OCR
Oxford Cambridge and RSA

Level 3 Cambridge Technical in Engineering
05822/05823/05824/05825/05873

Unit 3: Principles of mechanical engineering

Monday 22 May 2017 – Morning
Time allowed: 1 hour 30 minutes

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. If additional space is required, you should use the lined page(s) at the end of this booklet. The question number(s) must be clearly shown.
- 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	/13
3	/10
4	/7
5	/10
6	/10
Total	**/60**

Answer **all** questions.

1 **(a)** Fig. 1 shows a steel plate aligned within a Cartesian coordinate system, (x, y), with the origin at point O. Dimensions are shown in millimetres.

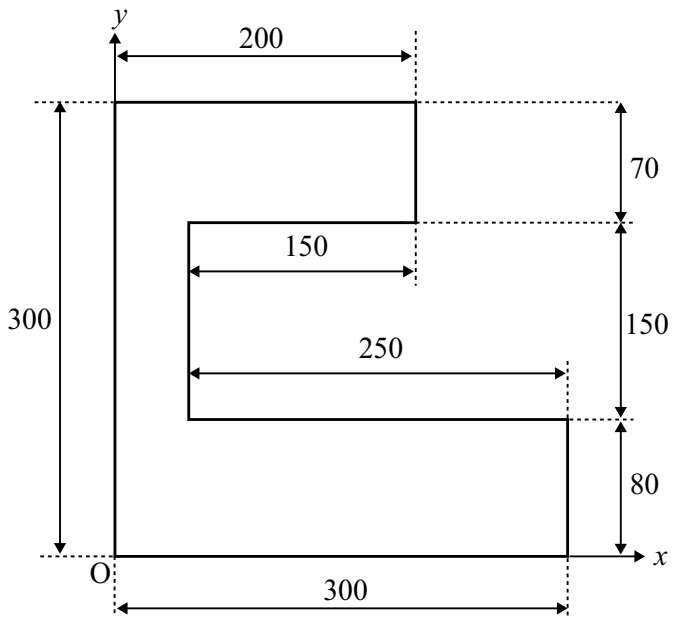

Fig. 1

Calculate the coordinates, $\bar{x}$ and $\bar{y}$, of the centroid of the plate.

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

(b) (i) A steel component operates at a working axial stress of 110 MPa. The ultimate stress of the material is 240 MPa. Calculate the Factor of Safety of this component.

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

(ii) Explain the implications for the behavior of this component if the operational stress level were to exceed the elastic limit of the material.

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

(iii) The component is a circular metal bar with diameter 45 mm and is subjected to a shear force of 120 N. Calculate the shear stress in the component. You must give appropriate units with your answer.

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

2 **(a)** Give one reason for selecting a wormgear and wormwheel arrangement for an application.

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

(b) Give one example of a mechanism that uses a Class one lever.

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

(c) A Class 2 lever has a mechanical advantage (MA) of 1.95. The maximum load the lever can lift is 392 N.

(i) Calculate the effort required to lift this load.

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

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

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

(iii) The 392 N load lifted by the lever is a circular metal bar of uniform density 7000 kg m^{-3}. Calculate the volume of the bar.

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

(iv) The length of the bar is 0.35 m. Using your answer from part (c)(iii) calculate the diameter of the bar.

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

(d) (i) Two spur gears, A and C, are meshed together. A is the input gear and has 24 teeth. Calculate the number of teeth required on gear C such that it rotates at 1.5 times the speed of gear A.

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

(ii) The application for the gears A and C in part (d) (i) requires gear C to rotate in the same direction as gear A. An alternative gear train is proposed, with gear B inserted between gears A and C. The gears are represented as circles in Fig. 2.

