

OXFORD CAMBRIDGE AND RSA EXAMINATIONS

A2 GCE

4730/01

MATHEMATICS

Mechanics 3

QUESTION PAPER

WEDNESDAY 6 JUNE 2018: Morning

**DURATION: 1 hour 30 minutes
plus your additional time allowance**

MODIFIED ENLARGED

Candidates answer on the Printed Answer Book sent with the standard paper or any suitable paper provided by the centre. The centre may enlarge the Printed Answer Book.

OCR SUPPLIED MATERIALS:

Printed Answer Book sent with standard paper

List of Formulae (MF1) sent with standard paper

Insert for question 4(i)

OTHER MATERIALS REQUIRED:

Scientific or graphical calculator

READ INSTRUCTIONS OVERLEAF



INSTRUCTIONS TO CANDIDATES

Write your name, centre number and candidate number in the spaces provided on the Printed Answer Book or on the paper provided. Please write clearly and in capital letters.

IF YOU USE THE PRINTED ANSWER BOOK WRITE YOUR ANSWER TO EACH QUESTION IN THE SPACE PROVIDED. 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.

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 $g \text{ m s}^{-2}$. Unless otherwise instructed, when a numerical value is needed, use $g = 9.8$.

INFORMATION FOR CANDIDATES

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.

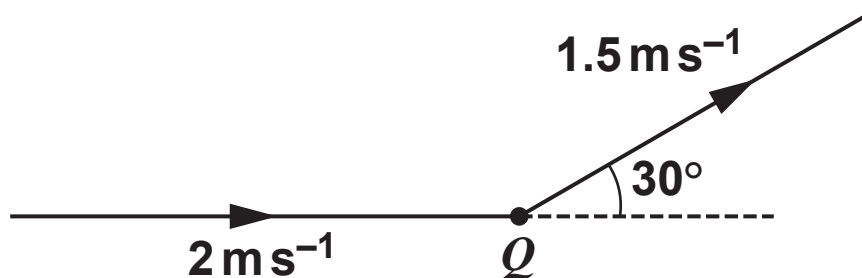
The total number of marks for this paper is 72.

INSTRUCTION TO EXAMS OFFICER/INVIGILATOR

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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 m s^{-1} when it is struck by a horizontal impulse of magnitude $I\text{ N s}$. After the impulse acts Q moves with speed 1.5 m s^{-1} in a direction making an angle of 30° with its original direction of motion (see diagram below).



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]

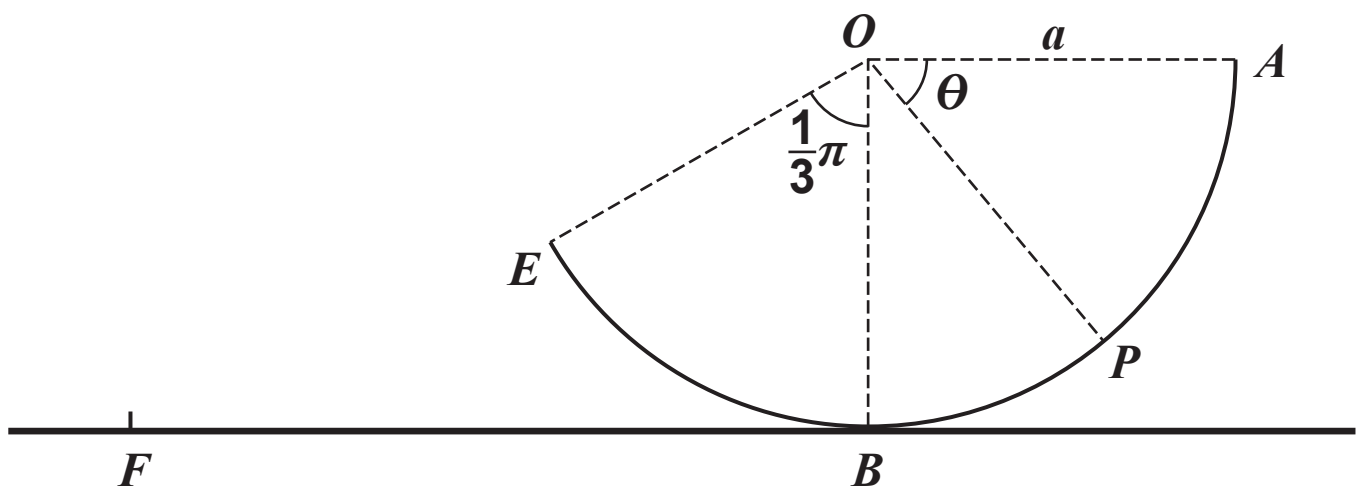
- 2 One end of a light elastic string of natural length 0.6 m and modulus of elasticity $3mg\text{ N}$ is attached to a fixed point O . A particle P of mass $m\text{ kg}$ is attached to the other end of the string, and moves in a vertical line below O . At an instant when P is 0.6 m below O it is moving downwards with speed 3.5 m s^{-1} . The greatest distance below O reached by P is $h\text{ m}$.
- (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 m s^{-1} from a fixed point O on a smooth horizontal plane. After t seconds P is $x\text{ m}$ from O and has velocity $v\text{ m s}^{-1}$ away from O . The only force acting on P has magnitude $Ae^{-t}\text{ N}$ 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]

