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Candidate surname	Other names

Pearson Edexcel
International
Advanced Level

Centre Number | | | | | |

Candidate Number | | | | |

Wednesday 22 January 2020

Morning (Time: 1 hour 30 minutes) | Paper Reference **WME02/01**

Mathematics

International Advanced Subsidiary/Advanced Level
Mechanics M2

You must have:
Mathematical Formulae and Statistical Tables (Blue), calculator

Total Marks

Candidates may use any calculator permitted by Pearson regulations. Calculators must not have the facility for symbolic algebra manipulation, differentiation and integration, or have retrievable mathematical formulae stored in them.

Instructions

- Use **black** ink or ball-point pen.
- If pencil is used for diagrams/sketches/graphs it must be dark (HB or B).
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions and ensure that your answers to parts of questions are clearly labelled.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*
- You should show sufficient working to make your methods clear. Answers without working may not gain full credit.
- Whenever a numerical value of g is required, take $g = 9.8\,\text{m s}^{-2}$, and give your answer to either 2 significant figures or 3 significant figures.

Information

- A booklet 'Mathematical Formulae and Statistical Tables' is provided.
- There are 8 questions in this question paper. The total mark for this paper is 75.
- The marks for each question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*

Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.
- If you change your mind about an answer, cross it out and put your new answer and any working underneath.

Turn over ▶

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1. A cyclist and his bicycle have a total mass of 75 kg. The cyclist is moving down a straight road that is inclined at an angle α to the horizontal, where $\sin\alpha = \frac{1}{15}$

The cyclist is working at a constant rate of 56 W. The magnitude of the resistance to motion is modelled as a constant force of magnitude 40 N. At the instant when the speed of the cyclist is $V\,\text{m s}^{-1}$, his acceleration is $\frac{1}{3}\,\text{m s}^{-2}$

Find the value of V.

(5)

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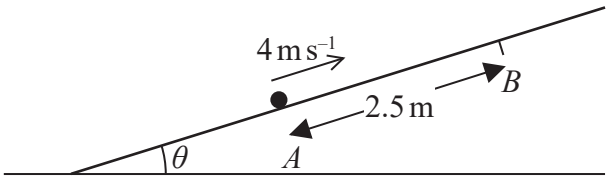


Figure 1

A rough straight ramp is fixed to horizontal ground. The ramp is inclined at an angle θ to the horizontal, where $\sin\theta = \frac{1}{7}$. The points A and B are on a line of greatest slope of the ramp with $AB = 2.5\,\text{m}$ and B above A, as shown in Figure 1. A package of mass 2 kg is projected up the ramp from A with speed $4\,\text{m s}^{-1}$ and first comes to instantaneous rest at B. The coefficient of friction between the package and the ramp is μ. The package is modelled as a particle.

Use the work-energy principle to find the value of μ.

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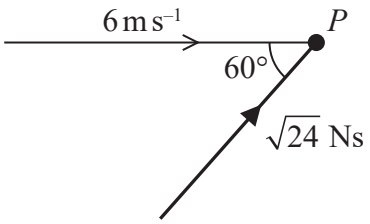


Figure 2

A particle P of mass 0.75 kg is moving along a straight line on a horizontal surface. At the instant when the speed of P is $6\,\text{m s}^{-1}$, it receives an impulse of magnitude $\sqrt{24}$ Ns. The impulse acts in the plane of the horizontal surface. At the instant when P receives the impulse, the line of action of the impulse makes an angle of 60° with the direction of motion of P, as shown in Figure 2.

Find

(i) the speed of P immediately after receiving the impulse,

(ii) the size of the angle between the direction of motion of P immediately before receiving the impulse and the direction of motion of P immediately after receiving the impulse.

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[*The centre of mass of a uniform semicircular lamina of radius r is* $\frac{4r}{3\pi}$ *from the centre.*]

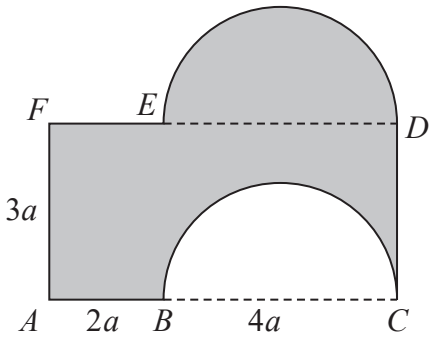


Figure 3

The uniform rectangular lamina $ABCDEF$ has sides $AC = FD = 6a$ and $AF = CD = 3a$. The point B lies on AC with $AB = 2a$ and the point E lies on FD with $FE = 2a$.

