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OXFORD CAMBRIDGE AND RSA EXAMINATIONS

Friday 14 January 2022 – Morning

Level 3 Cambridge Technical in Engineering

05822/05823/05824/05825/05873

Unit 3: Principles of mechanical engineering

Time allowed: 1 hour 30 minutes plus your additional time allowance

You must have:

the Formula Booklet for Level 3 Cambridge Technical in Engineering (with this document)

a ruler (cm/mm)

a scientific calculator

Please write clearly in black ink.

Centre number								
Candidate number								
First name(s)								
Last name								
Date of birth	D	D	M	M	Y	Y	Y	Y

READ INSTRUCTIONS OVERLEAF

INSTRUCTIONS

Use black ink. You can use an HB pencil, but only for graphs and diagrams.

Write your answer to each question in the space provided. If you need extra space use the lined pages at the end of this booklet. The question numbers must be clearly shown.

Answer ALL the questions.

Where appropriate, your answer should be supported with working. Marks might be given for using a correct method, even if your answer is wrong.

Give your final answers to a degree of accuracy that is appropriate to the context.

The acceleration due to gravity is denoted by g m s^{-2}. When a numerical value is needed use $g = 9.8$ unless a different value is specified in the question.

INFORMATION

The total mark for this paper is 60.

The marks for each question are shown in brackets [ ].

ADVICE

Read each question carefully before you start your answer.

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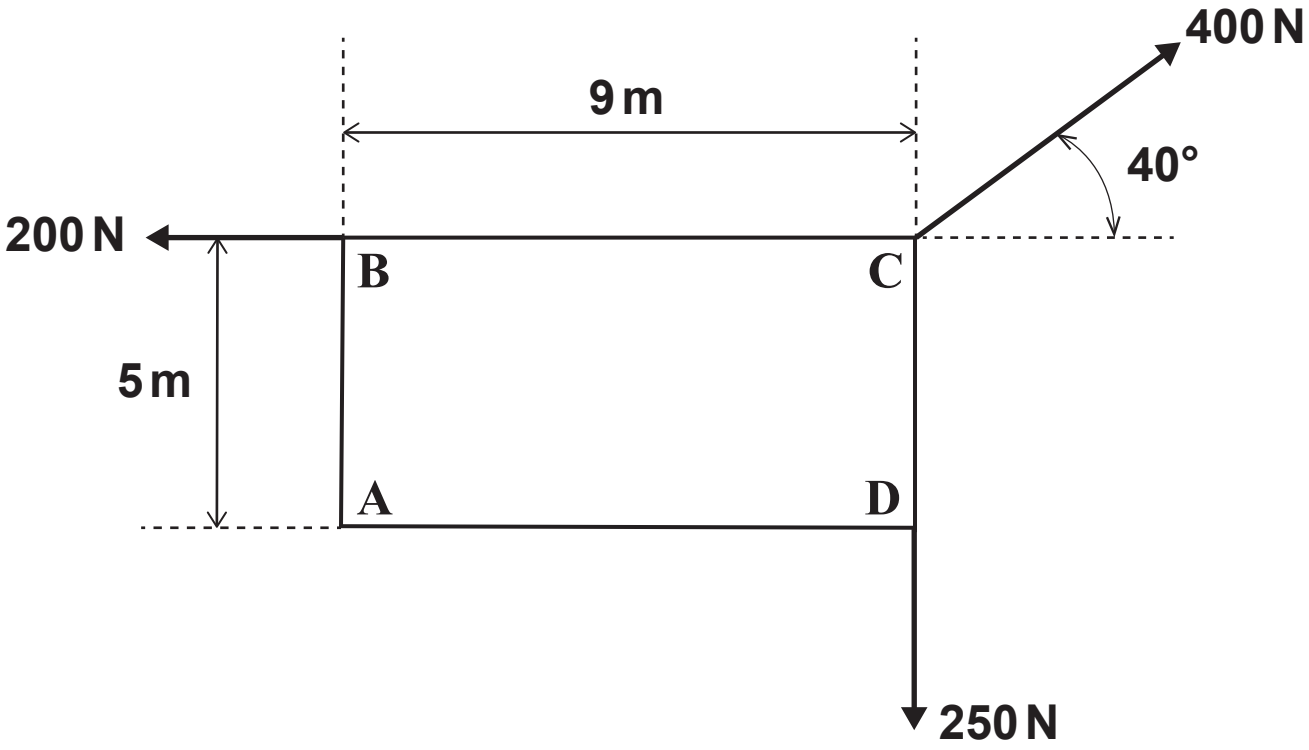
Answer ALL the questions.

