initial model of the motion of the stone as it moves from A to where it hits the ground

- the stone is modelled as a particle moving freely under gravity
- **the acceleration due to gravity is modelled as having magnitude $10\,\text{m s}^{-2}$**

Using the model,

(a) find the value of U,

(3)

(b) find the value of T.

(2)

(c) Suggest one refinement, apart from including air resistance, that would make the model more realistic.

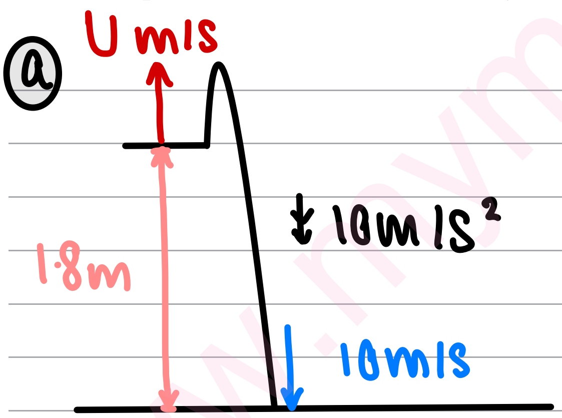
(1)

In reality the stone will not move freely under gravity and will be subject to air resistance.

(d) Explain how this would affect your answer to part (a).

(1)

(a)



using $v^2 - u^2 = 2as$
treating upwards (↑) as positive

$v = -10$
$u = u$
$a = -10$
$s = -1.8$

$(-10)^2 - (u)^2 = 2 \times -10 \times -1.8$

$100 - u^2 = 36$

$u^2 = 64$

$\therefore u = 8$ m/s

(b) $t = T$
$u = 8$
$v = -10$
$a = -10$

using $v = u + at$

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

$T = \frac{-10-8}{-10} = 1.8s$

$T = 1.8s$

(c) use a more accurate value for g

(d) the initial velocity will be greater than the value calculated in (a)

As air resistance slows down the stone faster than otherwise, so it must start at a higher velocity to reach a velocity of -10 m/s after t seconds still.

2. A train travels along a straight horizontal track from station P to station Q.

In a model of the motion of the train, at time $t = 0$ the train starts from rest at P, and moves with constant acceleration until it reaches its maximum speed of $25\,\text{m s}^{-1}$

The train then travels at this constant speed of $25\,\text{m s}^{-1}$ before finally moving with constant deceleration until it comes to rest at Q.

The time spent decelerating is four times the time spent accelerating.

The journey from P to Q takes 700 s.

Using the model,

(a) sketch a speed-time graph for the motion of the train between the two stations P and Q. **(1)**

The distance between the two stations is 15 km.

Using the model,

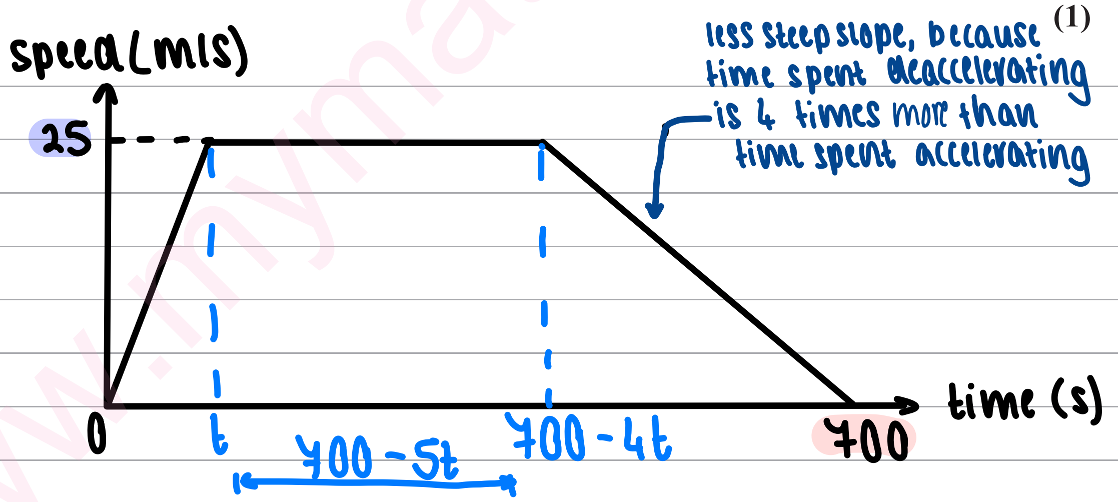
(b) show that the time spent accelerating by the train is 40 s, **(3)**

(c) find the acceleration, in m s^{-2}, of the train, **(1)**

(d) find the speed of the train 572 s after leaving P. **(2)**

(e) State one limitation of the model which could affect your answers to parts (b) and (c). **(1)**

(a)



