OCR
Oxford Cambridge and RSA

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

Unit 3: Principles of mechanical engineering

Monday 23 May 2016 – Afternoon
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								

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 ms^{-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 details 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 **16** pages.

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

Answer **all** questions.

1 **(a)** Fig. 1 shows a trapezium shaped plate ABCD.

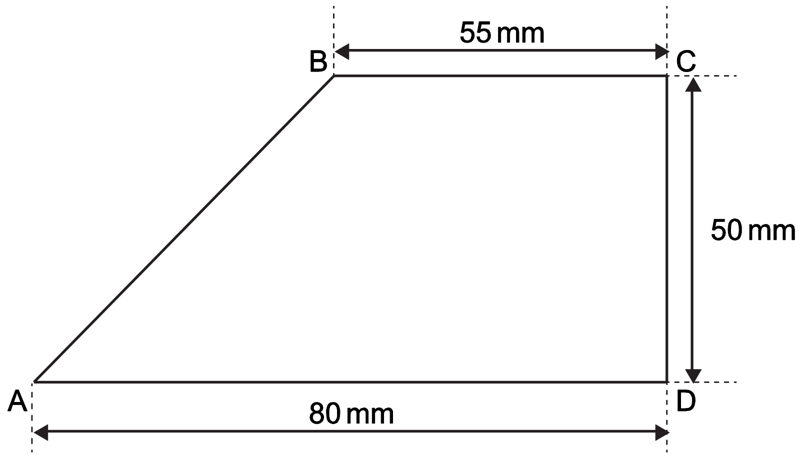

Fig. 1

Calculate the coordinates of the centroid of the plate relative to point A.

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.... **[5]**

(b) The plate in Fig.1 is acted on by three forces. The forces are shown in Fig. 2.

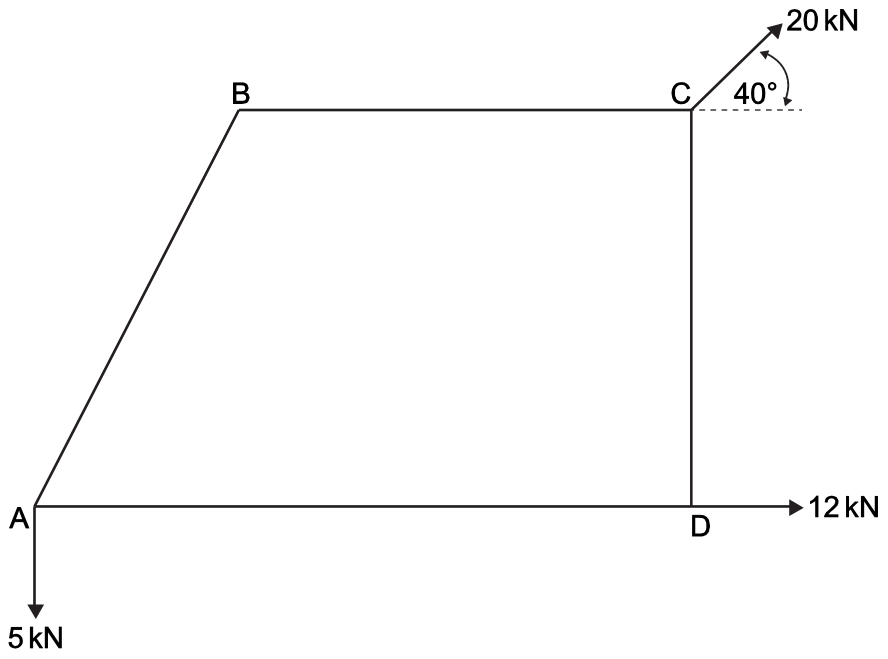

Fig. 2

Calculate:

(i) the magnitude of the resultant force.

....

....

.... **[3]**

(ii) the angle that the resultant force makes with the horizontal.

....**[1]**

(iii) the moment at point C due to the forces acting on the plate.

.... **[1]**

2 Fig. 3 shows a car of mass 1200 kg travelling up a rough hill inclined at a constant angle of 5°. The engine produces a driving force *P* N in the direction of motion.

