OCR
Oxford Cambridge and RSA

Tuesday 14 January 2020 – Morning

Level 3 Cambridge Technical in Engineering

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

Time allowed: 1 hour 30 minutes
C303/2001

C303_1_2001

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.

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 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.
- 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}. Use g = 9.8 unless the question says something different.

INFORMATION
- The total mark for this paper is **60**.
- The marks for each question are shown in brackets **[ ]**.
- This document has **16** pages.

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

FOR EXAMINER USE ONLY	
Question No	**Mark**
1	/10
2	/8
3	/11
4	/10
5	/12
6	/9
Total	**/60**

Answer **all** the questions.

1 Fig. 1 shows a steel plate aligned within a Cartesian coordinate system (x. y). Units for both x and y values are centimetres (cm).

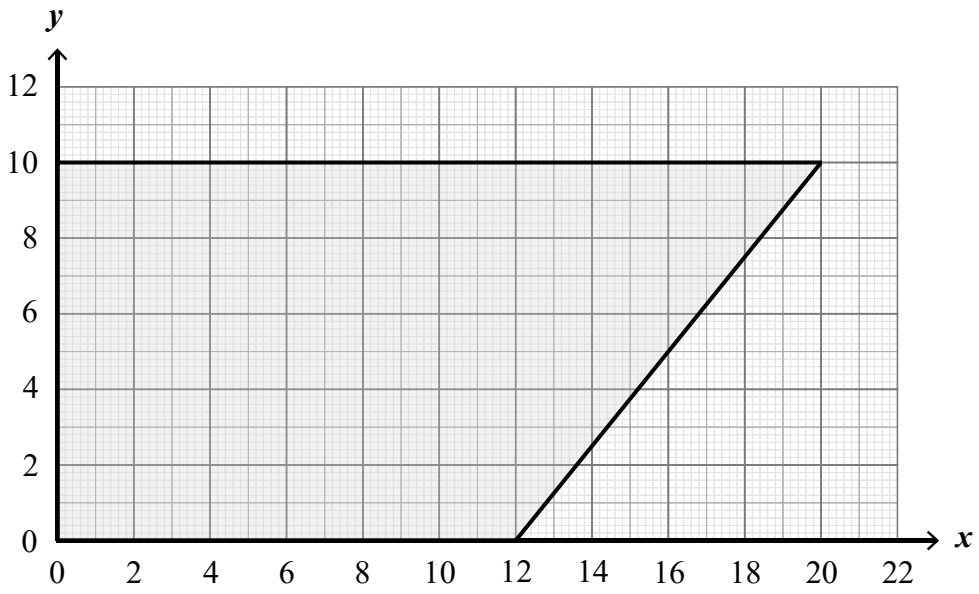

Fig. 1

(i) Calculate the area of the plate in square centimetres (cm^2).

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

(ii) The thickness of the plate is 0.5 cm and is made of steel with a density of 8 g cm^{-3}. Calculate the mass of the plate in kilograms (kg).

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

(iii) Calculate the coordinates of the centroid of the plate.

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..... **[5]**

2 **(a)** An aluminium rod has a Young's Modulus of 70 GPa.

Calculate the stress in the rod when it is subjected to a strain of 0.15%.

Give the units for your answer.

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

(b) A brass bolt of diameter 10 mm is subjected to a double shear force of 30 kN.

Calculate the shear stress in the bolt.

Give the units for your answer.

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

(c) Fig. 2 shows a typical stress-strain graph.

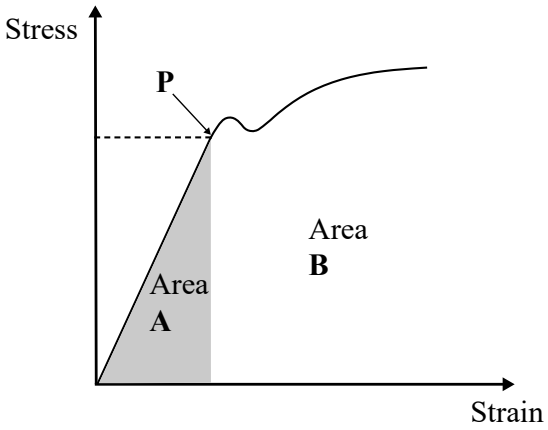

Fig. 2

State the names of the following.

(i) Point **P** on the graph.

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

(ii) The shaded area **A** under the graph.

