Pearson Edexcel International Advanced Level

Thursday 11 June 2026

Afternoon (Time: 1 hour 30 minutes)

Paper reference **WME03/01A**

Mathematics

International Advanced Subsidiary/Advanced Level
Mechanics M3
Question paper

You must have:
Answer book (sent separately).
Do not return this question paper with the answer book.

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Pearson

1.

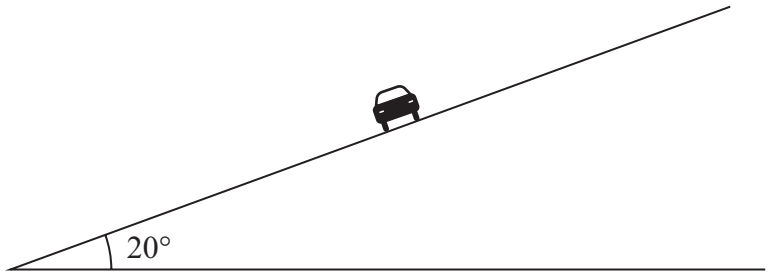

Figure 1

A car moves on a horizontal circular path round a banked bend on a race track.
The radius of the path is 60 m.
The bend is banked at 20° to the horizontal, as shown in Figure 1.

The coefficient of friction between the car and the track is 0.25
The maximum speed at which the car can be driven round the bend without slipping sideways is $V\,\text{m s}^{-1}$
The car and driver are modelled as a single particle of mass 700 kg.

Using the model,

(a) find the magnitude of the normal reaction between the car and the track when the speed of the car is $V\,\text{m s}^{-1}$

(4)

(b) find the value of V.

(4)

(Total for Question 1 is 8 marks)

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2. **In this question you must show all stages of your working.**
Solutions relying entirely on calculator technology are not acceptable.

A particle is moving along the x-axis.

At time t seconds, $t \geqslant 0$

- the particle has velocity $v\,\text{m s}^{-1}$ in the positive x direction
- the particle has acceleration $\left(3 - \dfrac{8}{2t+3}\right)\text{m s}^{-2}$ in the positive x direction

When $t = 0$, the particle passes through the origin with velocity $2(\ln 3)\,\text{m s}^{-1}$ in the positive x direction.

(a) Use algebraic integration to show that $v = pt + q\ln(2t+3) + r\ln 3$, where p, q and r are constants to be found.

(4)

(b) Use algebraic integration to find the distance of the particle from the origin at time $t = 3$, giving your answer to 3 significant figures.

(4)

(Total for Question 2 is 8 marks)

3. (a) Use algebraic integration to show that the centre of mass of a uniform semicircular lamina of radius r is $\frac{4r}{3\pi}$ from the centre of the semicircle.

[You may assume, without proof, that the area of a circle of radius r is πr^2]

(5)

In the template shown shaded in Figure 2, C_1 is a semicircular lamina with a semicircular lamina C_3 removed. A semicircular lamina C_2 is attached to C_1.

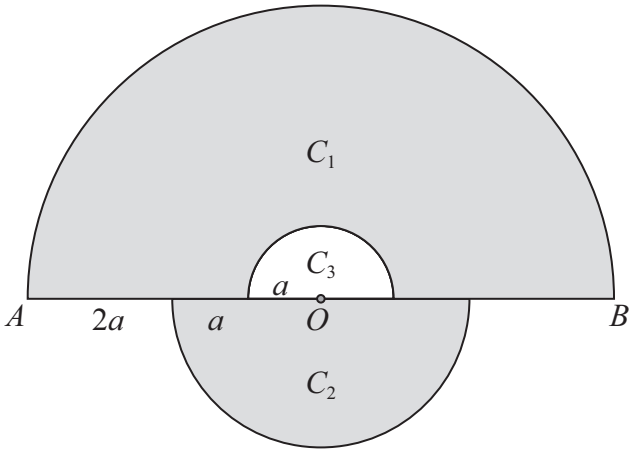

Figure 2

- C_1 has radius $4a$, diameter AB and centre O
- C_2 has radius $2a$ and centre O
- C_3 has radius a and centre O

Laminas C_1 and C_2 are made from the same material and lie in the same plane.

The template is freely suspended from A and hangs in equilibrium with AB at an angle of $\theta°$ to the downward vertical.

(b) Find the value of θ

(7)

(Total for Question 3 is 12 marks)

4. A light elastic **spring**, of natural length $4a$ and modulus of elasticity $3mg$, has one end attached to a fixed point A.
A particle of mass m is attached to the other end of the spring. The particle hangs vertically below A.

The particle is pulled vertically downwards to the point B, where $AB = 7a$, and released from rest.
Air resistance is ignored.

(a) Find the acceleration of the particle at the instant it is released from rest.

(3)

(b) By considering energy, find in terms of g and a, the speed of the particle when it is a distance $5a$ below A.

(5)

The particle first comes to instantaneous rest at the point C, where $AC = ka$ and k is a constant.

(c) By considering energy, find the value of k.

(5)

(Total for Question 4 is 13 marks)

5.

