OXFORD CAMBRIDGE AND RSA EXAMINATIONS

A2 GCE

4762/01

MATHEMATICS (MEI)

Mechanics 2

QUESTION PAPER

WEDNESDAY 13 MAY 2015: Morning

DURATION: 1 hour 30 minutes

plus your additional time allowance

MODIFIED ENLARGED 24pt

Candidates answer on the Printed Answer Book or any suitable paper provided by the centre. The Printed Answer Book may be enlarged by the centre.

OCR SUPPLIED MATERIALS:
Printed Answer Book 4762/01
MEI Examination Formulae and Tables (MF2)

OTHER MATERIALS REQUIRED:
Scientific or graphical calculator

READ INSTRUCTIONS OVERLEAF

DC (NF/SW) 5320621377 109285

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 by the centre. Please write clearly and in capital letters.

IF YOU USE THE PRINTED ANSWER BOOK, WRITE YOUR ANSWER TO EACH QUESTION IN THE SPACE PROVIDED. Additional paper may be used if necessary but you must clearly show your candidate number, centre number and question number(s).

Use black ink. HB pencil may be used for graphs and diagrams only.

Read each question carefully. Make sure you know what you have to do before starting your answer.

Answer ALL the questions.

You are permitted to use a scientific or graphical calculator in this paper.

Final answers should be given to a degree of accuracy appropriate to the context.

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

The number of marks is given in brackets [ ] at the end of each question or part question on the Question Paper.

You are advised that an answer may receive NO MARKS unless you show sufficient detail of the working to indicate that a correct method is being used.

The total number of marks for this paper is 72.

Any blank pages are indicated.

INSTRUCTION TO EXAMS OFFICER / INVIGILATOR

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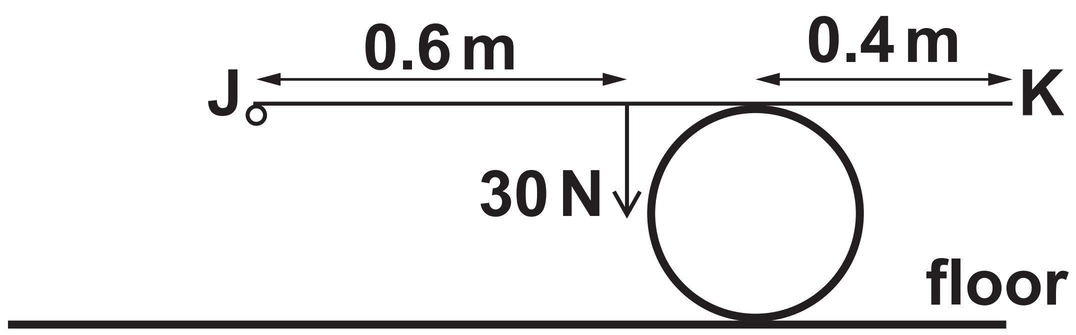
1 A thin uniform rigid rod JK of length 1.2 m and weight 30 N is resting on a rough circular cylinder which is fixed to a floor. The axis of symmetry of the cylinder is horizontal and at all times the rod is perpendicular to this axis.

Initially, the rod is horizontal and its point of contact with the cylinder is 0.4 m from K. It is held in equilibrium by resting on a small peg at J. This situation is shown in Fig. 1.1 below.

FIG. 1.1



(i) Calculate the force exerted by the peg on the rod and also the force exerted by the cylinder on the rod. [3]

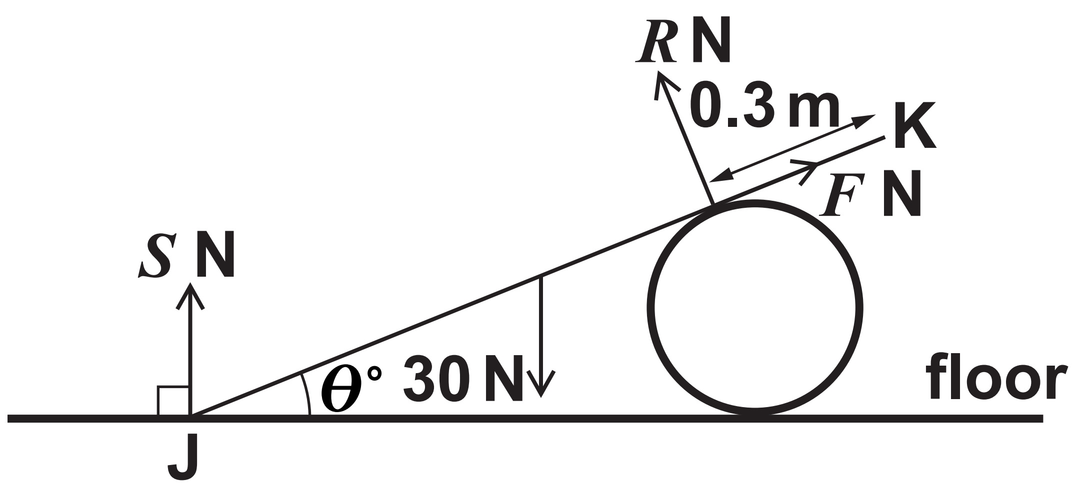
A small object of weight W N is attached to the rod at K.