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

(iii) The unshaded area **B** under the graph.

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

3 **(a)** Fig. 3 shows a diagram of a compound gear train. The input gear, **A**, has 40 teeth and the output gear, **D**, has 20 teeth. The compound gear consists of gears **B** and **C** which rotate together on the same shaft. Gear **B** has 30 teeth and gear **C** has 80 teeth.

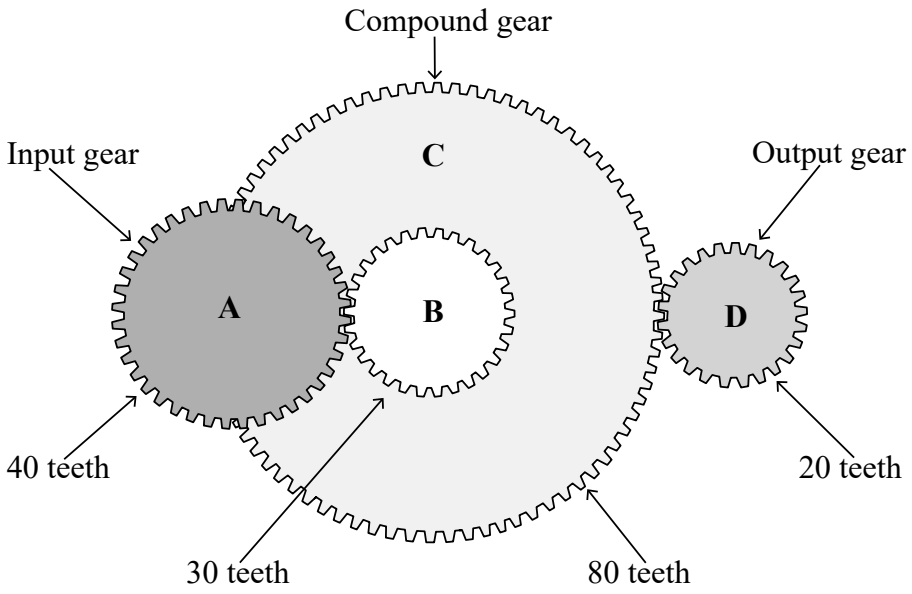

Fig. 3

(i) The input gear rotates at a speed of 90 rpm.

Calculate the rotational speed of the output gear.

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

(ii) Gear **A** is now replaced with a new gear, **E**.

Calculate the number of teeth required on gear **E** in order to achieve an overall Velocity Ratio (VR) of 6.

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

(b) State the special feature of an application involving gears that would require a bevel gear arrangement.

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

(c) A belt and pulley system has a Velocity Ratio (VR) of 1.4. The diameter of the output pulley is 80 cm.

Calculate the diameter of the input pulley.

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

(d) Give **one** practical example of a mechanism that uses a Class Three Lever.

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

(e) A Class Two Lever has a Mechanical Advantage (MA) of 2.05. The input force is 160 N.

(i) Calculate the maximum load that the lever can lift. Give your answer in Newtons.

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

(ii) The input force is applied at a distance of 1.2 m away from the fulcrum.
Calculate the distance between the load and the fulcrum.

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

4 **(a)** Fig. 4 shows a particle subjected to three forces.

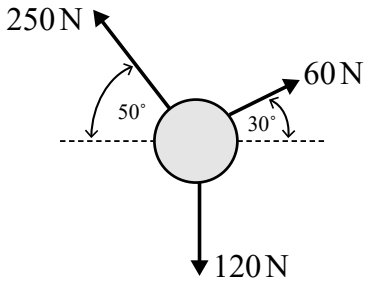

Fig. 4

(i) Calculate the magnitude of the resultant force acting on the particle.

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

(ii) Calculate the angle that the resultant force makes with the vertical.

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

(iii) At a particular time the particle is travelling with a speed of 1.2 m s^{-1}.

Calculate the instantaneous power of the resultant force at this time.

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

(b) A machine in a factory lifts a component with a mass of 4 kg through a height of 0.8 m from the floor to a bench. While moving the component the work done by the machine to overcome friction is 50 J.

Calculate the total work done by the machine to lift the component.

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

5 A box of components in a factory is required to slide down a sloping ramp which is 4 m long. The box starts from rest at the top of the slope and slides with constant acceleration. An engineer is considering appropriate values for the coefficient of friction in order to decide on the material to be used for the ramp.

