OCR
Oxford Cambridge and RSA

Tuesday 14 January 2025 – Morning

Level 3 Cambridge Technical in Engineering

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

Time allowed: 1 hour 30 minutes

C303/2501

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

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. You can use extra paper if you need to, but you must clearly show your candidate number, the centre number and the question numbers.
- 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.

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1

(a) The square cross-section of a mild steel tube is shown below.
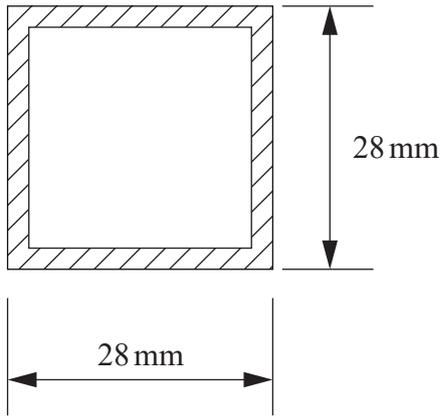
The thickness of the walls of the tube is 2 mm.

(i) Calculate the cross-sectional area of the mild steel in the tube.

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.... **[2]**

(ii) The length of the tube is 750 mm. The density of mild steel used is $7870 \, kg \, m^{-3}$.

Calculate the mass of the tube.

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.... **[3]**

(b) A solid mild steel bar of length 100 mm with a cross-sectional area of 175 mm^2 is subjected to an axial load of 1250 N.

(i) Calculate the stress in the bar.

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.... **[1]**

(ii) Young's modulus for the mild steel used is 210 GPa. The initial length of the bar is 100 mm.

Calculate the change in length of the bar caused by the load.

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.... **[3]**

2

(a) A chained gear system is shown below. The chain is in the position required to provide the highest velocity ratio for the system.

Input   Output

50 Teeth 34 Teeth Chain 28 Teeth 11 Teeth
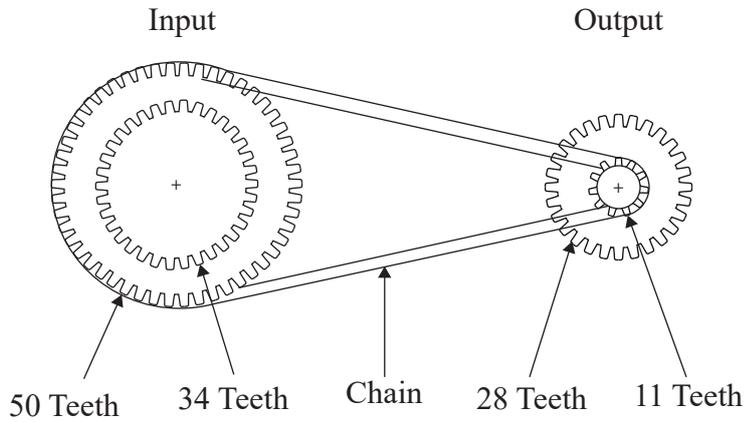
(i) Calculate the velocity ratio of the system shown.

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.... **[2]**

The chain is now repositioned so that the system provides the lowest velocity ratio. In this arrangement the input gear rotates at 80 rpm.

(ii) Calculate the speed of the output gear when the system has the lowest velocity ratio.

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.... **[2]**

(iii) Calculate the difference in the speed of the output gear between the lowest and highest velocity ratios.

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.... **[2]**

(b) A pair of end cutting pliers is shown in the diagram below.
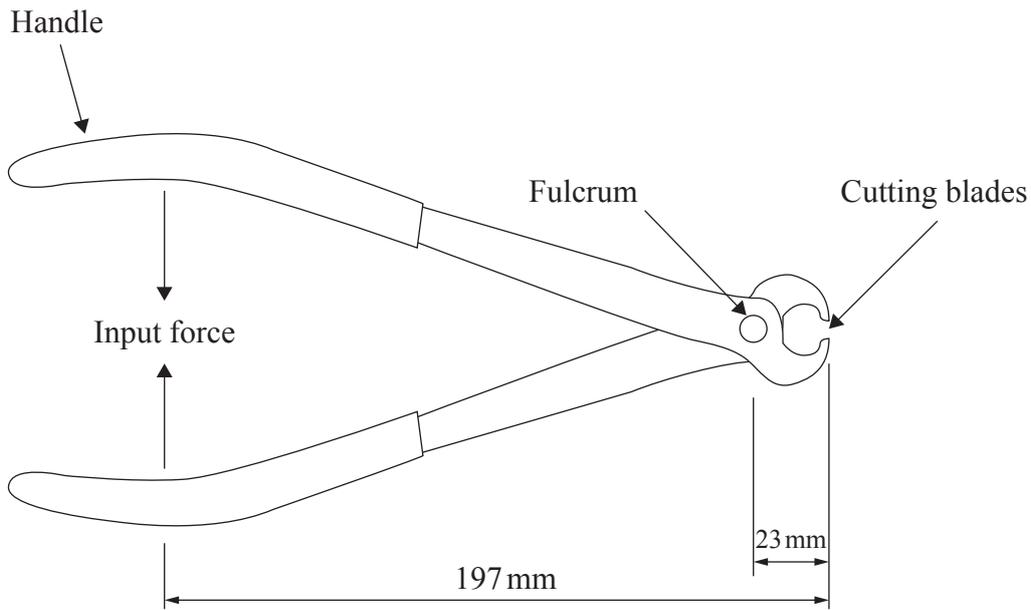
(i) The pliers are used to cut a piece of 1.5 mm diameter brass wire. Calculate the force required at the cutting blades to cut the wire if the maximum shear stress of brass is 270 N mm^{-2}.

