

Thursday 31 May 2012 – Morning

A2 GCE MATHEMATICS (MEI)

4763 Mechanics 3

QUESTION PAPER

Candidates answer on the Printed Answer Book.

OCR supplied materials:

- Printed Answer Book 4763
- 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 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.
- 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 $g \text{ m s}^{-2}$. 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 **12** pages. The Question Paper consists of **8** pages. Any blank pages are indicated.

INSTRUCTION TO EXAMS OFFICER/INVIGILATOR

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- 1 The fixed point A is at a height $4b$ above a smooth horizontal surface, and C is the point on the surface which is vertically below A. A light elastic string, of natural length $3b$ and modulus of elasticity λ , has one end attached to A and the other end attached to a block of mass m . The block is released from rest at a point B on the surface where $BC = 3b$, as shown in Fig. 1. You are given that the block remains on the surface and moves along the line BC.

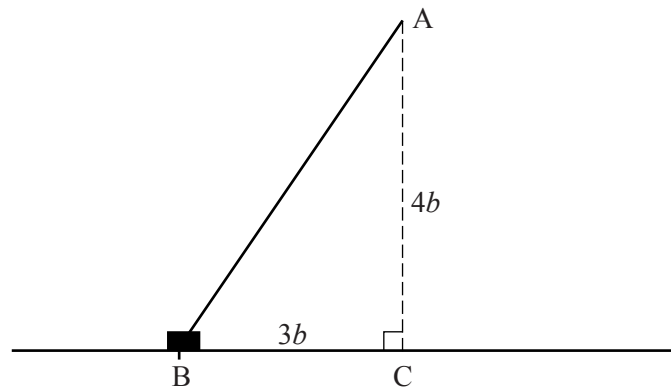


Fig. 1

- (i) Show that immediately after release the acceleration of the block is $\frac{2\lambda}{5m}$. [4]
- (ii) Show that, when the block reaches C, its speed v is given by $v^2 = \frac{\lambda b}{m}$. [4]
- (iii) Show that the equation $v^2 = \frac{\lambda b}{m}$ is dimensionally consistent. [3]

The time taken for the block to move from B to C is given by $km^\alpha b^\beta \lambda^\gamma$, where k is a dimensionless constant.

- (iv) Use dimensional analysis to find α , β and γ . [4]

When the string has natural length 1.2 m and modulus of elasticity 125 N, and the block has mass 8 kg, the time taken for the block to move from B to C is 0.718 s.

- (v) Find the time taken for the block to move from B to C when the string has natural length 9 m and modulus of elasticity 20 N, and the block has mass 75 kg. [3]

- 2 (a) Fig. 2 shows a car of mass 800 kg moving at constant speed in a horizontal circle with centre C and radius 45 m , on a road which is banked at an angle of 18° to the horizontal. The forces shown are the weight W of the car, the normal reaction, R , of the road on the car and the frictional force F .

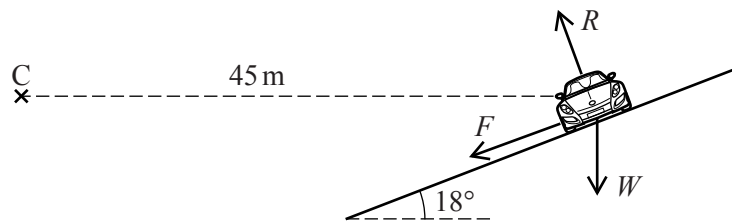


Fig. 2

- (i) Given that the frictional force is zero, find the speed of the car. [4]
- (ii) Given instead that the speed of the car is 15 m s^{-1} , find the frictional force and the normal reaction. [7]
- (b) One end of a light inextensible string is attached to a fixed point O , and the other end is attached to a particle P of mass $m\text{ kg}$. Starting with the string taut and P vertically below O , P is set in motion with a horizontal velocity of 7 m s^{-1} . It then moves in part of a vertical circle with centre O . The string becomes slack when the speed of P is 2.8 m s^{-1} .

Find the length of the string. Find also the angle that OP makes with the upward vertical at the instant when the string becomes slack. [7]

- 3 A particle Q is performing simple harmonic motion in a vertical line. Its height, x metres, above a fixed level at time t seconds is given by

$$x = c + A\cos(\omega t - \phi)$$

where c , A , ω and ϕ are constants.

