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Pearson Edexcel
International
Advanced Level

Centre Number | | | | | |

Candidate Number | | | | |

Mechanics M2

Advanced/Advanced Subsidiary

Tuesday 23 January 2018 – Morning
Time: 1 hour 30 minutes

Paper Reference
WME02/01

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

Total Marks

Candidates may use any calculator allowed by the regulations of the Joint Council for Qualifications. 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). Coloured pencils and highlighter pens must not be used.
- **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 $g = 9.8$ m s^{-2}, and give your answer to either two significant figures or three significant figures.
- When a calculator is used, the answer should be given to an appropriate degree of accuracy.

Information

- 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.

Turn over ▶

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1. A ball of mass 0.5 kg is moving with velocity $(2\mathbf{i} - 3\mathbf{j})$ m s^{-1} when it receives an impulse $(4\mathbf{i} + 5\mathbf{j})$ N s. Find the gain in kinetic energy of the ball due to the impulse.

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Question 1 continued

Q1

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2. A particle P moves in a straight line. At time $t = 0$, P passes through a point O on the line. At time t seconds, the velocity of P is v m s^{-1} where

$$v = (2t - 1)(1 - t)$$

(a) Find the acceleration of P when $t = \frac{1}{2}$

(3)

(b) Find the distance travelled by P in the interval $0 \leqslant t \leqslant 1$

(6)

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Question 2 continued

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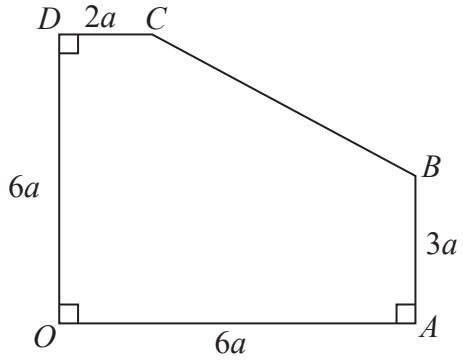

Figure 1

The uniform lamina $OABCD$ is shown in Figure 1, with $OA = 6a$, $AB = 3a$, $CD = 2a$ and $DO = 6a$ and with right angles at O, A and D.

(a) Find the distance of the centre of mass of the lamina

(i) from OD,

(ii) from OA.

(6)

The lamina is suspended from C and hangs freely in equilibrium with CB inclined at an angle α to the vertical.

(b) Find, to the nearest degree, the size of the angle α.

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4. A particle P of mass $2m$ is moving in a straight line with speed u on a smooth horizontal plane. The particle P collides directly with a particle Q, of mass m, which is moving on the plane along the same straight line as P but in the opposite direction to P. Immediately before the collision the speed of Q is $3u$. The coefficient of restitution between P and Q is e, where $e > \frac{1}{8}$

(a) Find, in terms of u and e,

(i) the speed of P immediately after the collision,

(ii) the speed of Q immediately after the collision.

(7)

(b) Show that, for all possible values of e, the direction of motion of P is reversed by the collision.

(2)

After the collision, Q strikes a smooth fixed vertical wall, which is perpendicular to the direction of motion of Q, and rebounds. The coefficient of restitution between Q and the wall is f.

Given that $e = \frac{3}{4}$ and that there is a second collision between Q and P,

(c) find the range of possible values of f.

(4)

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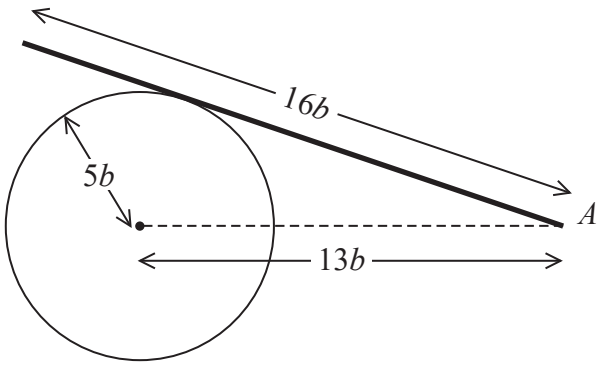

Figure 2

A uniform rod, of weight W and length $16b$, has one end freely hinged to a fixed point A. The rod rests against a smooth circular cylinder, of radius $5b$, fixed with its axis horizontal and at the same horizontal level as A. The distance of A from the axis of the cylinder is $13b$, as shown in Figure 2. The rod rests in a vertical plane which is perpendicular to the axis of the cylinder.

(a) Find, in terms of W, the magnitude of the reaction on the rod at its point of contact with the cylinder.

(4)

(b) Show that the resultant force acting on the rod at A is inclined to the vertical at an angle α where $\tan \alpha = \frac{40}{73}$

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6. A car of mass 800 kg pulls a trailer of mass 300 kg up a straight road which is inclined to the horizontal at an angle α, where $\sin \alpha = \frac{1}{14}$. The trailer is attached to the car by a light inextensible towbar which is parallel to the direction of motion of the car. The car's engine works at a constant rate of P kW. The non-gravitational resistances to motion are constant and of magnitude 600 N on the car and 200 N on the trailer.

At a given instant the car is moving at 10 m s^{-1} and is accelerating at 0.5 m s^{-2}

(a) Find the value of P.

(5)

When the car is moving up the road at 12 m s^{-1}, the towbar breaks. The trailer comes to instantaneous rest after moving a distance d metres up the road from the point where the towbar broke. The non-gravitational resistance to the motion of the trailer remains constant and of magnitude 200 N.

(b) Find, using the work-energy principle, the value of d.

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7. A particle is projected from a point O with speed U at an angle of elevation α to the horizontal and moves freely under gravity. When the particle has moved a horizontal distance x, its height above O is y.

(a) Show that

$$y = x\tan\alpha - \frac{gx^2(1+\tan^2\alpha)}{2U^2}$$

(7)

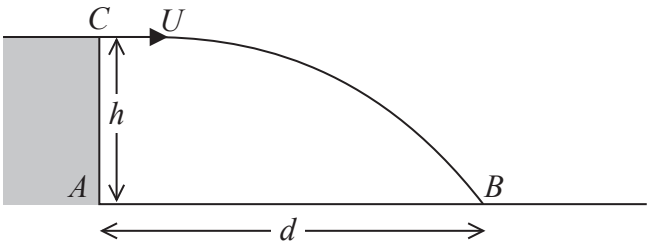

Figure 3

A small stone is projected horizontally with speed U from a point C at the top of a vertical cliff AC so as to hit a fixed target B on the horizontal ground. The point C is a height h above the ground, as shown in Figure 3. The time of flight of the stone from C to B is T, and the stone is modelled as a particle moving freely under gravity.

(b) Find, in terms of U, g and T, the speed of the stone as it hits the target at B.

(4)

It is found that, using the same initial speed U, the target can also be hit by projecting the stone from C at an angle α above the horizontal. The stone is again modelled as a particle moving freely under gravity and the distance $AB = d$.

(c) Using the result in part (a), or otherwise, show that

$$d = \frac{1}{2}gT^2\tan\alpha$$

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