1 (a) A ridged rectangular plate with corners A, B, C and D is subjected to three coplanar forces at corners B, C and D as shown in Fig. 1.

Fig. 1



(i) Resolve the 400 N force into horizontal and vertical components.

Horizontal _____

Vertical _____

[2]

(ii) **Calculate the moment about corner A caused by all of the forces acting on the plate.**

_____

_____

_____

_____ **[3]**

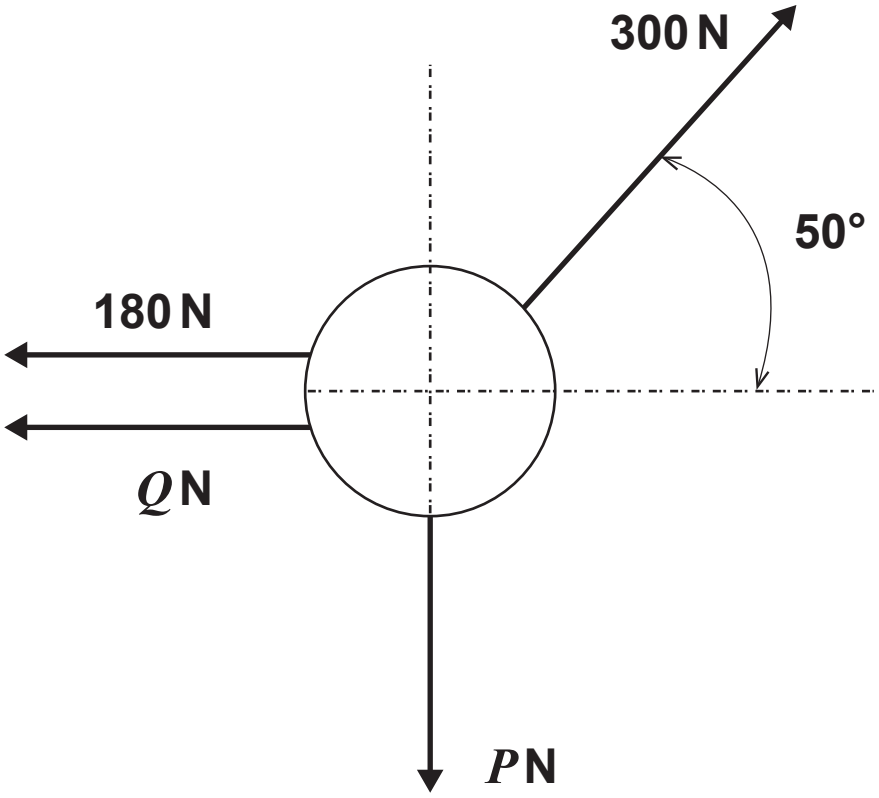
(iii) **Explain why the forces cause a zero moment about corner C.**

_____

_____ **[1]**

(b) A particle suspended in space is subjected to four coplanar forces with magnitudes 180 N, 300 N, Q N and P N as shown in Fig. 2.

Fig. 2



Calculate the magnitudes of P and Q so that the particle remains in static equilibrium.

[3]

2 (a) Name THREE types of gear system used to transmit rotary motion.

1_____

2_____

3_____

[3]

(b) Calculate the Mechanical Advantage (MA) of a gear system that has a Velocity Ratio (VR) of 0.4.