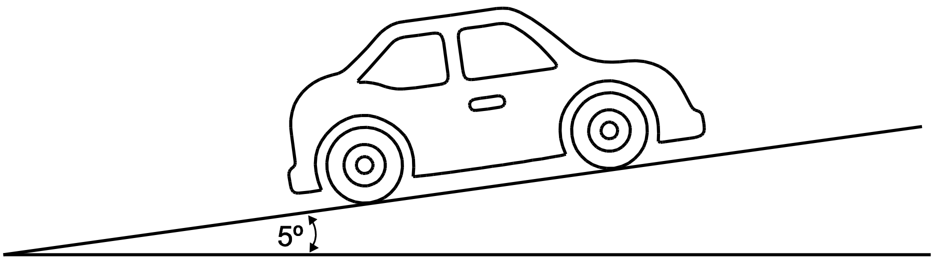

Fig. 3

(a) **(i)** Draw a diagram showing all the forces acting on the car. You may represent the car as a box in your diagram.

[2]

(ii) Calculate the maximum friction force acting on the car if the coefficient of friction $\mu = 0.15$.

....

....

.... **[2]**

(iii) The driving force P of the car is 3500 N. Calculate the acceleration of the car up the hill.

....

....

....

.... **[3]**

(b) (i) The car now travels along a horizontal road. The Highway Code specifies that a vehicle travelling at 26.8 ms^{-1} (60 mph) must be able to achieve a stopping distance of 55 m when a braking force is applied. Assume that deceleration is uniform when a braking force is applied.
Calculate the deceleration needed to achieve this stopping distance.

....

....

.... **[2]**

(ii) The work done by the brakes of the car in this situation is 334 000 J. Given that it takes 4.1 seconds to stop, determine the average braking power of the car.

....

.... **[1]**

3 **(a)** Fig. 4 shows the cross-section of a steel beam used in standard structural engineering applications. All dimensions are in millimetres (mm).

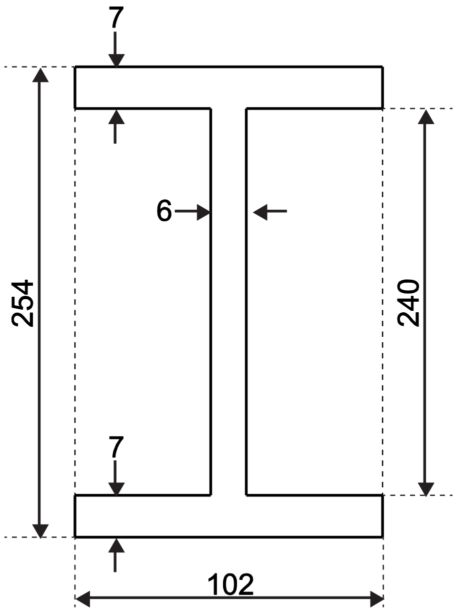

Fig. 4

(i) Calculate the cross-sectional area of the beam. Your answer must be in units of $\mathbf{m^2}$.

....

.... **[2]**

(ii) The beam in Fig. 4 has a length of 12 m. The density of the steel is 8000 kg m^{-3}.

Calculate the mass of the beam.

....

....

.... **[3]**

(b) The diagram in Fig. 5 shows a simply supported beam. There are loads of 14 kN and 16 kN at points A and C. It is supported at points B and D.

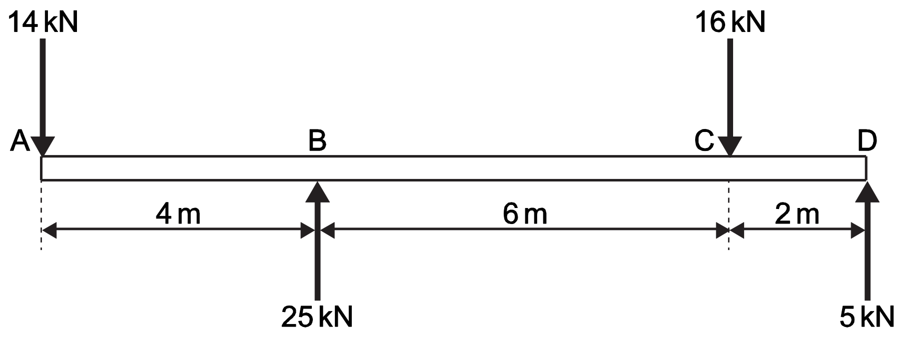

Fig. 5

The reaction forces at B and D have been calculated for you: the reaction at B is 25 kN upwards and the reaction at D is 5 kN upwards.