The template, T, shown shaded in Figure 3, is formed by removing the semicircular lamina with diameter BC from the rectangular lamina and then fixing this semicircular lamina to the opposite side, FD, of the rectangular lamina. The diameter of the semicircular lamina coincides with ED and the semicircular arc ED is outside the rectangle $ABCDEF$. All points of T lie in the same plane.

(a) Show that the centre of mass of T is a distance $\left(\frac{9 + 2\pi}{6}\right)a$ from AC.

(4)

The mass of T is M. A particle of mass kM is attached to T at C. The loaded template is freely suspended from A and hangs in equilibrium with AF at angle ϕ to the downward vertical through A.

Given that $\tan\phi = \frac{3}{2}$

(b) find the value of k.

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5. At time t seconds ($t \geqslant 0$), a particle P has velocity $\mathbf{v}\,\text{m s}^{-1}$, where

$$\mathbf{v} = (3t^2 - 4)\mathbf{i} + (2t - 4)\mathbf{j}$$

When $t = 0$, P is at the fixed point O.

(a) Find the acceleration of P at the instant when $t = 0$

(2)

(b) Find the exact speed of P at the instant when P is moving in the direction of the vector $(11\mathbf{i} + \mathbf{j})$ for the second time.

(4)

(c) Show that P never returns to O.

(4)

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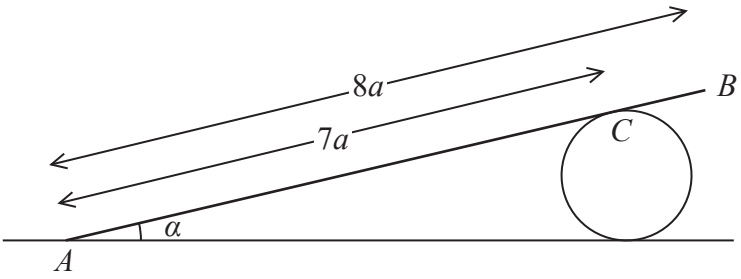


Figure 4

A uniform rod, AB, of weight W and length $8a$, rests in equilibrium with the end A on rough horizontal ground. The rod rests on a smooth cylinder. The cylinder is fixed to the ground with its axis horizontal. The point of contact between the rod and the cylinder is C, where $AC = 7a$, as shown in Figure 4. The rod is resting in a vertical plane that is perpendicular to the axis of the cylinder. The rod makes an angle α with the horizontal.

(a) Show that the normal reaction of the ground on the rod at A has magnitude $W\left(1 - \frac{4}{7}\cos^2\alpha\right)$

(6)

Given that the coefficient of friction between the rod and the ground is μ and that $\cos\alpha = \frac{3}{\sqrt{10}}$

(b) find the range of possible values of μ.

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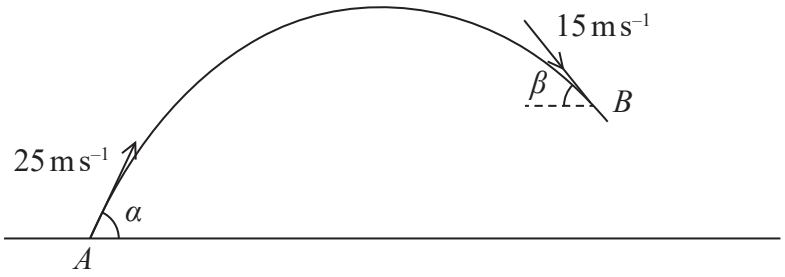


Figure 5

At time $t = 0$ a particle P is projected from a fixed point A on horizontal ground. The particle is projected with speed $25\,\text{m s}^{-1}$ at an angle α to the ground. The particle moves freely under gravity. At time $t = 3$ seconds, P is passing through the point B with speed $15\,\text{m s}^{-1}$ and is moving downwards at an angle β to the horizontal, as shown in Figure 5.

(a) By considering energy, find the height of B above the ground.

(3)

(b) Find the size of angle α.

(3)

(c) Find the size of angle β.

(3)

(d) Find the least speed of P as P travels from A to B.

(2)

As P travels from A to B, the speed, $v\,\text{m s}^{-1}$, of P is such that $v \leqslant 15$ for an interval of T seconds.

(e) Find the value of T.

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8. A particle A has mass $4m$ and a particle B has mass $3m$. The particles are moving along the same straight line on a smooth horizontal plane. They are moving in opposite directions towards each other and collide directly.

Immediately before the collision the speed of A is $2u$ and the speed of B is $3u$.

The direction of motion of each particle is reversed by the collision.

The total kinetic energy lost in the collision is $\frac{473}{24}mu^2$

Find

(i) the coefficient of restitution between A and B,

(ii) the magnitude of the impulse received by A in the collision.

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