Pearson Edexcel Level 3 GCE

Mixed topics

Paper reference **9MA0/32**

Mathematics
Advanced
PAPER 32: Mechanics

You must have:
Mathematical Formulae and Statistical Tables (Green), calculator

Total Marks ☐

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, whenever a value of g is required, take $g = 9.8\,\mathrm{m\,s^{-2}}$ 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 50. There are 6 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 ▶

1.
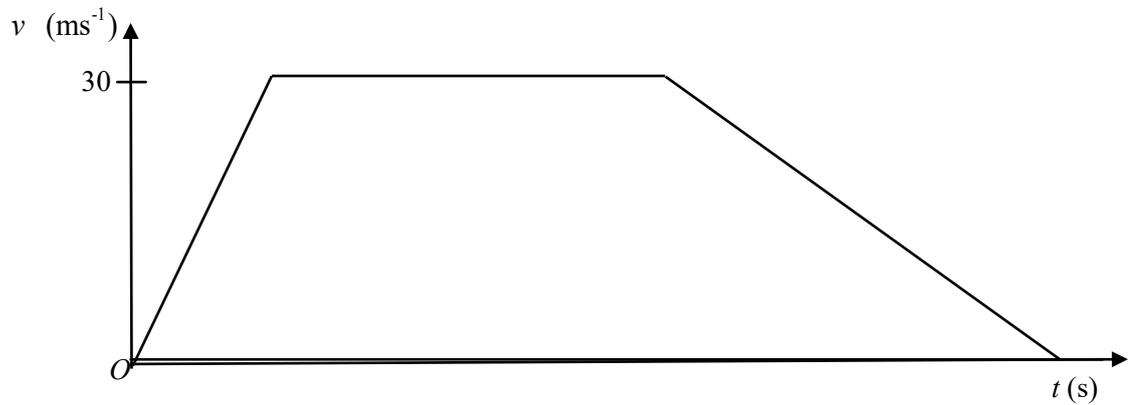
Figure 1

Figure 1 shows a speed-time graph for a model of the motion of a train moving in a straight line between two stations A and B.

In the model

- the train starts from rest at A and moves with constant acceleration until its speed is 30 m s^{-1}
- the train then moves with constant speed 30 m s^{-1} for 600 seconds
- the train then moves with constant deceleration, coming to rest at B
- the magnitude of the acceleration is four times the magnitude of the deceleration
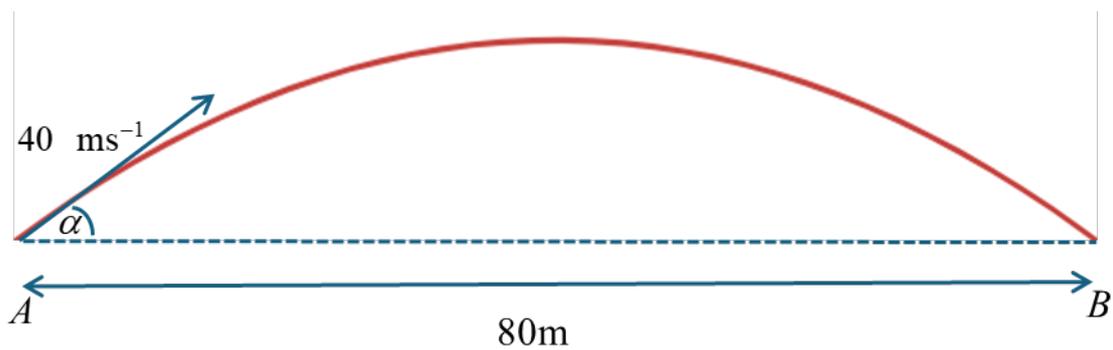
The distance between the stations is 27 km.

Find the time, in seconds, for which the train is accelerating.

(4)

(Total for Question 1 is 4 marks)

2.

Figure 2

Figure 2 shows an arrow fired from a point A. The arrow initially moves at an angle α to the horizontal. It hits a target at the point B which is at the same vertical height as A. The motion of the arrow is modelled as a particle moving freely under gravity.

In this question, **use** $g = 10 \text{ m s}^{-2}$.

The initial speed of the arrow is 40 ms^{-1} and the distance $AB = 80$ m.

(a) Show that $\sin(2\alpha) = \dfrac{1}{2}$

(8)

(b) Find the greatest possible height of the arrow above the level of A.

(3)

(Total for Question 2 is 11 marks)

3. A firework is launched vertically upwards from ground level with speed U ms^{-1}.

It reaches a height H m and then falls vertically, hitting the ground T seconds after its launch.

Model the firework as a particle moving freely under gravity,

The displacement of the firework is measured from ground level.

(a) Sketch the displacement - time graph for the T seconds that the firework is in the air. Your graph should indicate the height H and the time T.

(2)

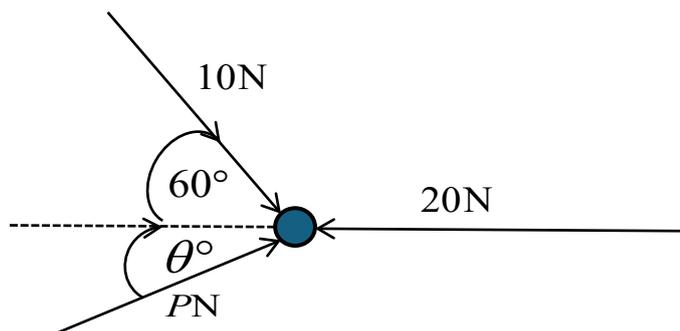(b) Sketch the velocity - time graph for the T seconds that the firework is in the air. Your graph should indicate the initial velocity, the velocity at time $\frac{1}{2}T$ and the velocity at time T.