Draw a labelled bending moment diagram for this beam.

....

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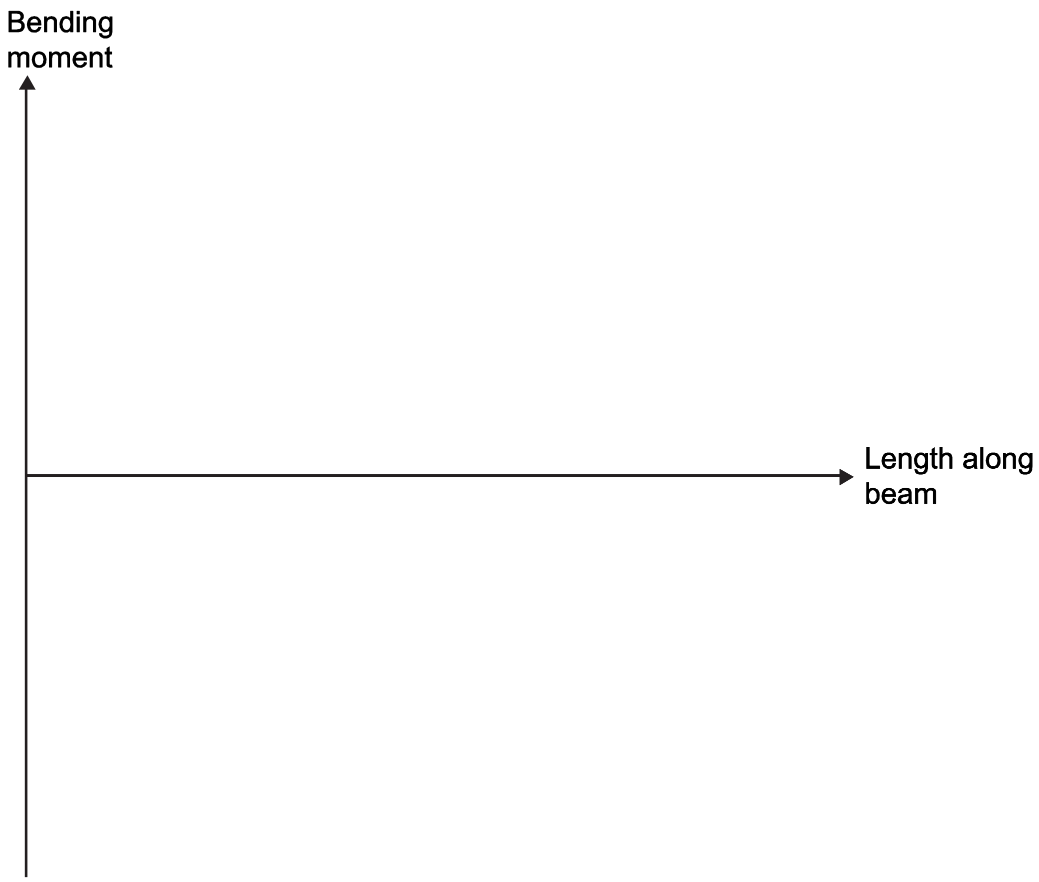


[5]

4 Fig. 6 shows a small crane lifting a load of 2000 N with the jib of length 3.5 m inclined at an angle of $\theta = 30°$ to the horizontal.

