OCR
Oxford Cambridge and RSA

Monday 19 May 2025 – Afternoon

Level 3 Cambridge Technical in Engineering

05822/05823/05824/05825/05873 Unit 3: Principles of mechanical engineering

Time allowed: 1 hour 30 minutes
C303/2506

C303/2506

You must have:
- the Formula Booklet for Level 3 Cambridge Technical in Engineering (inside this document)
- a ruler (cm/mm)
- a scientific calculator

05822-03

Please write clearly in black ink. **Do not write in the barcodes.**

Centre number | | | | | | Candidate number | | | | |

First name(s) _____

Last name _____

Date of birth | D | D | M | M | Y | Y | Y | Y |

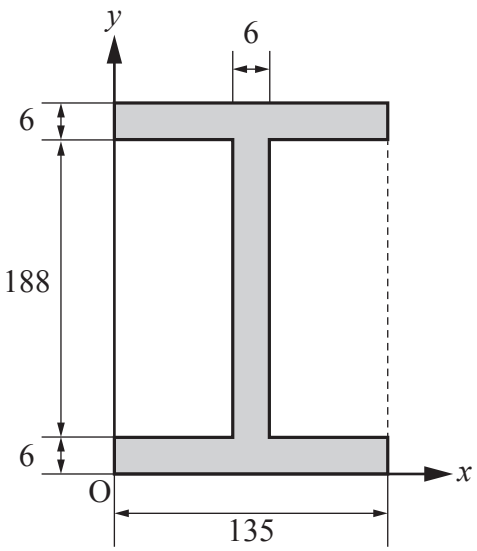
INSTRUCTIONS
- Use black ink. You can use an HB pencil, but only for graphs and diagrams.
- Write your answer to each question in the space provided. If you need extra space use the lined page at the end of this booklet. The question numbers must be clearly shown.
- Answer **all** the questions.
- Where 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 $g\,\mathrm{m\,s^{-2}}$. 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 **[ ]**.
- This document has **12** pages.

ADVICE
- Read each question carefully before you start your answer.

1 The cross-section of a symmetrical rigid steel joist (RSJ) is shown below aligned within a Cartesian coordinate system (x, y) with the origin at point O as indicated.

The units of all dimensions are millimetres.



(a)

(i) Write down the coordinates of the centroid of this cross-section.

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..... **[2]**

(ii) A steel joist with this cross-section has a length of 2000 mm.

Calculate the volume of the joist in mm^3.

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..... **[3]**

(iii) The joist has a mass of 43.14 kg.

Calculate the density of the steel in the joist. Give your answer in kg m^{-3}.

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..... **[2]**

(iv) The steel in the joist has a Young's modulus of 210 GPa.

Calculate the axial, compressive force required on the cross-sectional area of the joist that will cause its length to be reduced by 0.05 mm.

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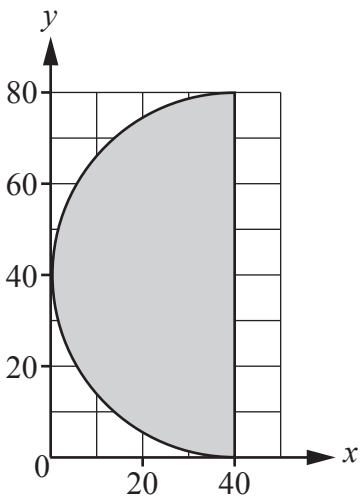
..... **[3]**

(b) A semicircular plate with a radius of 40 mm aligned with a Cartesian axis system (x, y) is shown below.



Calculate the coordinates of the centroid of the plate.

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..... **[2]**

2

(a) A class one lever with a mechanical advantage of 1.84 is used to lift a load of 290 N.

(i) Calculate the minimum effort required to lift the load.

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..... **[2]**

(ii) The distance between the fulcrum and the load is 1.4 m.

Calculate the distance between the position of the load and the position of the effort.

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..... **[2]**

(iii) Draw a labelled diagram of the lever showing the load, effort and fulcrum.

..... **[3]**

(b) Three gear systems are listed in the table below.

Put a tick (✓) in the boxes to indicate the correct properties of the listed systems.

Systems can have one of the properties, more than one of the properties or none of the properties.

	Properties		
	Axis of rotation changes 90°	**Converts rotational movement to linear movement**	**Direction of transmission can be reversed**
Bevel gear			
Rack and pinion			
Wormgear and wormwheel			

[3]

(c) Give **one** reason for placing an idler gear between two adjacent gears in a gear train.

