OCR
Oxford Cambridge and RSA

Tuesday 15 January 2019 – Morning

LEVEL 3 CAMBRIDGE TECHNICAL IN ENGINEERING

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

Duration: 1 hour 30 minutes

C303/1901

C303 – 1901

You must have:
- the formula booklet for Level 3 Cambridge Technical in Engineering (inserted)
- a ruler (cm/mm)
- a scientific calculator

First Name		Last Name	

Centre Number						Candidate Number				

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.
- Complete the boxes above with your name, centre number, candidate number and date of birth.
- 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	/12
2	/10
3	/9
4	/10
5	/10
6	/9
Total	**/60**

Answer **all** the questions.

1 An aluminium plate with a uniform thickness of 5 mm comprises a semi-circular section with a radius of 50 mm and a rectangular section with a length of 120 mm and a width of 40 mm. The plate, OABCD, is shown in Fig. 1 aligned within a Cartesian coordinate system, (x, y) with the origin at corner O.

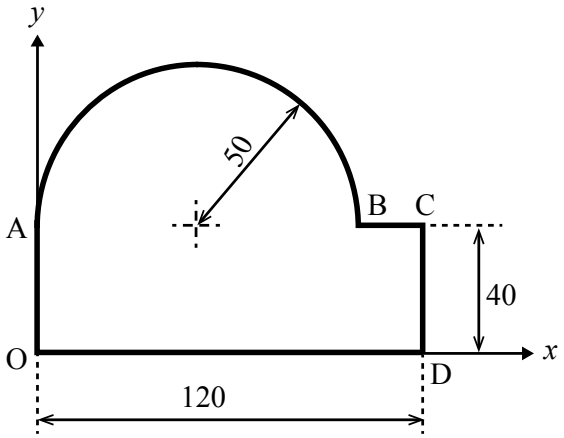

Fig. 1

(i) The density of the aluminium plate is 2700 kg m^{-3}. Calculate the mass of the plate.

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

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

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

(iii) The plate is suspended from corner D. Calculate the angle that side CD makes with the vertical.

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

Turn over for the next question.

2 **(a)** Fig. 2 shows a diagram of a compound gear train. The input gear, labelled A, has 100 teeth and the output gear, labelled D, has 120 teeth. The compound gear consists of gears B and C which rotate together on the same shaft. Gear B has 200 teeth and gear C has 80 teeth.

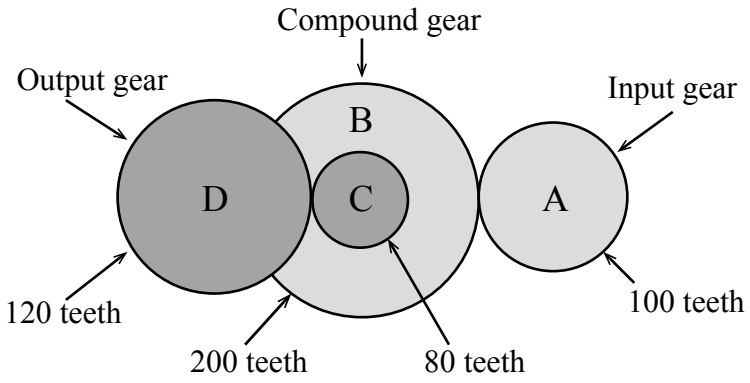

Fig. 2

(i) Calculate the overall Velocity Ratio (VR) of this gear train.

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

(ii) The output gear must rotate at a speed of 60 rpm. Calculate the rotation speed of the input gear.

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

(iii) Calculate the Mechanical Advantage (MA) of this gear system.

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

(b) A belt and pulley system has a velocity ratio of 1.8. The diameter of the input pulley is 85 cm. Calculate the diameter of the output pulley.

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

(c) Fig. 3 shows a diagram of a lever with a length of 0.8 m. The lever has a fulcrum at one end and an input force, F_I N, at the other end. A load on the lever is positioned at 0.5 m from the fulcrum.

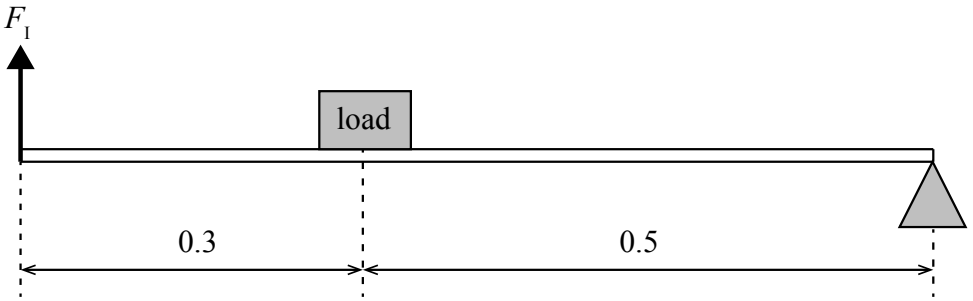

Fig. 3

(i) State the class of lever.