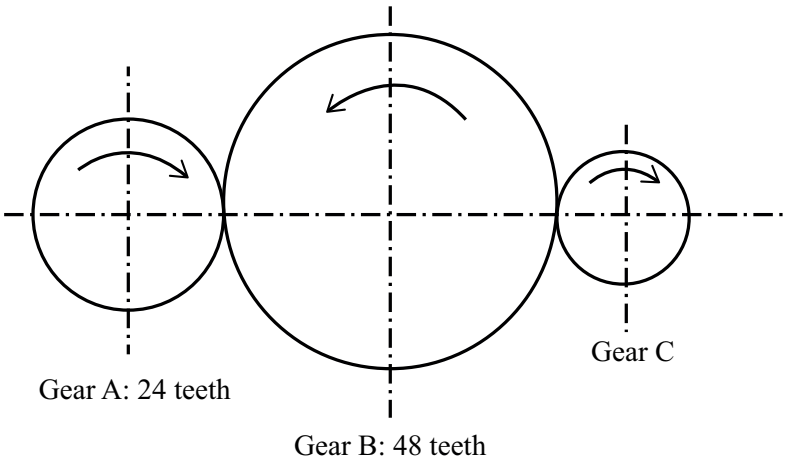

Fig. 2

State the name for gear B as used in this application.

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

(iii) Gear B has 48 teeth. It is still required that gear C rotates at 1.5 times the speed of gear A. Calculate the number of teeth required on gear C for this alternative gear train.

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

(iv) An alternative system to transfer rotary motion between two shafts would be a belt and pulley system. Give **one** advantage to using a gear system such as the one shown in Fig. 2 rather than a belt and pulley system.

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

3 **(a)** **(i)** In a game of curling a player is using a force of 20 N to propel a curling stone to a speed of 5 m s^{-1}. Calculate the instantaneous power of the stone.

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

(ii) The curling stone has a mass of 19.5 kg and after it has been released by the player it travels along the ice until its speed has reduced to 3 m s^{-1}. Calculate the kinetic energy of the stone at this time.

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

(iii) At this time the curling stone hits another stationary stone of mass 17.5 kg. After the collision the stationary stone is pushed forward at a speed of 1 m s^{-1}. Assuming conservation of momentum calculate the speed of the 19.5 kg stone immediately after the collision.

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

(b) At a particular time while a ball is travelling through the air it is acted upon by three forces as shown in Fig. 3.

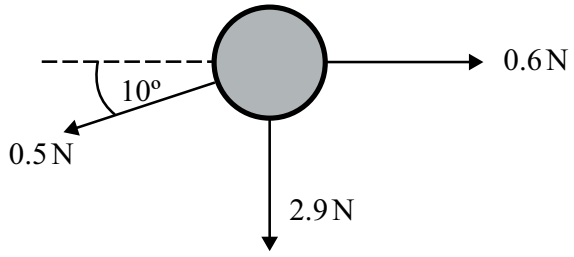

Fig. 3

(i) State what the 2.9 N force shown in the diagram represents.

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

(ii) Calculate the magnitude of the resultant force acting on the ball.

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

(iii) Calculate the acceleration of the ball in the direction of this resultant force.

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

4 A lorry of mass 4000 kg travels along a rough horizontal road.

(i) The lorry starts from rest and accelerates uniformly for 14 seconds until it reaches a speed of 24.5 m s^{-1}. Calculate the acceleration of the lorry.

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

(ii) The coefficient of friction between the road surface and the tyres of the lorry is 0.22. Calculate the frictional force acting on the lorry.

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

(iii) The engine of the lorry produces a driving force F N. Calculate the value of the driving force required to achieve the acceleration as calculated in part (i). You may assume that no other forces are acting on the lorry except for the friction force calculated in part (ii).

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

5 **(a)** Give an example of what could cause the following types of load on a structure.

(i) Uniformly Distributed Load (UDL)

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

(ii) Point Load

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

(b) Fig. 4 shows a simply-supported beam with supports A and B. The beam is subjected to three forces, 2000 N, 4000 N and 1500 N in the directions shown.