(b) area under the curve = distance = 15 km = 15,000 m

time spent accelerating = t
time spent deaccelerating = 4t

Question 2 continued

using the formula area of a trapezium $= \frac{1}{2}(a+b) \times h$

$15{,}000 = \frac{1}{2}(700 + 700 - 5t) \times 25$

$15000 = 25\left(\frac{1400 - 5t}{2}\right)$

$\frac{15000}{25} \times 2 = 1400 - 5t$

$1200 = 1400 - 5t$

$5t = 200$

$t = 40$

(c) using $a = \frac{v-u}{t}$

where:

$u = 0$

$v = 25$

$t = 40$

$a = a$

$a = \frac{25 - 0}{40}$

$a = \frac{5}{8} = 0.625 \text{ m/s}^2$

(d) first we need to determine the time at which the train begins to deaccelerate

this occurs at $700 - 4t$ seconds

using $t = 40$ from part a: $700 - 4(40) = 540\text{s}$

Question 2 continued

∴ at 570s, the train has been deaccelerating for 30 s

We also know that the magnitude of deacceleration is 1/4 of the magnitude of the acceleration

So deacceleration $= \frac{5}{8} \times \frac{1}{4} = -\frac{5}{32}$ m/s²

using $v = u + at$

$u = 25$
$a = -5/32$
$t = 30$
$v = v$

$v = 25 + -5/32(30)$

$v = 20.3125$ m/s

$v = 20$ m/s to 3sf.

3. A fixed point O lies on a straight line.

A particle P moves along the straight line.

At time t seconds, $t \geqslant 0$, the distance, s metres, of P from O is given by

$$s = \frac{1}{3}t^3 - \frac{5}{2}t^2 + 6t$$

(a) Find the acceleration of P at each of the times when P is at instantaneous rest. **(6)**

(b) Find the total distance travelled by P in the interval $0 \leqslant t \leqslant 4$ **(3)**

ⓐ P is at rest when $v = 0$

$s = \frac{1}{3}t^3 - \frac{5}{2}t^2 + 6t$

$v = \frac{ds}{dt}$

$v = t^2 - 5t + 6 = 0$

$(t-2)(t-3) = 0$

$t = 2$ or 3

∴ it is instantaneously at rest when $t = 2$ and $t = 3$

acceleration $= \frac{dv}{dt}$

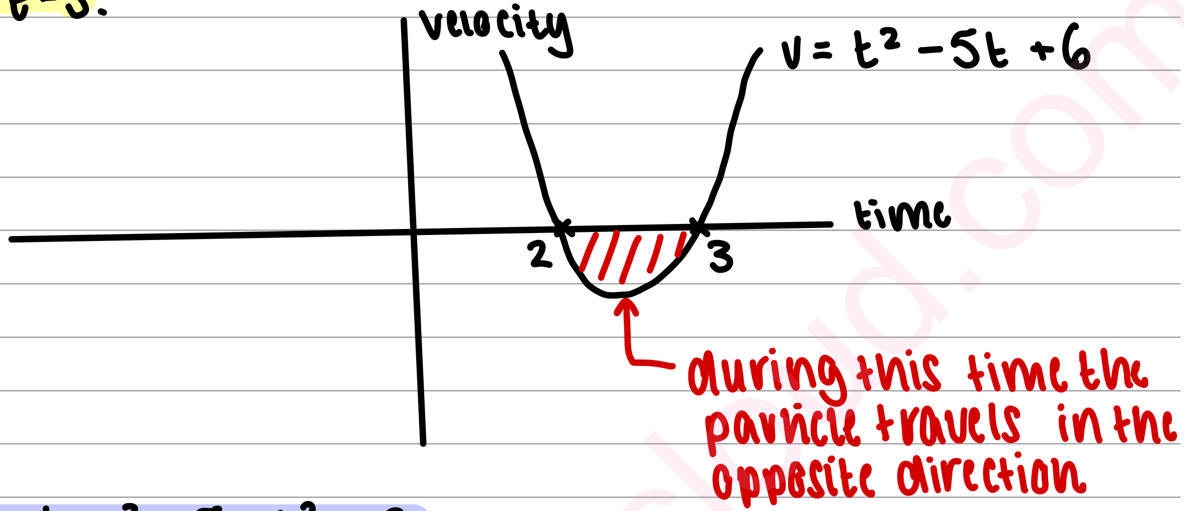
$\frac{dv}{dt} = 2t - 5$

acceleration when $t = 2$: $2(2) - 5 = -1\ \text{m/s}^2$

acceleration when $t = 3$: $2(3) - 5 = 1\ \text{m/s}^2$

Question 3 continued

(b) The particle will be instantaneously at rest before it changes direction. From part (a) we know the particle was travelling in the opposite direction between $t=2$ and $t=3$.