(ii) Find the greatest value of W for which the rod maintains its contact at J. [2]

The object at K is removed. Fig. 1.2 below shows the rod resting on the cylinder with its end J on the floor, which is smooth and horizontal. The point of contact of the rod with the cylinder is 0.3 m from K. Fig. 1.2 also shows the normal reaction, S N, of the floor on the rod, the normal reaction, R N, of the cylinder on the rod and the frictional force F N between the cylinder and the rod.

Suppose the rod is in equilibrium at an angle of $\theta°$ to the horizontal, where $\theta < 90$.

FIG. 1.2



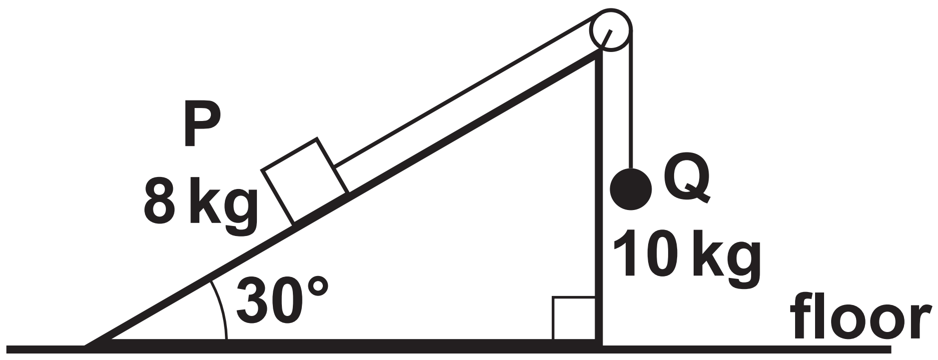
(iii) Find S. Find also expressions in terms of θ for R and F. [8]

The coefficient of friction between the cylinder and the rod is μ.

(iv) Determine a relationship between μ and θ. [3]

2 **Fig. 2 below shows a wedge of angle 30° fixed to a horizontal floor. Small objects P, of mass 8 kg, and Q, of mass 10 kg, are connected by a light inextensible string that passes over a smooth pulley at the top of the wedge. The part of the string between P and the pulley is parallel to a line of greatest slope of the wedge. Q hangs freely and at no time does either P or Q reach the pulley or P reach the floor.**

FIG. 2



(i) Assuming the string remains taut, find the change in the gravitational potential energy of the system when Q descends h m, stating whether it is a loss or a gain. [3]

Object P makes smooth contact with the wedge. The system is set in motion with the string taut.

(ii) Find the speed at which Q hits the floor if

(*A*) the system is released from rest with Q a distance of 1.2 m above the floor, [3]

(*B*) instead, the system is set in motion with Q a distance of 0.3 m above the floor and P travelling DOWN the slope at 1.05 m s^{-1}. [3]

The sloping face is roughened so that the coefficient of friction between object P and the wedge is 0.9. The system is set in motion with the string taut and P travelling down the slope at $2\,\mathrm{m\,s^{-1}}$.

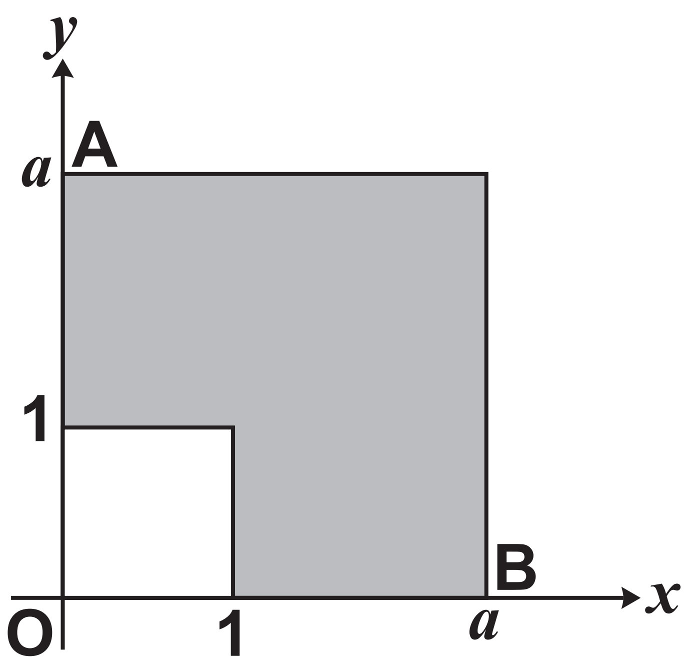
(iii) How far does P move before it reaches its lowest point? [5]

