

AS Level Further Mathematics B (MEI)

Y411 Mechanics a

Sample Question Paper

Version 2

Date – Morning/Afternoon

Time allowed: 1 hour 15 minutes

You must have:

- Printed Answer Booklet
- Formulae Further Mathematics B (MEI)

You may use:

- a scientific or graphical calculator



INSTRUCTIONS

- Use black ink. HB pencil may be used for graphs and diagrams only.
- Complete the boxes provided on the Printed Answer Booklet with your name, centre number and candidate number.
- Answer **all** the questions.
- **Write your answer to each question in the space provided in the Printed Answer Booklet.** Additional paper may be used if necessary but you must clearly show your candidate number, centre number and question number(s).
- 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

- The total number of marks for this paper is **60**.
- The marks for each question are shown in brackets [].
- 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 used. You should communicate your method with correct reasoning.
- The Printed Answer Booklet consists of **12** pages. The Question Paper consists of **8** pages.

Answer **all** the questions

- 1 A clock is driven by a 5 kg sphere falling once through a vertical distance of 120 cm over 2 days.

Calculate, in watts, the average power developed by the falling sphere.

[4]

- 2 A triangular lamina, ABC, is cut from a piece of thin uniform plane sheet metal. The dimensions of ABC are shown in Fig. 2.

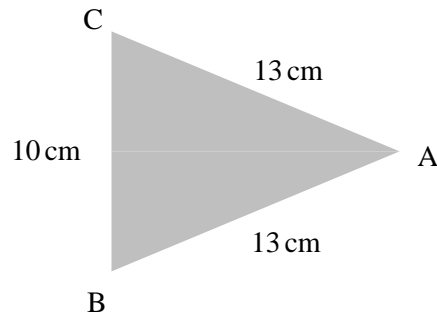


Fig. 2

This piece of metal is freely suspended from a string attached to C and hangs in equilibrium.

Calculate the angle of BC with the downward vertical, giving your answer in degrees.

[5]

- 3 Solid toy aeroplane nose cones of various sizes are made in the shape shown in Fig. 3.1, where OA is its line of symmetry.

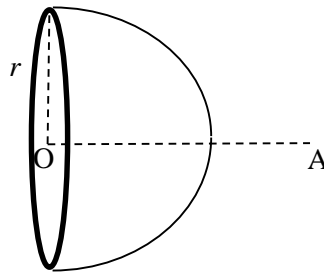


Fig. 3.1

The air resistance against the nose cone as the aeroplane flies through the air is initially modelled by $R = kr\nu\eta$, where R is the air resistance, r is the radius of the circular flat end of the nose cone, ν is the velocity of the nose cone, η is the viscosity of the air and k is a dimensionless constant.

- (i) Use dimensional analysis to show that the dimensions of η are $ML^{-1}T^{-1}$. [3]

In an experiment conducted on a particular nose cone, measurements of air resistance are taken for different velocities. The viscosity of the air does not vary during the experiment. The graph in Fig. 3.2 shows the results. Measurements are given using the appropriate S.I. units.

