Write your name here

Surname	Other names

Pearson Edexcel
International
Advanced Level

Centre Number | | | | | |

Candidate Number | | | | |

Mechanics M2

Advanced/Advanced Subsidiary

Wednesday 2 November 2016 – 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. Three particles of masses m, $4m$ and km are placed at the points whose coordinates are $(-3, 2)$, $(4, 3)$ and $(6, -4)$ respectively. The centre of mass of the three particles is at the point with coordinates $(c, 0)$.

Find

(a) the value of k,

(3)

(b) the value of c.

(3)

Leave blank

Question 1 continued

Q1

(Total 6 marks)

Leave blank

2. A particle of mass 2 kg is moving with velocity $3\mathbf{i}\ \text{m s}^{-1}$ when it receives an impulse $(\lambda\mathbf{i} - 2\lambda\mathbf{j})\ \text{N s}$, where λ is a constant. Immediately after the impulse is received, the speed of the particle is $6\ \text{m s}^{-1}$.

Find the possible values of λ.

(8)

Leave blank

Question 2 continued

Q2

(Total 8 marks)

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3. A particle P of mass 4 kg is projected with speed $6\,\text{m s}^{-1}$ up a line of greatest slope of a fixed rough inclined plane. The plane is inclined at angle α to the horizontal, where $\sin\alpha = \frac{1}{7}$. The particle is projected from the point A on the plane and comes to instantaneous rest at the point B on the plane, where $AB = 10\,\text{m}$.

(a) Show that the work done against friction as P moves from A to B is 16 joules.

(4)

After coming to instantaneous rest at B, the particle slides back down the plane.

(b) Use the work-energy principle to find the speed of P at the instant it returns to A.

(3)

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Question 3 continued

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Question 3 continued

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Question 3 continued

Q3

(Total 7 marks)

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

$$\mathbf{r} = \left(t^3 - \frac{9}{2}t^2 - 24t\right)\mathbf{i} + \left(-t^3 + 3t^2 + 12t\right)\mathbf{j}$$

At time T seconds, P is moving in a direction parallel to the vector $-\mathbf{i} - \mathbf{j}$

Find

(a) the value of T,

(5)

(b) the magnitude of the acceleration of P at the instant when $t = T$.

(5)

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Question 4 continued

(Total 10 marks)

Q4

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5.

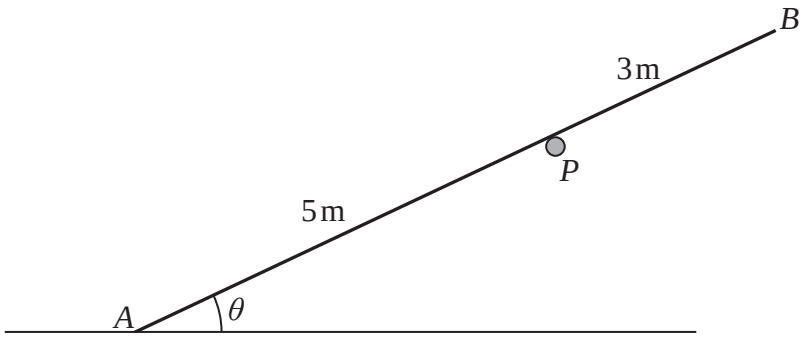

Figure 1

A uniform rod AB of length 8m and weight W newtons rests in equilibrium against a rough horizontal peg P. The end A is on rough horizontal ground. The friction is limiting at both A and P. The distance AP is 5m, as shown in Figure 1. The rod rests at angle θ to the horizontal, where $\tan\theta = \frac{4}{3}$. The rod is in a vertical plane which is perpendicular to P. The coefficient of friction between the rod and P is $\frac{1}{4}$ and the coefficient of friction between the rod and the ground is μ.

(a) Show that the magnitude of the normal reaction between the rod and P is $0.48W$ newtons.

(3)

(b) Find the value of μ.

(7)

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Question 5 continued

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Question 5 continued

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Question 5 continued

(Total 10 marks)

Q5

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6.