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

(ii) Calculate the Mechanical Advantage of the lever.

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

(iii) A child is attempting to use the lever to lift a load of 30 kg. The maximum input force that the child can apply is 200 N. Determine whether or not the child is able to lift the load. Your answer must be supported by suitable calculations. The mass of the lever can be ignored.

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3 **(a)** A particle is subjected to three co-planar, concurrent forces, as shown in Fig. 4.

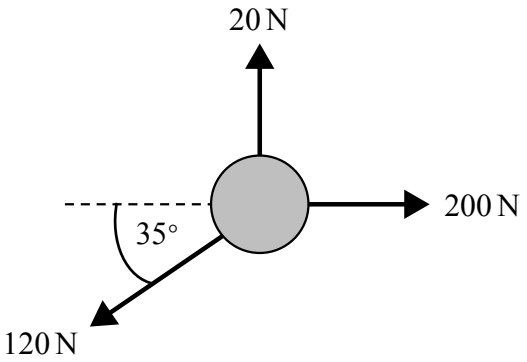

Fig. 4

(i) Calculate the magnitude of the resultant force.

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

(ii) The particle has a mass of 3 kg, and is acted upon by the forces shown in Fig. 4 for a period of 8 seconds. The initial speed of the particle is 4 m s^{-1} in the same direction as the resultant force. Calculate the distance travelled by the particle during the 8 seconds period.

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(b) A car travels at a constant speed of 25 m s^{-1} for 20 seconds while producing a constant driving force of 3200 N. Calculate the work done by the driving force during this period.

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

4 A child pushes a toy go-cart of mass 15 kg along rough horizontal ground by applying a constant horizontal force of 40 N. The coefficient of friction between the ground and the wheels of the go-cart is 0.04.

(i) Draw a diagram showing all the forces acting on the go-cart.

[2]

(ii) Calculate the magnitude of the friction force acting on the go-cart.

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

(iii) Calculate the acceleration of the go-cart.

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

(iv) The child releases the go-cart when it is travelling at a speed of 2.7 m s^{-1}. Calculate the kinetic energy of the go-cart at this time.

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

(v) After the go-cart has been released, calculate the distance travelled before it comes to rest. Use an energy method and you may assume no other forces act on the go-cart except for friction.

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5 **(a)** Fig. 5 shows a steel bolt of diameter 8 mm which is in double shear when subjected to a tensile force of 2000 N. Calculate the shear stress in the bolt. You must include appropriate units in your answer.

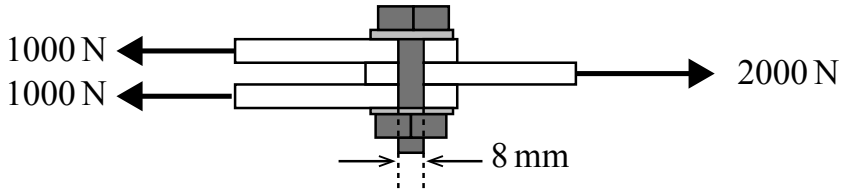

Fig. 5

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

(b) Name the term used in engineering that represents the stiffness of material.

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

(c) A cable has an extension of 6 mm when subjected to a strain of 0.4%. Calculate the original length of the cable.

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(d) (i) Name the type of gear system shown in Fig. 6.

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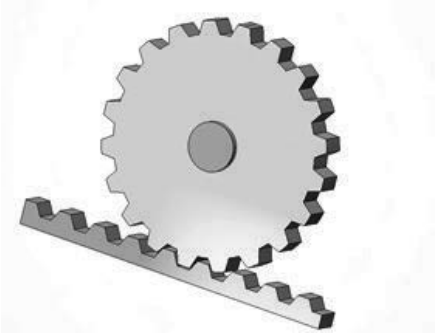

Fig. 6

(ii) Name one application of this gear system.

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(e) An engineer must decide whether to use a flat belt and pulley system or a chain and sprocket set to transfer rotational motion between two mechanisms.

(i) Name one advantage to using a chain and sprocket set instead of a flat belt and pulley system.

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

(ii) Name one advantage to using a flat belt and pulley system instead of a chain and sprocket set.

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

6 (a) Name the type of beam shown in Fig. 7.

