Paper Reference(s)

6679

Edexcel GCE

Mechanics M3

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 M3), the paper reference (6679), 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.

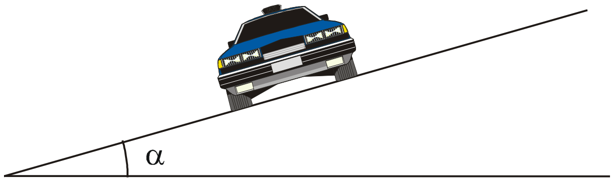
Information for Candidates

A booklet ‘Mathematical Formulae and Statistical Tables’ is provided.
Full marks may be obtained for answers to ALL questions.
This paper has seven 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. **Figure 1**



A car moves round a bend in a road which is banked at an angle α to the horizontal, as shown in Fig. 1. The car is modelled as a particle moving in a horizontal circle of radius 100 m. When the car moves at a constant speed of 14 m s^{-1}, there is no sideways frictional force on the car.

Find, in degrees to one decimal place, the value of α.

(7)

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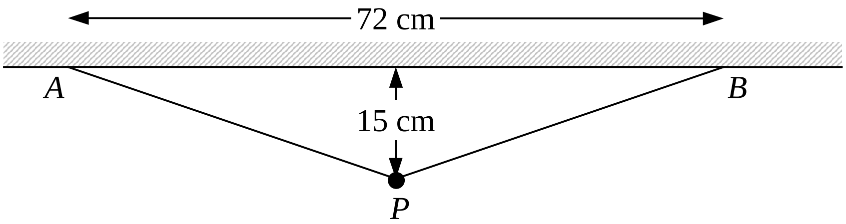
2. **Figure 2**



Two elastic ropes each have natural length 30 cm and modulus of elasticity λ N. One end of each rope is attached to a lead weight P of mass 2 kg and the other ends are attached to two points A and B on a horizontal ceiling, where AB = 72 cm. The weight hangs in equilibrium 15 cm below the ceiling, as shown in Fig. 2. By modelling P as a particle and the ropes as light elastic strings,

(*a*) find, to one decimal place, the value of λ .

(6)

(*b*) State how you have used the fact that P is modelled as a particle.

(1)

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3. A particle P of mass 0.5 kg moves away from the origin O along the positive x-axis under the action of a force directed towards O of magnitude $\frac{2}{x^2}$ N, where $OP = x$ metres. When $x = 1$, the speed of P is 3 m s^{-1}. Find the distance of P from O when its speed has been reduced to 1.5 m s^{-1}.

(8)

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4. A man of mass 75 kg is attached to one end of a light elastic rope of natural length 12 m. The other end of the rope is attached to a point on the edge of a horizontal ledge 19 m above the ground. The man steps off the ledge and falls vertically under gravity. The man is modelled as a particle falling from rest. He is brought to instantaneous rest by the rope when he is 1 m above the ground.
Find

(*a*) the modulus of elasticity of the rope,

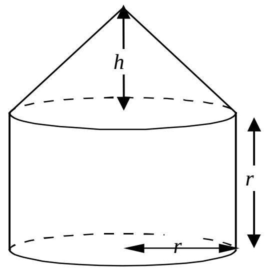
(5)

(*b*) the speed of the man when he is 2 m above the ground, giving your answer in m s^{-1} to 3 significant figures.

(5)

5.

Figure 3



A uniform solid, *S*, is placed with its plane face on horizontal ground. The solid consists of a right circular cylinder, of radius *r* and height *r*, joined to a right circular cone, of radius *r* and height *h*. The plane face of the cone coincides with one of the plane faces of the cylinder, as shown in Fig. 3.

(*a*) Show that the distance of the centre of mass of *S* from the ground is

$$\frac{6r^2 + 4rh + h^2}{4(3r + h)}.$$

(8)

The solid is now placed with its plane face on a rough plane which is inclined at an angle α to the horizontal. The plane is rough enough to prevent *S* from sliding. Given that $h = 2r$, and that *S* is on the point of toppling,

(*b*) find, to the nearest degree, the value of α.

(5)

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6. A particle P is attached to one end of a light inextensible string of length a. The other end of the string is attached to a fixed point O. The particle is hanging in equilibrium below O when it receives a horizontal impulse giving it a speed u, where $u^2 = 3ga$. The string becomes slack when P is at the point B. The line OB makes an angle θ with the upward vertical.

(*a*) Show that $\cos\theta = \frac{1}{3}$.

(9)

(*b*) Show that the greatest height of P above B in the subsequent motion is $\dfrac{4a}{27}$.

(6)

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7. A particle P of mass m is attached to one end of a light elastic string of natural length a and modulus of elasticity $6mg$. The other end of the string is attached to a fixed point O. When the particle hangs in equilibrium with the string vertical, the extension of the string is e.

(*a*) Find e.

(2)

The particle is now pulled down a vertical distance $\frac{1}{3}a$ below its equilibrium position and released from rest. At time t after being released, during the time when the string remains taut, the extension of the string is $e + x$. By forming a differential equation for the motion of P while the string remains taut,

(*b*) show that during this time P moves with simple harmonic motion of period $2\pi\sqrt{\dfrac{a}{6g}}$.

(6)

(*c*) Show that, while the string remains taut, the greatest speed of P is $\frac{1}{3}\sqrt{(6ga)}$.

(2)

(*d*) Find t when the string becomes slack for the first time.

(5)

END