OCR
Oxford Cambridge and RSA

Monday 20 May 2019 – Morning

LEVEL 3 CAMBRIDGE TECHNICAL IN ENGINEERING

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

Time allowed: 1 hour 30 minutes
C303/1906

C303_1906

You must have:
- the formula booklet for Level 3 Cambridge Technical in Engineering (inserted)
- 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 may use an HB pencil for graphs and diagrams.
- Answer **all** the questions.
- Write your answer to each question in the space provided. Additional paper may be used if required but you must clearly show your candidate number, centre number and question number(s).
- The acceleration due to gravity is denoted by g m s^{-2}. Unless otherwise instructed, when a numerical value is needed, use g = 9.8.

INFORMATION
- The total mark for this paper is **60**.
- The marks for each question are shown in brackets **[ ]**.
- Where appropriate, your answers should be supported with working. Marks may be given for a correct method even if the answer is incorrect.
- An answer may receive no marks unless you show sufficient detail of the working to indicate that a correct method is being used.
- Final answers should be given to a degree of accuracy appropriate to the context.
- This document consists of **12** pages.

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

Answer **all** the questions

1 A rigid, rectangular plate, ABCD, with a length of 1.3 m and a width of 0.6 m is acted upon by three co-planar forces with magnitudes of 500 N, 700 N and 400 N as shown in Fig.1.

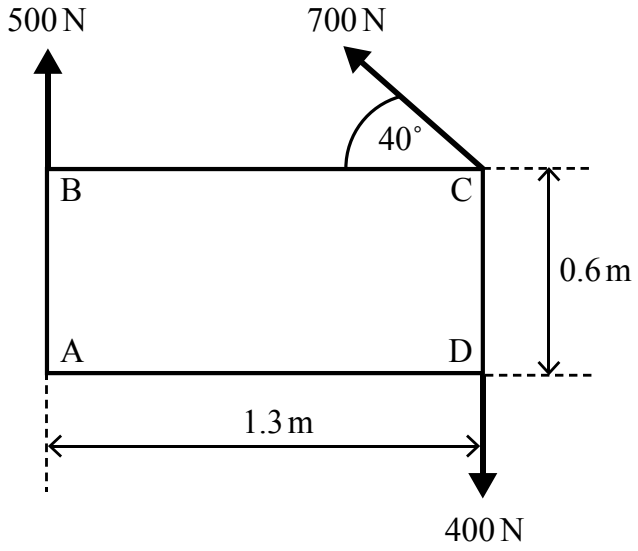

Fig. 1

(i) Resolve the force of 700 N into horizontal and vertical components.

Horizontal component ..... **[1]**

Vertical component ..... **[1]**

(ii) Calculate the magnitude of the resultant of the three forces acting on the plate.

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

(iii) Calculate the moment about corner A due to the three forces.

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

(iv) An additional force of 500 N acting perpendicular to the side AD is to be applied so that the moment about corner A becomes zero. Calculate the horizontal distance from corner A at which this force acts and state its direction.

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

2 Fig. 2 shows the shape and dimensions, expressed in **millimetres**, of the top surface of a component made from ABS plastic with a uniform thickness. The component is shown aligned within a Cartesian coordinate system (*x, y*) with the origin at point O.

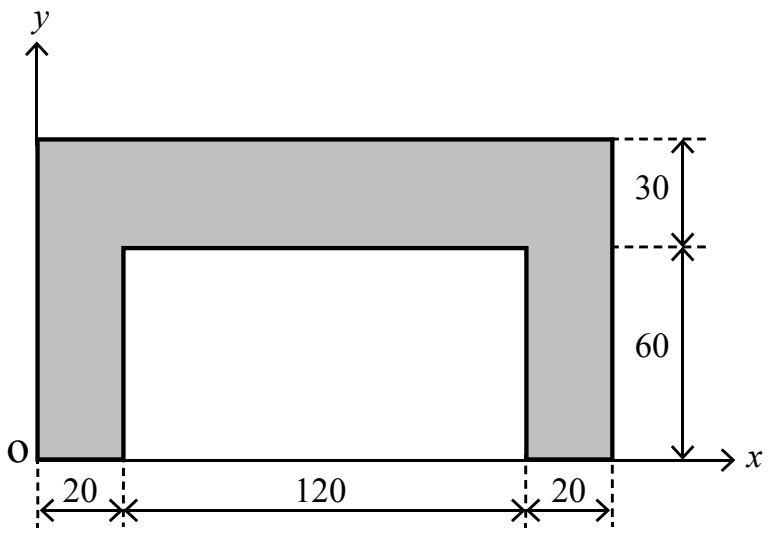

Fig. 2

(i) Calculate the surface area of the plastic shown in Fig. 2, expressing your final answer in **square centimetres**.