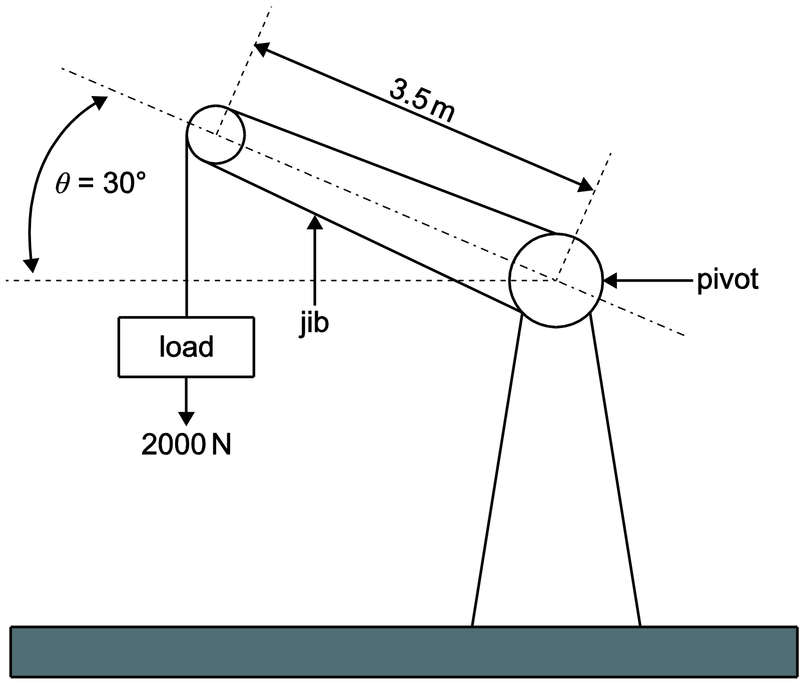


Fig. 6

(a) (i) Calculate the components of the load which act parallel to and perpendicular to the jib of the crane.

Parallel...

Perpendicular...

[2]

(ii) Using your answer from part **(a) (i)** calculate the moment at the pivot of the crane.

.... **[1]**

(b) The jib is manufactured from a hollow steel section with the cross-section shown in Fig. 7.
All dimensions are in millimetres (mm).

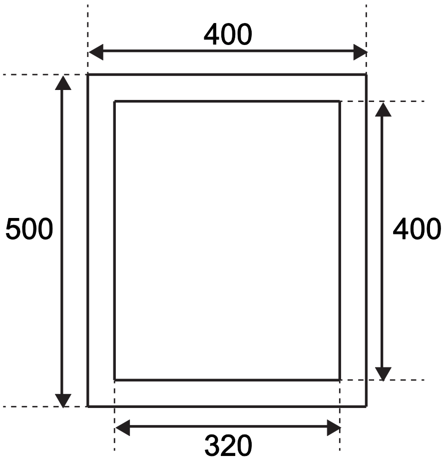


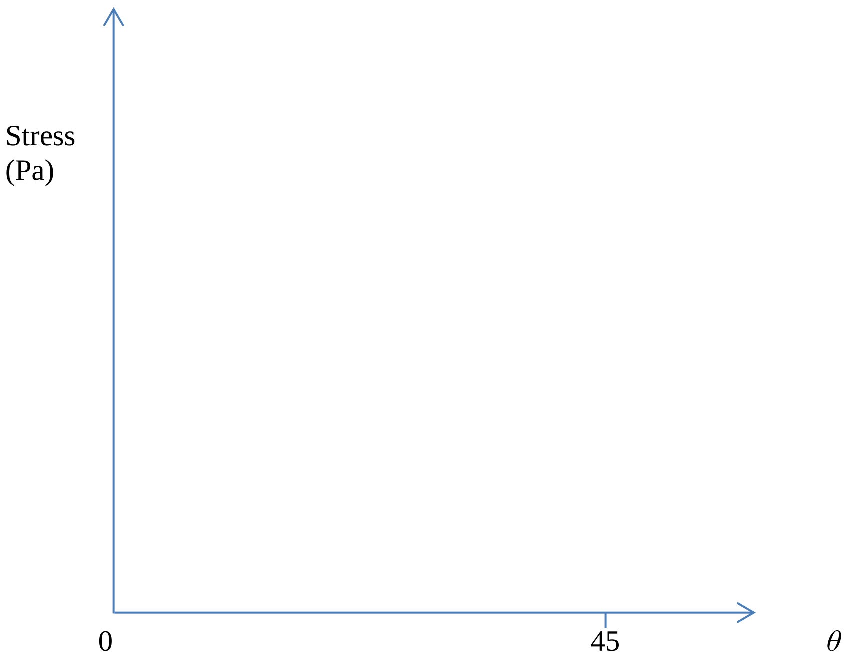
Fig. 7

(i) The jib is lowered such that it is horizontal and $\theta = 0$. Assuming the load is still 2000 N calculate the shear stress in the material. State the units in your final answer.

....

.... **[2]**

(ii) As the jib is raised and θ increases from 0 to 45° the values of the shear stress and the axial stress will change.
Sketch a graph on the axis below showing how they change as θ increases. You are **not** required to make any additional calculations to your answer in part **(b) (i)** but critical values should be marked on your axes and your graphs should be clearly labelled.