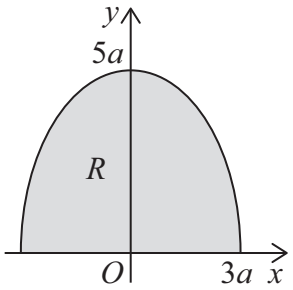

Figure 3

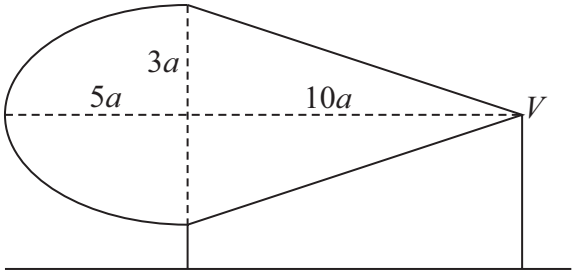

Figure 4

The region R, shown shaded in Figure 3, is the region enclosed between the x-axis and the curve with equation $\frac{x^2}{9a^2} + \frac{y^2}{25a^2} = 1$

Region R is rotated through π radians about the y-axis to form a solid of revolution.
A uniform solid S has the same shape and size as this solid of revolution.

The volume of S is $30\pi a^3$

The distance of the centre of mass of S from O is d.

(a) Use algebraic integration to show that $d = \frac{15}{8}a$.

(6)

The solid S is joined to a uniform solid right circular cone C that is made of the **same material** as S to form a model.
The cone has vertex V, height $10a$ and base radius $3a$.
The plane face of S and the plane face of C coincide.
The model is supported on two light vertical rods.

- the first rod has one end attached to the model at V and the other end attached to horizontal ground
- the second rod has one end attached to the model at a point on the rim of the common plane face and the other end attached to the horizontal ground

The model rests in equilibrium with its axis of symmetry horizontal and in the same vertical plane as the two rods, as shown in Figure 4.

Given that the weight of the model is $2W$

(b) find, in terms of W, the thrust in the rod attached to the model at V.

(4)

(Total for Question 5 is 10 marks)

6.

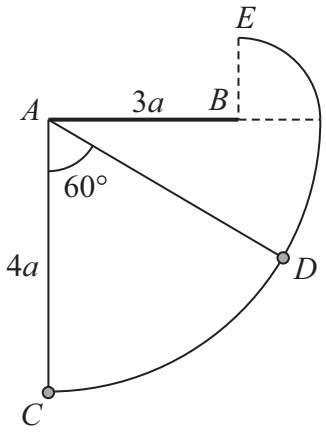

Figure 5

A thin fixed horizontal shelf AB has length $3a$.
A particle of mass m is attached to one end of a light inextensible string of length $4a$.
The other end of the string is attached to the underneath of the shelf at A.
The particle is hanging at rest at C, vertically below A, when it is projected horizontally with speed u.
The particle starts to move, with the string taut, in a vertical plane that is perpendicular to the plane of the shelf. The edge of the shelf is perpendicular to the circular path of the particle.
Air resistance is ignored.
When the string is horizontal, the string wraps round the end of the shelf and the particle continues to move in the vertical plane.
The particle follows the path CDE, as shown in Figure 5.

The point D on the circular path of the particle is such that angle $CAD = 60°$

(a) Find, in terms of m, u, a and g, the tension in the string at the instant when the particle is at D.

(5)

The point E is vertically above B, with $BE = a$.
Given that the particle is still moving in a vertical circle when it reaches E

(b) show that $u \geqslant \sqrt{11ga}$

(3)

At the instant when the particle is at E, the particle breaks free from the string.
The particle moves freely under gravity and first lands on the shelf at the point F.

Given that $u = \sqrt{12ga}$

(c) find, in terms of a, the distance BF.

(4)

(Total for Question 6 is 12 marks)

7.

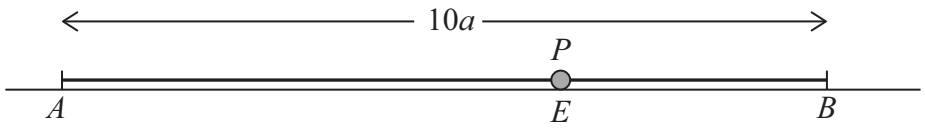

Figure 6

The fixed points A and B lie on a smooth horizontal surface with $AB = 10a$.

A particle P has mass m.

One end of a light elastic string, of natural length $5a$ and modulus of elasticity $\frac{1}{3}mg$,

is attached to P and the other end is attached to A.

One end of another light elastic string, of natural length $3a$ and modulus of elasticity

$\frac{2}{5}mg$, is attached to P and the other end is attached to B.

The particle P is resting in equilibrium at the point E on the surface, as shown in Figure 6.

(a) Show that $EB = \frac{11a}{3}$

(3)

Particle P is now held on the surface at the point C, between A and B, where $CB = 3a$, and released from rest.

(b) Show that P moves with simple harmonic motion about E.

(4)

(c) Show that the simple harmonic motion has period $2\pi\sqrt{\frac{5a}{g}}$

(2)

In any one complete oscillation of the simple harmonic motion, the particle is less than

a distance $\frac{1}{3}a$ from E for a time S.

(d) Find S in terms of π, a and g.

(3)

(Total for Question 7 is 12 marks)

TOTAL FOR PAPER IS 75 MARKS

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