Please check the examination details below before entering your candidate information

Candidate surname	Other names

Pearson Edexcel
International
Advanced Level

Centre Number | | | | | |

Candidate Number | | | | |

Tuesday 12 November 2019

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 $g = 9.8\,\text{m}\,\text{s}^{-2}$, 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. Three particles of masses m, $3m$ and km are placed at the points whose coordinates are (2, 1), (4, 3) and (1, 5) respectively. The centre of mass of the three particles lies on the straight line with equation $y = 2x$.

Find the value of k.

(6)

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Question 1 continued

Q1

(Total 6 marks)

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2. A van has mass 750 kg. The van is moving up a straight road at constant speed U m s^{-1}

The road is inclined to the horizontal at an angle θ, where $\sin\theta = \frac{1}{15}$

The resistance to the motion of the van from non-gravitational forces is modelled as a single force of magnitude $30U$ newtons. The engine of the van is working at a constant rate of 16 kW.

Find the value of U.

(5)

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Question 2 continued

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Question 2 continued

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Question 2 continued

Q2

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3. A particle, Q, of mass 2 kg is moving under the action of a single force **F** newtons. At time t seconds ($t \geqslant 0$), the position vector of Q, relative to a fixed point O, is **r** metres and the velocity of Q is $\mathbf{v}\,\text{m}\,\text{s}^{-1}$ where

$$\mathbf{v} = (2t + 10)\mathbf{i} + 9t^{\frac{1}{2}}\mathbf{j}$$

Given that $\mathbf{r} = -20\mathbf{j}$ when $t = 0$, find

(a) **F** when $t = 4$

(3)

(b) **r** when $t = 4$

(3)

(c) the values of t for which Q is moving in the direction $\mathbf{i} + \mathbf{j}$.

(3)

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Question 3 continued

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Question 3 continued

Q3

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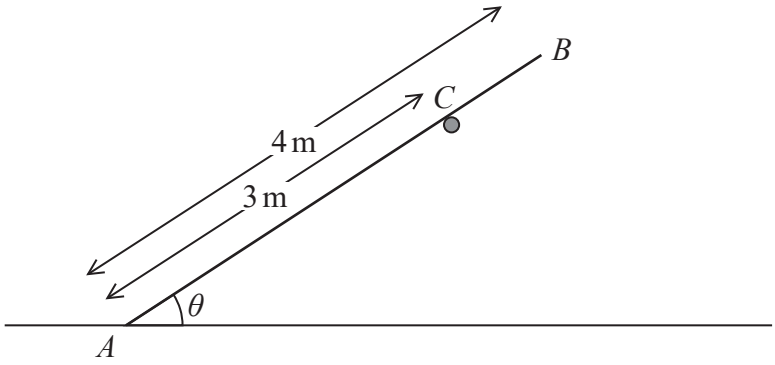

Figure 1

A uniform rod, AB, has length 4 m and weight 160 N. The rod rests against a fixed small smooth horizontal peg. The peg is perpendicular to the vertical plane containing AB. The rod rests on the peg at C, where $AC = 3$ m. The end A of the rod rests on rough horizontal ground and the rod is at an angle θ to the ground, as shown in Figure 1.

Given that $\cos\theta = \frac{3}{4}$ and the rod is in limiting equilibrium,

(a) show that the magnitude of the force acting on the rod at C is 80 N,

(3)

(b) find the coefficient of friction between the rod and the ground.

(6)

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Q4

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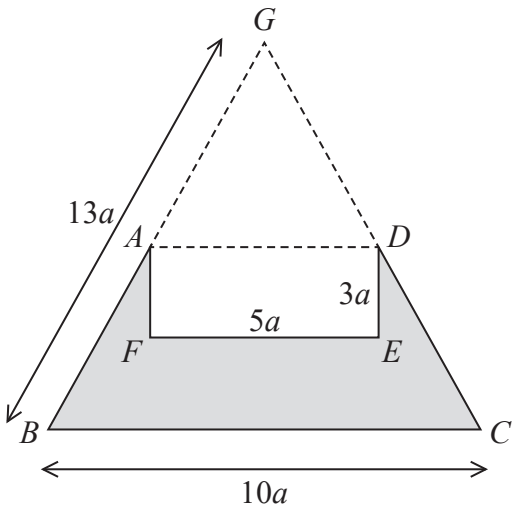

Figure 2

The uniform lamina GBC is in the shape of an isosceles triangle with $GB = GC = 13a$ and $BC = 10a$. The midpoint of GB is A and the midpoint of GC is D. The rectangle $AFED$ is such that $FE = 5a$ and $DE = 3a$.

