Please check the examination details below before entering your candidate information

Candidate surname	Other names

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 ▶

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P 6 6 8 0 7 A 0 1 1 2

Pearson

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

at the same level as A but on the other side

1)

a) $s = 0$ (at same level relative to where started)

$u = 14.7$

$v =$

$a = -9.8$ (a is always neg when take ↑ as positive sense)

$t =$

+ ↑

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

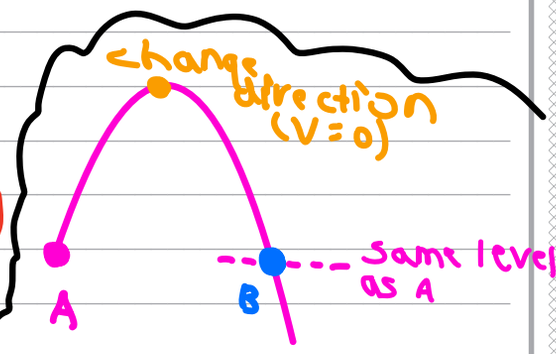
$v^2 = 14.7^2 + 2(-9.8)(0)$

$v^2 = 14.7^2$

$v = \pm 14.7$

$v = +14.7$ start

-14.7 end

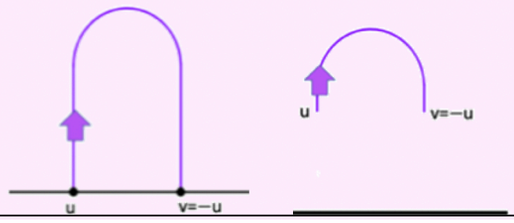


Be aware of:

- v is a negative when changed direction
- s is negative when below where started
- s talks about where you are relative to where you started

Note: you should have known that $v = -14.7$ from the start without doing SUVAT. Why?

When back on the same level, displacement is zero, so $v^2 = u^2 + 2as$ becomes $v^2 = u^2$ hence $v = \pm u$
We know $v = u$ solution is from beginning of motion and $v = -u$ is from when changed direction



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Let's do SUVAT again to find T

$s = 0$
$u = 14.7$
$v = -14.7$
$a = -9.8$
$t = T$

$v = u + at$

$-14.7 = 14.7 - 9.8T$

$9.8T = 29.4$

$T = 3$ seconds

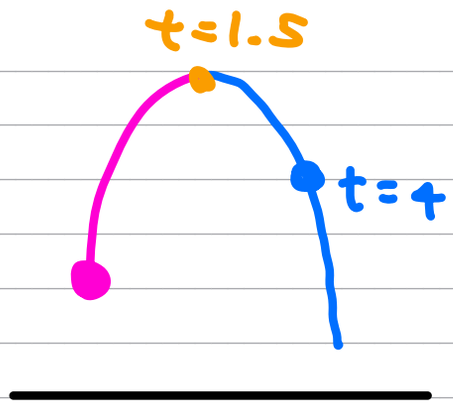
ii) Total distance is only the same as displacement if haven't changed direction, so we can't just blindly find s.
We need to check the time at which changed direction and if this was before 4 seconds, we have to split the motion up and look at up and down separately.

$s =$
$u = -14.7$
$v = 0$
$a = -9.8$
$t = t$

$v = u + at$
$0 = -14.7 - 9.8t$
$t = 1.5$

Alternative method: since B is on the same level as A (but on the other side) and the motion is symmetrical, we know time is $\frac{1}{2}$ of 3 which is 1.5

(Total for Question 1 is 7 marks)



So it took 1.5 seconds to change direction

We do 1 SUVAT for each motion

+ ↑
$s = s_1$
$u = 14.7$
$v =$
$a = -9.8$
$t = 1.5$

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

$s_1 = 14.7(1.5) + \frac{1}{2}(-9.8)(1.5)^2$

$= 11.025$

+ ↓
$s = s_2$
$u = 0$
$v =$
$a = 9.8$
$t = 4 - 1.5 = 2.5$

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

$s_2 = 0 + \frac{1}{2}(9.8)(2.5)^2$

$= 30.625$

Total distance $= 11.025 + 30.625$

$= 41.7$ m

c)
- dimension of stone should be taken into account
- do not model the stone as a particle
- use a more accurate value for gravity