_____

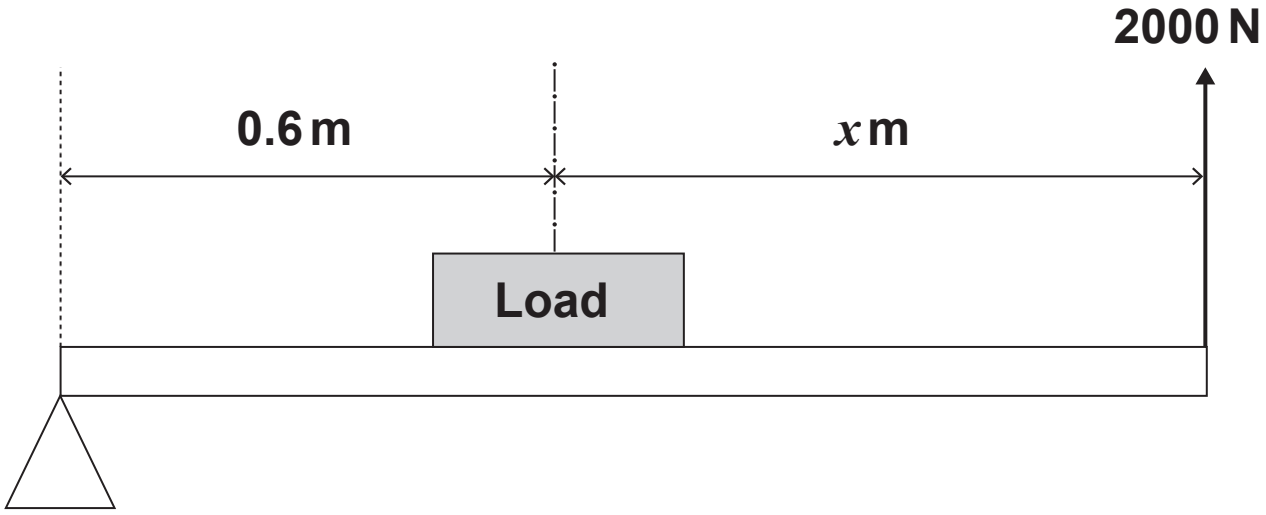
_____ [1]

(c) Fig. 3 shows a lever which has an upward input force of 2000 N at one end and a fulcrum at the other end.

A load is positioned at a distance of 0.6 m from the fulcrum and x m from the input force.

Fig. 3

NOT TO SCALE



(i) State the class of this lever.

_____ [1]

(ii) The value of x is set so that the Mechanical Advantage (MA) of the lever is 2.5.

Calculate the maximum mass of the load that can be lifted.

Give your answer in kilograms.

_____

_____

_____ [2]

(iii) Calculate the value of x.

[2]

(d) In a belt and pulley system, the diameter of the input pulley is 120 mm.

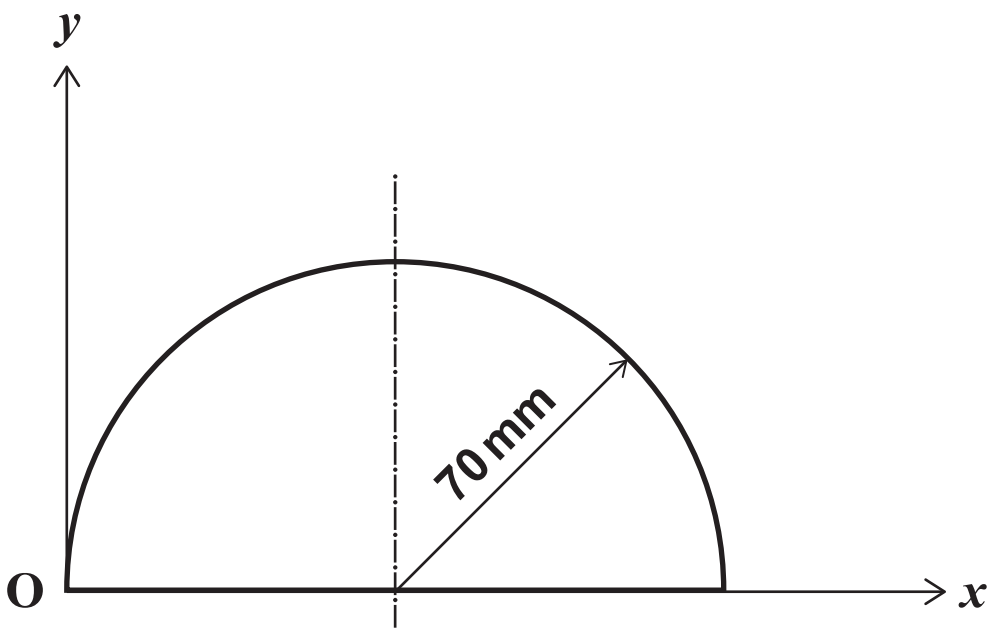
When the output pulley moves through an angle of $\frac{\pi}{3}$ radians, a point on its circumference moves through an arc of length 80 mm.

