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Wednesday 20 May 2015 – Morning

A2 GCE MATHEMATICS (MEI)

4763/01 Mechanics 3

QUESTION PAPER

Candidates answer on the Printed Answer Book.

OCR supplied materials:
- Printed Answer Book 4763/01
- MEI Examination Formulae and Tables (MF2)

Other materials required:
- Scientific or graphical calculator

Duration: 1 hour 30 minutes

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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**. 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.
- Do **not** write in the bar codes.
- 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

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 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**.
- The Printed Answer Book consists of **16** pages. The Question Paper consists of **8** pages. Any blank pages are indicated.

INSTRUCTION TO EXAMS OFFICER / INVIGILATOR

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1 **(i)** Give the dimensions of force, work and power. **[3]**

The force due to air resistance acting on a car is given by λv^2, where v is the speed and λ is a constant for that car.

(ii) Find the dimensions of λ. **[2]**

The power P of the car and its maximum speed U are related by the equation $P = \lambda U^3$.

(iii) Show that this equation is dimensionally consistent. **[2]**

The time t taken for the car to accelerate from speed $\frac{1}{3}U$ to speed $\frac{2}{3}U$ is given by $t = km^{\alpha}P^{\beta}\lambda^{\gamma}$, where m is the mass of the car and k is a dimensionless constant.

(iv) Find α, β and γ. **[4]**

Car C has mass 800 kg, power 35 kW, maximum speed 45 m s^{-1}, and takes 9.18 s to accelerate from 15 m s^{-1} to 30 m s^{-1}.

(v) Find the value of λ for Car C

(A) in SI units (based on kilograms, metres and seconds),

(B) in a system of units based on pounds, miles and hours, given that

1 pound = 0.454 kg, 1 mile = 1609 m, 1 hour = 3600 s. **[3]**

(vi) Car D has mass 1250 kg, power 75 kW and maximum speed 54 m s^{-1}. Find the time taken for Car D to accelerate from 18 m s^{-1} to 36 m s^{-1}. **[4]**

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2 **(a)** A particle P of mass m is attached to a fixed point O by a light inextensible string of length a. P is moving without resistance in a complete vertical circle with centre O and radius a. When P is at the highest point of the circle, the tension in the string is T_1. When OP makes an angle θ with the upward vertical, the tension in the string is T_2. Show that

$$T_2 = T_1 + 3mg(1 - \cos\theta).$$ **[6]**

(b) The fixed point A is 1.2 m vertically above the fixed point C. A particle Q of mass 0.9 kg is joined to A, to C, and to a particle R of mass 1.5 kg, by three light inextensible strings of lengths 1.3 m, 0.5 m and 1.8 m respectively. The particle Q moves in a horizontal circle with centre C, and R moves in a horizontal circle at the same constant angular speed as Q, in such a way that A, C, Q and R are always coplanar. The string QR makes an angle of 60° with the downward vertical. This situation is shown in Fig. 2.

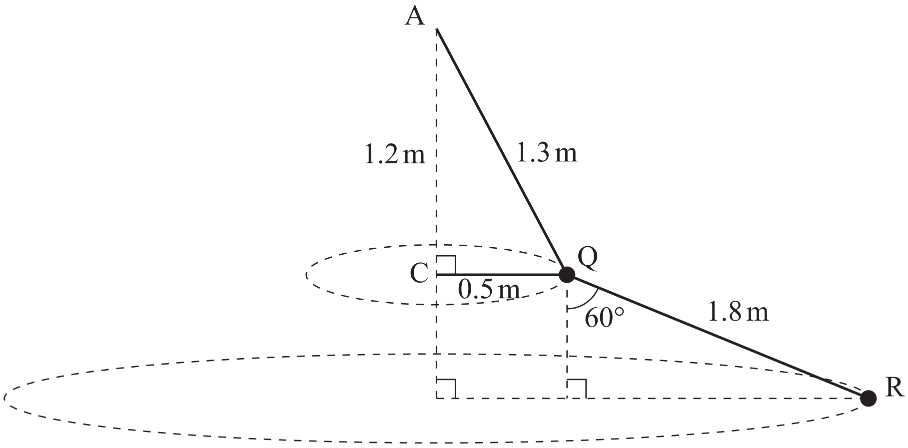

Fig. 2

(i) Find the tensions in the strings QR and AQ. **[5]**

(ii) Find the angular speed of the system. **[3]**

(iii) Find the tension in the string CQ. **[4]**

Question 3 begins on page 4.

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3 Fig. 3 shows the fixed points A and F which are 9.5 m apart on a smooth horizontal surface and points B and D on the line AF such that AB = DF = 3.0 m. A small block of mass 10.5 kg is joined to A by a light elastic string of natural length 3.0 m and stiffness 12 N m^{-1}; the block is joined to F by a light elastic string of natural length 3.0 m and stiffness 30 N m^{-1}. The block is released from rest at B and then slides along part of the line AF. The block has zero acceleration when it is at a point C, and it comes to instantaneous rest at a point E.

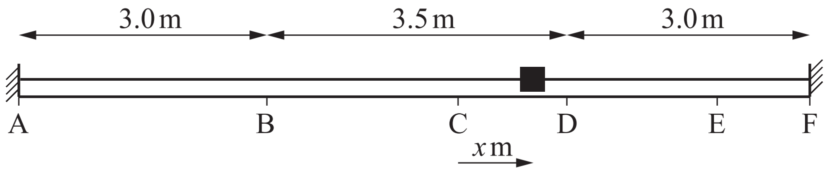

Fig. 3

(i) Find the distance BC. **[3]**

At time t s the displacement of the block from C is x m, measured in the direction AF.

(ii) Show that, when the block is between B and D, $\frac{d^2x}{dt^2} = -4x$. **[4]**

(iii) Find the maximum speed of the block. **[2]**

(iv) Find the distance of the block from C when its speed is 4.8 m s^{-1}. **[2]**

(v) Find the time taken for the block to travel from B to D. **[4]**

(vi) Find the distance DE. **[3]**

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4 **(a)** A uniform lamina occupies the region bounded by the x-axis and the curve $y = \dfrac{x^2(a-x)}{a^2}$ for $0 \leqslant x \leqslant a$. Find the coordinates of the centre of mass of this lamina. **[9]**

(b) The region A is bounded by the x-axis, the y-axis, the curve $y = \sqrt{x^2 + 16}$ and the line $x = 3$. The region B is bounded by the y-axis, the curve $y = \sqrt{x^2 + 16}$ and the line $y = 5$. These regions are shown in Fig. 4.

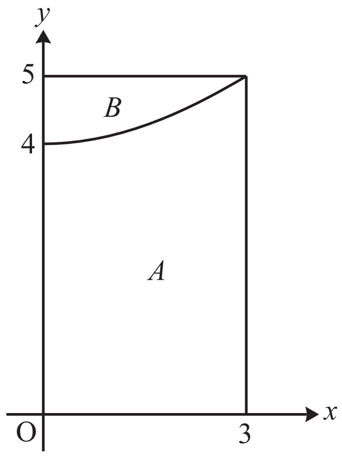

Fig. 4

(i) Find the x-coordinate of the centre of mass of the uniform solid of revolution formed when the region A is rotated through 2π radians about the x-axis. **[5]**

(ii) Using your answer to part **(i)**, or otherwise, find the x-coordinate of the centre of mass of the uniform solid of revolution formed when the region B is rotated through 2π radians about the x-axis. **[4]**

END OF QUESTION PAPER

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