OCR
Oxford Cambridge and RSA

# Tuesday 21 May 2024 – Morning

## Level 3 Cambridge Technical in Engineering

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

**Time allowed: 1 hour 30 minutes**
**C303/2406**

C303-2406

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

0 5 8 2 2 – 0 3

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 |

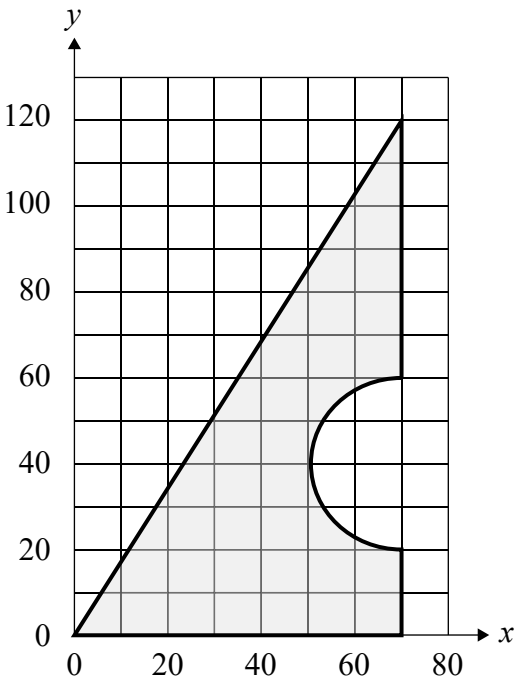
**INSTRUCTIONS**
- Use black ink. You can use an HB pencil, but only for graphs and diagrams.
- Write your answer to each question in the space provided. If you need extra space use the lined pages at the end of this booklet. The question numbers must be clearly shown.
- Answer **all** the questions.
- 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 **[ ]**.
- This document has **16** pages.

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

**1**

**(a)** The shaded area in the diagram below shows a triangular aluminium plate with a semi-circular cutaway section. The plate is aligned within a Cartesian coordinate system, $(x, y)$. Both $x$ and $y$ are measured in units of millimetres.




**(i)** Calculate the area of the plate.

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

**(ii)** Calculate the coordinates of the centroid of the plate.

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..... **[7]**

**2**

**(a)** Complete the paragraph below.

Choose words from the following list. The words can be used once, more than once or not at all.

**flat-toothed** **linear** **oscillating** **rotational** **spur** **worm**

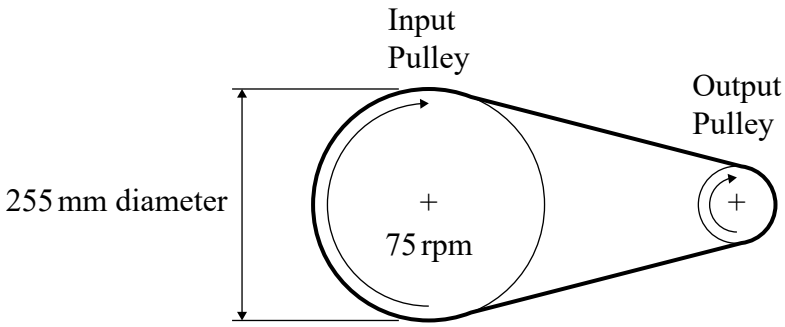
A rack and pinion gear system consists of a ..... gear known as the pinion and a ..... component known as the rack. It is used to convert ..... motion to ..... motion.

**[4]**

**(b)** State a suitable example of where a chained sprocket system could be used.

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

**(c)** The diagram below shows a belt and pulley system in which the input pulley has a diameter of 255 mm and rotates at 75 rpm.




Calculate the diameter of the output pulley if it is to rotate at 225 rpm.

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

**(d)** Give **two** advantages and **one** disadvantage of using a belt and pulley system in preference to a simple gear system.

Advantage 1: .....

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Advantage 2: .....

