www.dynamicpapers.com

Please check the examination details below before entering your candidate information

| Candidate surname | Other names |
|---|---|
| | |

**Pearson Edexcel**
**International**
**Advanced Level**

Centre Number | | | | | |

Candidate Number | | | | |

# Wednesday 22 January 2020

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 $g = 9.8\,\text{m s}^{-2}$, 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* ▶

P61166A

©2020 Pearson Education Ltd.

1/1/1/1/1/

P 6 1 1 6 6 A 0 1 2 8

Pearson

www.dynamicpapers.com

Leave blank

**1.** A cyclist and his bicycle have a total mass of 75 kg. The cyclist is moving down a straight road that is inclined at an angle $\alpha$ to the horizontal, where $\sin\alpha = \frac{1}{15}$

The cyclist is working at a constant rate of 56 W. The magnitude of the resistance to motion is modelled as a constant force of magnitude 40 N. At the instant when the speed of the cyclist is $V\,\text{m s}^{-1}$, his acceleration is $\frac{1}{3}\,\text{m s}^{-2}$

Find the value of $V$.

**(5)**

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

www.dynamicpapers.com

Leave blank

**Question 1 continued**

**Q1**

**(Total 5 marks)**

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

www.dynamicpapers.com

Leave blank

**2.**

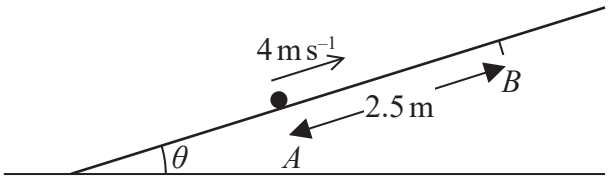


**Figure 1**

A rough straight ramp is fixed to horizontal ground. The ramp is inclined at an angle $\theta$ to the horizontal, where $\sin\theta = \frac{1}{7}$. The points $A$ and $B$ are on a line of greatest slope of the ramp with $AB = 2.5\,\text{m}$ and $B$ above $A$, as shown in Figure 1. A package of mass 2 kg is projected up the ramp from $A$ with speed $4\,\text{m s}^{-1}$ and first comes to instantaneous rest at $B$. The coefficient of friction between the package and the ramp is $\mu$. The package is modelled as a particle.

Use the work-energy principle to find the value of $\mu$.

**(6)**

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

www.dynamicpapers.com

Leave blank

**Question 2 continued**

**Q2**

**(Total 6 marks)**

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

www.dynamicpapers.com

Leave blank

**3.**

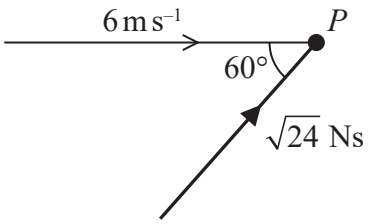


**Figure 2**

A particle $P$ of mass 0.75 kg is moving along a straight line on a horizontal surface. At the instant when the speed of $P$ is $6\,\text{m s}^{-1}$, it receives an impulse of magnitude $\sqrt{24}$ Ns. The impulse acts in the plane of the horizontal surface. At the instant when $P$ receives the impulse, the line of action of the impulse makes an angle of 60° with the direction of motion of $P$, as shown in Figure 2.

Find

(i) the speed of $P$ immediately after receiving the impulse,

(ii) the size of the angle between the direction of motion of $P$ immediately before receiving the impulse and the direction of motion of $P$ immediately after receiving the impulse.