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.... **[2]**

(ii) Calculate the total input force required on the handles to cut the wire.

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.... **[3]**

3 A cyclist is travelling along a road at a speed of 25.2 kilometres per hour. The cyclist and bike have a combined mass of 73 kg.

(a) Calculate the combined kinetic energy of the cyclist and bike.

Give your answer in SI units.

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.... **[4]**

(b) Whilst travelling at 25.2 kilometres per hour the cyclist stops pedalling but then continues to roll along an upward slope in the road with a constant incline of 7° to the horizontal.

Using the conservation of energy principle and neglecting any frictional forces, calculate the distance that the cyclist will roll along the slope before stopping.

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.... **[4]**

4 A box of mass 14.5 kg is being pulled along a horizontal surface by a rope which is parallel to the surface. The tension in the rope is 85 N and the coefficient of friction between the box and the horizontal surface is 0.4.

(a) Calculate the normal reaction force on the box.

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.... **[2]**

(b) Calculate the frictional force between the box and the horizontal surface.

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.... **[2]**

(c) Show all forces acting on the box on the diagram below.

[2]

(d) Calculate the acceleration of the box.

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.... **[2]**

5

(a) The diagram below shows a smoothly running pulley system subjected to two forces of 900 N and P N.

Calculate the magnitude of force P and the angle α when the combined resultant of both forces is 2700 N in a vertical, downward direction.

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magnitude of P ....

angle α ....

[6]

(b) The diagram below shows the surface of a semicircular plate with a radius of 60 mm aligned with a Cartesian coordinate system (x, y).
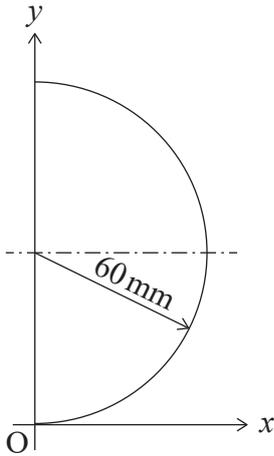
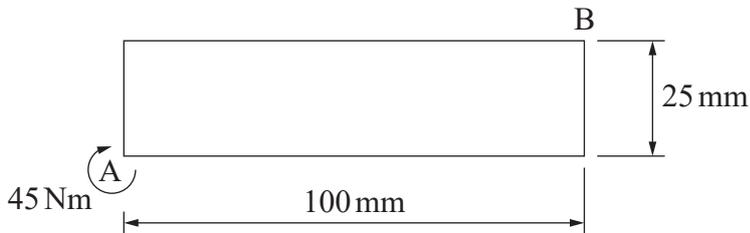Calculate the coordinates of the centroid of the plate.

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.... **[3]**

(c) The plate shown in the diagram below has been subjected to several non-concurrent forces that have a resultant clockwise moment of 45 N m about corner A.

Calculate the magnitude and direction (up or down) of a vertical force to be applied to corner B so that there is no moment about corner A.

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.... **[3]**

Turn over

6

(a) A simply supported beam of length 7 m shown below is subjected to a uniformly distributed load of $20\,\text{kN}\,\text{m}^{-1}$ and two point loads of 50 kN and 75 kN. The weight of the beam can be neglected.

50 kN　　　　　75 kN

20 kN/m

A　　　　　　　　　　　　　　　　　　　　　　B

4 m　　　　　　　1.5 m　　　1 m

7 m

Calculate the reactions at supports A and B.

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reaction at support A = ...

reaction at support B = ...

[5]

(b) The diagram below shows a cantilevered beam subjected to three forces.

Draw a bending moment diagram for the beam on the grid below. Label the axis with appropriate units and values. The weight of the beam can be neglected.

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.... **[7]**

END OF QUESTION PAPER

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