(i) In order to prevent any breakages the maximum speed of the box at the bottom of the ramp must not exceed 0.8 m s^{-1}.

Calculate the maximum acceleration of the box in this case.

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

(ii) The ramp has a rough surface and has a constant angle of 10° to the horizontal. The box has a mass of 15 kg and is subjected to a constant frictional force of F N as it slides down the ramp.

Draw a diagram showing all forces acting on the box.

[2]

(iii) Assuming that the box travels with the constant acceleration as calculated in part **(i)** calculate the magnitude of the frictional force F.

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

(iv) Calculate the corresponding coefficient of friction, μ, between the box and the surface of the ramp.

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

(v) If the coefficient of friction, μ, is too high the box will remain stationary at the top of the slope.

Find the required range of values of μ so that the box will slide down the ramp but will not exceed the maximum speed of 0.8 m s^{-1}.

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

Turn over for the next question

6 **(a)** Name the type of beam with a fixed support at both ends.

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

(b) Fig. 5 shows a beam of length 8 m simply supported at each end with supports A and B. The beam is subjected to two downward forces of 20 000 N and 60 000 N at the positions shown. The self-weight of the beam is negligible.

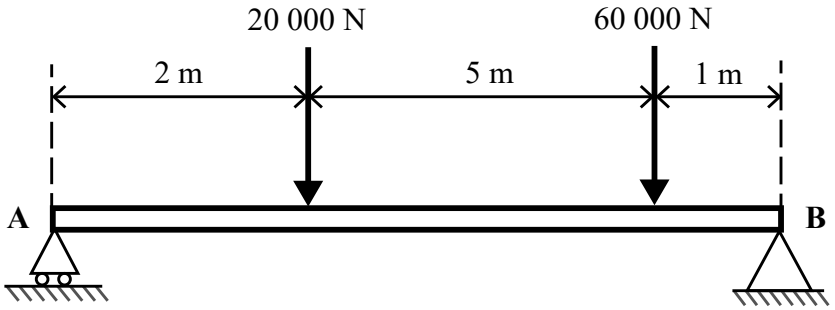

Fig. 5

(i) Calculate the vertical reaction forces at supports **A** and **B**.

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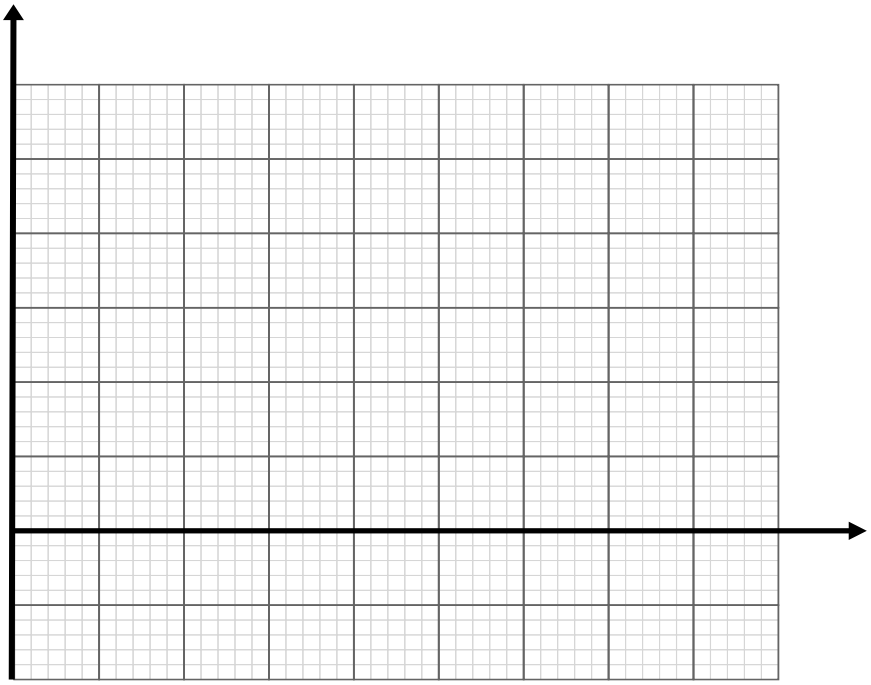
..... **[4]**

(ii) Draw a labelled bending moment diagram for the beam in Fig. 5 on the grid below.



[4]

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, 4(b) or 6(b)(ii).

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