Calculate the Velocity Ratio (VR) of this belt and pulley system.

[3]

3 (a) Fig. 4 shows a semicircle with a radius of 70 mm aligned within a Cartesian coordinate system, (x, y), with the origin at point O.

Fig. 4



Calculate the coordinates of the centroid of this semicircle.

_____

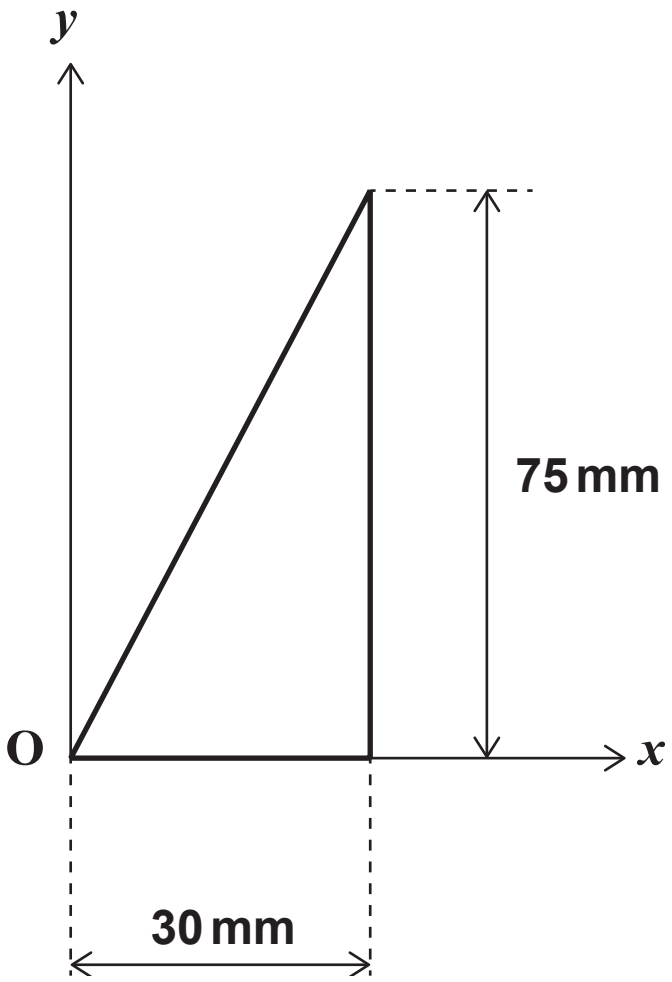
_____

_____

_____ [2]

(b) Fig. 5 shows a triangle aligned within a Cartesian coordinate system (x, y), with the origin at point O.

Fig. 5



Calculate the coordinates of the centroid of this triangle.