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Disadvantage: .....

.....

**[3]**

**Turn over for the next question**

**3**

**(a)** A piece of steel measuring 200 mm × 100 mm × 2 mm is to be cut into two pieces each measuring 100 mm × 100 mm × 2 mm using a guillotine. Assuming the steel has a shear stress of 250 N mm$^{-2}$ calculate the force required to shear the steel plate.

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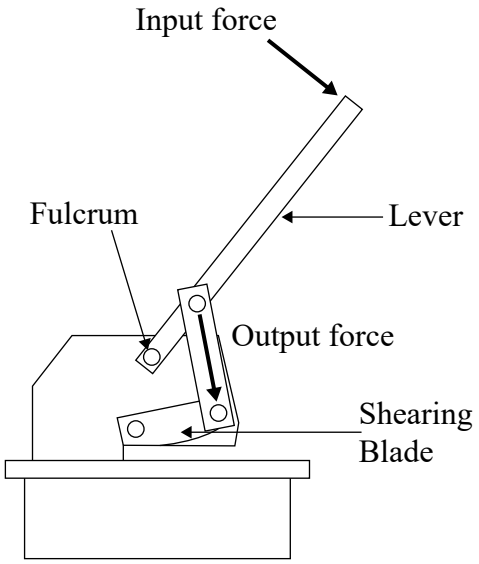
..... **[3]**

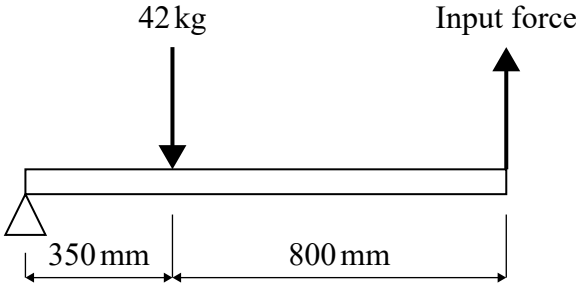
**(b)** The diagram below shows a guillotine containing a lever.

State the class of this lever.




Class: ..... **[1]**

**(c)** A wheelbarrow holding a mass of 42 kg is represented by the lever diagram shown below.




**(i)** Calculate the mechanical advantage of the lever.

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

**(ii)** Calculate the minimum input force required to lift the 42 kg mass.

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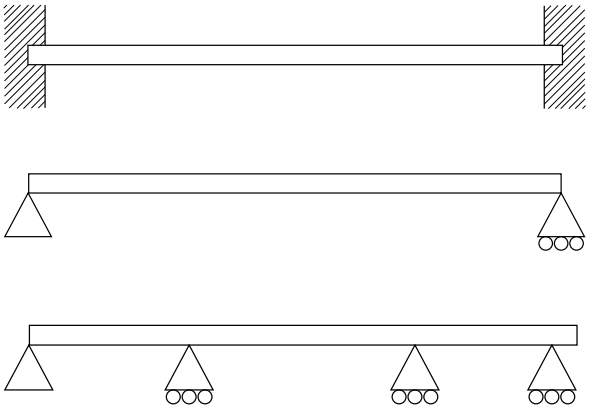
..... **[2]**

**4**

**(a)** State the type of beam shown in each of the following diagrams.



Beam type

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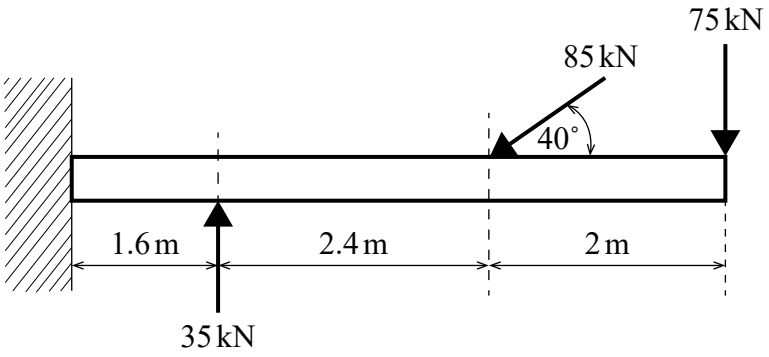
**[3]**

**(b)** A cantilever beam is subjected to three forces of 35 kN, 85 kN and 75 kN at positions and in directions as shown in the diagram below. For this question the self weight of the beam need not be considered.