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

(ii) Calculate the coordinates of the centroid of the surface of the component as shown in Fig. 2.

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

(iii) The component is made from ABS plastic with a uniform thickness of 0.5 cm and a density of 1.05 g cm^{-3}. The cost of ABS plastic is £14 per kg. Calculate the cost of material in **800 components**.

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

3 **(a)** A class one lever with a length of 1.3 m is being used to lift a load with a mass of 950 kg. The load is at one end of the lever at a distance of 0.1 m from the fulcrum. The input force required to lift the load is applied at the other end of the lever. The mass of the lever can be neglected.

(i) Draw a labelled diagram showing the lever, with dimensions, fulcrum, input force and output force.

[2]

(ii) Calculate the magnitude of the minimum **output** force required to lift the load.

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

(iii) Calculate the magnitude of the minimum **input** force required to lift the load.

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

(iv) Calculate the mechanical advantage of the lever.

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

(b) A simple gear system comprises an input gear with 60 teeth meshed together with an output gear. The mechanical advantage of the system is 1.25. Calculate the number of teeth on the output gear.

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

(c) An engineer requires a gear system for a milling machine. The gear system must have the following features.

- Small and compact
- High mechanical advantage
- The axes of rotation of the input gear and output gear are perpendicular
- The direction of transmission is not reversible

Name the type of gear system that the engineer should select.

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

(d) A belt and pulley system has an input pulley that rotates at 50 rpm and an output pulley that rotates at 100 rpm. The diameter of the input pulley is x cm and the diameter of the output pulley is $(2x - 30)$ cm. Calculate the value of x.

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

4 **(a)** Fig. 3a shows a cantilever beam of length 11 m attached to a wall. The beam has a uniform mass of 30 kg per metre length and is subjected to an upward force of 3000 N applied at a distance of 2 m from the wall and a downward force of 5000 N at a distance of 8 m from the wall.

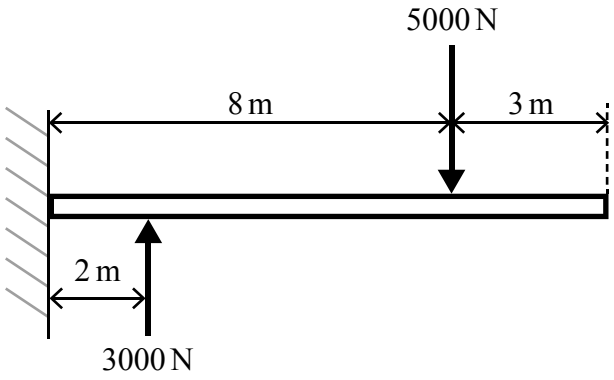

Fig. 3a

(i) The self weight of the beam is to be modelled as force acting at a single point.

(A) Calculate the magnitude of this force.

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

(B) Indicate the position and direction of this force on Fig. 3b.

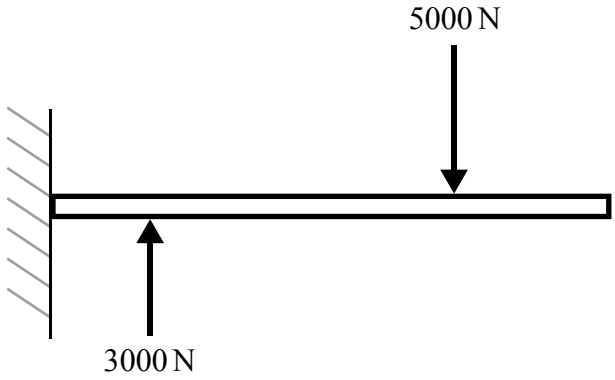

Fig. 3b

[1]

(ii) Name the type of support used to attach a cantilever beam such as this to a wall.

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

(iii) The self weight of the beam is one example of a uniformly distributed load (UDL). Provide another example of something that could cause a UDL.

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

(iv) Calculate the vertical reaction at the wall, stating the direction in which it acts.