_____

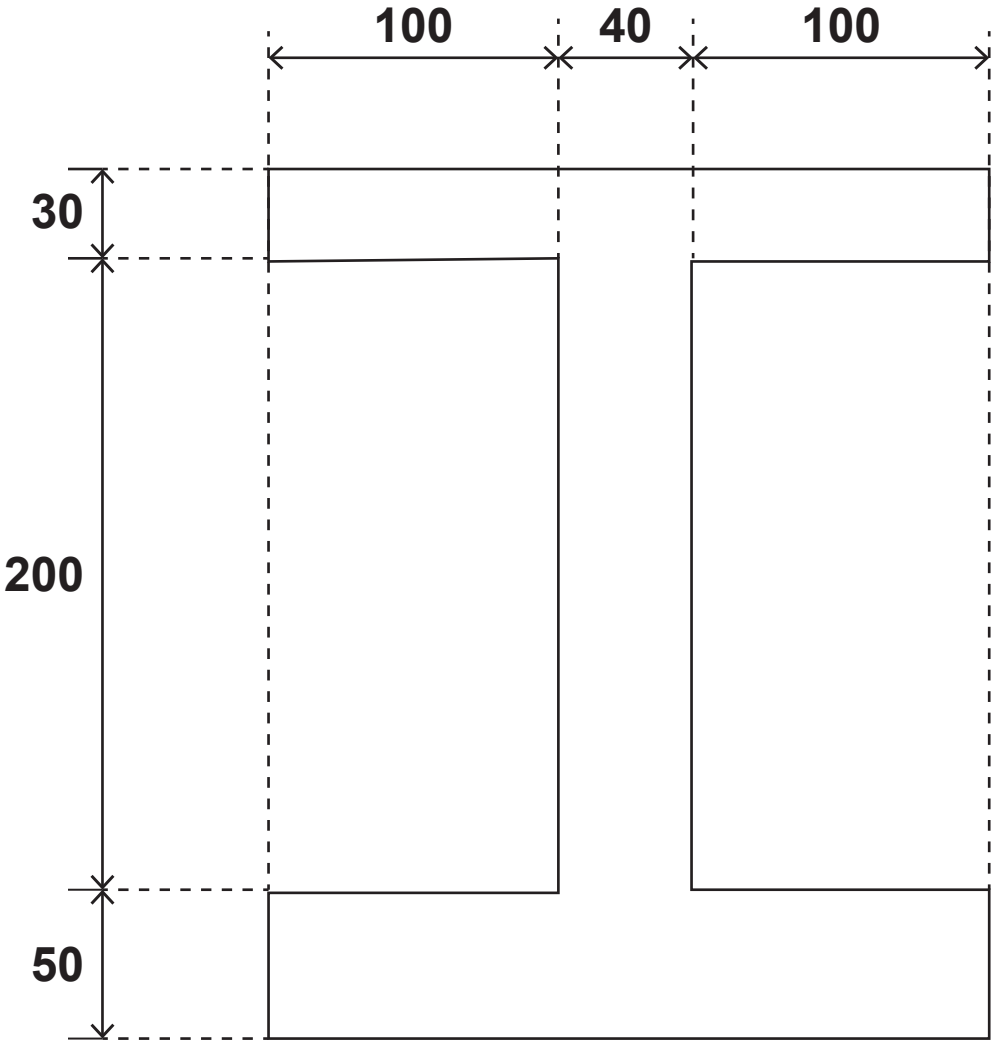
_____

_____

_____ [2]

(c) Fig. 6 shows the cross-section of a beam. All dimensions shown are in millimetres (mm).

Fig. 6



(i) Calculate the area of the beam's cross-section.

Give your answer in square metres (m^2).

_____

_____

_____

_____ [3]

(ii) The beam is 9 m long and made from steel with a density of 8000 kg m^{-3}.

Calculate the mass of the beam.

_____

_____

_____ [2]

(iii) A stress of 150 MPa in the beam is caused by a compressive force of *F* N.

Calculate the magnitude of *F*.

_____

_____

_____ [2]

4 **An aircraft with a mass of 80 000 kg flying in a straight path at a constant altitude is subjected to four principal forces as follows:**

a forward thrust force, F N, generated by the engine,

a backward aerodynamic drag force, D N,

an upward lift force, L N, provided by the wings,

a downward force, W N, due to the mass of the aircraft.

(i) Draw a diagram showing all forces acting on the aircraft. You can represent the aircraft as a box. [2]

(ii) Calculate the magnitude of the lift force, L, so that the aircraft remains at a constant altitude.

_____

_____ [2]

(iii) At a particular moment in time the aircraft is flying with a speed of 144 km h^{-1} and has a constant horizontal acceleration of 0.3 m s^{-2}.

Calculate the time it would take the aircraft to travel a further 2 kilometres.

_____

_____

_____

_____

_____

_____

_____

_____ [4]

(iv) When the aircraft is experiencing a constant drag force of 70 000 N, calculate the thrust force required to maintain a forward acceleration of 0.3 m s^{-2}.

_____

_____

_____

_____ [3]

(v) When the aircraft is flying with a speed of 144 km h^{-1} and the engine is producing the thrust force as calculated in part (iv), calculate the instantaneous power of the engine.