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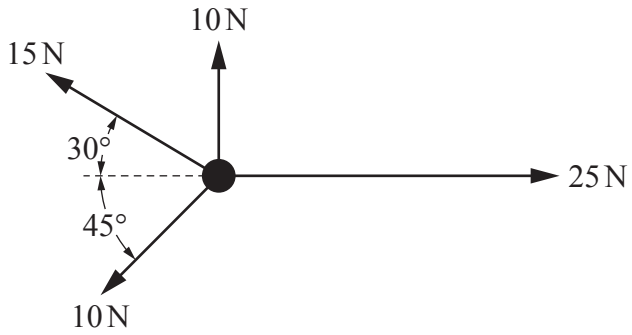
..... **[1]**

3 A particle lies on a smooth horizontal surface and is acted on by four coplanar forces as shown in the diagram.



(a) Calculate the magnitude of the resultant force.

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..... **[4]**

(b) The particle has a mass of 2.5 kg. Calculate the magnitude of the acceleration of the particle when acted upon by the four forces.

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..... **[2]**

(c) The particle accelerates from rest at the rate calculated in part **(b)**. Calculate the magnitude of the velocity of the particle after it has travelled a distance of 6 m.

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..... **[3]**

4

(a) The instantaneous power of a car travelling at $16\,m\,s^{-1}$ is 50 kW. Calculate the force exerted by the car at this time.

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..... **[2]**

(b) A toy rocket is launched vertically from ground level with an initial speed of $30\,m\,s^{-1}$. Assuming that the motion of the rocket is only affected by gravity after it is launched, calculate the maximum height that it reaches.

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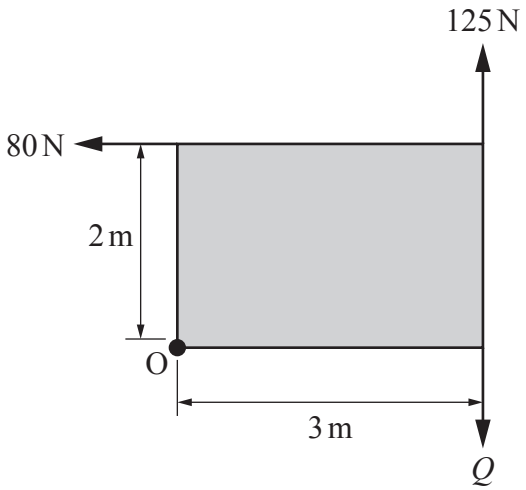
..... **[3]**

(c)



Three forces are applied to a uniform plate resting on a smooth, horizontal surface, as shown above. Calculate the magnitude of force Q so that there will be no turning moment about corner O.

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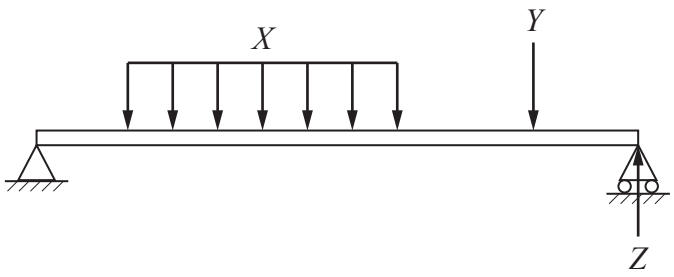
..... **[2]**

5

(a) A horizontal, simply supported beam is shown below.



(i) Name the types of load indicated on the diagram.

load *X* .....

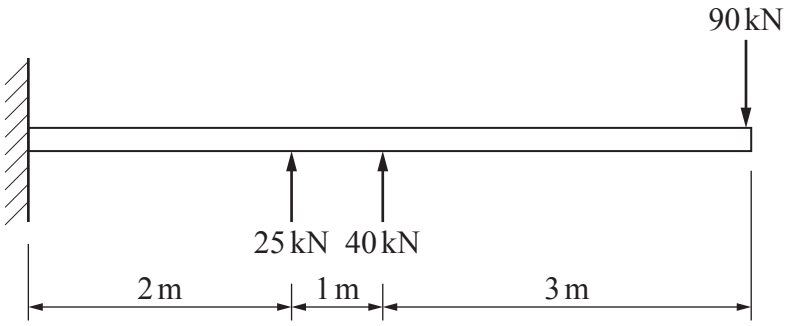
load *Y* .....

[2]

(ii) Name the type of force indicated by arrow *Z* on the diagram.

force *Z* ..... **[1]**

(b) A loaded, horizontal cantilever beam attached to a wall is shown below.



(i) Calculate the vertical reaction at the wall. The self weight of the beam can be ignored.

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..... **[2]**

(ii) Calculate the bending moment at the wall.

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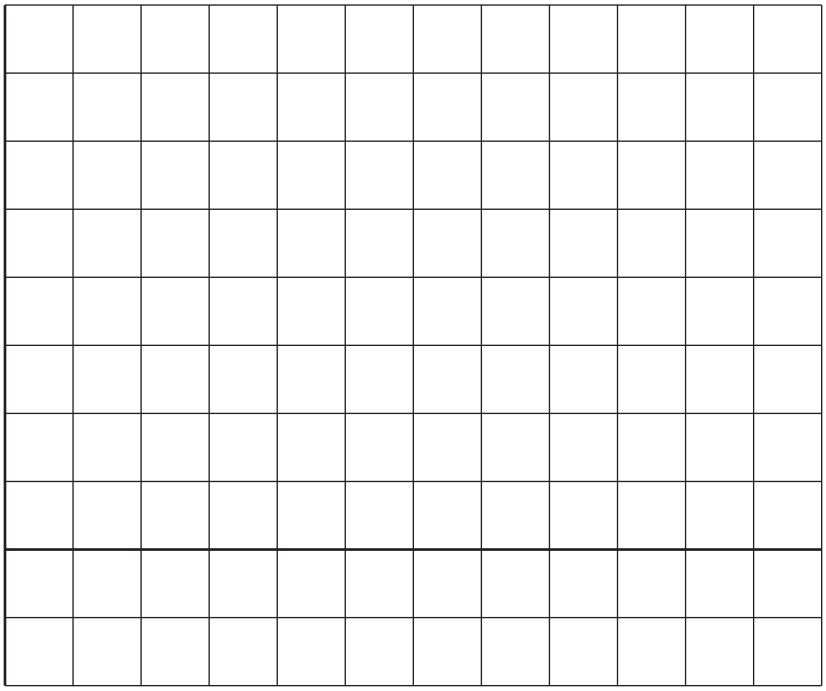
(iii) Draw a labelled bending moment diagram for the beam on the grid below.



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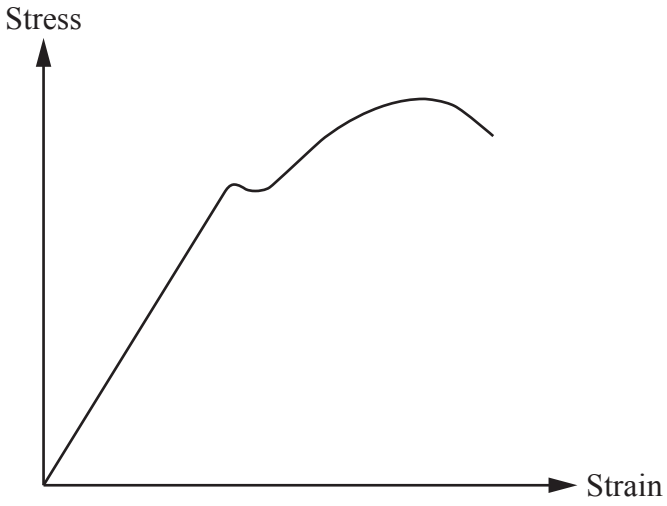
..... **[4]**

6

(a) A stress–strain graph of a metallic material is shown below.



(i) Indicate with an arrow on the graph the location of the elastic limit of the material. **[1]**

(ii) State what happens when the operational stress levels of the material exceed the elastic limit.

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..... **[1]**

(iii) The aluminium in a bar has an ultimate stress of $550\,N\,mm^{-2}$. The bar is used in a structure that has a safety factor of 1.75.

Calculate the allowable working stress of the structure.

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..... **[2]**

(b) The mass of a rollercoaster car is 8700 kg. The car is stationary on the top of a downward-sloping track at a height of 24 m above the ground.

(i) Calculate the gravitational potential energy of the car relative to ground level.

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..... **[2]**

(ii) The car then rolls down the slope until it reaches ground level. Neglecting frictional forces and assuming the conservation of energy, calculate the speed of the car when it reaches ground level.

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..... **[3]**

END OF QUESTION PAPER

EXTRA ANSWER SPACE

If you need extra space use this lined page. You must write the question numbers clearly in the margin.