$s = \frac{1}{3}t^3 - \frac{5}{2}t^2 + 6t$

So total distance $= (S_2 - S_0) + (S_2 - S_3) + (S_4 - S_3)$

$S_0 = 0$

$S_2 = \frac{1}{3}(2)^3 - \frac{5}{2}(2)^2 + 6(2) = \frac{14}{3}$

$S_3 = \frac{1}{3}(3)^3 - \frac{5}{2}(3)^2 + 6(3) = \frac{9}{2}$

$S_4 = \frac{1}{3}(4)^3 - \frac{5}{2}(4)^2 + 6(4) = \frac{16}{3}$

total distance $= (\frac{14}{3} - 0) + (\frac{14}{3} - \frac{9}{2}) + (\frac{16}{3} - \frac{9}{2})$

$= 5\frac{2}{3}$ meters

4.

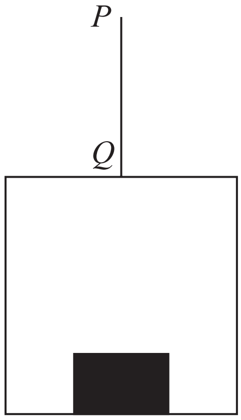


Figure 1

A vertical rope PQ has its end Q attached to the top of a small lift cage.

The lift cage has mass 40 kg and carries a block of mass 10 kg, as shown in Figure 1.

The lift cage is raised vertically by moving the end P of the rope vertically upwards with constant acceleration $0.2\,\text{m}\,\text{s}^{-2}$

The rope is modelled as being light and inextensible and air resistance is ignored.

Using the model,

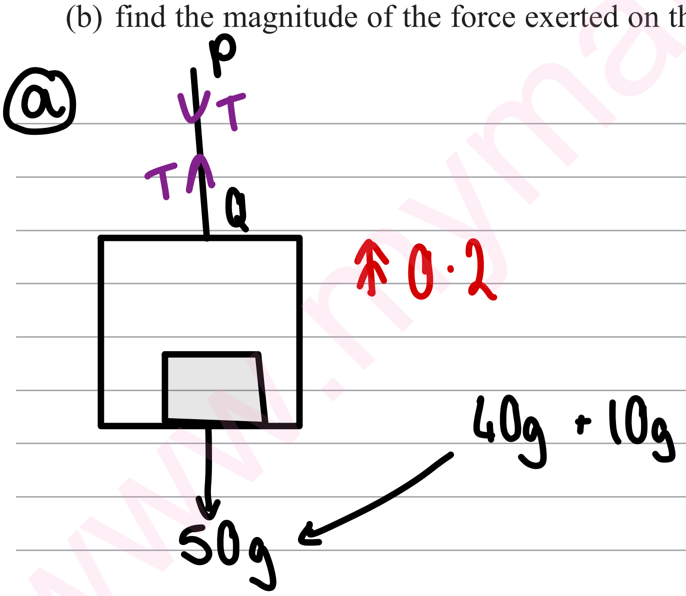
(a) find the tension in the rope PQ

(3)

(b) find the magnitude of the force exerted on the block by the lift cage.

(3)

(a)



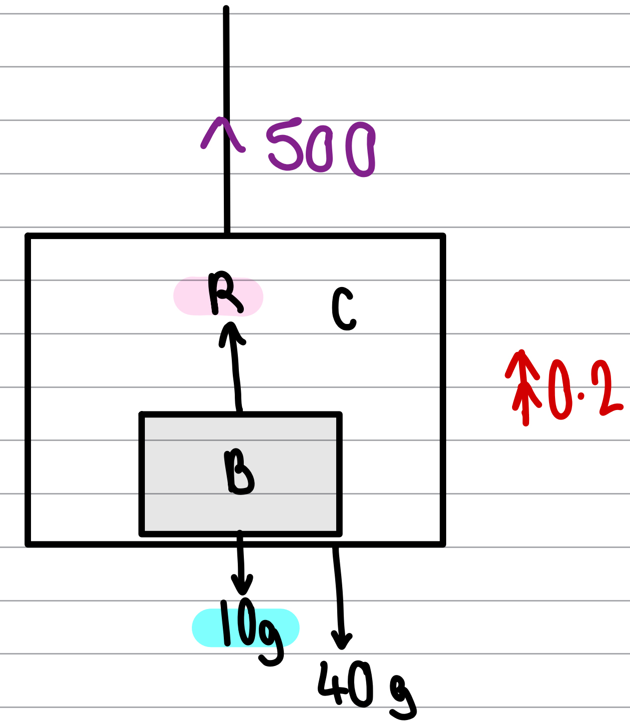
treating upwards as positive, and using F = ma

$T - 50g = 50 \times 0.2$

$T = 500\text{N}$

Question 4 continued

(b)



Using $F = ma$

Equation for block B:

$R - 10g = 10 \times 0.2$

$R = 100\text{ N}$