[2]

(c) Fig. 8 shows the stress-strain graph for steel.

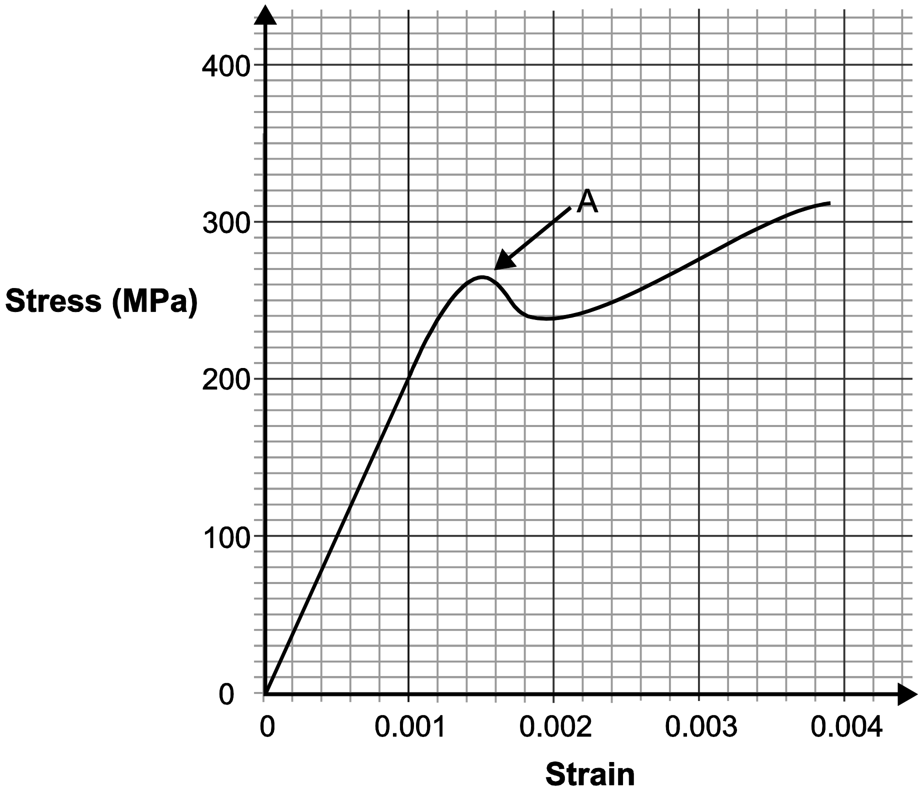


Fig. 8

(i) Estimate Young's Modulus of steel from this graph.

....

.... **[2]**

(ii) State what is happening to the steel between stresses of 0 and 240 MPa.

.... **[1]**

5 **(a)** Name **one** application of a chain-driven sprocket gear system.

.... **[1]**

(b) Fig. 9 shows an image of a common gear system as used in a hand drill.

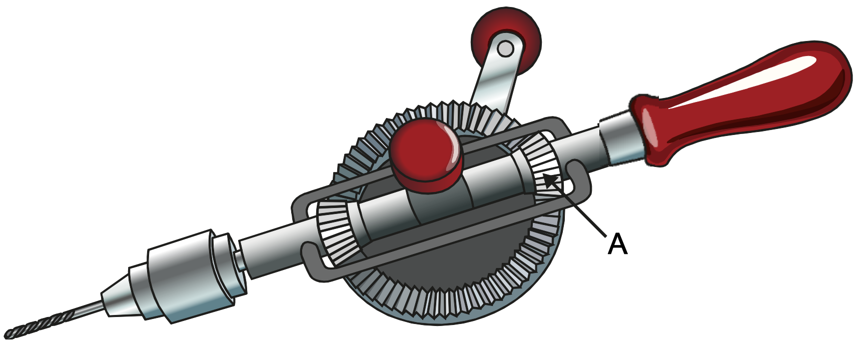


Fig. 9

Name component A.

.... **[1]**

(c) Fig. 10 shows a lever system.