(2)

(Total for Question 3 is 4 marks)

4.

Figure 3

Figure 3 shows a particle on a horizontal plane in equilibrium under the action of three horizontal forces of magnitudes 10 N, 20 N and P N.

The angle between the directions of the 10 N and 20 N forces is 120°.

The angle between the directions of the 10 N and P N forces is $(60 + \theta)°$.

(a) Show that $\tan \theta° = \dfrac{\sqrt{3}}{3}$

(6)

(b) Find the exact value of P

(2)

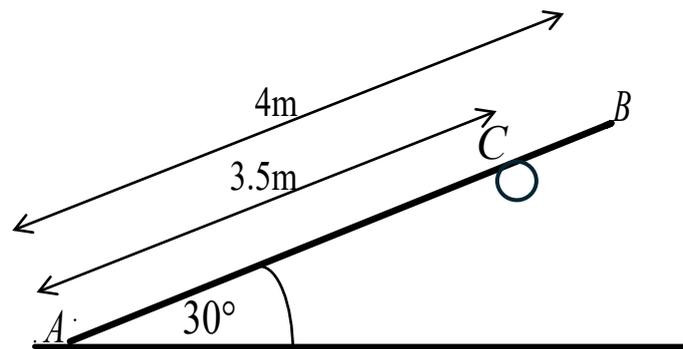**(Total for Question 4 is 8 marks)**

5.

Figure 4

Figure 4 shows a uniform rod AB of length 4 m and mass M kg. The rod is resting in limiting equilibrium against a small smooth fixed horizontal peg. The point C of the rod is in contact with the peg and the end A is on rough horizontal ground. The rod lies in a vertical plane which is perpendicular to the peg.

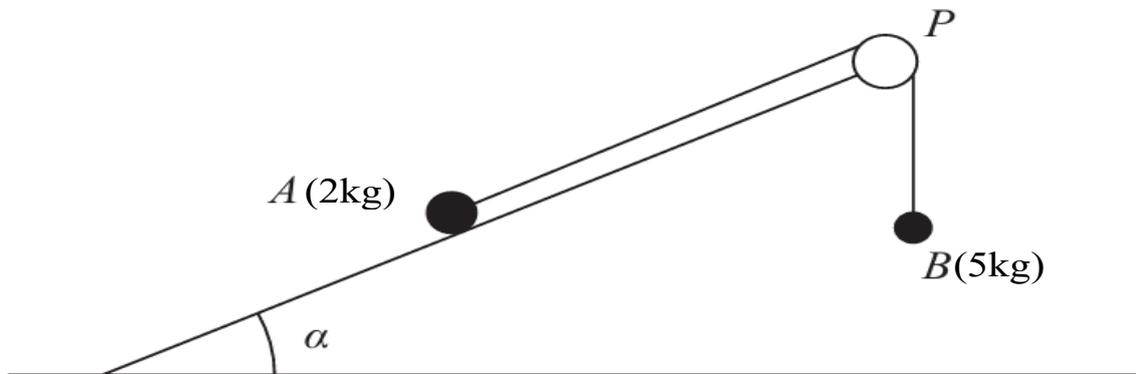The rod is inclined to the horizontal at an angle of 30° and $AC = 3.5$ m

Show that the coefficient of friction between the rod and the ground is $\dfrac{\sqrt{3}}{4}$

(8)

(Total for Question 5 is 8 marks)

6.

Figure 5

Figure 5 shows a particle A of mass 2 kg at rest on a rough inclined plane. The particle A is attached to one end of a light inextensible string. A particle B of mass 5 kg is attached to the other end of the string. The string passes over a small smooth pulley P which is fixed at the top of the plane.

The plane is inclined at an angle α to the horizontal, where $\tan\alpha = \dfrac{5}{12}$

The coefficient of friction between A and the plane is $\dfrac{1}{4}$.

The system is held at rest with B hanging vertically below P. The portion of the string between A and P lies along a line of greatest slope of the inclined plane and A, P and B all lie in the same vertical plane.

The system is released from rest with the string taut and B begins to move downwards.

Find

(a) the acceleration of A, giving your answer in terms of g,

(7)

(b) the tension in the string.

(1)

(Total for Question 6 is 8 marks)

7. At time t seconds, a particle P has velocity $\mathbf{v}$ ms^{-1}, where

$$\mathbf{v} = \sqrt{t}\,\mathbf{i} + (1 - 6t)\,\mathbf{j}$$

(a) Find the time when P is moving in the direction of $(\mathbf{i} - \mathbf{j})$.

(4)

At time t seconds, the position vector of P relative to an origin O is $\mathbf{r}$ m.

When $t = 0, \mathbf{r} = 4\mathbf{j}$

(b) Find an expression for $\mathbf{r}$ in terms of t, giving your answer in terms of $\mathbf{i}$ and $\mathbf{j}$.

(3)

(Total for Question 7 is 7 marks)

TOTAL FOR PAPER: 50 MARKS