Please check the examination details below before entering your candidate information

Candidate surname	Other names

Centre Number | Candidate Number

Pearson Edexcel Level 3 GCE

Thursday 23 May 2024

Afternoon

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 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 ▶

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Pearson

1.

distance = speed x time

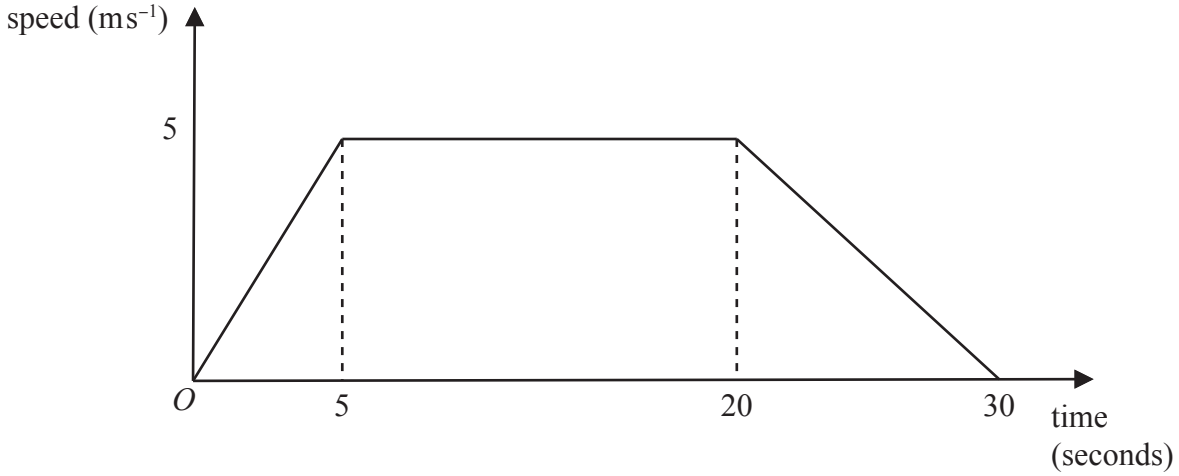


Figure 1

Figure 1 shows the speed-time graph for the journey of a car moving in a long queue of traffic on a straight horizontal road.

At time $t = 0$, the car is at rest at the point A.

The car then accelerates uniformly for 5 seconds until it reaches a speed of $5\,\text{ms}^{-1}$

For the next 15 seconds the car travels at a constant speed of $5\,\text{ms}^{-1}$

The car then decelerates uniformly until it comes to rest at the point B.

The total journey time is 30 seconds.

(a) Find the distance AB.

(3)

(b) Sketch a distance-time graph for the journey of the car from A to B.

(3)

a) Distance AB = area under the graph

from t = 0 to t = 5,

Area = $\frac{1}{2} \times 5 \times 5 = 12.5$ m (1)

from t = 5 to t = 20,

Area = $(20-5) \times 5 = 75$ m

from t = 20 to t = 30, (1)

