GCE Examinations

Mechanics
Module M2

Advanced Subsidiary / Advanced Level

Paper A

Time: 1 hour 30 minutes

Instructions and Information

Candidates may use any calculator except those with a facility for symbolic algebra and / or calculus.

Full marks may be obtained for answers to ALL questions.

Mathematical and statistical formulae and tables are available.

This paper has 7 questions.

When a numerical value of g is required, use $g = 9.8 \text{ m s}^{-2}$.

Advice to Candidates

You must show sufficient working to make your methods clear to an examiner. Answers without working will gain no credit.

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1. Two identical particles are approaching each other along a straight horizontal track. Just before they collide, they are moving with speeds 5 m s^{-1} and 3 m s^{-1} respectively. The coefficient of restitution between the particles is $\frac{1}{2}$.

Find the speeds of the particles immediately after the impact. **(6 marks)**

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2. A particle P of mass 3 kg moves such that at time t seconds its position vector, $\mathbf{r}$ metres, relative to a fixed origin, O, is given by

$$\mathbf{r} = (t^2 - 3t)\mathbf{i} + \tfrac{1}{6}t^3\mathbf{j},$$

where $\mathbf{i}$ and $\mathbf{j}$ are perpendicular horizontal unit vectors.

(a) Find the velocity of P when $t = 0$. **(3 marks)**

(b) Find the kinetic energy lost by P in the interval $0 \leq t \leq 2$. **(5 marks)**

3.

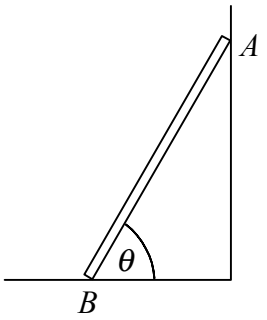


Fig. 1

Figure 1 shows a uniform ladder of mass 15 kg and length 8 m which rests against a smooth vertical wall at A with its lower end on rough horizontal ground at B. The coefficient of friction between the ladder and the ground is $\frac{1}{3}$ and the ladder is inclined at an angle θ to the horizontal, where $\tan\theta = 2$.

A man of mass 75 kg ascends the ladder until he reaches a point P. The ladder is then on the point of slipping.

(a) Write down suitable models for

(i) the ladder,

(ii) the man. **(2 marks)**

(b) Find the distance AP. **(8 marks)**

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4. A particle P moves in a straight horizontal line such that its acceleration at time t seconds is proportional to $(3t^2 - 5)$.

Given that at time $t = 0$, P is at rest at the origin O and that at time $t = 3$, its velocity is 3 m s^{-1},

(a) find, in m s^{-2}, the acceleration of P in terms of t, **(7 marks)**

(b) show that the displacement of the particle, s metres, from O at time t is given by

$$s = \tfrac{1}{16}t^2(t^2 - 10).$$ **(4 marks)**

5.

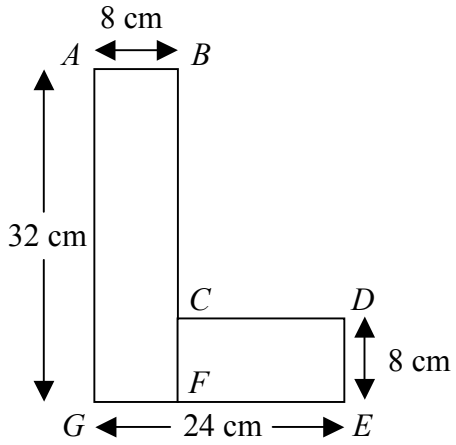


Fig. 2

Figure 2 shows a uniform plane lamina $ABCDEG$ in the shape of a letter 'L' consisting of a rectangle $ABFG$ joined to another rectangle $CDEF$. The sides AB and DE are both 8 cm long and the sides EG and GA are of length 24 cm and 32 cm respectively.

(a) Show that the centre of mass of the lamina lies on the line BF. **(5 marks)**

(b) Find the distance of the centre of mass from the line AB. **(4 marks)**

The uniform lamina in Figure 2 is a model of the letter 'L' in a sign above a shop. The letter is normally suspended from a wall at A and B so that AB is horizontal but the fixing at B has broken and the letter hangs in equilibrium from the point A.

(c) Find, in degrees to one decimal place, the acute angle AG makes with the vertical.

(3 marks)

Turn over

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6. The engine of a car of mass 1200 kg is working at a constant rate of 90 kW as the car moves along a straight horizontal road. The resistive forces opposing the motion of the car are constant and of magnitude 1800 N.

(a) Find the acceleration of the car when it is travelling at 20 $\mathrm{m\,s^{-1}}$. **(4 marks)**

(b) Find, in kJ, the kinetic energy of the car when it is travelling at maximum speed.

(4 marks)

The car ascends a hill which is straight and makes an angle α with the horizontal. The power output of the engine and the non-gravitational forces opposing the motion remain the same.

Given that the car can attain a maximum speed of 25 $\mathrm{m\,s^{-1}}$,

(c) find, in degrees correct to one decimal place, the value of α. **(5 marks)**

7.

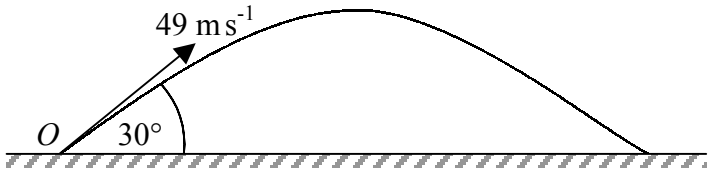


Fig. 3

Figure 3 shows the path of a golf ball which is hit from the point O with speed 49 $\mathrm{m\,s^{-1}}$ at an angle of 30° to the horizontal. The path of the ball is in a vertical plane containing O and the hole at which the ball is aimed.

The hole is 170 m from O and on the same horizontal level as O.

(a) Suggest a suitable model for the motion of the golf ball. **(2 marks)**

Find, correct to 3 significant figures,

(b) the distance beyond the hole at which the ball hits the ground, **(6 marks)**

(c) the magnitude and direction of the velocity of the ball when it is directly above the hole.

(7 marks)

END

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