

GCE Examinations

Mechanics Module M2

Advanced Subsidiary / Advanced Level

Paper F

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. An ice hockey puck of mass 0.5 kg is moving with velocity $(5\mathbf{i} - 8\mathbf{j}) \text{ m s}^{-1}$, where \mathbf{i} and \mathbf{j} are perpendicular horizontal unit vectors, when it is struck by a stick. After the impact, the puck travels with velocity $(13\mathbf{i} + 7\mathbf{j}) \text{ m s}^{-1}$.

Find the magnitude of the impulse exerted by the stick on the puck.

(5 marks)

2. A car of mass 1 tonne is climbing a hill inclined at an angle θ to the horizontal where $\sin \theta = \frac{1}{7}$. When the car passes a point X on the hill, it is travelling at 20 m s^{-1} . When the car passes the point Y , 200 m further up the hill, it has speed 10 m s^{-1} .

In a preliminary model of the situation, the car engine is assumed only to be doing work against gravity. Using this model,

- (a) find the change in the total mechanical energy of the car as it moves from X to Y .

(6 marks)

In a more sophisticated model, the car engine is also assumed to work against other forces.

- (b) Write down two other forces which this model might include.

(2 marks)

3. A particle moves along a straight horizontal track such that its displacement, s metres, from a fixed point O on the line after t seconds is given by

$$s = 2t^3 - 13t^2 + 20t.$$

- (a) Find the values of t for which the particle is at O .

(4 marks)

- (b) Find the values of t at which the particle comes instantaneously to rest.

(4 marks)

Turn over

4.

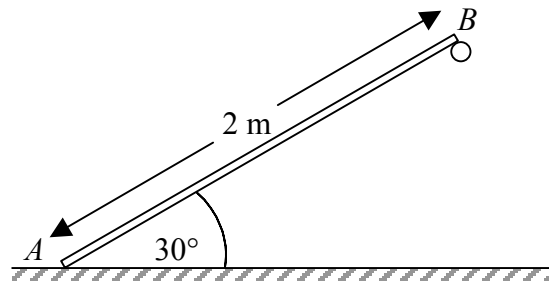


Fig. 1

Figure 1 shows a uniform rod AB of length 2 m and mass 6 kg inclined at an angle of 30° to the horizontal with A on smooth horizontal ground and B supported by a rough peg. The rod is in limiting equilibrium and the coefficient of friction between B and the peg is μ .

- (a) Find, in terms of g , the magnitude of the reactions at A and B . **(6 marks)**
- (b) Show that $\mu = \frac{1}{\sqrt{3}}$. **(3 marks)**

5.

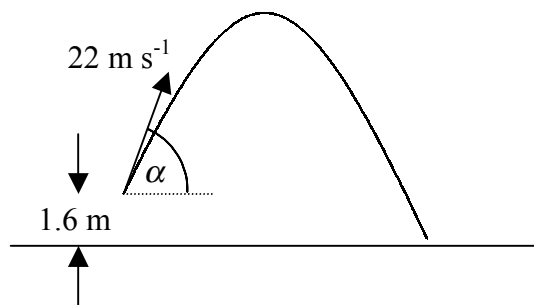


Fig. 2

During a cricket match, a batsman hits the ball giving it an initial velocity of 22 m s^{-1} at an angle α to the horizontal where $\sin \alpha = \frac{7}{8}$. When the batsman strikes the ball it is 1.6 metres above the ground, as shown in Figure 2, and it subsequently moves freely under gravity.

- (a) Find, correct to 3 significant figures, the maximum height above the ground reached by the ball. **(4 marks)**

The ball is caught by a fielder when it is 0.2 metres above the ground.

- (b) Find the length of time for which the ball is in the air. **(4 marks)**

Assuming that the fielder who caught the ball ran at a constant speed of 6 m s^{-1} ,

- (c) find, correct to 3 significant figures, the maximum distance that the fielder could have been from the ball when it was struck. **(4 marks)**

Turn over

6.

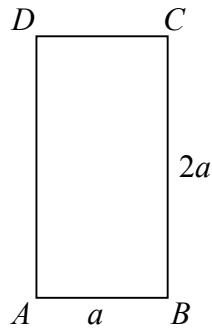


Fig. 3

Figure 3 shows a uniform rectangular lamina $ABCD$ of mass $8m$ in which the sides AB and BC are of length a and $2a$ respectively. Particles of mass $2m$, $6m$ and $4m$ are fixed to the lamina at the points A , B and D respectively.

- (a) Write down the distance of the centre of mass from AD . (1 mark)
- (b) Show that the distance of the centre of mass from AB is $\frac{4}{5}a$. (5 marks)

Another particle of mass km is attached to the lamina at the point B .

- (c) Show that the distance of the centre of mass from AD is now given by $\frac{(10+k)a}{20+k}$. (4 marks)

Given that when the lamina is suspended freely from the point A the side AB makes an angle of 45° with the vertical,

- (d) find the value of k . (6 marks)

7. Particle A of mass 7 kg is moving with speed u_1 on a smooth horizontal surface when it collides directly with particle B of mass 4 kg moving in the same direction as A with speed u_2 .

After the impact, A continues to move in the same direction but its speed has been halved. Given that the coefficient of restitution between the particles is e ,

- (a) show that $8u_2(e + 1) = u_1(8e - 3)$. (7 marks)

Given also that $u_1 = 14 \text{ m s}^{-1}$ and $u_2 = 3 \text{ m s}^{-1}$,

- (b) find e , (3 marks)
- (c) show that the percentage of the kinetic energy of the particles lost as a result of the impact is 9.6% , correct to 2 significant figures. (7 marks)

END