



Thursday 22 May 2014 – 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 $g \text{ m s}^{-2}$. 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 (a) The speed v of sound in a solid material is given by $v = \sqrt{\frac{E}{\rho}}$, where E is Young's modulus for the material and ρ is its density.

(i) Find the dimensions of Young's modulus. [3]

The density of steel is 7800 kg m^{-3} and the speed of sound in steel is 6100 m s^{-1} .

(ii) Find Young's modulus for steel, stating the units in which your answer is measured. [2]

A tuning fork has cylindrical prongs of radius r and length l . The frequency f at which the tuning fork vibrates is given by $f = kc^\alpha E^\beta \rho^\gamma$, where $c = \frac{l^2}{r}$ and k is a dimensionless constant.

(iii) Find α , β and γ . [4]

- (b) A particle P is performing simple harmonic motion along a straight line, and the centre of the oscillations is O. The points X and Y on the line are on the same side of O, at distances 3.9 m and 6.0 m from O respectively. The speed of P is 1.04 m s^{-1} when it passes through X and 0.5 m s^{-1} when it passes through Y.

(i) Find the amplitude and the period of the oscillations. [5]

(ii) Find the time taken for P to travel directly from X to Y. [4]

- 2 (a) The fixed point A is vertically above the fixed point B. A light inextensible string of length 5.4 m has one end attached to A and the other end attached to B. The string passes through a small smooth ring R of mass 0.24 kg, and R is moving at constant angular speed in a horizontal circle. The circle has radius 1.6 m, and AR = 3.4 m, RB = 2.0 m, as shown in Fig. 2.

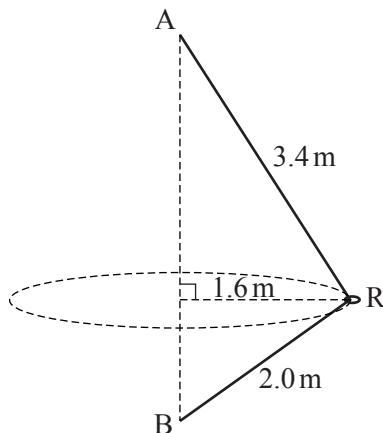


Fig. 2

- (i) Find the tension in the string. [3]
- (ii) Find the angular speed of R. [3]
- (b) A particle P of mass 0.3 kg is joined to a fixed point O by a light inextensible string of length 1.8 m. The particle P moves without resistance in part of a vertical circle with centre O and radius 1.8 m. When OP makes an angle of 25° with the downward vertical, the tension in the string is 15 N.
- (i) Find the speed of P when OP makes an angle of 25° with the downward vertical. [3]
- (ii) Find the tension in the string when OP makes an angle of 60° with the upward vertical. [5]
- (iii) Find the speed of P at the instant when the string becomes slack. [5]

- 3 The fixed points A and B lie on a line of greatest slope of a smooth inclined plane, with B higher than A. The horizontal distance from A to B is 2.4 m and the vertical distance is 0.7 m. The fixed point C is 2.5 m vertically above B. A light elastic string of natural length 2.2 m has one end attached to C and the other end attached to a small block of mass 9 kg which is in contact with the plane. The block is in equilibrium when it is at A, as shown in Fig. 3.

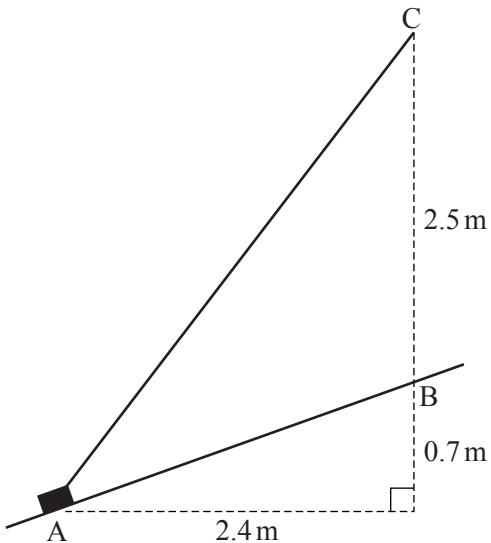


Fig. 3

- (i) Show that the modulus of elasticity of the string is 37.73 N. [5]

The block starts at A and is at rest. A constant force of 18 N, acting in the direction AB, is then applied to the block so that it slides along the line AB.

- (ii) Find the magnitude and direction of the acceleration of the block

(A) when it leaves the point A,

(B) when it reaches the point B. [6]

- (iii) Find the speed of the block when it reaches the point B. [6]

- 4 The region R is bounded by the x -axis, the y -axis, the curve $y = e^{-x}$ and the line $x = k$, where k is a positive constant.

- (i) The region R is rotated through 2π radians about the x -axis to form a uniform solid of revolution. Find the x -coordinate of the centre of mass of this solid, and show that it can be written in the form

$$\frac{1}{2} - \frac{k}{e^{2k} - 1}. \quad [7]$$

- (ii) The solid in part (i) is placed with its larger circular face in contact with a rough plane inclined at 60° to the horizontal, as shown in Fig. 4, and you are given that no slipping occurs.

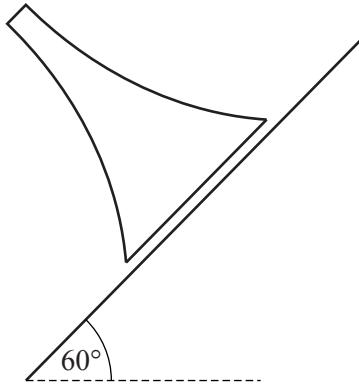


Fig. 4

Show that, whatever the value of k , the solid will not topple. [4]

- (iii) A uniform lamina occupies the region R . Find, in terms of k , the coordinates of the centre of mass of this lamina. [7]

END OF QUESTION PAPER

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