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**Pearson Edexcel GCE**

| Centre Number | Candidate Number |
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# Mechanics M2

## Advanced/Advanced Subsidiary

Friday 15 June 2018 – Afternoon
**Time: 1 hour 30 minutes**

Paper Reference
**6678/01**

**You must have:**
Mathematical Formulae and Statistical Tables (Pink)

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.** A truck of mass 750 kg is moving with constant speed $v$ m s$^{-1}$ down a straight road inclined at an angle $\theta$ to the horizontal, where $\sin\theta = \frac{3}{49}$. The resistance to motion of the truck is modelled as a constant force of magnitude 1200 N. The engine of the truck is working at a constant rate of 9 kW.

(a) Find the value of $v$.

**(4)**

On another occasion the truck is moving up the same straight road. The resistance to motion of the truck from non-gravitational forces is modelled as a constant force of magnitude 1200 N. The engine of the truck is working at a constant rate of 9 kW.

(b) Find the acceleration of the truck at the instant when it is moving with speed 4.5 m s$^{-1}$.

**(4)**

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**Question 1 continued**

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**Question 1 continued**

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**Question 1 continued**

**Q1**

**(Total 8 marks)**

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**2.**

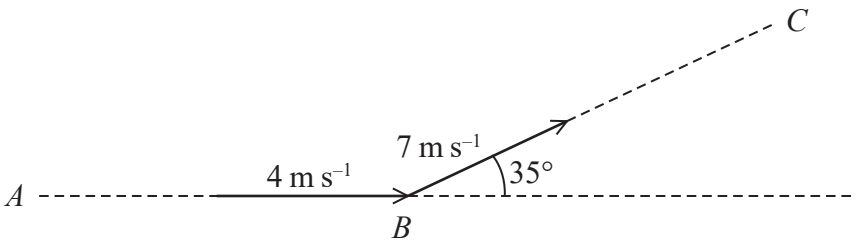


**Figure 1**

The points $A$, $B$ and $C$ lie on a smooth horizontal plane. A small ball of mass 0.2 kg is moving along the line $AB$ with speed 4 m s$^{-1}$. When the ball is at $B$, the ball is given an impulse. Immediately after the impulse is given, the ball moves along the line $BC$ with speed 7 m s$^{-1}$. The line $BC$ makes an angle of 35° with the line $AB$, as shown in Figure 1.

(a) Find the magnitude of the impulse given to the ball.

**(4)**

(b) Find the size of the angle between the direction of the impulse and the original direction of motion of the ball.

**(3)**

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**Question 2 continued**

**Q2**

**(Total 7 marks)**

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

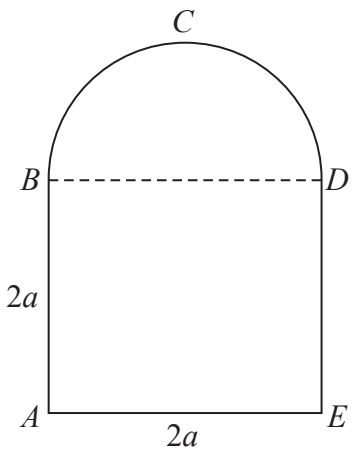


**Figure 2**

Figure 2 shows the uniform lamina *ABCDE*, such that *ABDE* is a square with sides of length 2*a* and *BCD* is a semicircle with diameter *BD*.

(a) Show that the distance of the centre of mass of the lamina from *BD* is $\frac{20a}{3(8+\pi)}$. **(5)**

The lamina is freely suspended from *D* and hangs in equilibrium.

