OCR
Oxford Cambridge and RSA

Wednesday 6 June 2018 – Morning

A2 GCE MATHEMATICS

4730/01 Mechanics 3

QUESTION PAPER

Candidates answer on the Printed Answer Book.

OCR supplied materials:
- Printed Answer Book 4730/01
- List of Formulae (MF1)

Other materials required:
- Scientific or graphical calculator

Duration: 1 hour 30 minutes

INSTRUCTIONS TO CANDIDATES

These instructions are the same on the Printed Answer Book and the Question Paper.

- The Question Paper will be found inside the Printed Answer Book.
- Write your name, centre number and candidate number in the spaces provided on the Printed Answer Book. Please write clearly and in capital letters.
- **Write your answer to each question in the space provided in the Printed Answer Book.** If additional space is required, you should use the lined page(s) at the end of this booklet. The question number(s) must be clearly shown.
- Use black ink. HB pencil may be used for graphs and diagrams only.
- Answer **all** the questions.
- Read each question carefully. Make sure you know what you have to do before starting your answer.
- Do **not** write in the barcodes.
- You are permitted to use a scientific or graphical calculator in this paper.
- Give non-exact numerical answers correct to 3 significant figures unless a different degree of accuracy is specified in the question or is clearly appropriate.
- The acceleration due to gravity is denoted by $g\,\mathrm{m\,s^{-2}}$. Unless otherwise instructed, when a numerical value is needed, use $g = 9.8$.

INFORMATION FOR CANDIDATES

This information is the same on the Printed Answer Book and the Question Paper.

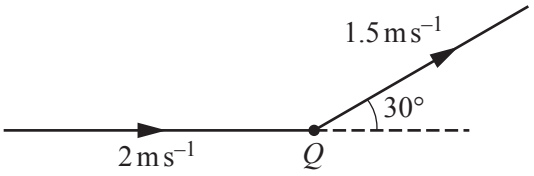
- The number of marks is given in brackets **[ ]** at the end of each question or part question on the Question Paper.
- **You are reminded of the need for clear presentation in your answers.**
- The total number of marks for this paper is **72**.
- The Printed Answer Book consists of **16** pages. The Question Paper consists of **4** pages. Any blank pages are indicated.

INSTRUCTION TO EXAMS OFFICER/INVIGILATOR

- Do not send this Question Paper for marking; it should be retained in the centre or recycled. Please contact OCR Copyright should you wish to re-use this document.

Answer **all** the questions.

1



A particle Q of mass 0.3 kg is moving in a straight line on a smooth horizontal surface with speed $2\,\text{m s}^{-1}$ when it is struck by a horizontal impulse of magnitude I N s. After the impulse acts Q moves with speed $1.5\,\text{m s}^{-1}$ in a direction making an angle of 30° with its original direction of motion (see diagram).

Find I and the angle the line of action of the impulse makes with the original direction of motion of Q. Draw a sketch to show this angle. **[4]**

2 One end of a light elastic string of natural length 0.6 m and modulus of elasticity $3mg$ N is attached to a fixed point O. A particle P of mass m kg is attached to the other end of the string, and moves in a vertical line below O. At an instant when P is 0.6 m below O it is moving downwards with speed $3.5\,\text{m s}^{-1}$. The greatest distance below O reached by P is h m.

(i) By considering energy, show that $h^2 + ah + b = 0$, where a and b are constants to be determined. **[5]**

(ii) Hence find the greatest distance below O reached by P. **[1]**

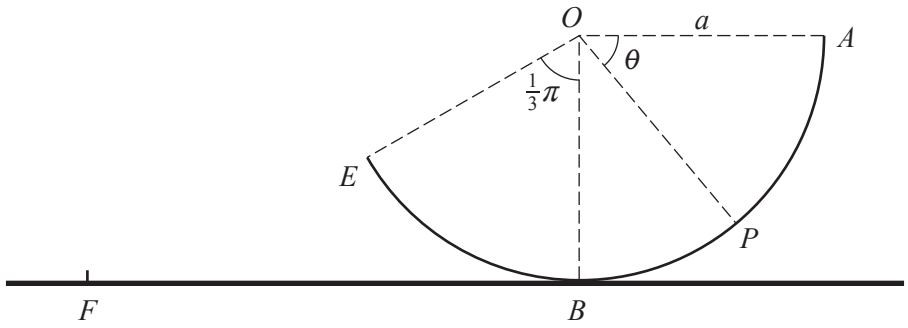
(iii) State with a reason whether the quadratic equation in part **(i)** can be used to find the least distance of P below O. **[1]**

3 A particle P of mass 0.2 kg is projected with velocity $5\,\text{m s}^{-1}$ from a fixed point O on a smooth horizontal plane. After t seconds P is x m from O and has velocity $v\,\text{m s}^{-1}$ away from O. The only force acting on P has magnitude Ae^{-t} N in the direction of motion of P, where A is a constant.