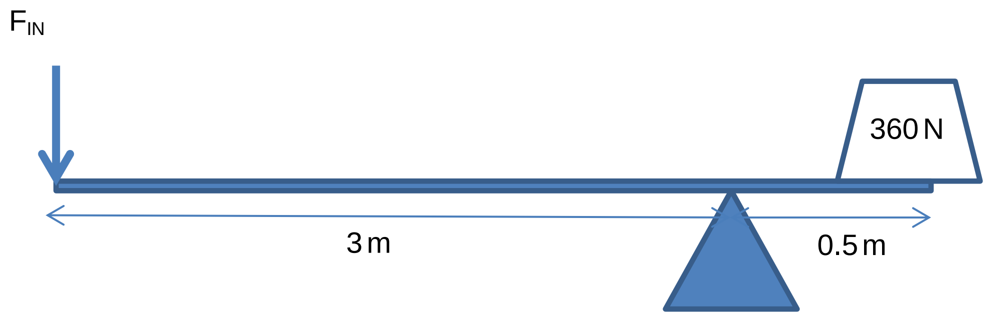


Fig. 10

(i) Name the class of lever.

.... **[1]**

(ii) Calculate the minimum value of F_{IN} required to lift the load **and** the Mechanical Advantage (MA) of this system.

....

....

.... **[3]**

(d) Fig. 11 shows a gear system consisting of four gears; A, B, C and D. Gears B and C are fixed onto a common shaft. The driver gear A rotates in a clockwise direction.

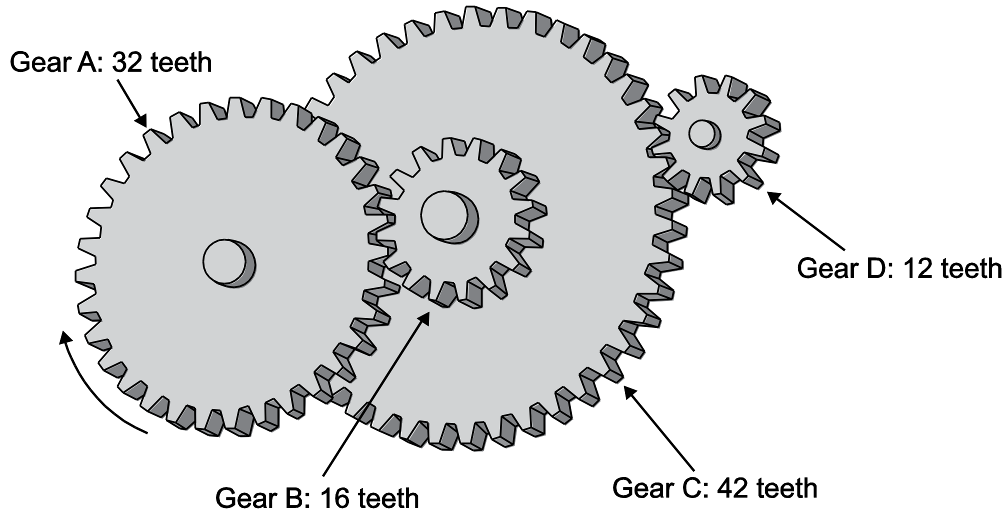


Fig. 11

(i) State the direction of rotation of the other gears.

Gear B ....

Gear C ....

Gear D ....
[1]

(ii) Gear A rotates at a speed of 800 rpm.
Calculate the speed of gear D.

....

....

.... **[2]**

(iii) Calculate the overall velocity ratio of the gear system.

