OCR
RECOGNISING ACHIEVEMENT

Monday 14 January 2013 – Morning

A2 GCE MATHEMATICS

4729/01 Mechanics 2

QUESTION PAPER

Candidates answer on the Printed Answer Book.

OCR supplied materials:
- Printed Answer Book 4729/01
- 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 in the centre of 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**. 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.
- 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 bar codes.
- 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 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 **12** pages. The Question Paper consists of **8** 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.

1 A block is being pushed in a straight line along horizontal ground by a force of 18 N inclined at 15° below the horizontal. The block moves a distance of 6 m in 5 s with constant speed. Find

(i) the work done by the force, **[3]**

(ii) the power with which the force is working. **[2]**

2 A car of mass 1500 kg travels along a straight horizontal road. The resistance to the motion of the car is $kv^{\frac{1}{2}}$ N, where v m s^{-1} is the speed of the car and k is a constant. At the instant when the engine produces a power of 15 000 W, the car has speed 15 m s^{-1} and is accelerating at 0.4 m s^{-2}.

(i) Find the value of k. **[4]**

It is given that the greatest steady speed of the car on this road is 30 m s^{-1}.

(ii) Find the greatest power that the engine can produce. **[3]**

3 A particle A is released from rest from the top of a smooth plane, which makes an angle of 30° with the horizontal. The particle A collides 2 s later with a particle B, which is moving up a line of greatest slope of the plane. The coefficient of restitution between the particles is 0.4 and the speed of B immediately before the collision is 2 m s^{-1}. B has velocity 1 m s^{-1} down the plane immediately after the collision. Find

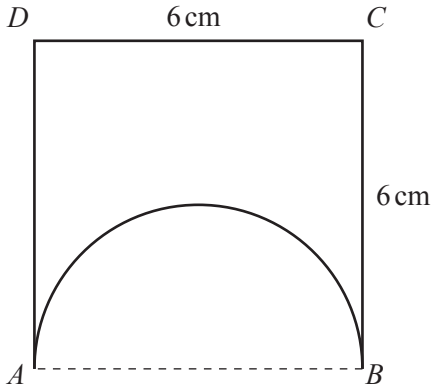
(i) the speed of A immediately after the collision, **[4]**

(ii) the distance A moves up the plane after the collision. **[2]**

The masses of A and B are 0.5 kg and m kg, respectively.

(iii) Find the value of m. **[3]**

4



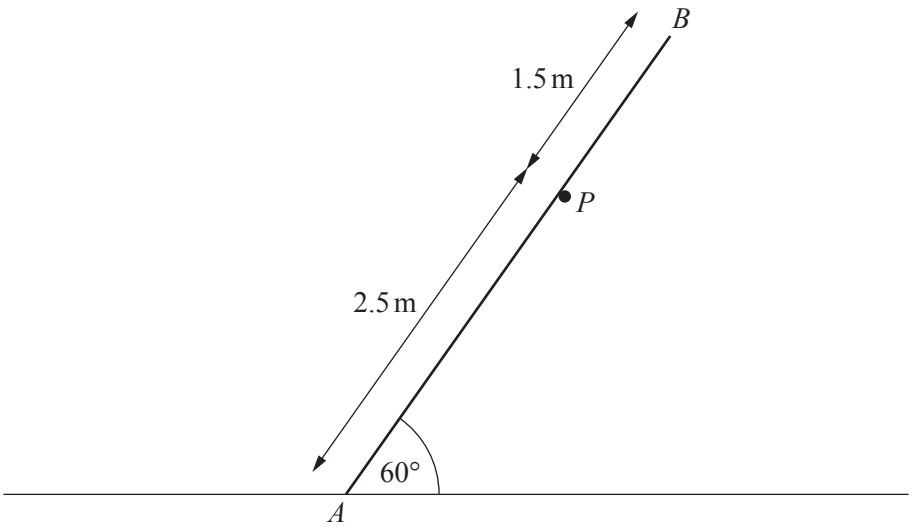
A uniform square lamina $ABCD$ of side 6 cm has a semicircular piece, with AB as diameter, removed (see diagram).

(i) Find the distance of the centre of mass of the remaining shape from CD. **[6]**

The remaining shape is suspended from a fixed point by a string attached at C and hangs in equilibrium.