**(7)**

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

www.dynamicpapers.com

Leave blank

**Question 3 continued**

**Q3**

**(Total 7 marks)**

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

www.dynamicpapers.com

Leave blank

**4.**

[*The centre of mass of a uniform semicircular lamina of radius r is* $\frac{4r}{3\pi}$ *from the centre.*]

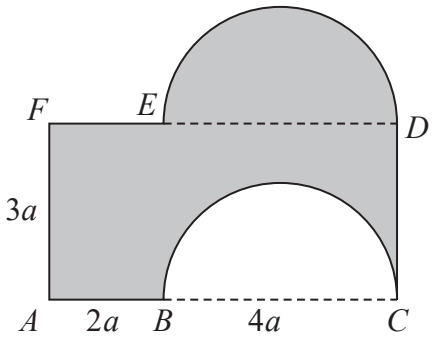


**Figure 3**

The uniform rectangular lamina $ABCDEF$ has sides $AC = FD = 6a$ and $AF = CD = 3a$. The point $B$ lies on $AC$ with $AB = 2a$ and the point $E$ lies on $FD$ with $FE = 2a$.

The template, $T$, shown shaded in Figure 3, is formed by removing the semicircular lamina with diameter $BC$ from the rectangular lamina and then fixing this semicircular lamina to the opposite side, $FD$, of the rectangular lamina. The diameter of the semicircular lamina coincides with $ED$ and the semicircular arc $ED$ is outside the rectangle $ABCDEF$. All points of $T$ lie in the same plane.

(a) Show that the centre of mass of $T$ is a distance $\left(\frac{9 + 2\pi}{6}\right)a$ from $AC$.

**(4)**

The mass of $T$ is $M$. A particle of mass $kM$ is attached to $T$ at $C$. The loaded template is freely suspended from $A$ and hangs in equilibrium with $AF$ at angle $\phi$ to the downward vertical through $A$.

Given that $\tan\phi = \frac{3}{2}$

(b) find the value of $k$.

**(6)**

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

www.dynamicpapers.com

Leave blank

**Question 4 continued**

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

www.dynamicpapers.com

Leave blank

**Question 4 continued**

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

www.dynamicpapers.com

Leave blank

**Question 4 continued**

**(Total 10 marks)**

**Q4**

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

www.dynamicpapers.com

Leave blank

**5.** At time $t$ seconds ($t \geqslant 0$), a particle $P$ has velocity $\mathbf{v}\,\text{m}\,\text{s}^{-1}$, where

$$\mathbf{v} = (3t^2 - 4)\mathbf{i} + (2t - 4)\mathbf{j}$$

When $t = 0$, $P$ is at the fixed point $O$.

(a) Find the acceleration of $P$ at the instant when $t = 0$

**(2)**

(b) Find the exact speed of $P$ at the instant when $P$ is moving in the direction of the vector $(11\mathbf{i} + \mathbf{j})$ for the second time.

**(4)**

(c) Show that $P$ never returns to $O$.

**(4)**

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

www.dynamicpapers.com

Leave blank

**Question 5 continued**

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

www.dynamicpapers.com

Leave blank

**Question 5 continued**

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

www.dynamicpapers.com

Leave blank

**Question 5 continued**

**Q5**

**(Total 10 marks)**

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

www.dynamicpapers.com

Leave blank

**6.**

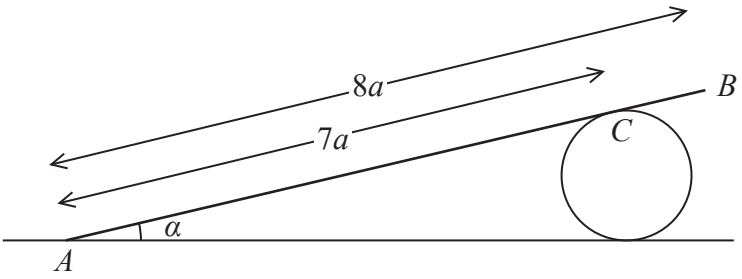


**Figure 4**

A uniform rod, $AB$, of weight $W$ and length $8a$, rests in equilibrium with the end $A$ on rough horizontal ground. The rod rests on a smooth cylinder. The cylinder is fixed to the ground with its axis horizontal. The point of contact between the rod and the cylinder is $C$, where $AC = 7a$, as shown in Figure 4. The rod is resting in a vertical plane that is perpendicular to the axis of the cylinder. The rod makes an angle $\alpha$ with the horizontal.