2. A particle P moves along a straight line.

At time t seconds, the velocity $v\,\text{m s}^{-1}$ 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 $t = 6$

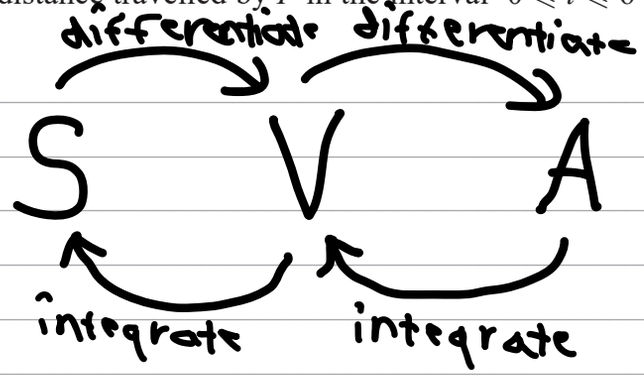
(b) Find the other value of t when P is instantaneously at rest.

(4)

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

(4)

given an equation in terms of t. This should make you realise this is not SUVAT like in question 1)



We use this for non constant accel i.e when given equations in terms of t

a) going from V → A so differentiate

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

b) $V = 0$, when $t = 6$

sub this into $V = 10t - t^2 - k$

$0 = 60 - 36 - k$

$k = 24$

$\Rightarrow V = 10t - t^2 - 24$

Solve $V = 0$ to find other times at rest

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

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

$(t - 6)(t - 4) = 0$

$t = 6, t = 4$

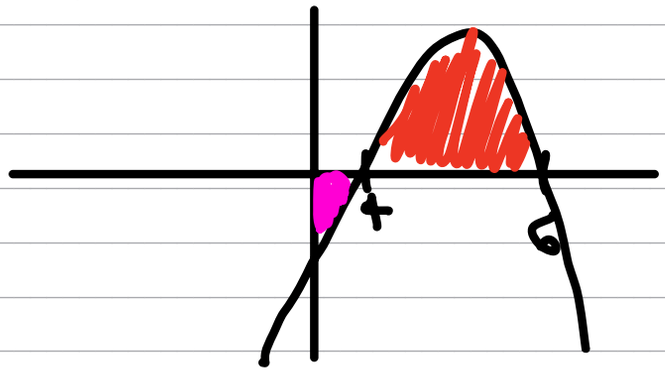
$t = 4$

c) integrating the velocity gives displacement

We want total distance so we have to check when changes direction (done) and then integrate separately between these times. Any integrals that give negative answers are taken as positive (i.e where the curve is below the x axis. This should make sense since, when v is negative (under curve) it indicates a change in direction.

changes direction at $t = 4$ and $t = 6$.

We're given $0 \leq t \leq 6$



Question 2 continued

$$\int_0^4 (10t - t^2 - 24)\,dt = \left[\frac{10t^2}{2} - \frac{t^3}{3} - 24t\right]_0^4 = -\frac{112}{3}$$

$$\int_4^6 (10t - t^2 - 24)\,dt = \left[\frac{10t^2}{2} - \frac{t^3}{3} - 24t\right]_4^6 = \frac{4}{3}$$

take the positive versions $\Rightarrow \frac{112}{3}$

$$\frac{112}{3} + \frac{4}{3} = \frac{116}{3}\ \text{m}$$

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3.

