Modified Enlarged 18 pt

OXFORD CAMBRIDGE AND RSA EXAMINATIONS

Monday 5 June 2023 – 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

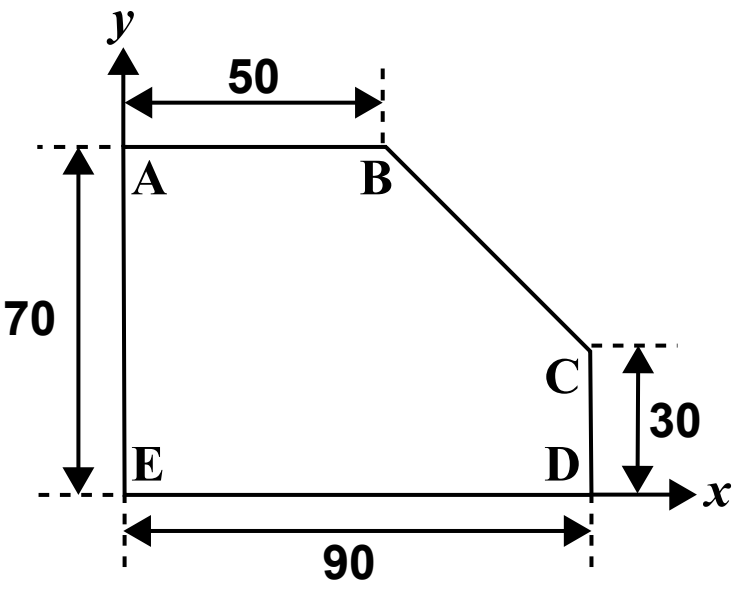
The total mark for this paper is 60.

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

ADVICE

Read each question carefully before you start your answer.

1 **The shape of a steel plate of uniform thickness is shown below. All dimensions are in millimetres.**



(i) **Calculate the cross-sectional area of this steel plate.**

_____

_____

_____

_____ **[2]**

(ii) The steel plate is aligned within a Cartesian coordinate system, (x, y), with the origin at corner E and with side ED along the x-axis.

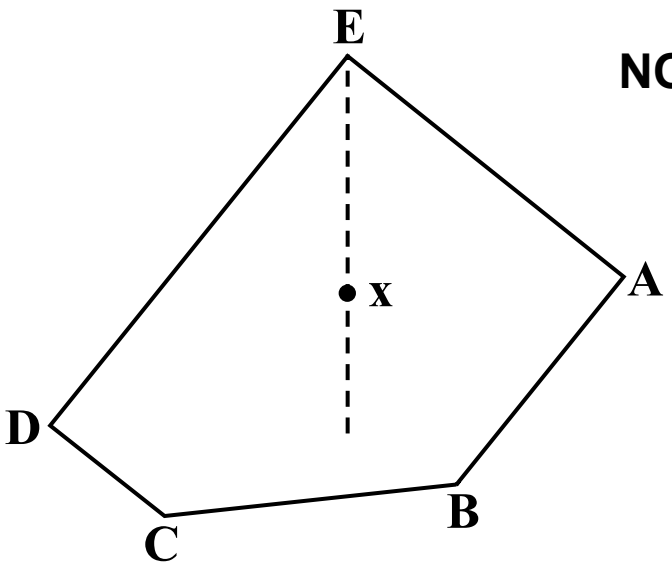
Calculate the coordinates of the centroid of the steel plate.

[5]

(iii) Explain what the centroid of the plate represents.

[1]

(iv) The plate is suspended from corner E.



NOT TO SCALE

In the diagram X represents the centroid.

Calculate the angle between side EA and the vertical.

_____

_____

_____

_____ **[2]**

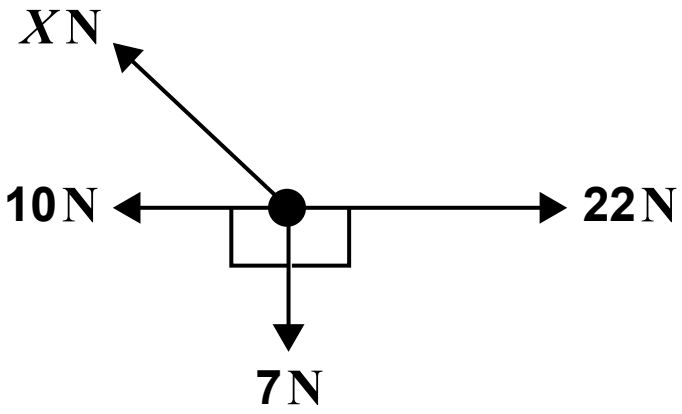
2 (a) Explain what CONCURRENT FORCES means.

