Paper Reference(s)

6678

Edexcel GCE

Mechanics M2

Advanced Level

Specimen Paper

Time: 1 hour 30 minutes

Materials required for examination
Answer Book (AB16)
Mathematical Formulae (Lilac)
Graph Paper (ASG2)

Items included with question papers
Nil

Candidates may use any calculator EXCEPT those with the facility for symbolic algebra, differentiation and/or integration. Thus candidates may NOT use calculators such as the Texas Instruments TI 89, TI 92, Casio CFX 9970G, Hewlett Packard HP 48G.

Instructions to Candidates

In the boxes on the answer book, write the name of the examining body (Edexcel), your centre number, candidate number, the unit title (Mechanics M2), the paper reference (6678), your surname, other name and signature.
Whenever a numerical value of g is required, take $g = 9.8$ m s^{-2}.
When a calculator is used, the answer should be given to an appropriate degree of accuracy.

Information for Candidates

A booklet 'Mathematical Formulae and Statistical Tables' is provided.
Full marks may be obtained for answers to ALL questions.
This paper has eight questions.

Advice to Candidates

You must ensure that your answers to parts of questions are clearly labelled.
You must show sufficient working to make your methods clear to the Examiner. Answers without working may gain no credit.

1. The vectors **i** and **j** are perpendicular unit vectors in a horizontal plane. A ball of mass 0.5 kg is moving with velocity $-20\mathbf{i}$ m s^{-1} when it is struck by a bat. The bat gives the ball an impulse of $(15\mathbf{i} + 10\mathbf{j})$ Ns.

Find, to 3 significant figures, the speed of the ball immediately after it has been struck.

(5)

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2. A bullet of mass 6 grams passes horizontally through a fixed, vertical board. After the bullet has travelled 2 cm through the board its speed is reduced from 400 m s^{-1} to 250 m s^{-1}. The board exerts a constant resistive force on the bullet.

Find, to 3 significant figures, the magnitude of this resistive force.

(5)

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3. At time t seconds, a particle P has position vector **r** metres relative to a fixed origin O, where

$$\mathbf{r} = (t^3 - 3t)\mathbf{i} + 4t^2\mathbf{j}, \quad t \geq 0.$$

Find

(a) the velocity of P at time t seconds,

(2)

(b) the time when P is moving parallel to the vector $\mathbf{i} + \mathbf{j}$.

(5)

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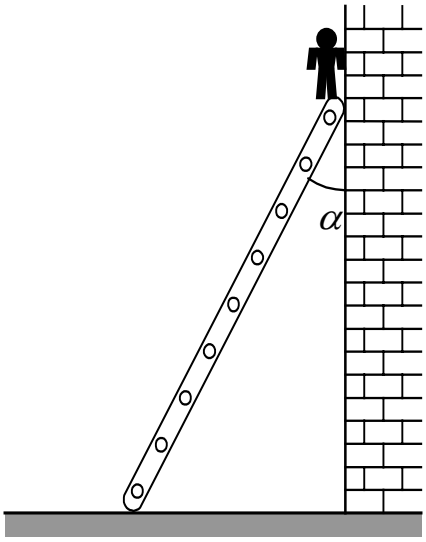
4. **Figure 1**



A uniform ladder, of mass m and length $2a$, has one end on rough horizontal ground. The other end rests against a smooth vertical wall. A man of mass $3m$ stands at the top of the ladder and the ladder is in equilibrium. The coefficient of friction between the ladder and the ground is $\frac{1}{4}$, and the ladder makes an angle α with the vertical, as shown in Fig. 1. The ladder is in a vertical plane perpendicular to the wall.

Show that $\tan\alpha \leq \frac{2}{7}$.

(9)

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5. A straight road is inclined at an angle α to the horizontal, where $\sin\alpha = \frac{1}{20}$. A lorry of mass 4800 kg moves up the road at a constant speed of 12 m s^{-1}. The non-gravitational resistance to the motion of the lorry is constant and has magnitude 2000 N.

(*a*) Find, in kW to 3 significant figures, the rate of working of the lorry's engine.

(5)

The road becomes horizontal. The lorry's engine continues to work at the same rate and the resistance to motion remains the same.

Find

(*b*) the acceleration of the lorry immediately after the road becomes horizontal,

(3)

(*c*) the maximum speed, in m s^{-1} to 3 significant figures, at which the lorry will go along the horizontal road.

(3)

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6. A cricket ball is hit from a height of 0.8 m above horizontal ground with a speed of 26 m s^{-1} at an angle α above the horizontal, where $\tan\alpha = \frac{5}{12}$. The motion of the ball is modelled as that of a particle moving freely under gravity.

(*a*) Find, to 2 significant figures, the greatest height above the ground reached by the ball.

(4)

When the ball has travelled a horizontal distance of 36 m, it hits a window.

(*b*) Find, to 2 significant figures, the height above the ground at which the ball hits the window.

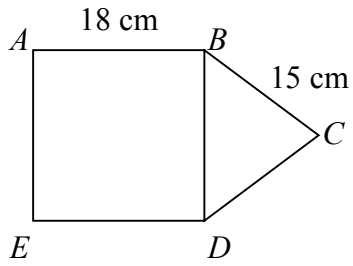
(7)

(*c*) State one physical factor which could be taken into account in any refinement of the model which would make it more realistic.

(1)

Figure 2

7.



A uniform plane lamina *ABCDE* is formed by joining a uniform square *ABDE* with a uniform triangular lamina *BCD*, of the same material, along the side *BD*, as shown in Fig. 2. The lengths *AB*, *BC* and *CD* are 18 cm, 15 cm and 15 cm respectively.

(a) Find the distance of the centre of mass of the lamina from *AE*.

(9)

The lamina is freely suspended from *B* and hangs in equilibrium.

(*b*) Find, in degrees to one decimal place, the angle which *BD* makes with the vertical.

(4)

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8. A particle A of mass m is moving with speed $3u$ on a smooth horizontal table when it collides directly with a particle B of mass $2m$ which is moving in the opposite direction with speed u. The direction of motion of A is reversed by the collision. The coefficient of restitution between A and B is e.

(a) Show that the speed of B immediately after the collision is $\frac{1}{3}(1 + 4e)u$.

(6)

(b) Show that $e > \frac{1}{8}$.

(3)

Subsequently B hits a wall fixed at right angles to the line of motion of A and B. The coefficient of restitution between B and the wall is $\frac{1}{2}$. After B rebounds from the wall, there is a further collision between A and B.

(c) Show that $e < \frac{1}{4}$.

(4)

END