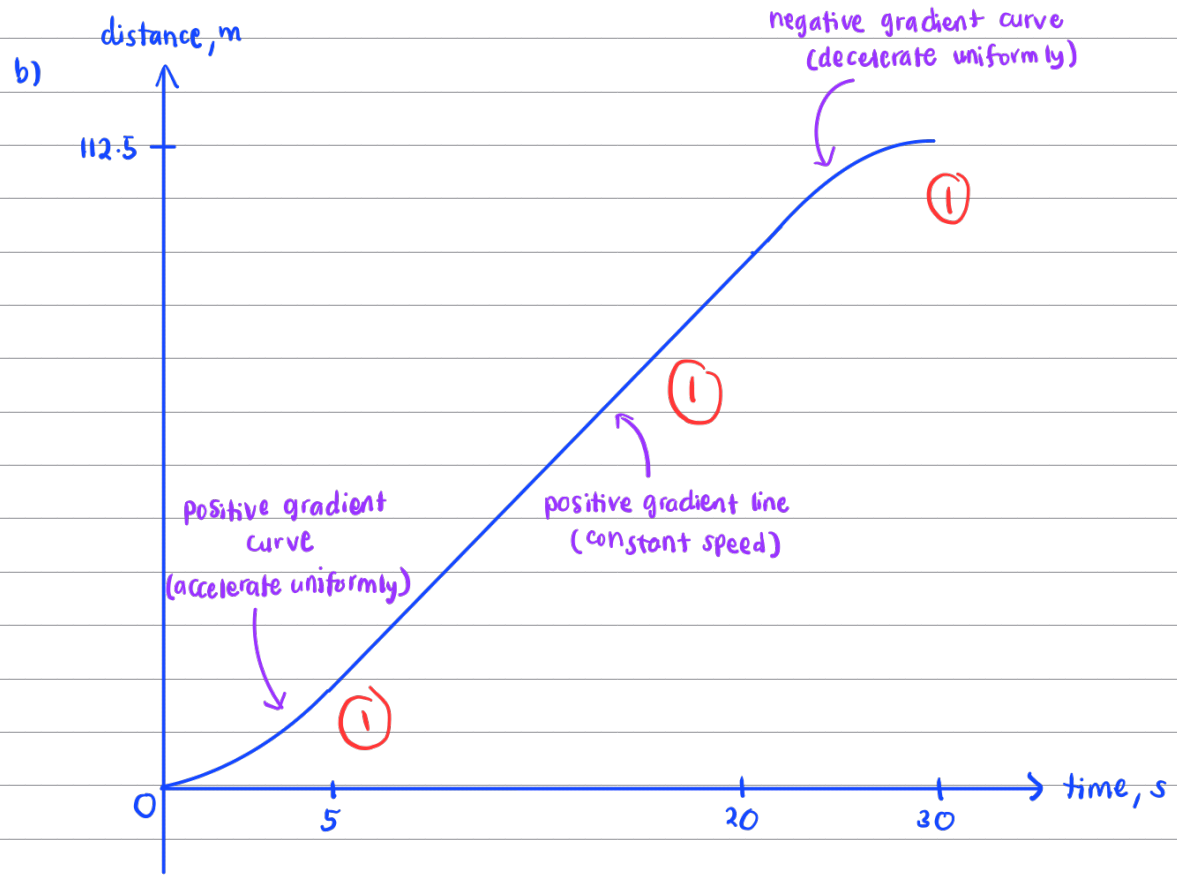
Area = $\frac{1}{2} \times (30-20) \times 5 = 25$ m

Question 1 continued

total area = distance AB

12.5 m + 75 m + 25 m = 112.5 m (1)

b)



(Total for Question 1 is 6 marks)

2. **In this question you must show all stages of your working.**

Solutions relying on calculator technology are not acceptable.

A particle is moving along a straight line.

At time t seconds, $t > 0$, the velocity of the particle is $v\,\text{m s}^{-1}$, where

$$v = 2t - 7\sqrt{t} + 6$$

(a) Find the acceleration of the particle when $t = 4$

(3)

When $t = 1$ the particle is at the point X.

When $t = 2$ the particle is at the point Y.

Given that the particle does not come to instantaneous rest in the interval $1 < t < 2$

(b) show that $XY = \frac{1}{3}\left(41 - 28\sqrt{2}\right)$ metres.

(4)

a) $a = \frac{dv}{dt}$

$v = 2t - 7t^{\frac{1}{2}} + 6$ (1)

$\frac{dv}{dt} = 2 - \frac{7}{2}t^{-\frac{1}{2}}$ (1)

acceleration when $t = 4$

$a = 2 - \frac{7}{2}(4)^{-\frac{1}{2}}$

$= 0.25\ \text{ms}^{-2}$ (1)

Question 2 continued

$s \xleftarrow{\int v\,dt} v \xrightarrow{\frac{dv}{dt}} a$

b) To find distance XY, we integrate the velocity equation.

$$v = 2t - 7t^{\frac{1}{2}} + 6$$

$$\int v\,dt = t^2 - \frac{14}{3}t^{\frac{3}{2}} + 6t + c \quad (1) \quad (1)$$

when $t = 1$, particle at point X.