_____

_____

_____ **[1]**

(b) Four co-planar forces are acting upon a body with magnitudes as shown.



Given the body is in equilibrium calculate the magnitude of force X.

_____

_____

_____

_____

_____

_____ **[3]**

(c) A structural column with a cross-sectional area of 5500 mm^2 is subjected to an axial compressive load of 2.5 kN.

(i) Calculate the stress in the column. Give the units for your answer.

[3]

(ii) The column is 3 m in length. Assuming Young's Modulus is 200 GPa calculate the change in length.

[4]

3 (a) **Identify TWO types of gear mechanisms that will allow the transfer of rotational motion between two adjacent shafts that are not in parallel alignment.**

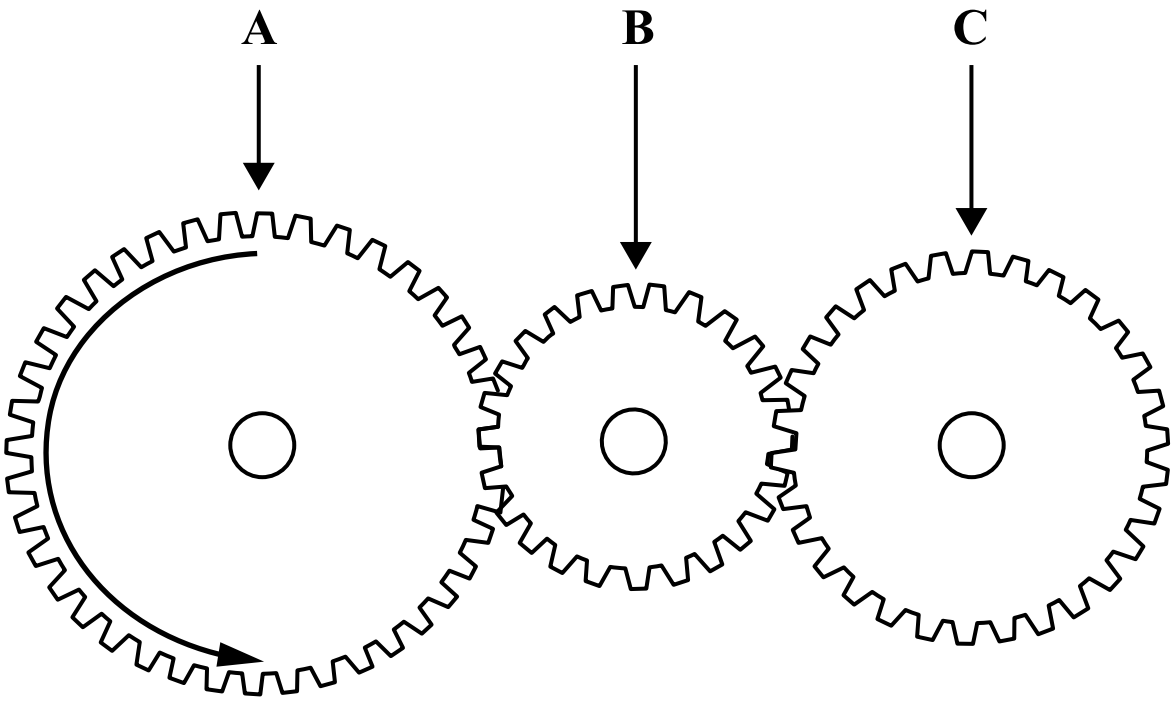
1 _____

2 _____

[2]

(b) **A gear train consisting of three gears, A, B, and C is shown below.**

Gear A is the input gear.



(i) Within a gear train it is often useful to associate each gear with a term that indicates its function or use.

Choose an appropriate term from the list below for gears **B** and **C**.

Compound gear	Driver gear
Idler gear	Output gear
Transition gear	

Gear **B** _____

Gear **C** _____

[2]

(ii) If gear **A** has 25 teeth, gear **B** 12 teeth and gear **C** 20 teeth, calculate the total velocity ratio of the gear train.

_____

_____

_____

_____ **[2]**

(iii) Give TWO reasons why an idler gear may be used within a gear train.

