GCE Examinations

Mechanics
Module M1

Advanced Subsidiary / Advanced Level

Paper D

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 8 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. A particle, P, of mass 5 kg moves with speed 3 m s^{-1} along a smooth horizontal track. It strikes a particle Q of mass 2 kg which is at rest on the track. Immediately after the collision, P and Q move in the same direction with speeds v and $2v$ m s^{-1} respectively.

(a) Calculate the value of v. **(3 marks)**

(b) Calculate the magnitude of the impulse received by Q on impact. **(2 marks)**

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2. A particle P moves with a constant velocity $(3\mathbf{i} + 2\mathbf{j})$ m s^{-1} with respect to a fixed origin O. It passes through the point A whose position vector is $(2\mathbf{i} + 11\mathbf{j})$ m at $t = 0$.

(a) Find the angle in degrees that the velocity vector of P makes with the vector $\mathbf{i}$.

(2 marks)

(b) Calculate the distance of P from O when $t = 2$. **(4 marks)**

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3. A car of mass 1250 kg is moving at constant speed up a hill, inclined at an angle α to the horizontal, where $\sin\alpha = \frac{1}{10}$. The driving force produced by the engine is 1800 N.

(a) Calculate the resistance to motion which the car experiences. **(4 marks)**

At the top of the hill, the road becomes horizontal.

(b) Find the initial acceleration of the car. **(3 marks)**

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4. A non-uniform plank AB of mass 20 kg and length 6 m is supported at both ends so that it is horizontal. When a woman of mass 60 kg stands on the plank at a distance of 2 m from B, the magnitude of the reaction at A is $35g$ N.

(a) Suggest a suitable model for

(i) the plank,

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

(b) Calculate the magnitude of the reaction at B, giving your answer in terms of g.

(2 marks)

(c) Explain briefly, in the context of the problem, the term 'non-uniform'. **(2 marks)**

(d) Find the distance of the centre of mass of the plank from A. **(4 marks)**

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5.

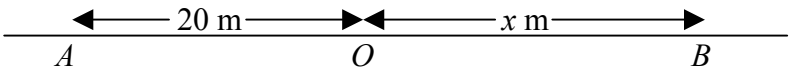


Fig. 1

The points A, O and B lie on a straight horizontal track as shown in Figure 1. A is 20 m from O and B is on the other side of O at a distance x m from O.

At time $t = 0$, a particle P starts from rest at O and moves towards B with uniform acceleration of 3 $\mathrm{m\,s^{-2}}$. At the same instant, another particle Q, which is at the point A, is moving with a velocity of 3 $\mathrm{m\,s^{-1}}$ in the direction of O with uniform acceleration of 4 $\mathrm{m\,s^{-2}}$ in the same direction.

Given that the Q collides with P at B, find the value of x. **(10 marks)**

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6. A sledge of mass 4 kg rests in limiting equilibrium on a rough slope inclined at an angle 10° to the horizontal. By modelling the sledge as a particle,

(a) show that the coefficient of friction, μ, between the sledge and the ground is 0.176 correct to 3 significant figures.

(6 marks)

The sledge is placed on a steeper part of the slope which is inclined at an angle 30° to the horizontal. The value of μ remains unchanged.

(b) Find the minimum extra force required along the line of greatest slope to prevent the sledge from slipping down the hill.

(5 marks)

Turn over

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7. Whilst looking over the edge of a vertical cliff, 122.5 metres in height, Jim dislodges a stone. The stone falls freely from rest towards the sea below.

Ignoring the effect of air resistance,

(a) calculate the time it would take for the stone to reach the sea, **(3 marks)**

(b) find the speed with which the stone would hit the water. **(2 marks)**

Two seconds after the stone begins to fall, Jim throws a tennis ball downwards at the stone. The tennis ball's initial speed is u m s^{-1} and it hits the stone before they both reach the water.

(c) Find the minimum value of u. **(5 marks)**

(d) If you had taken air resistance into account in your calculations, what effect would this have had on your answer to part *(c)*? Explain your answer. **(2 marks)**

8.

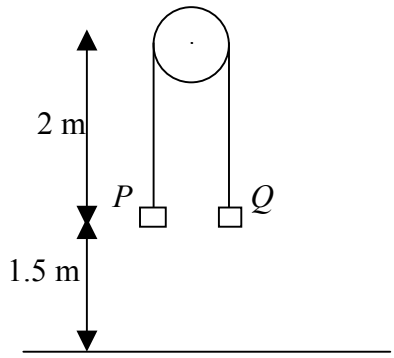


Fig. 2

Figure 2 shows two particles P and Q, of mass 3 kg and 2 kg respectively, attached to the ends of a light, inextensible string which passes over a smooth, fixed pulley. The system is released from rest with P and Q at the same level 1.5 metres above the ground and 2 metres below the pulley.

(a) Show that the initial acceleration of the system is $\frac{g}{5}$ m s^{-2}. **(4 marks)**

(b) Find the tension in the string. **(2 marks)**

(c) Find the speed with which P hits the ground. **(3 marks)**

When P hits the ground, it does not rebound.

(d) What is the closest that Q gets to the pulley. **(5 marks)**

END

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