.... **[1]**

6 Fig. 12 shows the profile view of a ski jump.

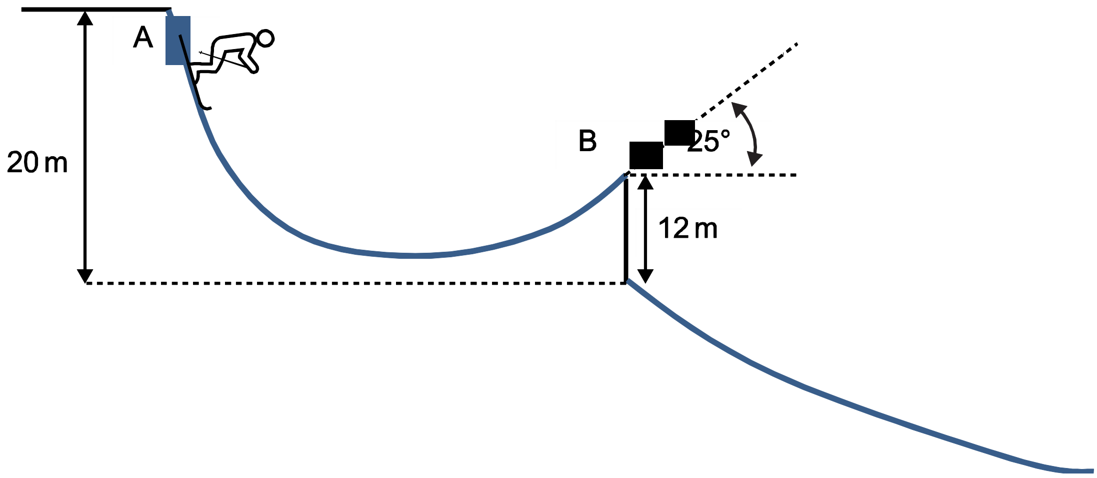


Fig. 12

(a) A skier of mass 80 kg starts from rest at point A.

(i) Calculate the loss in the potential energy of the skier between points A and B.

.... **[1]**

(ii) Given that the work done against resistance between points A and B is 2000 J, calculate the speed of the skier at point B.

....

....

.... **[3]**

(iii) The take-off point for the jump is point B where the slope is inclined at 25 degrees to the horizontal. Given that the skier is in the air for 1.8 seconds, calculate the **horizontal** distance travelled during the jump. You may assume horizontal resistance is zero.

....

.... **[2]**

(b) **(i)** The skier uses a chairlift to ascend to the top of the slope. The chair has a mass of 300 kg and is travelling at a speed of 0.8 ms^{-1} before the skier sits down. The skier is stationary before sitting on the chair. Assuming conservation of momentum, determine the combined velocity of the skier and the chair immediately after the skier sits down.

....

.... **[2]**

(ii) The chair can be modelled as a beam with a worst case loading scenario as shown in Fig. 13.

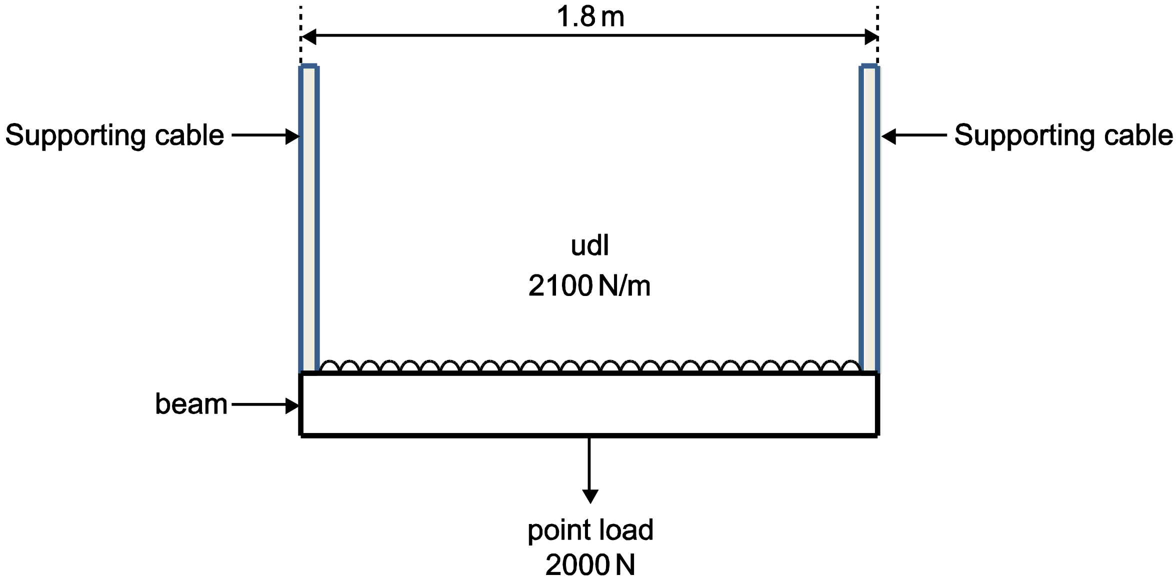


Fig. 13

Calculate the tension in the each of the supporting cables under this loading.

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.... **[2]**

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.