| Please check the examination details below                | v before entering your candidate information |
|-----------------------------------------------------------|----------------------------------------------|
| Candidate surname                                         | Other names                                  |
|                                                           |                                              |
| Centre Number Candidate Num                               | nber                                         |
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| <b>Pearson Edexcel Intern</b>                             | ational Advanced Level                       |
| Thursday 25 May 2023                                      |                                              |
| Morning (Time: 1 hour 30 minutes)                         | Paper WME02/01                               |
| <b>International Adva</b>                                 | anced                                        |
| Subsidiary/Advance                                        | ced Level                                    |
| · · · · · · · · · · · · · · · · · · ·                     |                                              |
| Mechanics M2                                              |                                              |
|                                                           |                                              |
| You must have:<br>Mathematical Formulae and Statistical T | Tables (Yellow), calculator                  |
|                                                           |                                              |

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.
- 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 7 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 ▶







| 1. | A particle $P$ of mass 0.3 kg is moving with velocity $5i \text{ m s}^{-1}$                                     |            |
|----|-----------------------------------------------------------------------------------------------------------------|------------|
|    | The particle receives an impulse I Ns.                                                                          |            |
|    | Immediately after receiving the impulse, the velocity of $P$ is $(7\mathbf{i} + 7\mathbf{j})$ m s <sup>-1</sup> |            |
|    | (a) Find the magnitude of <b>I</b>                                                                              |            |
|    | (a) I find the magnitude of I                                                                                   | <b>(4)</b> |
|    | (b) Find the angle between the direction of $\mathbf{I}$ and the direction of motion of $P$                     |            |
|    | immediately before receiving the impulse.                                                                       | (2)        |
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| (Total for Question 1 = 7 marks) |  |  |  |  |  |
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**2.** [In this question, the perpendicular unit vectors  $\mathbf{i}$  and  $\mathbf{j}$  are in a horizontal plane.]

In this question you must show all stages of your working. Solutions relying on calculator technology are not acceptable.

A particle *P* is moving on a smooth horizontal plane.

At time t seconds  $(t \ge 0)$ , the position vector of P, relative to a fixed point O, is  $\mathbf{r}$  metres and the velocity of P is  $\mathbf{v}$  m s<sup>-1</sup> where

$$\mathbf{v} = (4t^2 - 5t)\mathbf{i} + (-10t - 12)\mathbf{j}$$

When t = 0, r = 2i + 6j

(a) Find  $\mathbf{r}$  when t = 2

**(4)** 

When t = T particle P is moving in the direction of the vector  $\mathbf{i} - 2\mathbf{j}$ 

(b) Find the value of T

**(3)** 

(c) Find the exact magnitude of the acceleration of P when t = 2.5

(3)



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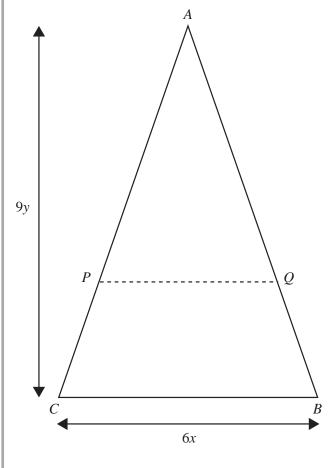
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**3.** 



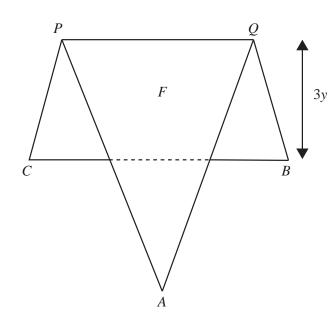


Figure 1

The uniform triangular lamina ABC, shown in Figure 1, has height 9y, base BC = 6x, and AB = AC

The points P and Q are such that AP : PC = AQ : QB = 2 : 1

The lamina is folded along PQ to form the folded lamina F

The distance of the centre of mass of F from PQ is d

(a) Show that 
$$d = \frac{16}{9}y$$

(5)

The folded lamina is suspended from P and hangs freely in equilibrium with PQ at an angle  $\alpha$  to the downward vertical.