1 _____

_____

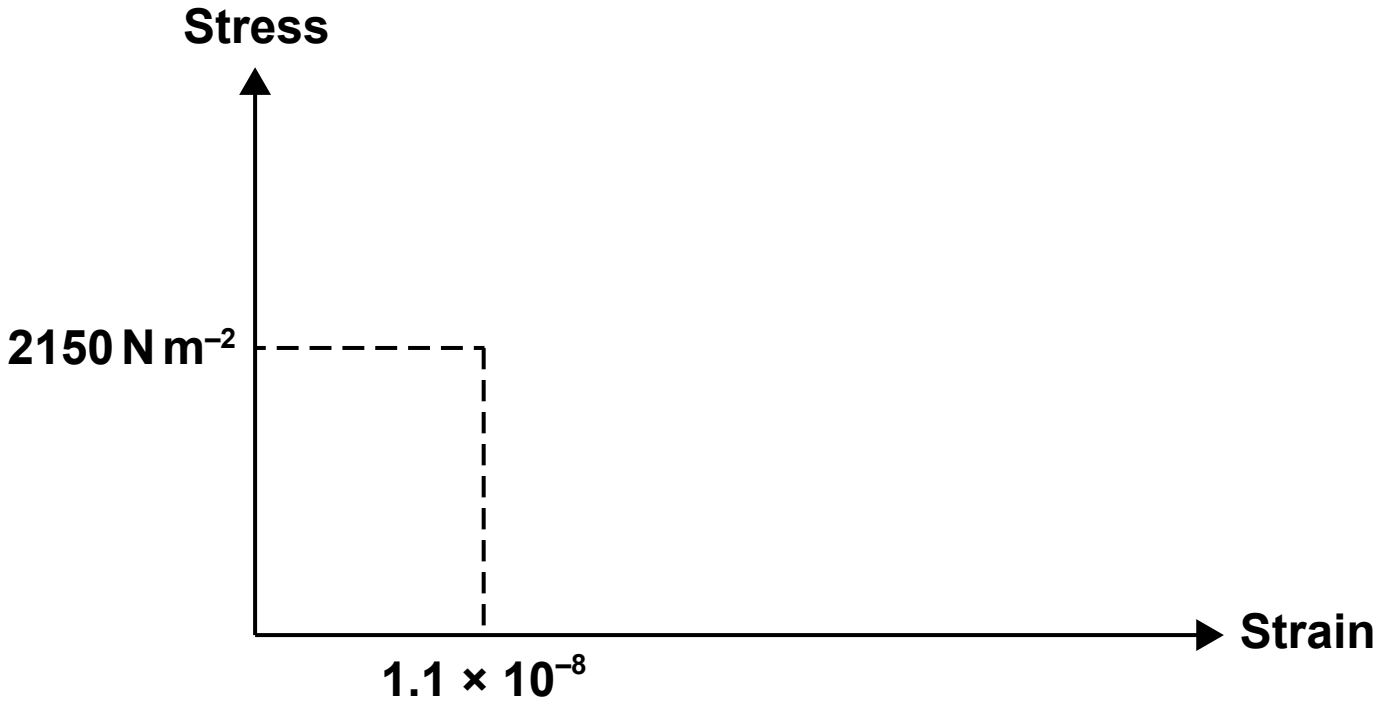
2 _____

_____

[2]

4 (a) (i) Sketch a typical stress–strain graph for a metallic material on the axes shown in FIG. 1. The values on the axes indicate the limits of the region where the Young's modulus remains constant (so Hooke's law applies). [2]

FIG. 1



(ii) **The table below lists the values for Young's modulus of four common metals.**

Metal	Young's Modulus
Aluminium	$70 \times 10^9\ N\,m^{-2}$
Steel	$200 \times 10^9\ N\,m^{-2}$
Copper	$110 \times 10^9\ N\,m^{-2}$
Cast Iron	$120 \times 10^9\ N\,m^{-2}$

Using this table determine the most likely type of metal associated with the values indicated on the axes shown in FIG. 1.

Justify your answer.