(i) Find an expression in terms of A and t for the velocity of P at time t. **[5]**

(ii) Given that the velocity of P tends to $12\,\text{m s}^{-1}$ as t increases, find the distance of P from O when its velocity is $6\,\text{m s}^{-1}$. **[7]**

4



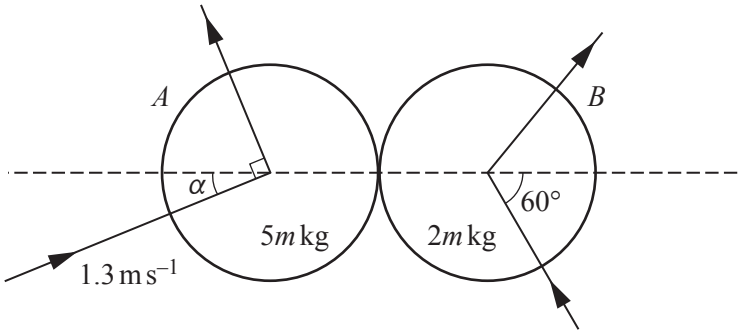
The diagram shows a smooth track $APBE$ in the form of an arc of a circle with centre O and radius a. The track is fixed in a vertical plane with its lowest point B in contact with horizontal ground. A particle Q, of mass m, is released from rest at A, which is at the same horizontal level as O. The particle Q passes through P, where angle $AOP = \theta$. The track finishes at E, where angle $BOE = \frac{1}{3}\pi$. Q leaves the track at E and moves freely under gravity, landing on the ground at a point F.

(i) On the diagram in the Printed Answer Book, show the radial and transverse components of the acceleration of Q when it is at P. State the magnitude of each component and make the direction of each component clear. **[2]**

(ii) Find, in terms of m, g and θ, an expression for the force exerted on Q by the track when Q is at P. **[4]**

(iii) Find, in terms of a, an expression for the distance BF. **[7]**

5



Two small uniform smooth spheres A and B, of equal radius, have masses $5m$ kg and $2m$ kg respectively. The spheres are moving on a smooth horizontal surface when they collide. Before the collision A is moving with speed $1.3\,\text{m s}^{-1}$ in a direction making an angle α with the line of centres, where $\tan\alpha = \frac{5}{12}$, and B is moving towards A in a direction making an angle of 60° with the line of centres. After the collision A moves in a direction at right angles to its original direction of motion (see diagram). The coefficient of restitution between A and B is $\frac{5}{6}$.

(i) Find the speed of A after the collision. **[3]**

(ii) Find the component of the velocity of B parallel to the line of centres after the collision. **[7]**

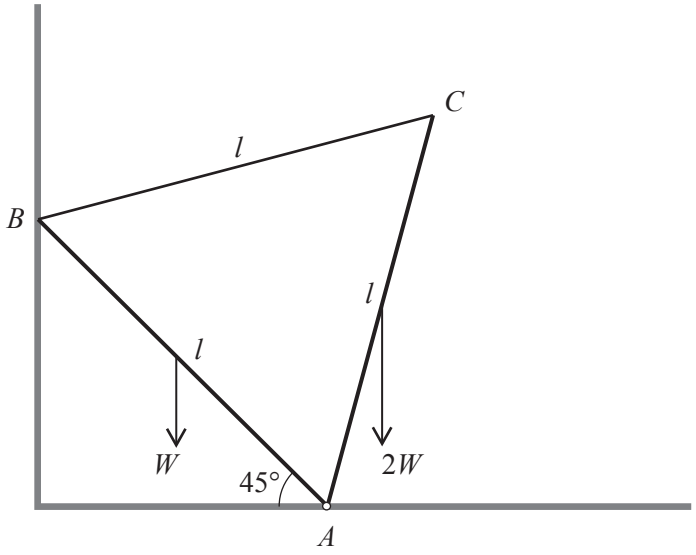
6 One end of a light elastic string of natural length 1.0 m and modulus of elasticity $5mg$ N is attached to a fixed point O. A particle P of mass m kg is attached to the other end of the string. P is held at a point 1.5 m vertically below O and then released.

(i) Show that P initially moves with simple harmonic motion and find the distance of the centre of this simple harmonic motion from O. **[5]**

The highest point P reaches in its subsequent motion is H.

(ii) Find the distance OH and the time taken for P to travel from its point of release to H. **[8]**

7



The uniform rods AB, of length l and weight W, and AC, of length l and weight $2W$, are freely pivoted to a fixed point A. The rods are at rest in equilibrium in a vertical plane which is perpendicular to a smooth vertical wall. B rests against the wall and A is on a horizontal floor. AB is inclined at an angle of 45° to the horizontal. The ends B and C of the rods are joined by a light inextensible string of length l so that triangle ABC is equilateral (see diagram).

(i) Show that the tension in the string BC is $W\dfrac{\cos 75°}{\cos 30°}$. **[2]**

(ii) The normal reaction between the rod AB and the wall at B is αW. Find the value of α correct to 3 significant figures. **[4]**

The string of length l is now replaced by a light inextensible string which has length y. The system now rests in equilibrium with AC making an angle θ with the floor, where $0° < \theta < 90°$.

(iii) Find, in terms of l, the range of possible values of y. **[7]**

END OF QUESTION PAPER