

# OCR

Oxford Cambridge and RSA

## Wednesday 20 May 2015 – Morning

### A2 GCE MATHEMATICS (MEI)

4763/01 Mechanics 3

#### QUESTION PAPER

Candidates answer on the Printed Answer Book.

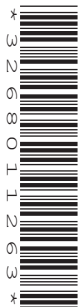
##### OCR supplied materials:

- Printed Answer Book 4763/01
- MEI Examination Formulae and Tables (MF2)

##### Other materials required:

- Scientific or graphical calculator

**Duration:** 1 hour 30 minutes



#### 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  $g \text{ ms}^{-2}$ . 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

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

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

- (ii) Find the dimensions of  $\lambda$ . [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  $\alpha$ ,  $\beta$  and  $\gamma$ . [4]

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

- (v) Find the value of  $\lambda$  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

$$1 \text{ pound} = 0.454 \text{ kg}, \quad 1 \text{ mile} = 1609 \text{ m}, \quad 1 \text{ hour} = 3600 \text{ s}. \quad [3]$$

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

- 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  $\theta$  with the upward vertical, the tension in the string is  $T_2$ . Show that

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

- (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  $60^\circ$  with the downward vertical. This situation is shown in Fig. 2.

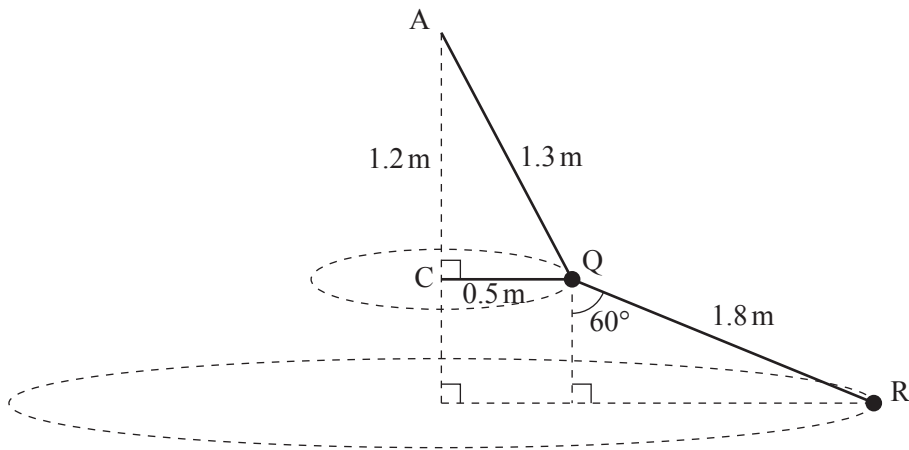


Fig. 2

- (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.

- 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  $12 \text{ N m}^{-1}$ ; the block is joined to F by a light elastic string of natural length 3.0 m and stiffness  $30 \text{ N m}^{-1}$ . 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.

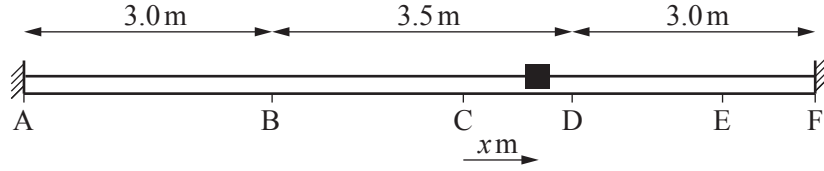


Fig. 3

- (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  $4.8 \text{ m s}^{-1}$ . [2]

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

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

- 4 (a) A uniform lamina occupies the region bounded by the  $x$ -axis and the curve  $y = \frac{x^2(a-x)}{a^2}$  for  $0 \leq x \leq a$ . 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.

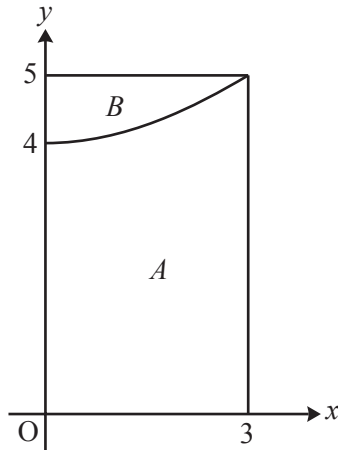


Fig. 4

- (i) Find the  $x$ -coordinate of the centre of mass of the uniform solid of revolution formed when the region  $A$  is rotated through  $2\pi$  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  $2\pi$  radians about the  $x$ -axis. [4]

**END OF QUESTION PAPER**

**BLANK PAGE**

**BLANK PAGE**

**Copyright Information**

OCR is committed to seeking permission to reproduce all third-party content that it uses in its assessment materials. OCR has attempted to identify and contact all copyright holders whose work is used in this paper. To avoid the issue of disclosure of answer-related information to candidates, all copyright acknowledgements are reproduced in the OCR Copyright Acknowledgements Booklet. This is produced for each series of examinations and is freely available to download from our public website ([www.ocr.org.uk](http://www.ocr.org.uk)) after the live examination series.

If OCR has unwittingly failed to correctly acknowledge or clear any third-party content in this assessment material, OCR will be happy to correct its mistake at the earliest possible opportunity.

For queries or further information please contact the Copyright Team, First Floor, 9 Hills Road, Cambridge CB2 1GE.

OCR is part of the Cambridge Assessment Group; Cambridge Assessment is the brand name of University of Cambridge Local Examinations Syndicate (UCLES), which is itself a department of the University of Cambridge.