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

$$= \frac{7}{3} + c$$

When $t = 2$, particle at point Y. (1)

$$y = (2)^2 - \frac{14}{3}(2)^{\frac{3}{2}} + 6(2) + c$$

$$= 16 - \frac{14}{3}\sqrt{8} + c$$

↗ distance from X to Y. (Y − X)

$$XY = 16 - \frac{14}{3}\sqrt{8} - \frac{7}{3}$$

$$= \frac{48}{3} - \frac{14}{3}\left(\sqrt{4}\sqrt{2}\right) - \frac{7}{3}$$

$$= \frac{1}{3}\left(41 - 28\sqrt{2}\right) \text{ metre} \quad (1)$$

(Total for Question 2 is 7 marks)

3. [*In this question,* **i** *and* **j** *are perpendicular unit vectors in a horizontal plane.*]

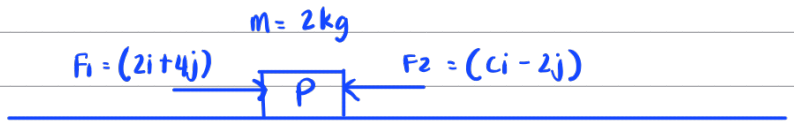
A particle P is moving on a smooth horizontal surface under the action of two forces.

Given that

- the mass of P is 2 kg
- the two forces are $(2\mathbf{i} + 4\mathbf{j})$ N and $(c\mathbf{i} - 2\mathbf{j})$ N, where c is a constant
- the magnitude of the acceleration of P is $\sqrt{5}\,\text{m s}^{-2}$

find the two possible values of c.

(5)



Resultant forces that act on P :

$(2+c)\underset{\sim}{i} + (4-2)\underset{\sim}{j} = (2+c)\underset{\sim}{i} + 2\underset{\sim}{j}$ (1)

Magnitude of resultant force :

$F_R = \sqrt{(2+c)^2 + (2)^2}$ (1)

$= \sqrt{(2+c)^2 + 4}$

Given : mass = 2kg and magnitude of acceleration = $\sqrt{5}\ ms^{-2}$

use $F = m \times a$

$F_R = 2 \times \sqrt{5}$

$\sqrt{(2+c)^2 + 4} = 2 \times \sqrt{5}$

$(2+c)^2 + 4 = 4 \times 5$ (1)

$2 + c = \pm\sqrt{16}$

Question 3 continued

$2 + c = 4$ or $2 + c = -4$

$c = 2$ or $c = -6$ (1)

$c = 2$ and -6 (1)

(Total for Question 3 is 5 marks)

4.

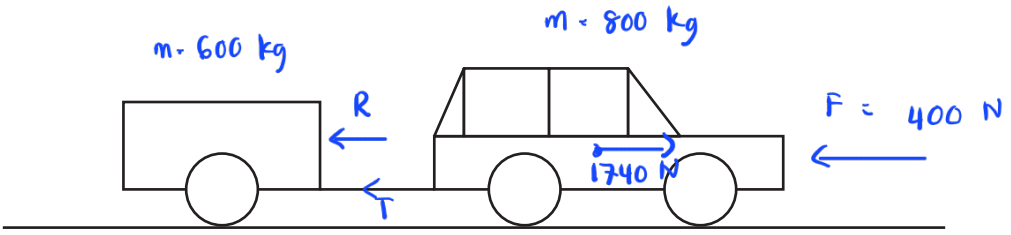


Figure 2

Figure 2 shows a car towing a trailer along a straight horizontal road.