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

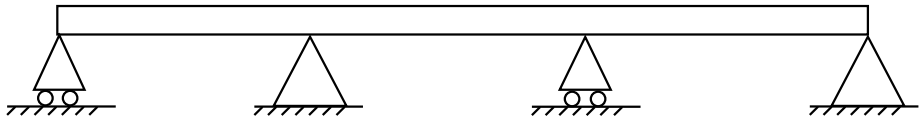

Fig. 7

(b) Fig. 8 shows a uniform beam of length 10 m which is simply supported at ends A and B. The beam is subjected to two external forces of 15 000 N and 20 000 N acting vertically downwards at the positions indicated. The self-weight of the beam is represented by a force of 6000 N acting vertically downwards at its centre as shown.

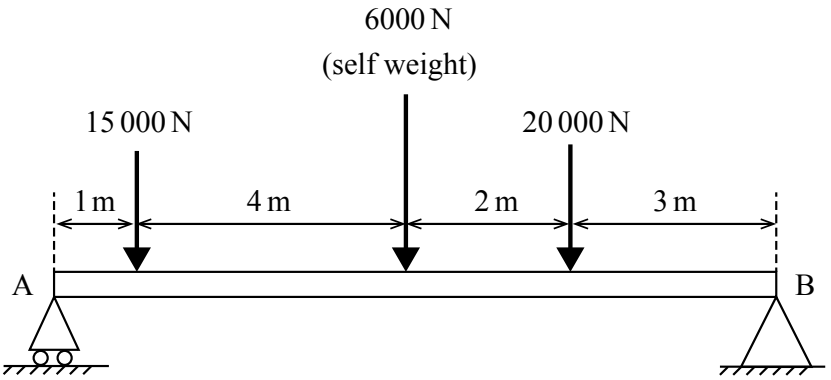

Fig. 8

(i) Calculate the reaction at the support at end A and the reaction at the support at end B.

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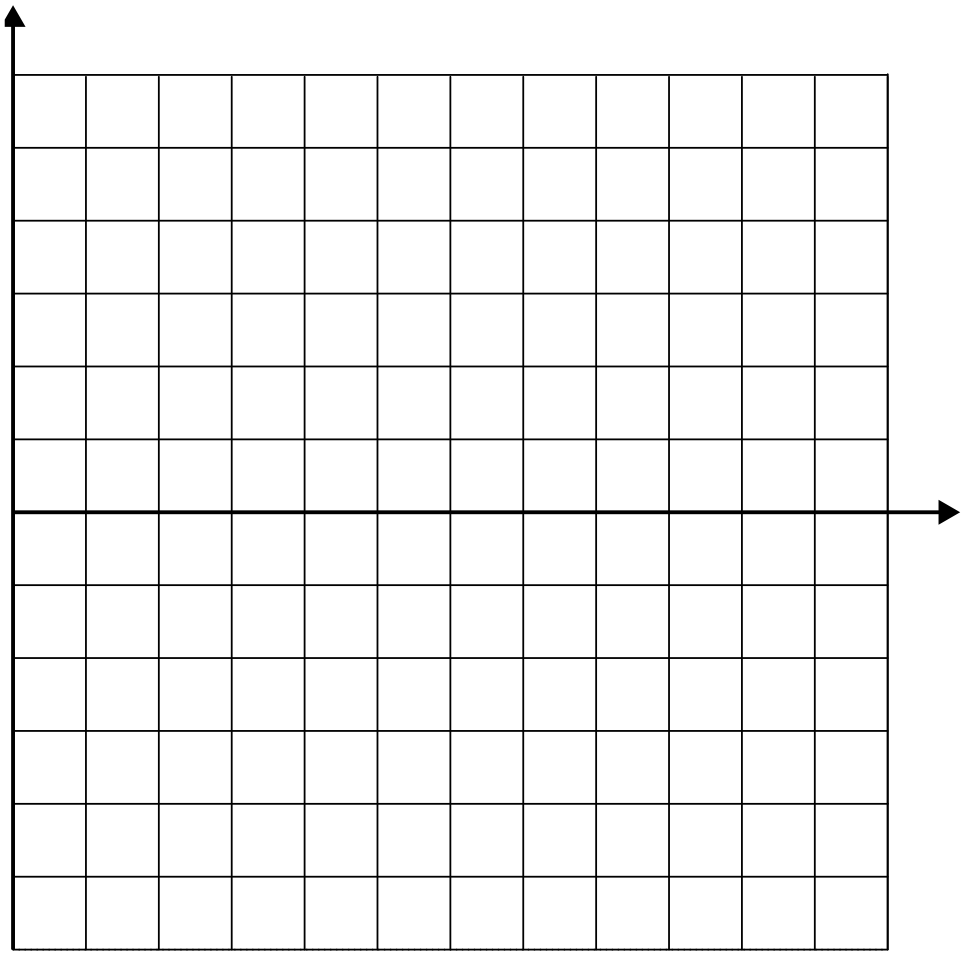
(ii) Draw a labelled bending moment diagram for the beam on the grid below.



[4]

END OF QUESTION PAPER