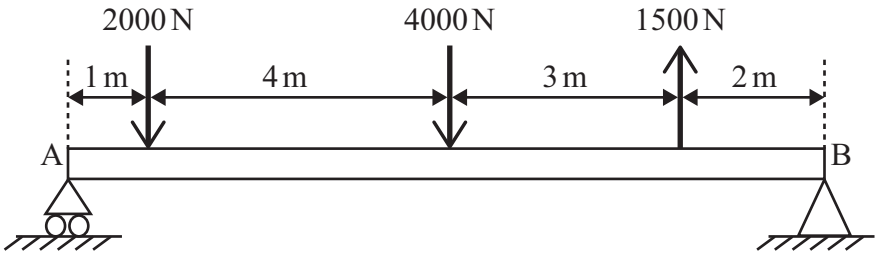

Fig. 4

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

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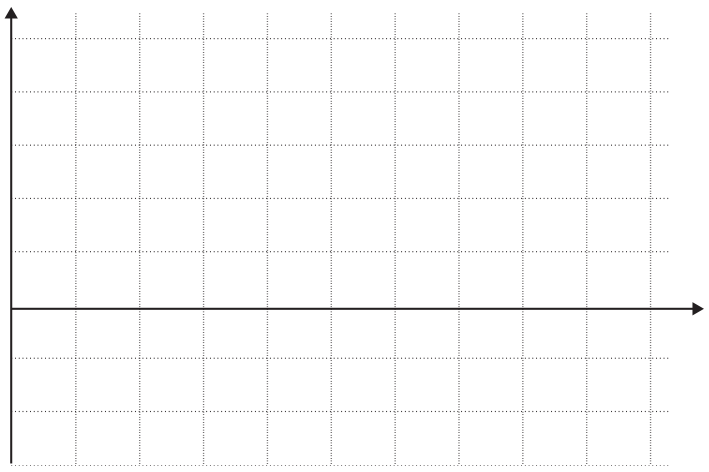
(ii) Calculate the bending moment at the centre of the beam.

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

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



[4]

6 **(a)** Fig. 5 shows a particle suspended in equilibrium. The particle is subjected to a vertical downward force of 210 N, a horizontal force of P N and a force of Q N acting at an upward angle of 35^{o} to the horizontal.

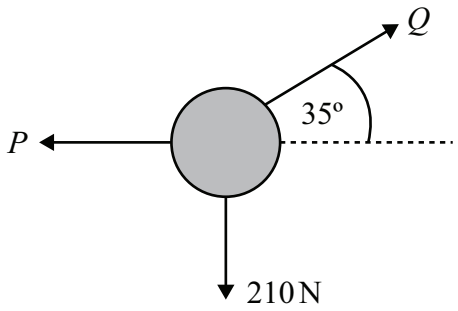


Fig. 5

Calculate the magnitudes of P and Q such that the particle remains suspended in equilibrium.

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

(b) Fig. 6 shows a rectangular plate ABCD subjected to five forces acting perpendicular to its sides. Force F acts at a distance of x m to the right of corner A.

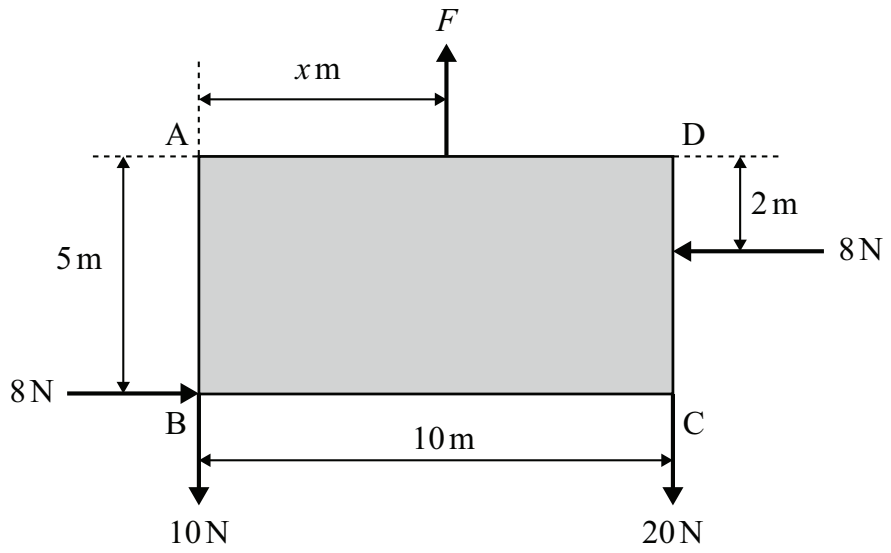

Fig. 6

Calculate the force F and the distance x required to maintain the plate in vertical, horizontal and rotational equilibrium.

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..... **[6]**

END OF QUESTION PAPER

ADDITIONAL ANSWER SPACE

If additional space is required, you should use the following lined page(s). The question number(s) must be clearly shown in the margins.

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