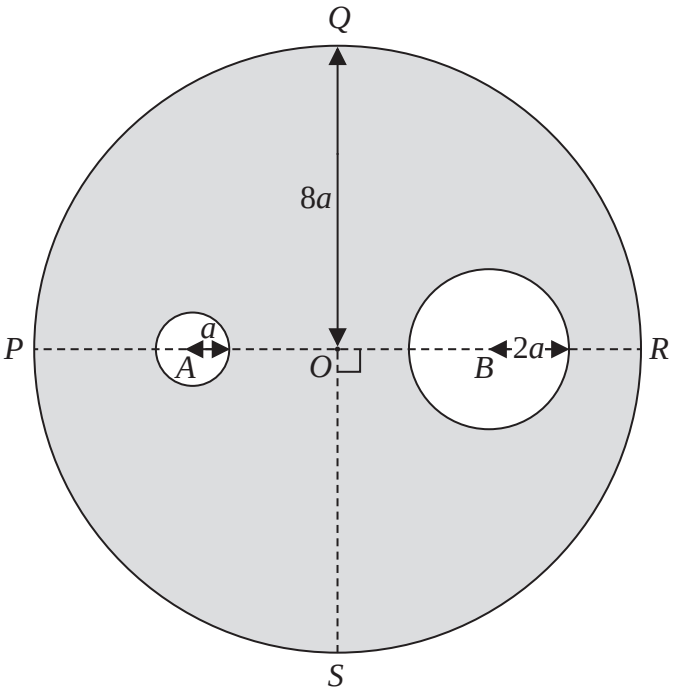

Figure 2

The uniform lamina L shown shaded in Figure 2 is formed by removing two circular discs, C_1 and C_2, from a circular disc with centre O and radius $8a$. Disc C_1 has centre A and radius a. Disc C_2 has centre B and radius $2a$. The diameters PR and QS are perpendicular. The midpoint of PO is A and the midpoint of OR is B.

(a) Show that the centre of mass of L is $\frac{484}{59}a$ from R.

(5)

The mass of L is M. A particle of mass kM is attached to L at S. The lamina with the attached particle is suspended from R and hangs freely in equilibrium with the diameter PR at an angle of $\arctan\left(\frac{1}{4}\right)$ to the downward vertical through R.

(b) Find the value of k.

(5)

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Question 6 continued

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Question 6 continued

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Question 6 continued

(Total 10 marks)

Q6

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7. [*In this question, the unit vectors* **i** *and* **j** *are in a vertical plane,* **i** *being horizontal and* **j** *being vertically upwards. Position vectors are given relative to a fixed origin O.*]

At time $t = 0$ seconds, the particle P is projected from O with velocity $(3\mathbf{i} + \lambda\mathbf{j})$ m s^{-1}, where λ is a positive constant. The particle moves freely under gravity. As P passes through the fixed point A it has velocity $(3\mathbf{i} - 4\mathbf{j})$ m s^{-1}. The kinetic energy of P at the instant it passes through A is half the initial kinetic energy of P.

Find the position vector of A, giving the components to 2 significant figures.

(10)

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Question 7 continued

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Question 7 continued

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Question 7 continued

(Total 10 marks)

Q7

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8. Particles A, B and C, of masses $4m$, km and $2m$ respectively, lie at rest in a straight line on a smooth horizontal surface with B between A and C. Particle A is projected towards particle B with speed $3u$ and collides directly with B. The coefficient of restitution between each pair of particles is $\frac{2}{3}$

Find

(a) the speed of A immediately after the collision with B, giving your answer in terms of u and k,

(6)

(b) the range of values of k for which A and B will both be moving in the same direction immediately after they collide.

(2)

After the collision between A and B, particle B collides directly with C.
Given that $k = 4$,

(c) show that there will not be a second collision between A and B.

(6)

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Question 8 continued

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Question 8 continued

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Question 8 continued

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Question 8 continued

Q8

(Total 14 marks)

TOTAL FOR PAPER: 75 MARKS

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