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Pearson Edexcel
International Advanced Level

Centre Number | Candidate Number

Mechanics M2

Advanced/Advanced Subsidiary

Wednesday 21 January 2015 – Afternoon
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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P 4 5 0 6 2 A 0 1 2 8

PEARSON

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1. A particle P of mass 0.6 kg is moving with velocity $(4\mathbf{i} - 2\mathbf{j})$ m s^{-1} when it receives an impulse $\mathbf{I}$ N s. Immediately after receiving the impulse, P has velocity $(2\mathbf{i} + 3\mathbf{j})$ m s^{-1}.

Find

(a) the magnitude of $\mathbf{I}$,

(4)

(b) the kinetic energy lost by P as a result of receiving the impulse.

(3)

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Question 1 continued

Q1

(Total 7 marks)

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2. A car of mass 500 kg is moving at a constant speed of $20\,\text{m}\,\text{s}^{-1}$ up a straight road inclined at an angle θ to the horizontal, where $\sin\theta = \frac{1}{20}$. The resistance to motion from non-gravitational forces is modelled as a constant force of magnitude 150 N.

(a) Find the rate of working of the engine of the car.

(5)

When the car is travelling up the road at $20\,\text{m}\,\text{s}^{-1}$, the engine is switched off. The car then comes to instantaneous rest, without braking, having moved a distance d metres up the road from the point where the engine was switched off. The resistance to motion from non-gravitational forces is again modelled as a constant force of magnitude 150 N.

(b) Use the work-energy principle to find the value of d.

(4)

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Question 2 continued

Question 2 continued

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Question 2 continued

Q2

(Total 9 marks)

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3. At time t seconds (t . 0) a particle P has position vector $\mathbf{r}$ metres, with respect to a fixed origin O, where

$$\mathbf{r} = \left(\frac{1}{8}t^4 - 2\lambda t^2 + 5\right)\mathbf{i} + (5t^2 - \lambda t)\mathbf{j}$$

and λ is a constant.

When $t = 4$, P is moving parallel to the vector $\mathbf{j}$.

(a) Show that $\lambda = 2$

(5)

(b) Find the speed of P when $t = 4$

(1)

(c) Find the acceleration of P when $t = 4$

(2)

When $t = 0$, P is at the point A. When $t = 4$, P is at the point B.

(d) Find the distance AB.

(4)

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Question 3 continued

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Question 3 continued

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Question 3 continued

Q3

(Total 12 marks)

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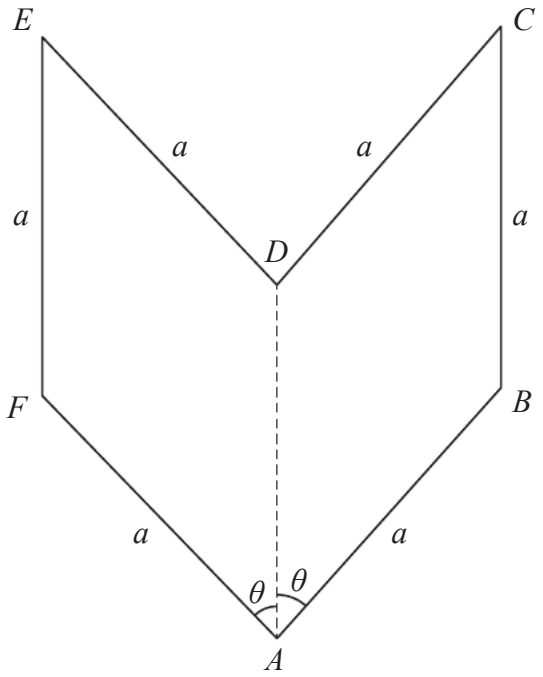

Figure 1

The uniform plane lamina $ABCDEF$ shown in Figure 1 is made from two identical rhombuses. Each rhombus has sides of length a and angle BAD = angle $DAF = \theta$. The centre of mass of the lamina is $0.9a$ from A.

(a) Show that $\cos\theta = 0.8$

(5)

The weight of the lamina is W. A particle of weight kW is fixed to the lamina at the point A. The lamina is freely suspended from B and hangs in equilibrium with DA horizontal.

(b) Find the value of k.