**(i)** Calculate the vertical component of the 85 kN force.

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

**(ii)** Calculate the magnitude of the vertical reaction force at the support.

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

**(iii)** Calculate the moment at the support.

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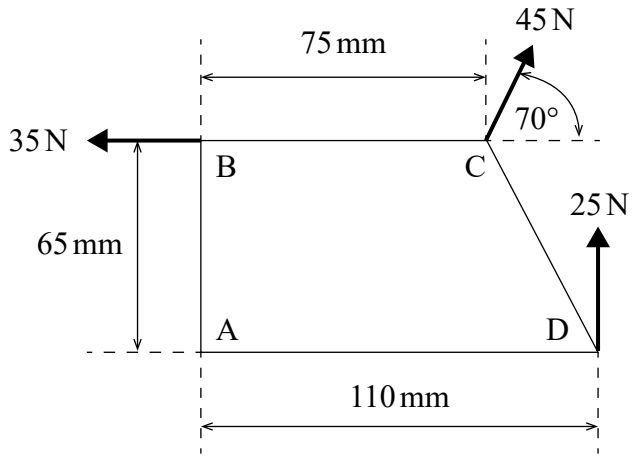
..... **[2]**

**Turn over for the next question**

**5** A steel plate ABCD, aligned in a vertical plane, is subjected to three forces of 35 N, 45 N and 25 N which act at positions and in directions as shown in the diagram below.




**(a)** Calculate the magnitude and direction, relative to the horizontal, of the resultant of the three forces shown in the diagram. Illustrate your answer in a diagram immediately after your calculations.

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**[5]**

**(b)** Calculate the moment about corner A. Give the units in your answer.

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

**(c)** An additional force of 85 N is added to the plate so that it acts vertically downwards on side AD.

Calculate the distance between this force and point A so that the total moment about point A becomes zero.

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

**6**

**(a)** A car with a mass of 1600 kg is travelling at a speed of 90 kilometres per hour.

**(i)** Calculate the kinetic energy of the car. Give your answer in Joules.

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

**(ii)** While travelling at this speed the driver disengages the engine and applies the brakes.

Calculate the total braking force, $F$, required to stop the car in a distance of 50 m on a horizontal road assuming a constant deceleration.

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

**(iii)** As soon as the brakes are applied the wheels are locked and stop rotating. This causes the car to slide along the road.

Assuming that the total braking force is solely due to the friction between the tyres and the road surface, draw a diagram showing **all** the forces acting between the road surface and the tyres while the car is decelerating.

Indicate the car's direction of travel in your diagram.

You may represent the car and all of its wheels as a single point mass.

**[2]**

**(iv)** Using the braking force calculated in part **(ii)** calculate the coefficient of friction, $\mu$, between the tyres of the car and the road surface.

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

**(v)** Calculate the constant rate of deceleration from the moment the brakes are engaged until the car stops.

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

**(b)** A lorry with a mass of 3500 kg travelling at 15 m s$^{-1}$ collides 'head-on' with a van of mass 1500 kg travelling in the opposite direction with a speed of 20 m s$^{-1}$.

Immediately after the collision the lorry continues to travel in the same direction with a speed of 3 m s$^{-1}$ while the van is forced backwards.

Assuming that total momentum is conserved, calculate the speed of the van immediately after the collision.

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

**END OF QUESTION PAPER**

## EXTRA ANSWER SPACE

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

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