_____

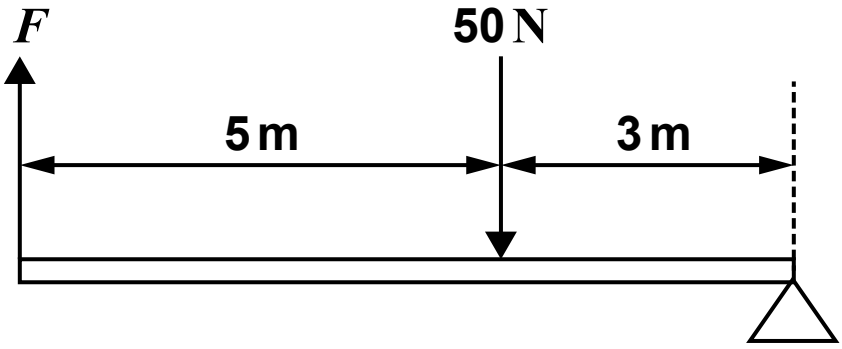
_____

_____

_____ **[2]**

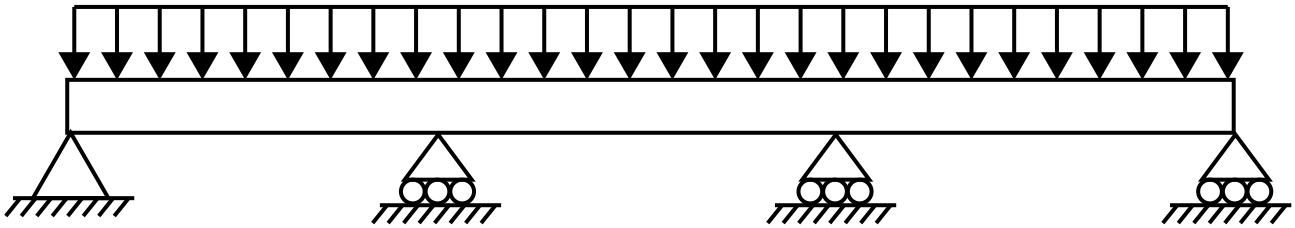
(b) Calculate the minimum force F, required to lift the load of 50 N shown on this lever.

Assume that the weight of the lever is negligible.



[3]

5 (a) A Uniform Distributed Load (UDL) is shown on a supported beam.



(i) State the name of this type of supported beam.

_____ **[1]**

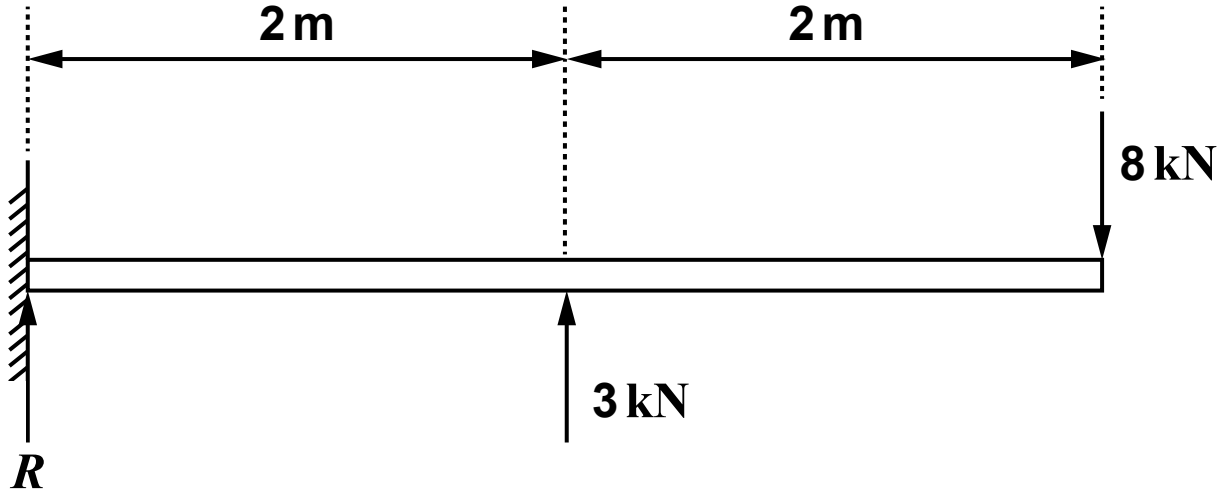
(ii) Give an example of what the UDL could represent.

_____ **[1]**

(b) FIG. 2 shows a cantilever beam attached to a wall.

The beam is subjected to two vertical forces of 3 kN and 8 kN.