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

(b)

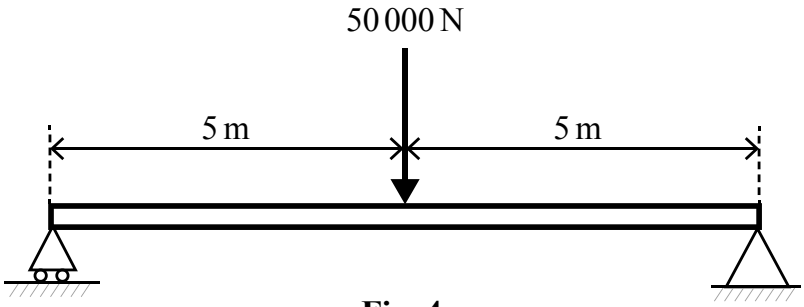
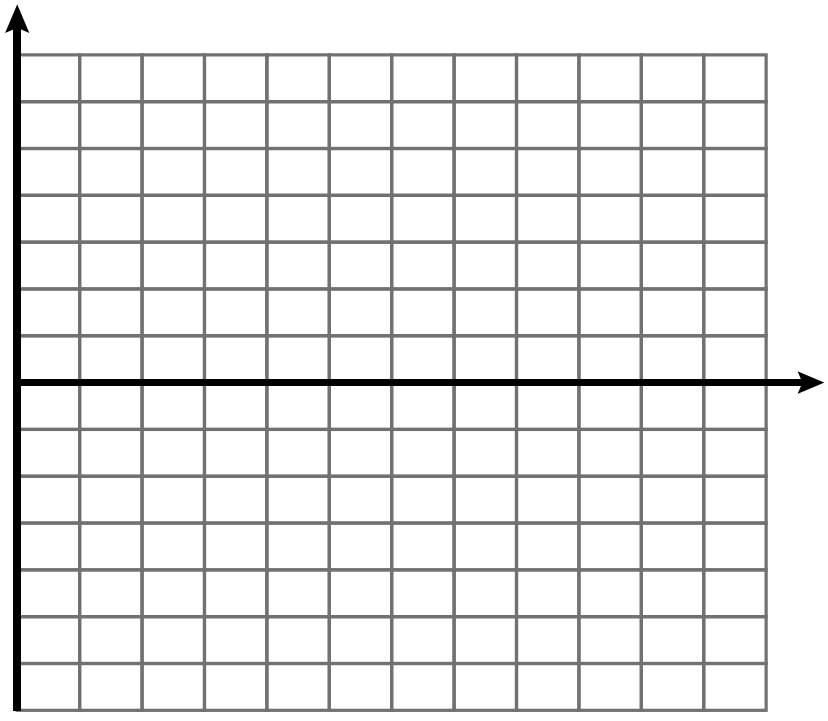


Fig. 4

Fig. 4 shows a simply-supported beam of length 10 m with a single downward force of 50 000 N acting at its centre. Draw a labelled bending moment diagram for the beam on the grid below. You may assume that the effect of the self weight of the beam can be neglected.



[3]

5 A car of mass 1800 kg is travelling along a rough horizontal road with a driving force of D N. The car is subjected to a force of 300 N due to the friction between its tyres and the surface of the road and an air resistance force of 200 N.

(i) Draw a diagram showing all the forces experienced by the car**.** (You may represent the car as a simple rectangle.)

[2]

(ii) The car accelerates uniformly from rest to a speed of 25 m s^{-1} in 20 s. Calculate the acceleration of the car during this period.

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

(iii) Using your answers to parts **(i)** and **(ii)**, calculate the magnitude of the driving force D N.

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(iv) Calculate the distance travelled during the 20 s period.

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(v) The car is now modelled as a solid rectangular block with a mass of 1800 kg moving across a rough surface. There is a frictional force of 300 N between the block and the surface. Calculate the coefficient of friction between the block and the surface.

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

6 **(a)** A large body of mass 14 kg moving with a speed of 3 m s^{-1} collides with a small stationary body of mass 2 kg. Immediately after the collision the large body continues to move in the same direction but with a reduced speed of 2.25 m s^{-1}.

(i) Calculate the kinetic energy of the large body before the collision.

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

(ii) After the collision the small body moves in the same direction as the large body. Assuming that linear momentum is conserved, calculate the speed of the small body immediately after the collision.

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

(iii) An **elastic** collision is one in which both kinetic energy and momentum are conserved. Using your results of parts **(i)** and **(ii)** determine whether or not the collision is elastic.

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(b) A steel dart of mass 0.05 kg is thrown into a cork board with an initial speed of 10 m s^{-1}. The tip of the dart becomes embedded in the board to a depth of 10 mm. By considering the work-energy principle, calculate the resistive force caused by the board.

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END OF QUESTION PAPER