The mass of the car is 800 kg and the mass of the trailer is 600 kg.

The trailer is attached to the car by a towbar which is parallel to the road and parallel to the direction of motion of the car and the trailer.

The towbar is modelled as a light rod.

The resistance to the motion of the car is modelled as a constant force of magnitude 400 N.

The resistance to the motion of the trailer is modelled as a constant force of magnitude R newtons.

The engine of the car is producing a constant driving force that is horizontal and of magnitude 1740 N.

The acceleration of the car is $0.6\,\text{m s}^{-2}$ and the tension in the towbar is T newtons.

Using the model,

(a) show that $R = 500$

(3)

(b) find the value of T.

(3)

At the instant when the speed of the car and the trailer is $12.5\ \text{m s}^{-1}$, the towbar breaks.

The trailer moves a further distance d metres before coming to rest.

The resistance to the motion of the trailer is modelled as a constant force of magnitude 500 N.

Using the model,

(c) show that, after the towbar breaks, the deceleration of the trailer is $\frac{5}{6}\,\text{m s}^{-2}$

(1)

(d) find the value of d.

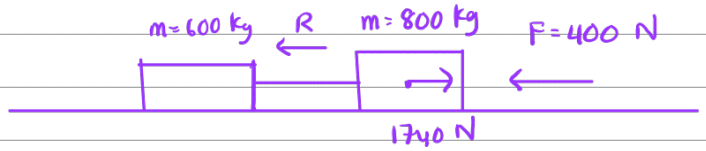
(3)

In reality, the distance d metres is likely to be different from the answer found in part (d).

(e) Give two **different** reasons why this is the case.

(2)

Question 4 continued



a) Given the acceleration = $0.6\ ms^{-2}$

Using equation of motion : (1)

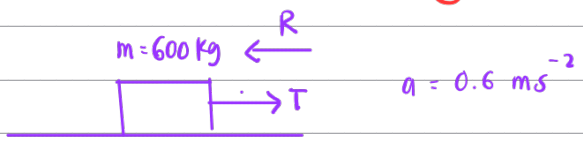
Resultant force = mass x acceleration

$1740 - 400 - R = (800 + 600) \times 0.6$ (1)

$R = 1740 - 400 - (1400 \times 0.6)$

$= 500\ N$ (1)

b) considering only the motion of trailer : (1)



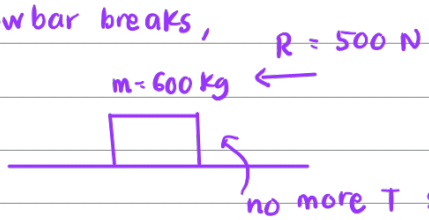
$T - R = 600 \times 0.6$ (1)

$T - 500 = 360$

$T = 860\ N$ (1)

Question 4 continued

c) When the towbar breaks,



The equation would be :

$F_R = m \times a$

$-500 = 600\,a$ (1)

negative means decelerating

$a = \frac{-500}{600} = -\frac{5}{6}$

$\therefore$ deceleration of $\frac{5}{6}\ ms^{-2}$ (1)

d) since no external force acting on the trailer, it decelerates constantly at $\frac{5}{6}\ ms^{-2}$ until coming to rest.

We can use constant acceleration formula to get d.

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

$= 12.5(t) + \frac{1}{2}\left(-\frac{5}{6}\right)t^2$ (1) , where $t = \frac{12.5}{5/6} = 15$

$t = \frac{\text{velocity}}{\text{acceleration}}$

$= 12.5(15) + \frac{1}{2}\left(-\frac{5}{6}\right)(15)^2$

$= 93.75\ m$ (1)

Question 4 continued

c) 1. The resistance to motion of trailer is unlikely to be constant at 500 N. (1)

2. The model does not take into account the unevenness of the road (1)

Question 4 continued

(Total for Question 4 is 12 marks)

TOTAL FOR MECHANICS IS 30 MARKS