_____

_____ [1]

5 (a) State whether each of the following situations should be modelled as a point load or a Uniform Distributed Load (UDL).

Snow accumulated on a flat roof.

_____

Heavy tiles covering a floor.

_____

A pedestrian standing on a footbridge.

_____

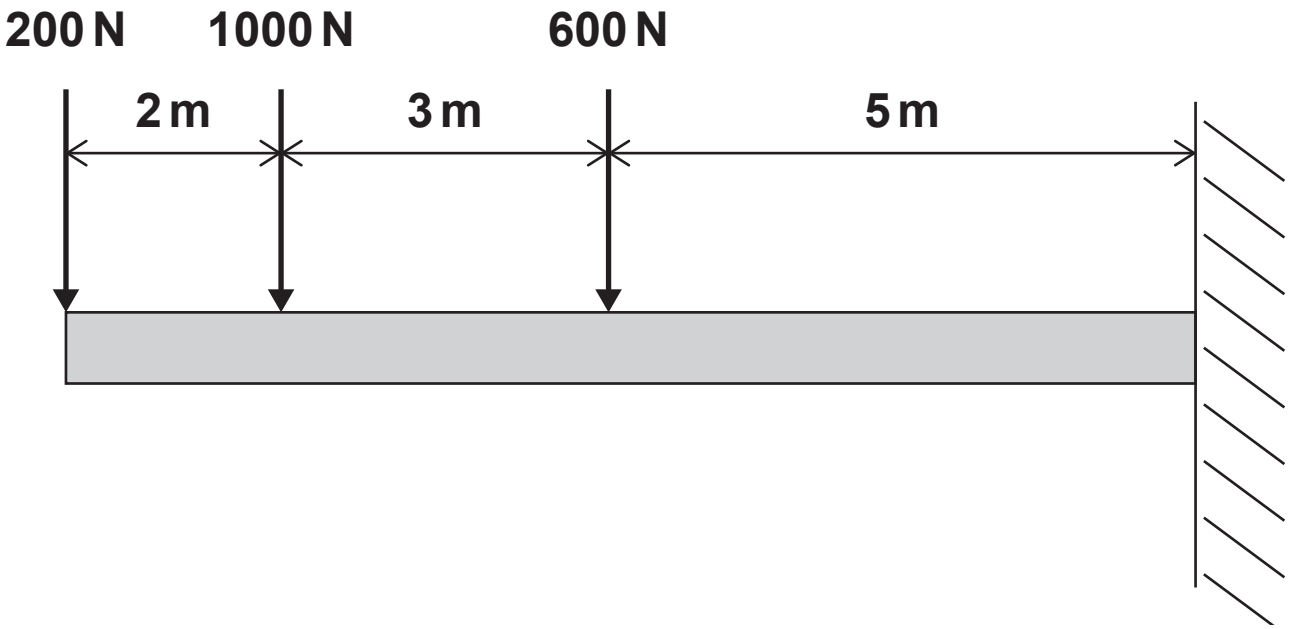
[1]

(b) Fig. 7 shows a beam with a length of 10 m securely attached to a wall at one end.

The weight of the beam is modelled by a force of 600 N acting vertically downward at a distance of 5 m from the wall.

A force of 200 N acts vertically downward at the free end of the beam while an additional force of 1000 N acts vertically downward at a point which is 8 m from the wall.

Fig. 7



(i) Name the type of beam.

_____ [1]

(ii) Calculate the vertical reaction at the wall.

_____ [1]

(iii) Calculate the bending moment at the wall.