The template, shown shaded in Figure 2, is formed by removing the triangle GAD and the rectangle $ADEF$ from the lamina GBC.

(a) Show that the centre of mass of the template is $\frac{7}{4}a$ from BC.

(5)

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, giving your answer to the nearest whole number.

(5)

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Question 5 continued

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Q5

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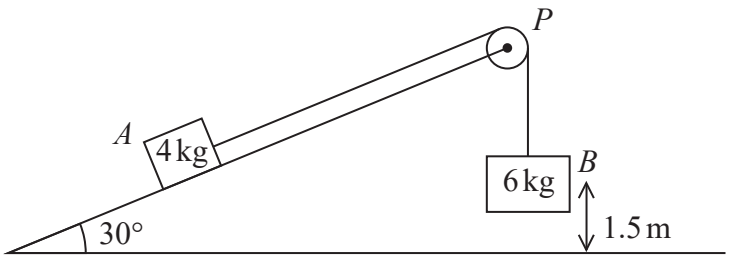

Figure 3

Two blocks, A and B, of masses 4 kg and 6 kg respectively, are connected by a light inextensible string. Block A is held at rest on a fixed rough ramp that is inclined at an angle of 30° to the horizontal. The string passes over a small smooth pulley, P, which is fixed at the top of the ramp. Block B hangs vertically below P, 1.5 m above the ground, as shown in Figure 3. Block A is more than 1.5 m from P. The blocks are released from rest with the string taut so that A moves up the ramp and the section of the string from A to P is parallel to a line of greatest slope of the ramp. The coefficient of friction between A and the ramp is $\frac{1}{\sqrt{3}}$

The blocks are modelled as particles and air resistance is ignored.

(a) Find the work done against friction as A moves 1.5 m up the ramp.

(4)

(b) Find the potential energy lost by the system as A moves 1.5 m up the ramp.

(3)

(c) Use the work-energy principle to find the speed of B at the instant immediately before it hits the ground.

(3)

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Question 6 continued

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Question 6 continued

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Q6

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7. Particles A, B and C, of masses $8m$, $2m$ and $3m$ respectively, lie at rest in a straight line on a smooth horizontal plane with B between A and C.

Particles B and C are projected towards each other with speeds ku and $4u$ respectively so that they collide directly. Immediately after the collision, the speed of B is $2u$ and the speed of C is u, and, as a result of the collision, the direction of motion of each of B and C is reversed.

The total kinetic energy lost in the collision between B and C is λmu^2, where λ is a constant.

(a) Find the value of λ.

(5)

After the collision between B and C, particle B, moving with speed $2u$, collides directly with particle A. The coefficient of restitution between A and B is e.

Given that there is a second collision between B and C,

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

(6)

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Question 7 continued

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Question 7 continued

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Question 7 continued

(Total 11 marks)

Q7

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8. [*In this question, the unit vectors* **i** *and* **j** *are in a vertical plane*, **i** *being horizontal and* **j** *being vertically upwards*.]

Two fixed points, X and Y, lie on horizontal ground with $XY = 60\,\text{m}$. At time $t = 0$ a particle, P, is projected from X with velocity $(12\mathbf{i} + b\mathbf{j})\,\text{m s}^{-1}$. At the same instant, another particle, Q, is projected from Y with velocity $(-c\mathbf{i} + d\mathbf{j})\,\text{m s}^{-1}$.

Given that the particles collide at a point Z and that b, c and d are positive constants,

(a) show that $b = d$.

(1)

The point Z is 10 m above the horizontal ground and the collision occurs at time $t = 3$ seconds.

(b) Find the value of d.

(2)

(c) Find the length of time for which Q is at least 10 m above the ground.

(3)

(d) Find the direction of motion of Q at the instant before it collides with P.

(5)

At time $t = T$ seconds, the direction of motion of P is perpendicular to its direction of motion at time $t = 0$

(e) Find the value of T.

(4)

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Q8

(Total 15 marks)

TOTAL FOR PAPER: 75 MARKS

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