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Surname	Other names

Pearson Edexcel
International
Advanced Level

Centre Number | | | | | |

Candidate Number | | | | |

Mechanics M2

Advanced/Advanced Subsidiary

Tuesday 24 January 2017 – 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.

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1. A car of mass 1200 kg moves up a straight road. The road is inclined to the horizontal at an angle α where $\sin\alpha = \frac{1}{15}$. The car is moving up the road with constant speed 10 m s^{-1} and the engine of the car is working at a constant rate of 11 760 watts. The non-gravitational resistance to motion has a constant magnitude of R newtons.

(a) Find the value of R.

(4)

The rate of working of the car is now increased to 50 kW. At the instant when the speed of the car is V m s^{-1}, the magnitude of the non-gravitational resistance to the motion of the car is 700 N and the acceleration of the car is 1.5 m s^{-2}.

(b) Find the value of V.

(6)

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Question 1 continued

Q1

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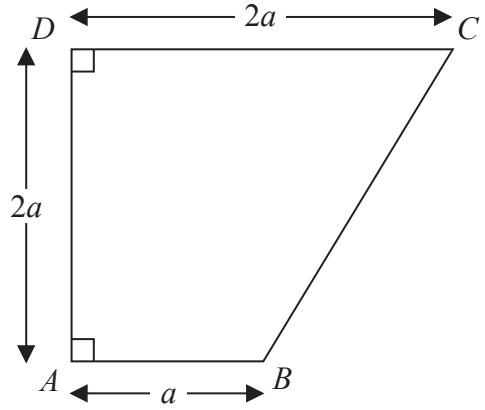

Figure 1

A uniform lamina is in the shape of a trapezium $ABCD$ with $AB = a$, $DA = DC = 2a$ and angle BAD = angle $ADC = 90°$, as shown in Figure 1.

The centre of mass of the lamina is at the point G.

(a) (i) Show that the distance of G from AB is $\frac{10a}{9}$.

(ii) Find the distance of G from AD.

(6)

The mass of the lamina is $3M$. A particle of mass kM is now attached to the lamina at B. The lamina is freely suspended from the midpoint of AD and hangs in equilibrium with AD horizontal.

(b) Find the value of k.

(3)

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Question 2 continued

Q2

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

$$v = (2t - 3)(t - 2)$$

At $t = 3$, P reaches the point B. Find the total distance moved by P as it travels from A to B.

(6)

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Question 3 continued

(Total 6 marks)

Q3

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4. A particle P of mass 0.2 kg is moving with velocity $(20\mathbf{i} - 16\mathbf{j})$ m s^{-1} when it receives an impulse $(-6\mathbf{i} + 8\mathbf{j})$ N s.

(a) Find the speed of P immediately after it receives the impulse.

(5)

(b) Find the size of the angle between the direction of motion of P before the impulse is received and the direction of motion of P after the impulse is received.

(4)

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Question 4 continued

Q4

(Total 9 marks)

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5. Two particles P and Q, of masses $2m$ and $3m$ respectively, are moving in opposite directions along the same straight line on a smooth horizontal plane. The particles collide directly and, as a result of the collision, the direction of motion of P is reversed and the direction of motion of Q is reversed. Immediately after the collision, the speed of P is v and the speed of Q is $\frac{3v}{2}$. The coefficient of restitution between P and Q is $\frac{1}{5}$.

(a) Find

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

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

(7)

After the collision with P, the particle Q moves on the plane and strikes at right angles a fixed smooth vertical wall and rebounds. The coefficient of restitution between Q and the wall is e. Given that there is a further collision between the particles,

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

(3)

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Q5

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6. A ball of mass 0.6 kg is projected vertically upwards with speed 22.4 m s^{-1} from a point which is 1.5 m above horizontal ground. The ball moves freely under gravity until it reaches the ground. The ground is soft and the ball sinks 2.5 cm into the ground before coming to rest. The ball is modelled as a particle and the ground is assumed to exert a constant resistive force of magnitude R newtons on the ball. Using the work-energy principle, find, to 3 significant figures, the value of R.

(5)

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Question 6 continued

Q6

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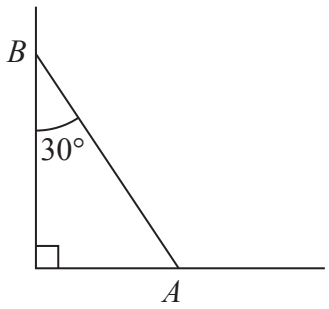

Figure 2

A uniform rod AB has mass m and length $2a$. The end A is in contact with rough horizontal ground and the end B is in contact with a smooth vertical wall. The rod rests in equilibrium in a vertical plane perpendicular to the wall and makes an angle of 30° with the wall, as shown in Figure 2. The coefficient of friction between the rod and the ground is μ.

(a) Find, in terms of m and g, the magnitude of the force exerted on the rod by the wall.

(4)

(b) Show that $\mu \geqslant \frac{\sqrt{3}}{6}$.

(3)

A particle of mass km is now attached to the rod at B. Given that $\mu = \frac{\sqrt{3}}{5}$ and that the rod is now in limiting equilibrium,

(c) find the value of k.

(6)

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Q7

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8. At time $t = 0$ seconds, a golf ball is hit from a point O on horizontal ground. The horizontal and vertical components of the initial velocity of the ball are $3U$ m s^{-1} and U m s^{-1} respectively. The ball hits the ground at the point A, where $OA = 120$ m. The ball is modelled as a particle moving freely under gravity.

(a) Show that $U = 14$

(5)

(b) Find the speed of the ball immediately before it hits the ground at A.

(2)

(c) Find the values of t when the ball is moving at an angle α to the horizontal, where $\tan\alpha = \frac{1}{4}$.

(6)

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Q8

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