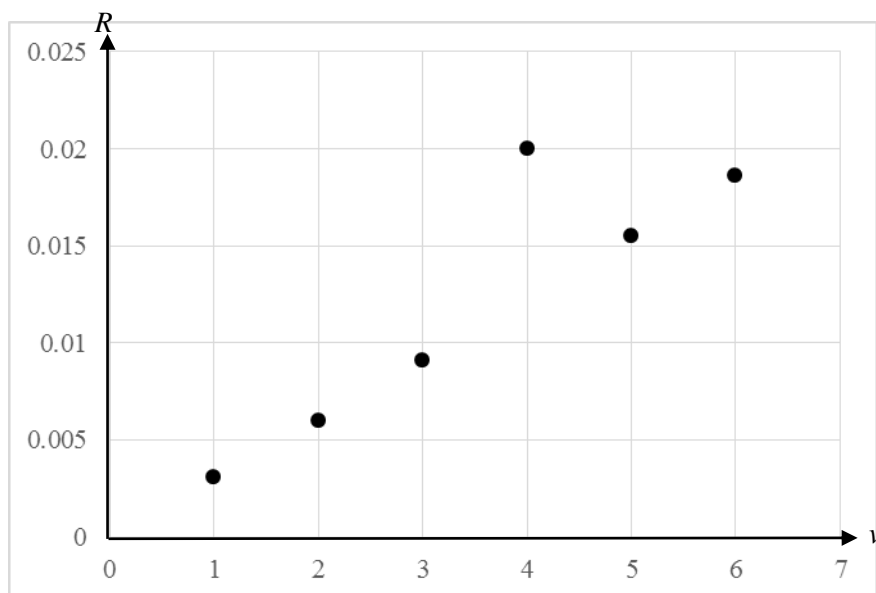


Fig. 3.2

- (ii) Comment on whether the results of this experiment are consistent with the initial model. [3]

It is now suggested that a better model for the air resistance is $R = Krv\eta\left(\frac{\rho rv}{\eta}\right)^\alpha$, where ρ is the density of the air, K is a dimensionless constant and R , r , v and η are as before.

(iii) (A) Find the dimensions of $\frac{\rho rv}{\eta}$. [2]

(B) Explain why you cannot use dimensional analysis to find the value of α . [1]

- 4 Fig. 4 shows a thin rigid non-uniform rod PQ of length 0.5 m. End P rests on a rough circular peg. A force of T N acts at the end Q at 60° to QP. The weight of the rod is 40 N and its centre of mass is 0.3 m from P.

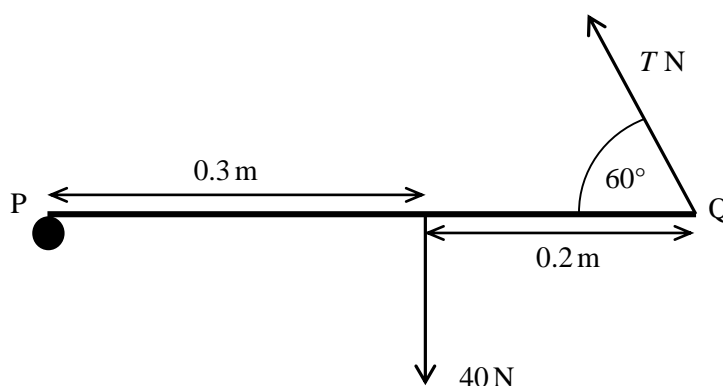


Fig. 4

The rod does not slip on the peg and is in equilibrium with PQ horizontal.

- (i) Show that the vertical component of T is 24 N. [2]
- (ii) F is the contact force at P between the rod and the peg.
Find
- the vertical component of F ,
 - the horizontal component of F . [4]
- (iii) Given that the rod is about to slip on the peg, find the coefficient of friction between the rod and the peg. [2]

5 In this question, all coordinates refer to the axes shown in Fig. 5.1.

Fig. 5.1 shows a system of four particles with masses $4m$, $3m$, m and $2m$ at the points A, B, C and D. These points have coordinates $(-3, 4)$, $(0, 0)$, $(2, 0)$ and $(5, 4)$.

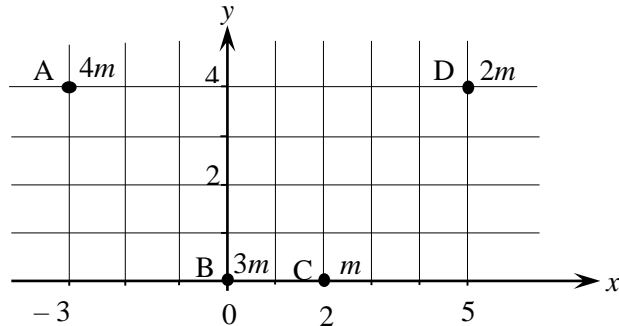


Fig. 5.1

(i) Calculate the coordinates of the centre of mass of the system of particles.

[4]

A thin uniform rigid wire of mass $12m$ connects the points A, B, C and D with straight line sections, as shown in Fig. 5.2.