(iv) Determine what happens to the system after P reaches its lowest point. [2]

(v) Calculate the power of the frictional force acting on P in part (iii) at the moment the system is set in motion. [2]

3 A uniform heavy lamina occupies the region shaded in Fig. 3. This region is formed by removing a square of side 1 unit from a square of side a units (where $a > 1$).

FIG. 3



Relative to the axes shown in Fig. 3 above, the centre of mass of the lamina is at $(\bar{x}, \bar{y})$.

(i) Show that $\bar{x} = \bar{y} = \dfrac{a^2 + a + 1}{2(a+1)}$.

[You may need to use the result $\dfrac{a^3 - 1}{2(a^2 - 1)} = \dfrac{a^2 + a + 1}{2(a+1)}$.] [5]

(ii) Show that the centre of mass of the lamina lies on its perimeter if $a = \frac{1}{2}(1 + \sqrt{5})$. [3]

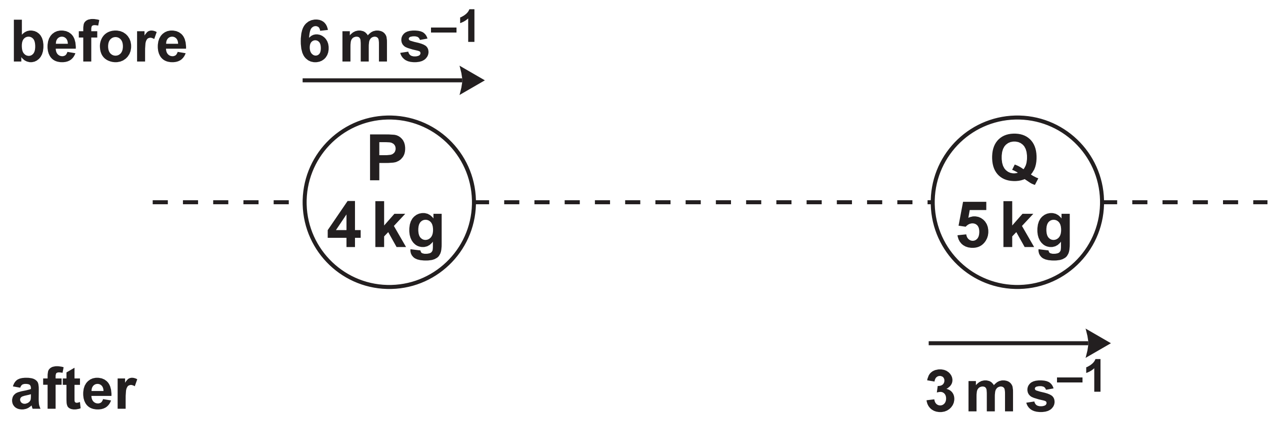
In another situation, $a = 4$.

A particle of mass one third that of the lamina is attached to the lamina at vertex B; the lamina with the particle is freely suspended from vertex A and hangs in equilibrium. The positions of A and B are shown in Fig. 3.

(iii) Calculate the angle that AB makes with the vertical. [10]

4 (a) Two discs, P of mass 4 kg and Q of mass 5 kg, are sliding along the same line on a smooth horizontal plane when they collide. The velocity of P before the collision and the velocity of Q after the collision are shown in Fig. 4 below. P loses $\frac{5}{9}$ of its kinetic energy in the collision.

FIG. 4



(i) Show that after the collision P has a velocity of $4\,\text{m}\,\text{s}^{-1}$ in the opposite direction to its original motion. [4]

While colliding, the discs are in contact for $\frac{1}{5}$ s.

(ii) Find the impulse on P in the collision and the average force acting on the discs. [4]

(iii) Find the velocity of Q before the collision and the coefficient of restitution between the two discs. [4]

(b) **A particle is projected from a point 2.5 m above a smooth horizontal plane. Its initial velocity is $5.95\,\mathrm{m\,s^{-1}}$ at an angle θ below the horizontal, where $\sin\theta = \frac{15}{17}$. The coefficient of restitution between the particle and the plane is $\frac{4}{5}$.**

(i) **Show that, after bouncing off the plane, the greatest height reached by the particle is 2.5 m. [5]**

(ii) **Calculate the horizontal distance between the two points at which the particle is 2.5 m above the plane. [3]**

END OF QUESTION PAPER

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