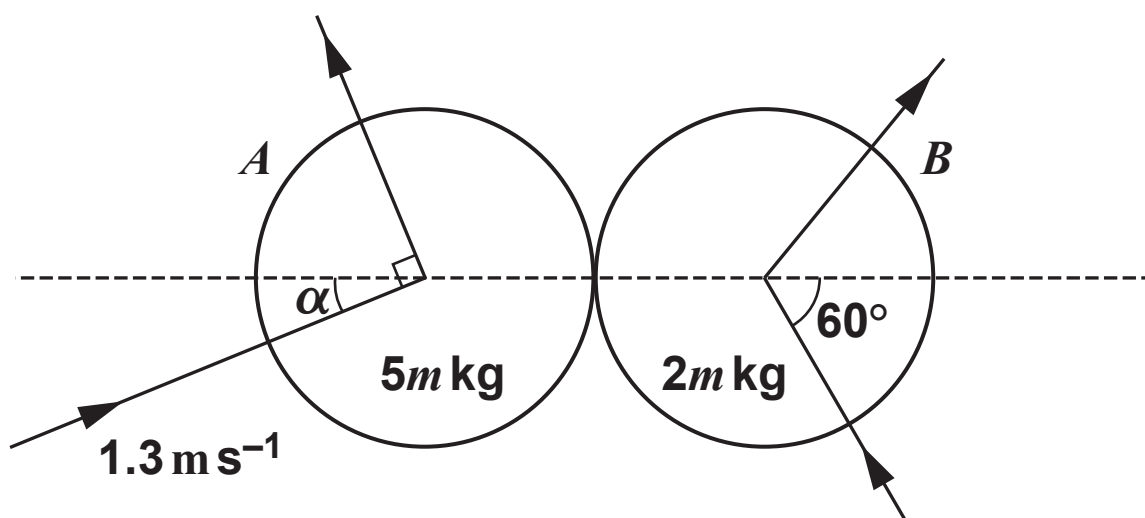
(ii) Given that the velocity of P tends to 12 m s^{-1} as t increases, find the distance of P from O when its velocity is 6 m s^{-1} . [7]

- 4 The diagram below 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 or on the insert, 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 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 below). 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 $5mg\text{ N}$ is attached to a fixed point O . A particle P of mass $m\text{ kg}$ is attached to the other end of the string. P is held at a point 1.5 m vertically below O and then released.

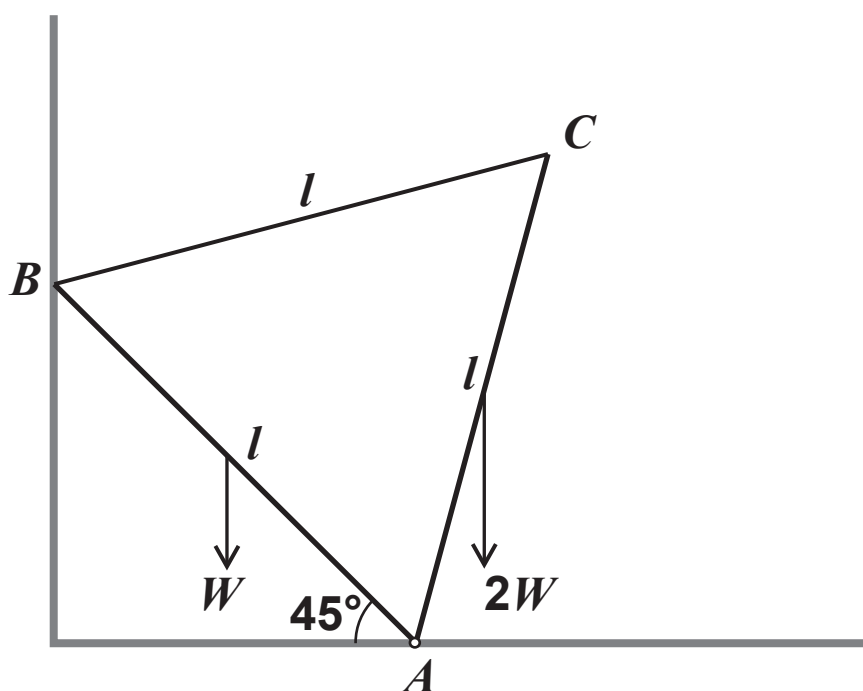
- (i) Show that P initially moves with simple harmonic motion and find the distance of the centre of this simple harmonic motion from O . [5]

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]

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- 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 below).



- (i) Show that the tension in the string BC is

$$W \frac{\cos 75^\circ}{\cos 30^\circ}. \quad [2]$$

- (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 $0^\circ < \theta < 90^\circ$.

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

END OF QUESTION PAPER

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