- (i) Show that $\ddot{x} = -\omega^2(x - c)$. [3]

Fig. 3 shows the displacement-time graph of Q for $0 \leq t \leq 14$.

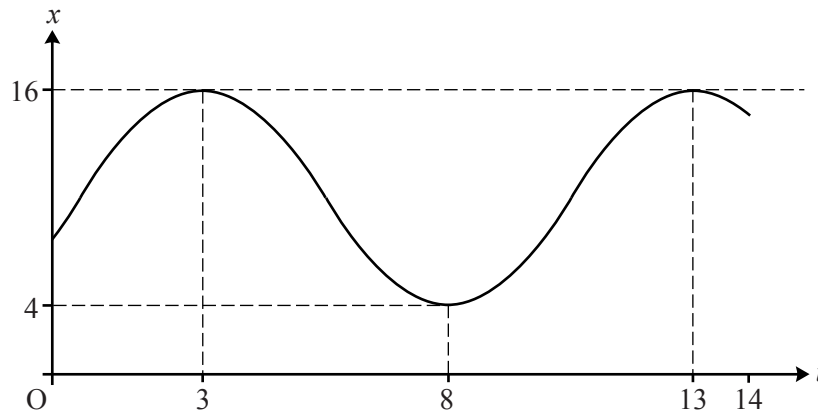


Fig. 3

- (ii) Find exact values for c , A , ω and ϕ . [6]
- (iii) Find the maximum speed of Q. [2]
- (iv) Find the height and the velocity of Q when $t = 0$. [3]
- (v) Find the distance travelled by Q between $t = 0$ and $t = 14$. [4]

- 4 (a) A uniform lamina occupies the region bounded by the x -axis, the y -axis and the curve $y = 3 - \sqrt{x}$ for $0 \leq x \leq 9$. Find the coordinates of the centre of mass of this lamina. [9]
- (b) Fig. 4.1 shows the region bounded by the line $x = 2$ and the part of the circle $y^2 = 25 - x^2$ for which $2 \leq x \leq 5$. This region is rotated about the x -axis to form a uniform solid of revolution S .

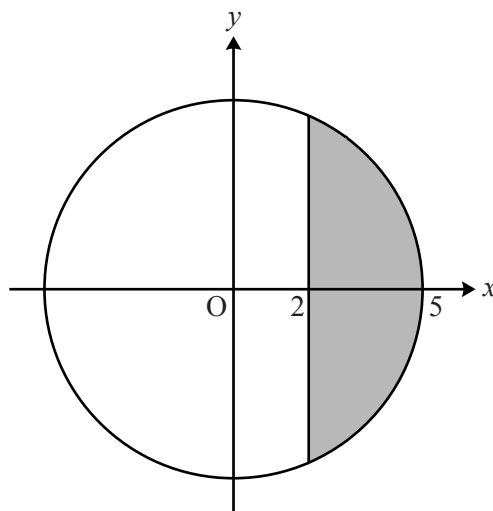


Fig. 4.1

- (i) Find the x -coordinate of the centre of mass of S . [5]

The solid S rests in equilibrium with its curved surface in contact with a rough plane inclined at 25° to the horizontal. Fig. 4.2 shows a vertical section containing AB , which is a diameter and also a line of greatest slope of the flat surface of S . This section also contains XY , which is a line of greatest slope of the plane.

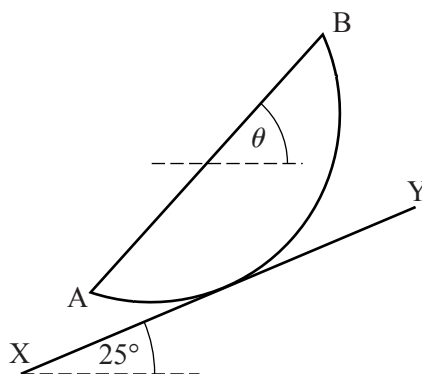


Fig. 4.2

- (ii) Find the angle θ that AB makes with the horizontal. [4]

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