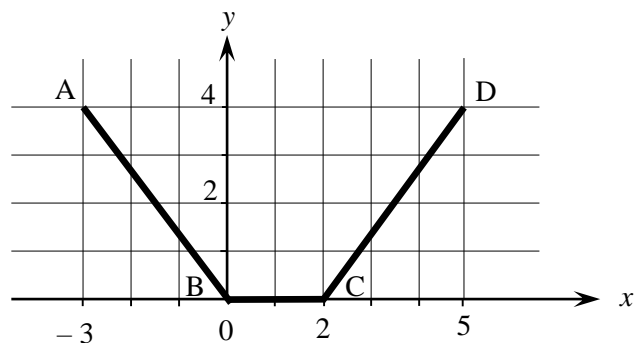


Fig. 5.2

(ii) Calculate the coordinates of the centre of mass of the wire.

[4]

The particles at A, B, C and D are now fixed to the wire to form a rigid object, R .

(iii) Calculate the x -coordinate of the centre of mass of R .

[2]

- 6 A sack of beans of mass 40 kg is pulled from rest at point A up a non-uniform slope onto and along a horizontal platform. Fig. 6 shows this slope AB and the platform BC, which is a vertical distance of 12 m above A.

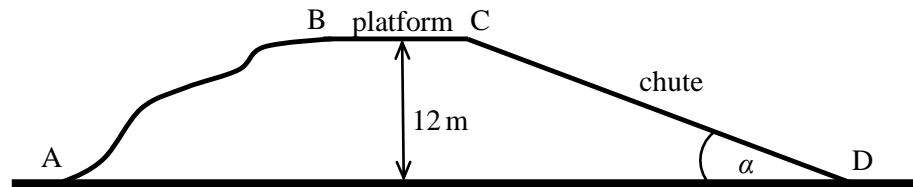


Fig. 6

- (i) Calculate the gain in the gravitational potential energy of the sack when it is moved from A to the platform. [1]

The sack has a speed of 4 m s^{-1} by the time it reaches C at the far end of the platform. The total work done against friction in moving the sack from A to C is 484 J. There are no other resistances to the sack's motion.

- (ii) Calculate the total work done in moving the sack between the points A and C. [3]

At point C, travelling at 4 m s^{-1} , the sack starts to slide down a straight chute inclined at α to the horizontal. Point D at the bottom of the chute is at the same vertical height as A, as shown in Fig. 6. The chute is rough and the coefficient of friction between the chute and the sack is 0.6. During this part of the motion, again the only resistance to the motion of the sack is friction.

- (iii) Use an energy method to calculate the value of α given that the sack is travelling at 3 m s^{-1} when it reaches D. [7]

For safety reasons the sack needs to arrive at D with a speed of less than 3 m s^{-1} . The value of α can be adjusted to try to achieve this.

- (iv) (A) Find the range of values of α which achieve a safe speed at D. [1]

- (B) Comment on whether adjusting α is a practical way of achieving a safe speed at D. [1]

- 7 Rose and Steve collide while sitting firmly on trays that are sliding on smooth horizontal ice. There are no external driving forces. Fig. 7 shows the masses of Rose and of Steve with their trays, their velocities just before their collision and the line of their motion and of their impact.

Immediately after the collision, Rose has a velocity of 0.28 m s^{-1} in the direction of her motion before the collision.

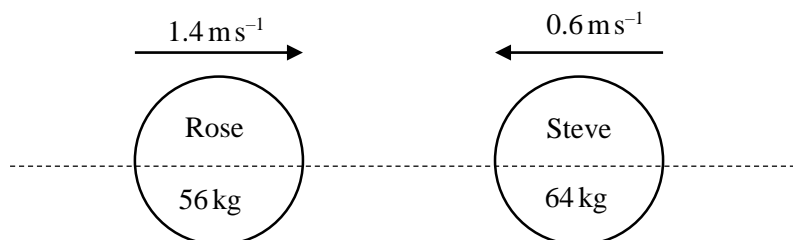


Fig. 7

- (i) Find Steve's velocity after the collision. [3]

- (ii) Find the coefficient of restitution between Rose and Steve on their trays. [2]

Shortly after the collision, Steve catches Rose's hand, pulls her towards him with a horizontal impulse of 4.48 N s and then lets go of her hand.

- (iii) Calculate Rose's velocity after the pull. [2]

When they collide again they hold one another and move together with a common speed of $V \text{ m s}^{-1}$.

- (iv) Calculate V . [3]

- (v) Why did you need to know that there are no driving forces and that the ice is smooth? [1]

END OF QUESTION PAPER

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