(a) Show that the normal reaction of the ground on the rod at $A$ has magnitude $W\left(1 - \frac{4}{7}\cos^2\alpha\right)$

**(6)**

Given that the coefficient of friction between the rod and the ground is $\mu$ and that $\cos\alpha = \frac{3}{\sqrt{10}}$

(b) find the range of possible values of $\mu$.

**(5)**

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

www.dynamicpapers.com

Leave blank

**Question 6 continued**

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

www.dynamicpapers.com

Leave blank

**Question 6 continued**

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

www.dynamicpapers.com

Leave blank

**Question 6 continued**

**(Total 11 marks)**

**Q6**

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

www.dynamicpapers.com

Leave blank

**7.**

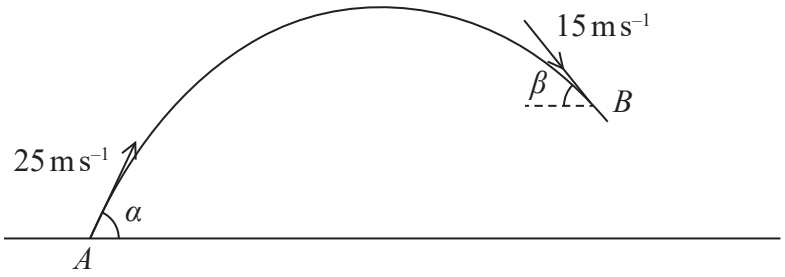


**Figure 5**

At time $t = 0$ a particle $P$ is projected from a fixed point $A$ on horizontal ground. The particle is projected with speed $25\,\text{m s}^{-1}$ at an angle $\alpha$ to the ground. The particle moves freely under gravity. At time $t = 3$ seconds, $P$ is passing through the point $B$ with speed $15\,\text{m s}^{-1}$ and is moving downwards at an angle $\beta$ to the horizontal, as shown in Figure 5.

(a) By considering energy, find the height of $B$ above the ground.

**(3)**

(b) Find the size of angle $\alpha$.

**(3)**

(c) Find the size of angle $\beta$.

**(3)**

(d) Find the least speed of $P$ as $P$ travels from $A$ to $B$.

**(2)**

As $P$ travels from $A$ to $B$, the speed, $v\,\text{m s}^{-1}$, of $P$ is such that $v \leqslant 15$ for an interval of $T$ seconds.

(e) Find the value of $T$.

**(3)**

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

www.dynamicpapers.com

Leave blank

**Question 7 continued**

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

www.dynamicpapers.com

Leave blank

**Question 7 continued**

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

www.dynamicpapers.com

Leave blank

**Question 7 continued**

**(Total 14 marks)**

**Q7**

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

www.dynamicpapers.com

Leave blank

**8.** A particle $A$ has mass $4m$ and a particle $B$ has mass $3m$. The particles are moving along the same straight line on a smooth horizontal plane. They are moving in opposite directions towards each other and collide directly.

Immediately before the collision the speed of $A$ is $2u$ and the speed of $B$ is $3u$.

The direction of motion of each particle is reversed by the collision.

The total kinetic energy lost in the collision is $\frac{473}{24}mu^2$

Find

(i) the coefficient of restitution between $A$ and $B$,

(ii) the magnitude of the impulse received by $A$ in the collision.

**(12)**

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

www.dynamicpapers.com

Leave blank

**Question 8 continued**

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

www.dynamicpapers.com

Leave blank

**Question 8 continued**

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

www.dynamicpapers.com

Leave blank

**Question 8 continued**

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

www.dynamicpapers.com

Leave blank

**Question 8 continued**

**Q8**

**(Total 12 marks)**

**TOTAL FOR PAPER: 75 MARKS**

**END**

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA