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OXFORD CAMBRIDGE AND RSA EXAMINATIONS

Monday 6 June 2022 – Afternoon

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.

Answer ALL the questions.

1 (i) A standard concrete brick is a cuboid with dimensions 215 × 102.5 × 65 mm.

The density of concrete is 2100 $\mathrm{kg\,m^{-3}}$.

Calculate the mass of ONE concrete brick.

_____

_____

_____

_____

_____ **[4]**

(ii) The bricks are stacked on a pallet ready to be transported.

The coefficient of friction between a brick on the top layer and the layer below it is 0.4.

Calculate the maximum horizontal force allowable before a brick on the top layer can slide relative to the layer below it.

_____

_____

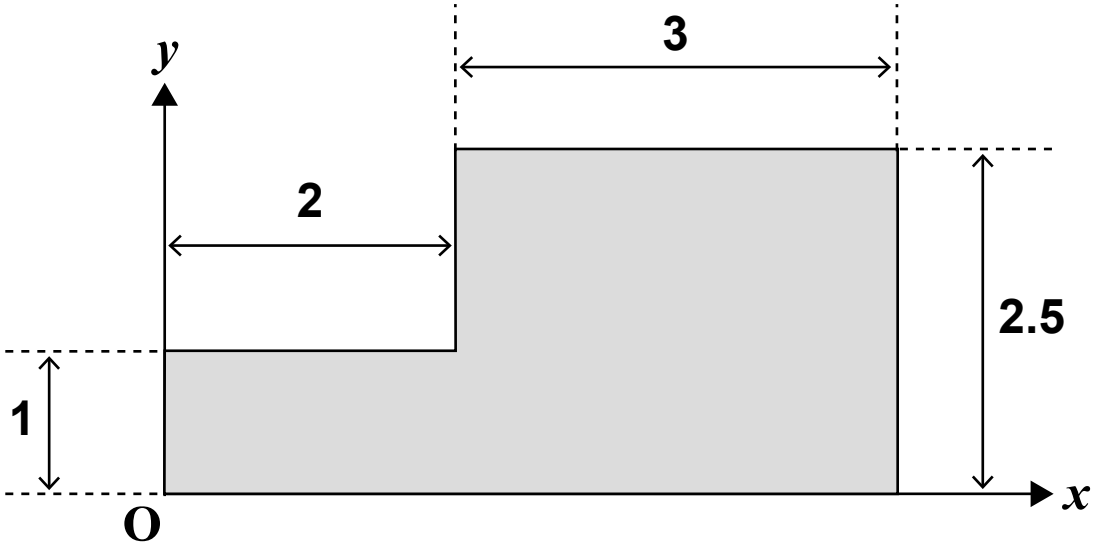
_____ **[2]**

(iii) A wall is built using the bricks.

FIG. 1 shows the side elevation view of the wall aligned within a coordinate system, (x, y), with the origin at point O.

All dimensions shown are in metres.

FIG. 1

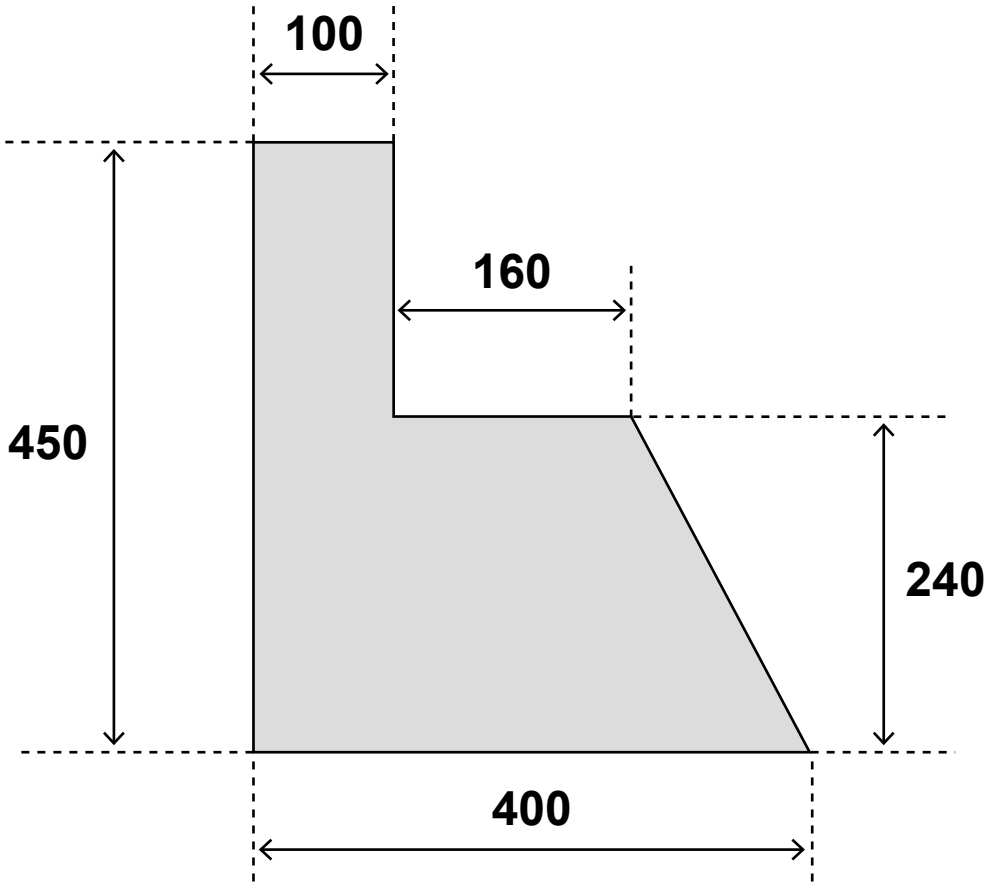


Calculate the x-coordinate and the y-coordinate of the centroid of the side elevation. [5]

2 (a) FIG. 2 shows a design of a base-plate.

All dimensions shown are in millimetres.

FIG. 2



(i) Calculate the area of this plate.

Give your answer in units of square millimetres.

_____

_____

_____

_____ [2]

(ii) Convert your answer from part (i) into units of square centimetres.

_____

_____ [1]

(b) An engineer is using a machine that applies an axial compressive force to a cylindrical titanium rod.

During testing the rod is subjected to a range of stress values within the elastic limit and a graph of stress against strain is produced.

The engineer calculates that the gradient of the graph remains constant with a value of 114 GPa.

(i) State what is represented by the gradient of this graph.

_____ [1]

(ii) Calculate the strain in the titanium rod when it is subjected to a stress of 600 MPa.

_____

_____

_____

_____ [2]

(iii) When the stress in the rod is 600 MPa, its diameter is measured as 12.2 mm.

Calculate the force that was applied by the machine.

State the units in your answer.

_____

_____

_____

_____

_____

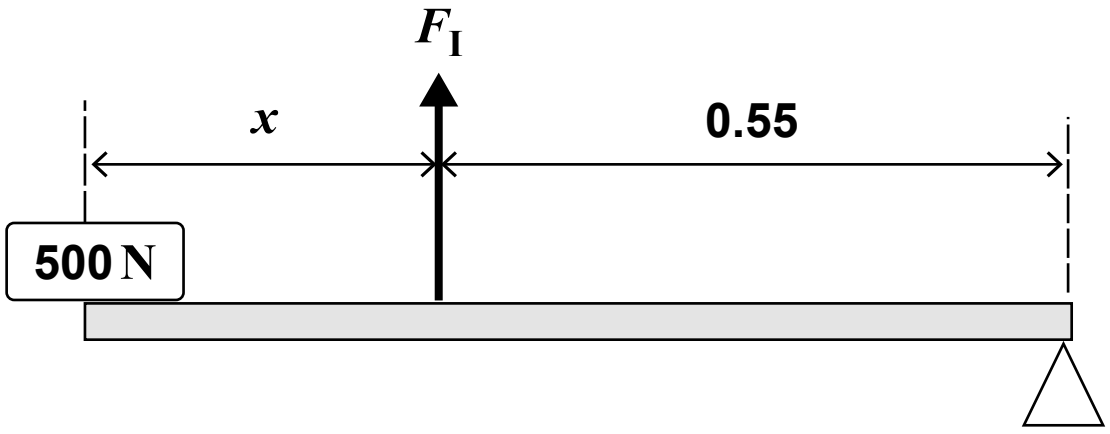
_____ [3]

3 (a) FIG. 3 shows a diagram of a lever used to lift a load of 500 N.

It has a Mechanical Advantage (MA) of 0.64.

The input force, F_I, is x m from the load and 0.55 m from the fulcrum.

FIG. 3



(i) State the class of lever shown.

_____ [1]

(ii) Calculate the minimum value of the input force required to lift the load.

_____

_____

_____ [2]

(iii) Calculate the distance x.

_____

_____

_____

_____ [2]

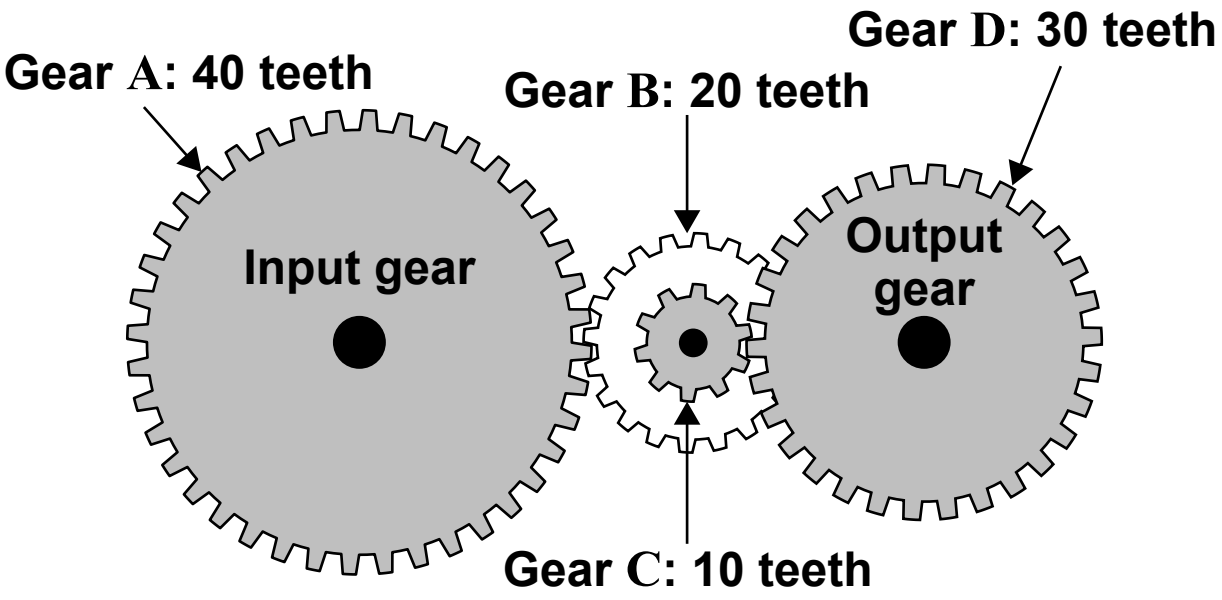
(b) A compound spur gear system is shown in FIG. 4.

Gear A is the input gear with 40 teeth and gear D is the output gear with 30 teeth.

Gear B has 20 teeth and rotates on the same shaft as gear C which has 10 teeth.

Gear A meshes with gear B and gear C meshes with gear D.

FIG. 4



(i) Calculate the overall Velocity Ratio (VR) of this system.

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_____

_____

_____

_____

_____ [3]

(ii) Calculate the Mechanical Advantage (MA) of this system.

_____

_____ [1]

(iii) A gear can be inserted into this system to cause the output gear to rotate in the opposite direction to the input gear while keeping the overall Velocity Ratio the same.

Name this type of gear.

_____ [1]

4 FIG. 5 shows a diagram of a trolley used to transport components around a factory.

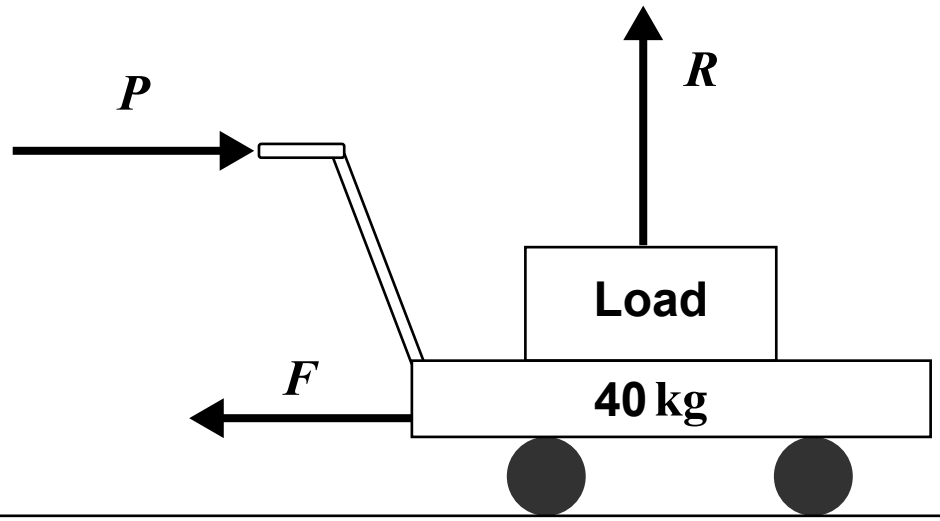
The trolley has a mass of 40 kg, while the mass of the load varies.

The total normal reaction force of the floor on the trolley is R N.

The trolley is being pushed with a horizontal force of P N.

There is also a resistance force, F N = 0.2 × R N acting in the opposite direction to P.

FIG. 5



(i) Calculate the value of the resistance force F on the trolley when it is carrying a load of 80 kg.

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_____

_____ [2]

(ii) Calculate the maximum load that the trolley can carry so that it will start to move when pushed with a force of 450 N.

_____

_____

_____

_____ [3]

The magnitude of P is changed such that the trolley now has a constant acceleration of $0.082\ \text{m s}^{-2}$.

The load is again 80 kg.

(iii) Calculate the magnitude of the pushing force P.

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_____ [3]

(iv) Assuming that the trolley starts from rest calculate the time it would take for it to reach a speed of $0.65\ \text{m s}^{-1}$.

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_____ [2]

(v) Calculate the work done by the person pushing the trolley during this period.

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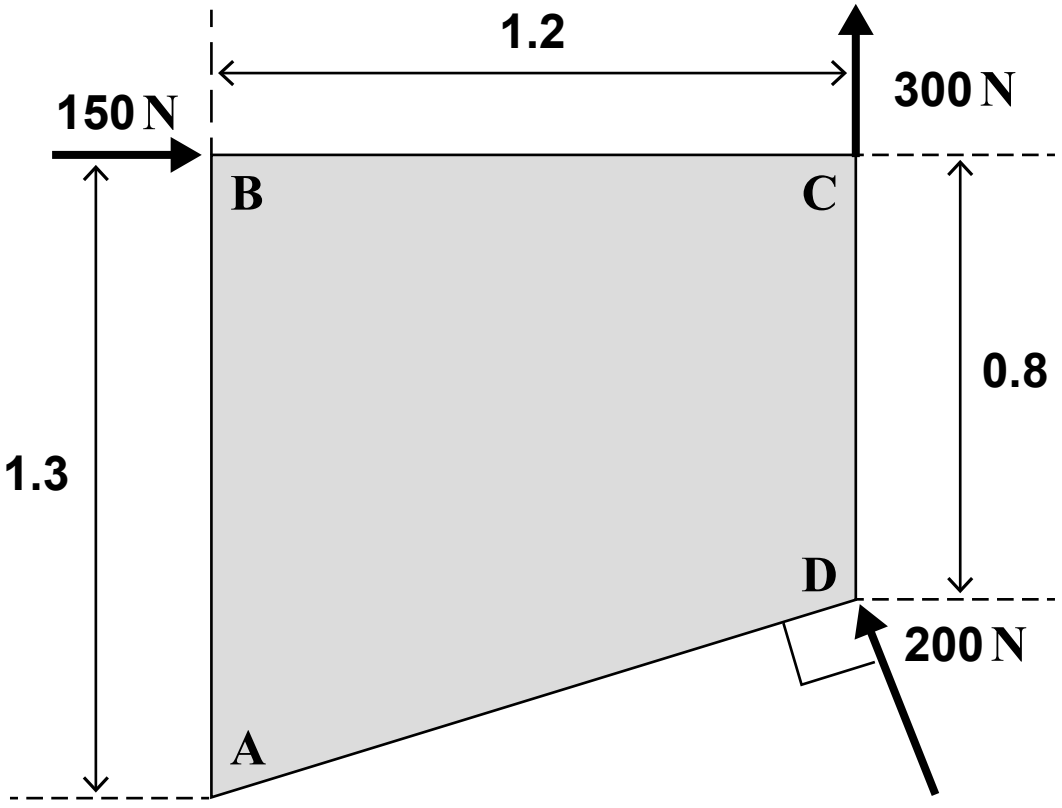
_____ [3]