Given that  $\tan \alpha = \frac{64}{81}$ 

(b) find x in terms of y

(3)

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| 4. | A particle $P$ of mass $3m$ and a particle $Q$ of mass $5m$ are moving towards each other along the same straight line on a smooth horizontal surface. The particles collide directly. |     |
|----|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|
|    | Immediately <b>before</b> the collision, the speed of $P$ is $u$ and the speed of $Q$ is $ku$ .                                                                                        |     |
|    | Immediately <b>after</b> the collision, the speed of $P$ is $2v$ and the speed of $Q$ is $v$ .                                                                                         |     |
|    | The direction of motion of each particle is reversed by the collision.                                                                                                                 |     |
|    | In the collision, $P$ receives an impulse of magnitude $15mv$ .                                                                                                                        |     |
|    | (a) Show that $u = 3v$ .                                                                                                                                                               | (2) |
|    |                                                                                                                                                                                        | (3) |
|    | (b) Find the value of k.                                                                                                                                                               | (3) |
|    | The coefficient of restitution between $P$ and $Q$ is $e$ .                                                                                                                            |     |
|    | (c) Find the value of <i>e</i> .                                                                                                                                                       |     |
|    |                                                                                                                                                                                        | (3) |
|    | The total kinetic energy lost in the collision is $\lambda mv^2$                                                                                                                       |     |
|    | (d) Find the value of $\lambda$ .                                                                                                                                                      | (3) |
|    |                                                                                                                                                                                        | (3) |
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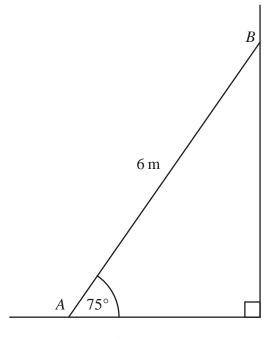


Figure 2

A uniform beam AB, of mass 15 kg and length 6 m, rests with end A on rough horizontal ground. The end B of the beam rests against a rough vertical wall.

The beam is inclined at  $75^{\circ}$  to the ground, as shown in Figure 2.

The coefficient of friction between the beam and the wall is 0.2

The coefficient of friction between the beam and the ground is  $\mu$ 

The beam is modelled as a uniform rod which lies in a vertical plane perpendicular to the wall.

The beam rests in limiting equilibrium.

(a) Find the magnitude of the normal reaction between the beam and the wall at B.

**(5)** 

(b) Find the value of  $\mu$ 

**(6)** 

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**6.** A van of mass 900 kg is moving along a straight horizontal road.

The resistance to the motion of the van is modelled as a constant force of magnitude  $600\,\mathrm{N}$ .

The engine of the van is working at a constant rate of 24 kW.

At the instant when the speed of the van is  $V \text{ m s}^{-1}$ , the acceleration of the van is  $2 \text{ m s}^{-2}$ 

(a) Find the value of V

**(4)** 

Later on, the van is towing a trailer of mass 700 kg up a straight road inclined at an angle  $\theta$  to the horizontal, where  $\sin \theta = \frac{1}{14}$ 

The trailer is attached to the van by a towbar, as shown in Figure 3.

The towbar is parallel to the direction of motion of the van and the trailer.

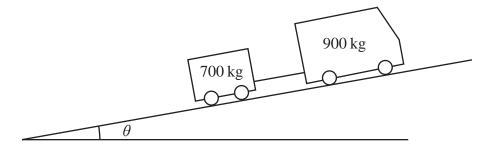


Figure 3

The resistance to the motion of the van from non-gravitational forces is modelled as a constant force of magnitude  $600\,\mathrm{N}$ .

The resistance to the motion of the trailer from non-gravitational forces is modelled as a constant force of magnitude 550 N.

The towbar is modelled as a light rod.

The engine of the van is working at a constant rate of 24 kW.

(b) Find the acceleration of the van at the instant when the van and the trailer are moving with speed  $8\,m\,s^{-1}$ 

**(4)** 

At the instant when the van and the trailer are moving up the road at 9 m s<sup>-1</sup>, the towbar breaks. The trailer continues to move in a straight line up the road until it comes to instantaneous rest.

The distance moved by the trailer as it slows from a speed of  $9 \text{ m s}^{-1}$  to instantaneous rest is d metres.

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

**(4)** 

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

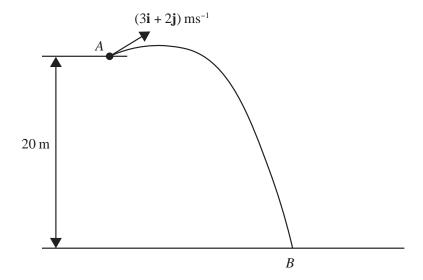


Figure 4

A small ball is projected with velocity (3i + 2j) ms<sup>-1</sup> from the fixed point A.

The point *A* is 20 m above horizontal ground.

The ball hits the ground at the point *B*, as shown in Figure 4.

The ball is modelled as a particle moving freely under gravity.

(a) By considering energy, find the speed of the ball at the instant immediately before it hits the ground.

**(3)** 

(b) Find the direction of motion of the ball at the instant immediately before it hits the ground.

**(3)** 

(c) Find the time taken for the ball to travel from A to B.

**(3)** 

At the instant when the direction of motion of the ball is perpendicular to  $(3\mathbf{i} + 2\mathbf{j})$  the ball is h metres above the ground.

(d) Find the value of h.

**(6)** 

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