(b) Find, to the nearest degree, the angle that *DE* makes with the downward vertical. **(3)**

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**Question 3 continued**

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**Question 3 continued**

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**Question 3 continued**

**Q3**

**(Total 8 marks)**

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**4.**

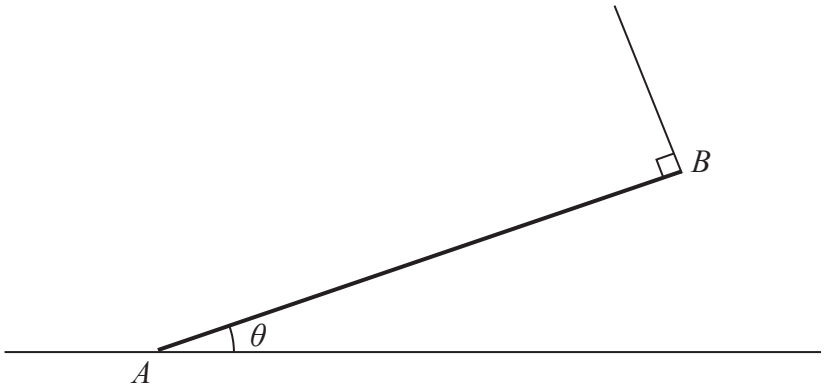


**Figure 3**

A uniform rod $AB$, of mass $m$ and length $2a$, rests with its end $A$ on rough horizontal ground. The rod is held in limiting equilibrium at an angle $\theta$ to the horizontal by a light string attached to the rod at $B$, as shown in Figure 3. The string is perpendicular to the rod and lies in the same vertical plane as the rod.

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

Show that $\mu = \dfrac{\cos\theta \sin\theta}{2 - \cos^2\theta}$

**(10)**

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**Question 4 continued**

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**Question 4 continued**

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**Question 4 continued**

**(Total 10 marks)**

**Q4**

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**5.** A particle $A$ of mass $3m$ is moving in a straight line with speed $2u$ on a smooth horizontal floor. Particle $A$ collides directly with another particle $B$ of mass $2m$ which is moving along the same straight line with speed $u$ but in the opposite direction to $A$. The coefficient of restitution between $A$ and $B$ is $\frac{1}{3}$.

(a) (i) Show that the speed of $B$ immediately after the collision is $\frac{7}{5}u$

(ii) Find the speed of $A$ immediately after the collision.

**(7)**

After the collision, $B$ hits a smooth vertical wall which is perpendicular to the direction of motion of $B$. The coefficient of restitution between $B$ and the wall is $\frac{1}{2}$. The first collision between $A$ and $B$ occurred at a distance $x$ from the wall. The particles collide again at a distance $y$ from the wall.

(b) Find $y$ in terms of $x$.

**(6)**

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**Question 5 continued**

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**Question 5 continued**

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**Question 5 continued**

**(Total 13 marks)**

**Q5**

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**6.** A particle $P$ of mass 0.5 kg moves under the action of a single force **F** newtons. At time $t$ seconds, $t \geqslant 0$, $P$ has velocity $\mathbf{v}$ m s$^{-1}$, where

$$\mathbf{v} = (4t - 3t^2)\mathbf{i} + (t^2 - 8t - 40)\mathbf{j}$$

(a) Find

(i) the magnitude of **F** when $t = 3$

(ii) the acceleration of $P$ at the instant when it is moving in the direction of the vector $-\mathbf{i} - \mathbf{j}$.

**(9)**

When $t = 1$, $P$ is at the point $A$. When $t = 2$, $P$ is at the point $B$.

(b) Find, in terms of **i** and **j**, the vector $\overrightarrow{AB}$.

**(5)**

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**Question 6 continued**

**(Total 14 marks)**

**Q6**

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**7.** A particle, of mass 0.3 kg, is projected from a point $O$ on horizontal ground with speed $u$. The particle is projected at an angle $\alpha$ above the horizontal, where $\tan\alpha = 2$, and moves freely under gravity. When the particle has moved a horizontal distance $x$ from $O$, its height above the ground is $y$.

(a) Show that

$$y = 2x - \frac{5g}{2u^2}x^2$$

**(5)**

The particle hits the ground at the point $A$, where $OA = 36\,\text{m}$.

(b) Find $u$, the speed of projection.

**(2)**

(c) Find the minimum kinetic energy of the particle as it moves between $O$ and $A$.

**(3)**

The point $B$ lies on the path of the particle. The direction of motion of the particle at $B$ is perpendicular to the initial direction of motion of the particle.

(d) Find the horizontal distance between $O$ and $B$.

**(5)**

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**Question 7 continued**

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**Q7**

**(Total 15 marks)**

**TOTAL FOR PAPER: 75 MARKS**

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