GCE Examinations

Mechanics
Module M1

Advanced Subsidiary / Advanced Level

Paper G

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.

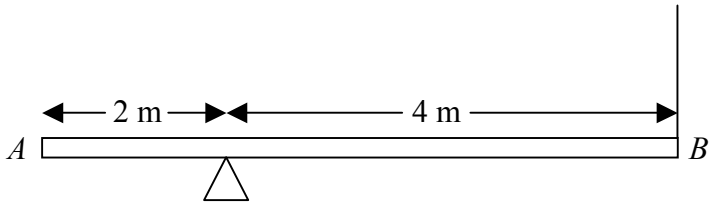


Fig. 1

Figure 1 shows a non-uniform beam AB of mass 10 kg and length 6 m resting in a horizontal position on a single support 2 m from A. The beam is supported at B by a vertical string.

Given that the magnitude of the tension in the string is 1.5 times the magnitude of the reaction at the support, find the distance of the centre of mass of the beam from A.

(6 marks)

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2. A ball of mass 2 kg moves on a smooth horizontal surface under the action of a constant force, $\mathbf{F}$. The initial velocity of the ball is $(2\mathbf{i} - 3\mathbf{j})$ m s^{-1} and 4 seconds later it has velocity $(10\mathbf{i} + 9\mathbf{j})$ m s^{-1} where $\mathbf{i}$ and $\mathbf{j}$ are perpendicular, horizontal unit vectors.

(a) Making reference to the mass of the ball and the force it experiences, explain why it is reasonable to assume that the acceleration is constant.

(2 marks)

(b) Find, giving your answers correct to 3 significant figures,

(i) the magnitude of the acceleration experienced by the ball,

(ii) the angle which $\mathbf{F}$ makes with the vector $\mathbf{i}$. **(7 marks)**

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3.

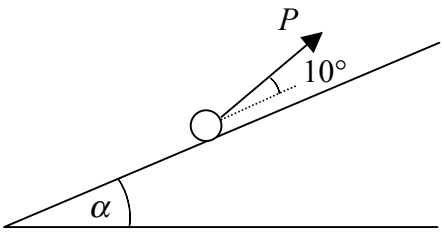


Fig. 2

Figure 2 shows a ball of mass 3 kg lying on a smooth plane inclined at an angle α to the horizontal where $\sin\alpha = \frac{3}{5}$. The ball is held in equilibrium by a force of magnitude P newtons, which acts at an angle of 10° to the line of greatest slope of the plane.

(a) Suggest a suitable model for the ball. **(1 mark)**

Giving your answers correct to 1 decimal place,

(b) find the value of P, **(4 marks)**

(c) find the magnitude of the reaction between the ball and the plane. **(4 marks)**

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4. A bullet of mass 50 g is fired horizontally at a wooden block of mass 4.95 kg which is lying at rest on a rough horizontal surface. The bullet enters the block at 400 m s^{-1} and becomes embedded in the block.

(a) Find the speed with which the block begins to move. **(3 marks)**

Given that the block decelerates uniformly to rest over a distance of 4 m,

(b) show that the coefficient of friction is $\frac{2}{g}$. **(6 marks)**

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5. Two dogs, Fido and Growler, are playing in a field. Fido is moving in a straight line so that at time t his position vector relative to a fixed origin, O, is given by $[(2t - 3)\mathbf{i} + t\mathbf{j}]$ metres. Growler is stationary at the point with position vector $(2\mathbf{i} + 5\mathbf{j})$ metres, where **i** and **j** are horizontal perpendicular unit vectors.

(a) Find the displacement vector of Fido from Growler in terms of t. **(2 marks)**

(b) Find the value of t for which the two dogs are closest. **(6 marks)**

(c) Find the minimum distance between the two dogs. **(3 marks)**

Turn over

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6. A particle moving in a straight line with speed $5U$ m s^{-1} undergoes a uniform deceleration for 6 seconds which reduces its speed to $2U$ m s^{-1}. It maintains this speed for 16 seconds before uniformly decelerating to rest in a further 2 seconds.

(a) Sketch a speed-time graph displaying this information. **(2 marks)**

(b) Find an expression for each of the decelerations in terms of U. **(4 marks)**

Given that the total distance travelled by the particle during this period of motion is 220 m,

(c) find the value of U. **(6 marks)**

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7. A car of mass 1200 kg tows a trailer of mass 800 kg along a straight level road by means of a rigid towbar. The resistances to the motion of the car and the trailer are proportional to their masses.

Given that the car experiences a resistance to motion of 300 N,

(a) find the resistance to motion which the trailer experiences. **(2 marks)**

Given that the engine of the car exerts a driving force of 3 kN,

(b) find the acceleration of the system, **(3 marks)**

(c) show that the tension in the towbar is 1200 N. **(3 marks)**

When the system has reached a speed of 24 m s^{-1}, it continues at constant speed until an electrical fault causes the engine of the car to switch off. The brakes are used to apply a constant retarding force until the system comes to rest.

Given that the retarding force of the brakes has magnitude 1 kN and assuming that the original resistances to motion of the car and the trailer remain constant,

(d) calculate the distance that the system travels during the braking period, **(5 marks)**

(e) find the magnitude and direction of the force exerted by the towbar on the car.

(4 marks)

(f) Comment on the assumption that the original resistances to motion of the car and the trailer remain constant throughout the motion.

(2 marks)

END

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