FIG. 2



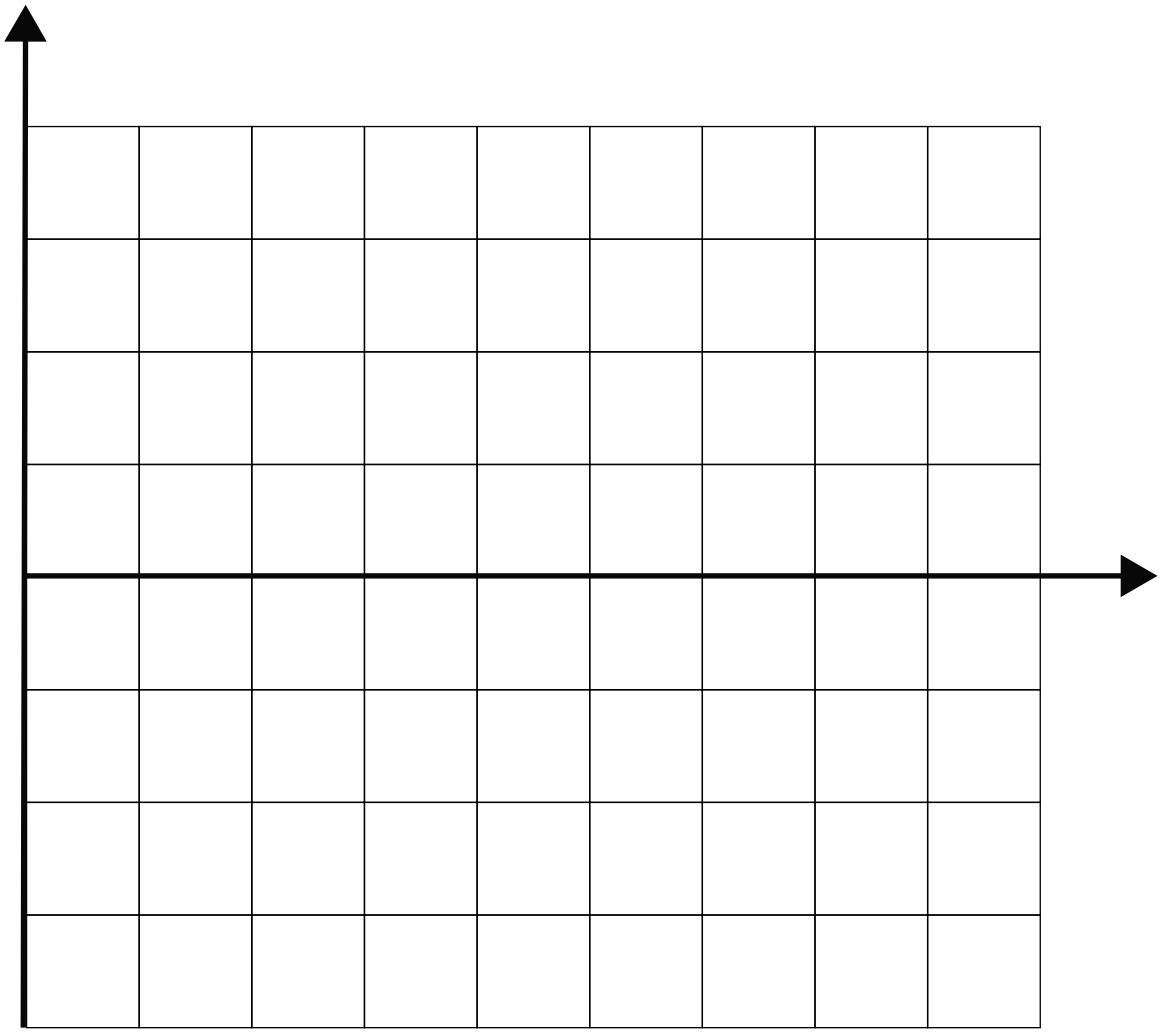
(i) Calculate the magnitude of the vertical reaction force, R, at the wall.

_____

_____

_____ [2]

(ii) Draw a labelled bending moment diagram on the grid below for the cantilever beam shown in FIG. 2. [5]



6 (a) Two vehicles, A and B, are travelling in the same direction. Vehicle A is directly behind vehicle B. Vehicle A has a mass of 2600 kg and a speed of 15.6 m s^{-1}. Vehicle B has a mass of 1600 kg and a speed of 13 m s^{-1}.

Vehicle A then collides into the back of vehicle B. Immediately after the collision both vehicles continue to travel in the same direction but the speed of vehicle A has reduced to 9.4 m s^{-1}.

(i) Assuming that total momentum is conserved calculate the speed of vehicle B immediately after the collision.

_____

_____

_____

_____

_____ [3]

Immediately after the collision both vehicles slow down with a constant deceleration of $4\,m\,s^{-2}$ until they come to rest.

(ii) Calculate the distance travelled by vehicle A after the collision to when it comes to rest.

_____

_____

_____

_____ [3]

(iii) Calculate the magnitude of the braking force experienced by vehicle A while it is decelerating.

_____

_____

_____

_____ [2]

(iv) Calculate the total work done by vehicle A while it is decelerating.

_____

_____

_____

_____ [2]

(b) A crane lifts a load with a mass of 150 kN to a height of 8.4 m above the ground. The cable holding the load then breaks and the load falls to the ground.

Air resistance can be neglected.

(i) Calculate the kinetic energy in the load when it reaches the ground.

_____

_____

_____

_____ **[2]**

(ii) Calculate the time it takes for the load to reach the ground.

_____

_____

_____

_____

_____

_____ **[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, 2(a) or 4(b).

Version 3