(4)

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Question 4 continued

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Question 4 continued

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Question 4 continued

Q4

(Total 9 marks)

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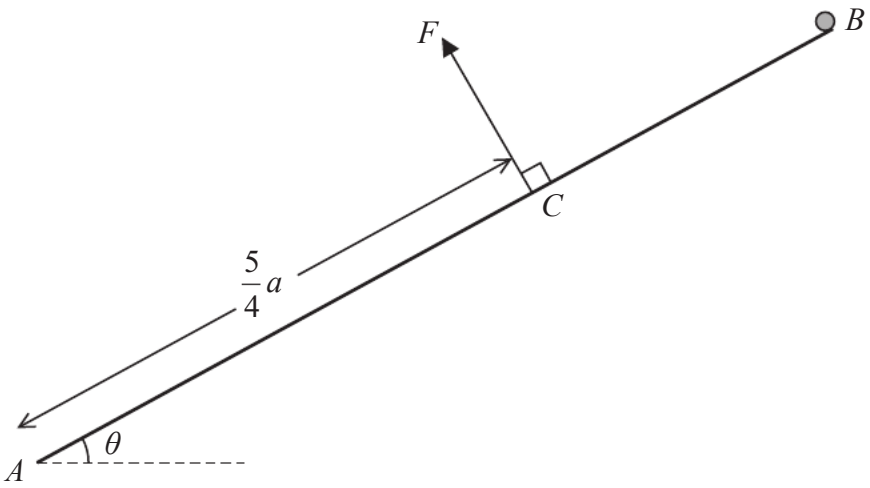

Figure 2

A uniform rod AB, of mass m and length $2a$, is freely hinged to a fixed point A. A particle of mass km is fixed to the rod at B. The rod is held in equilibrium, at an angle θ to the horizontal, by a force of magnitude F acting at the point C on the rod, where $AC = \frac{5}{4}a$, as shown in Figure 2. The line of action of the force at C is at right angles to AB and in the vertical plane containing AB.

Given that $\tan\theta = \frac{3}{4}$

(a) show that $F = \frac{16}{25}mg(1 + 2k)$,

(4)

(b) find, in terms of m, g and k,

(i) the horizontal component of the force exerted by the hinge on the rod at A,

(ii) the vertical component of the force exerted by the hinge on the rod at A.

(5)

Given also that the force acting on the rod at A acts at 45° above the horizontal,

(c) find the value of k.

(3)

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Question 5 continued

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Question 5 continued

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Question 5 continued

Q5

(Total 12 marks)

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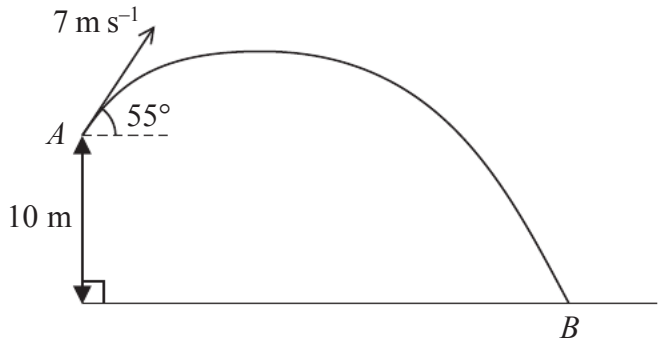

Figure 3

A small ball P is projected with speed $7\,\text{m s}^{-1}$ from a point A 10 m above horizontal ground. The angle of projection is 55° above the horizontal. The ball moves freely under gravity and hits the ground at the point B, as shown in Figure 3.

Find

(a) the speed of P as it hits the ground at B,

(4)

(b) the direction of motion of P as it hits the ground at B,

(3)

(c) the time taken for P to move from A to B.

(5)

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Question 6 continued

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Question 6 continued

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Question 6 continued

Q6

(Total 12 marks)

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7. Three particles P, Q and R lie at rest in a straight line on a smooth horizontal surface with Q between P and R. Particle P has mass m, particle Q has mass $2m$ and particle R has mass $3m$. The coefficient of restitution between each pair of particles is e. Particle P is projected towards Q with speed $3u$ and collides directly with Q.

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

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

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

(6)

(b) Find the range of values of e for which the direction of motion of P is reversed as a result of the collision with Q.

(2)

Immediately after the collision between P and Q, particle R is projected towards Q with speed u so that R and Q collide directly. Given that $e = \frac{2}{3}$

(c) show that there will be a second collision between P and Q.

(6)

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Question 7 continued

Q7

(Total 14 marks)

TOTAL FOR PAPER: 75 MARKS

END