(ii) Find the angle between CD and the vertical. **[2]**

5



A uniform rod AB, of mass 3 kg and length 4 m, is in limiting equilibrium with A on rough horizontal ground. The rod is at an angle of 60° to the horizontal and is supported by a small smooth peg P, such that the distance AP is 2.5 m (see diagram). Find

(i) the force acting on the rod at P, **[3]**

(ii) the coefficient of friction between the ground and the rod. **[5]**

6 A particle of mass 0.5 kg is held at rest at a point P, which is at the bottom of an inclined plane. The particle is given an impulse of 1.8 N s directed up a line of greatest slope of the plane.

(i) Find the speed at which the particle starts to move. **[2]**

The particle subsequently moves up the plane to a point Q, which is 0.3 m above the level of P.

(ii) Given that the plane is smooth, find the speed of the particle at Q. **[4]**

It is given instead that the plane is rough. The particle is now projected up the plane from P with initial speed 3 m s^{-1}, and comes to rest at a point R which is 0.2 m above the level of P.

(iii) Given that the plane is inclined at 30° to the horizontal, find the magnitude of the frictional force on the particle. **[4]**

7 A particle is projected with speed $u\,\text{m s}^{-1}$ at an angle of θ above the horizontal from a point O. At time t s after projection, the horizontal and vertically upwards displacements of the particle from O are x m and y m respectively.

(i) Express x and y in terms of t and θ and hence obtain the equation of trajectory

$$y = x\tan\theta - \frac{gx^2\sec^2\theta}{2u^2}.$$

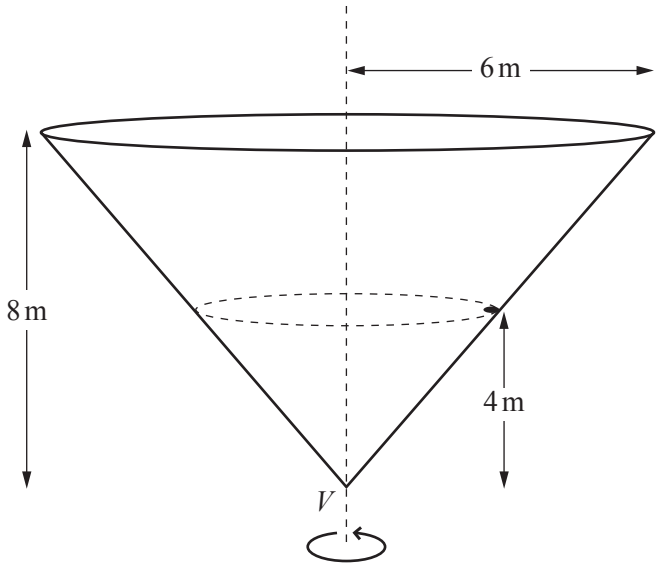
[4]

In a shot put competition, a shot is thrown from a height of 2.1 m above horizontal ground. It has initial velocity of $14\,\text{m s}^{-1}$ at an angle of θ above the horizontal. The shot travels a horizontal distance of 22 m before hitting the ground.

(ii) Show that $12.1\tan^2\theta - 22\tan\theta + 10 = 0$, and find the value of θ. **[5]**

(iii) Find the time of flight of the shot. **[2]**

8



A conical shell has radius 6 m and height 8 m. The shell, with its vertex V downwards, is rotating about its vertical axis. A particle, of mass 0.4 kg, is in contact with the rough inner surface of the shell. The particle is 4 m above the level of V (see diagram). The particle and shell rotate with the same constant angular speed. The coefficient of friction between the particle and the shell is μ.

(i) The frictional force on the particle is F N, and the normal force of the shell on the particle is R N. It is given that the speed of the particle is $4.5\,\text{m s}^{-1}$, which is the smallest possible speed for the particle not to slip.

(a) By resolving vertically, show that $4F + 3R = 19.6$. **[2]**

(b) By finding another equation connecting F and R, find the values of F and R and show that $\mu = 0.336$, correct to 3 significant figures. **[6]**

(ii) Find the largest possible angular speed of the shell for which the particle does not slip. **[6]**

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