5 FIG. 6 shows a rigid body with corners A, B, C and D that is subjected to three co-planar forces with magnitudes 150 N, 300 N and 200 N.

All dimensions shown are in metres.

FIG. 6



(i) Calculate the length of the side AD.

_____

_____

_____ [2]

(ii) Calculate the moment around corner A.

_____

_____

_____ [3]

(iii) Calculate the magnitude of the resultant force acting on the rigid body.

_____

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_____

_____

_____ [5]

6 (a) State the type of support that is found at each end of an encastre beam.

_____ [1]

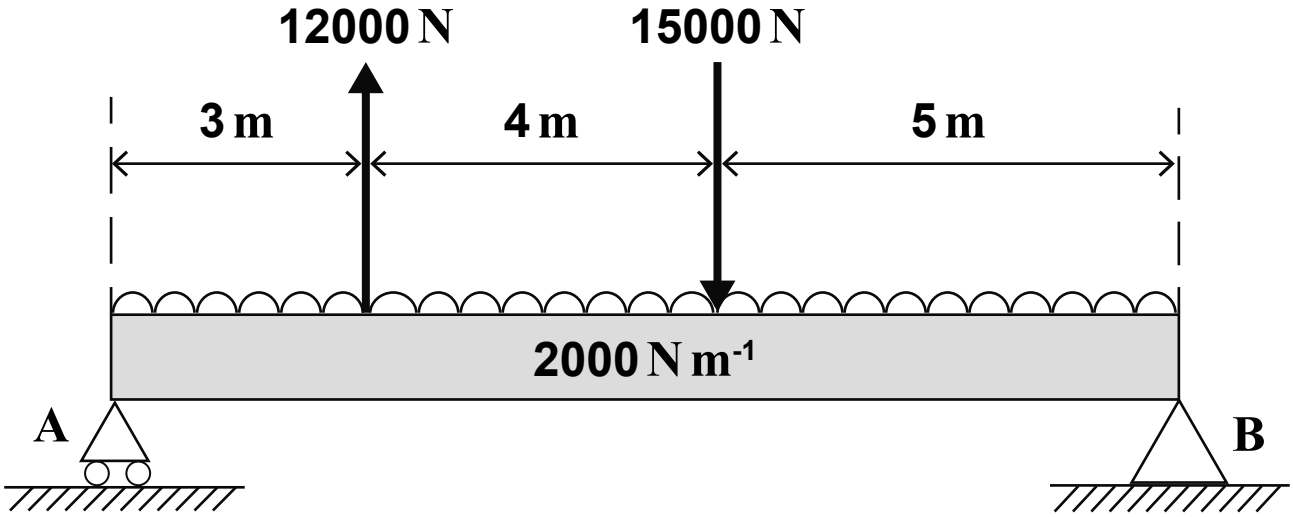
(b) For a simply-supported beam, name the type of support that can provide a vertical reaction force, no horizontal reaction force, and no moment.

_____ [1]

(c) FIG. 7 shows a simply-supported beam of length 12 m with supports A and B.

The beam is subjected to two vertical point loads with magnitudes 12000 N and 15000 N and a uniformly-distributed load of 2000 $\mathrm{N\,m^{-1}}$.

FIG. 7



Calculate the magnitude of the reaction forces at the supports A and B.

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_____

_____

_____

_____

_____

_____ **[5]**

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(i) or 2(a)(i).

Version 3