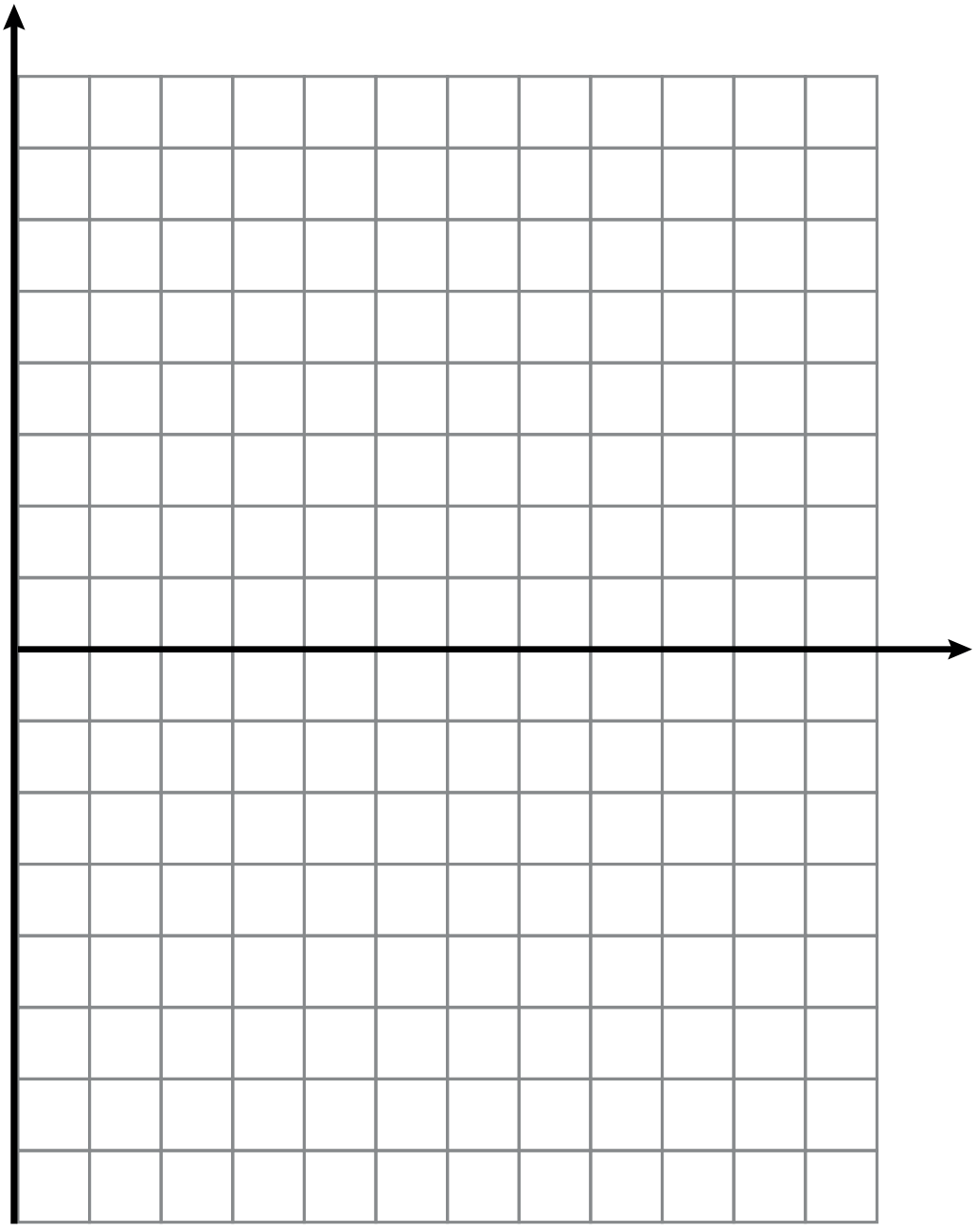
_____

_____

_____

_____ **[2]**

(iv) Draw a labelled bending moment diagram for the beam in Fig. 7 on the grid below. [4]



6 Two particles, A and B, are travelling directly towards each other and experience a collision.

Particle A has a mass of 1.5 kg and a speed of 4 m s^{-1}.

Particle B has a mass of 0.5 kg and a speed of 2 m s^{-1}.

After the collision, particle A continues in the same direction as before with a speed of 1 m s^{-1}.

(i) Assuming that momentum is conserved, calculate the speed and direction of particle B after the collision.

[4]

(ii) An elastic collision is one in which both momentum and kinetic energy are conserved.

Using your result from part (i) determine whether this is an elastic collision.

_____

_____

_____

_____

_____

_____ **[3]**

END OF QUESTION PAPER

ADDITIONAL ANSWER SPACE

If additional answer space is required, you should use the following lined pages. The question numbers must be clearly shown – for example, 1(b) or 6(i).

Version 5