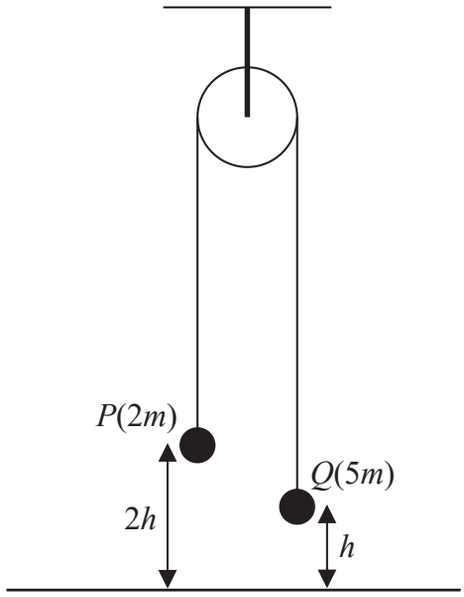


Figure 1

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).

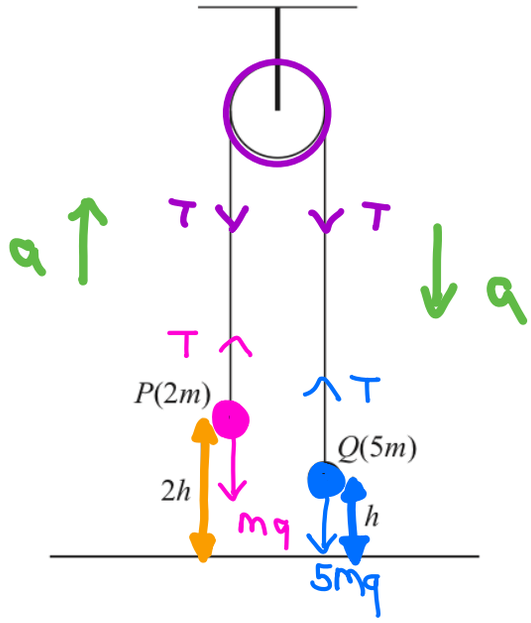
(1)

In reality, the string will not be inextensible.

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

(1)

Question 3 continued



i)

Consider P: Take ↑ as positive since moving this way
This means any forces going in the opp direction (down) will be negative

Note: you can take ↓ as pos. but then you'd need to have accel as negative

Follow the template f=ma:

$T - 2mg = 2ma$

ii)

Consider Q: Take ↓ as positive since moving this way
This means any forces going in the opp direction (up) will be negative

Follow the template f=ma:

$-T + 5mg = 5ma$

b) Need a first

from i) and iii) we have 2 equations

① $T - 2mg = 2ma \Rightarrow T = 2ma + 2mg$

② $-T + 5mg = 5ma \Rightarrow T = 5mg - 5ma$

Set both equal since both equal to T

$2ma + 2mg = 5mg - 5ma$

Cancel the m's

$2a + 2g = 5g - 5a$

$7a = 3g$

$a = \frac{3}{7}g = 4.2$

Now use SUVAT to get h

Consider Q 1st to get v since the speed that Q hits the ground is the starting speed for P

$s = h$
$u = 0$
$v = v$
$a = 4.2$ (looking at down motion only so +4.2)
$t =$

$v^2 = u^2 + 2as$
$= 0^2 + 2(4.2)h$
$v^2 = 8.4h$
$v = \sqrt{8.4h}$

Question 3 continued

once Q hits the ground, P moves up a bit more since the string is slack and allows P to move a bit. P then reaches its greatest height and comes to rest

$s = s$

$u = \sqrt{8.4h}$

$v = 0$ (comes to rest)

$a = -9.8$ (string slack so subject to gravity)

$t =$

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

$0 = 8.4h + 2(-9.8)s$

$s = \frac{8.4h}{2(9.8)}$

$s = \frac{3}{7}h$

Total height = height originally off the ground
+
distance P moves (since Q moves the same distance)
+
extra distance Q moves

$= 2h + h + \frac{3}{7}h$

$= \frac{24}{7}h$

c) The distance that Q falls to the ground is not exactly h

d) inextensible ⇒ acceleration is the same on both sides of the pulley, but in reality the accelerations of P and Q would not have the same magnitude

(Total for Question 3 is 13 marks)

TOTAL FOR MECHANICS IS 30 MARKS