Total No. of printed pages = 6

ME 181104

Roll No. of candidate | | | | | | | | | | |

2022

B.Tech. 1st Semester End-Term Examination

ENGINEERING MECHANICS

New Regulation (w.e.f. 2017-18) &
New Syllabus (Group – B) (w.e.f. 2018-19)

Full Marks – 70 Time – Three hours

The figures in the margin indicate full marks
for the questions.
Answer question No. 1 and any *four* from the rest.

1. Choose the correct answer : (10 × 1 = 10)

(i) Two forces of magnitudes P and Q respectively form a coplanar parallel force system and P > Q. The resultant R of this force system will act in the _____ direction as that of P and its position will be _____ . [Fill in the blanks]

(a) opposite, nearer to P (b) same, nearer to P
(c) opposite, nearer to Q (d) same, nearer to Q

(ii) While using the Method of Section to find out the forces in the members of a plane truss, the maximum number of members with unknown forces that the imaginary section can cut is:

(a) 6 members (b) 5 members
(c) 4 members (d) 3 members

(iii) A rectangular block weighing 10 kN is placed on a rough horizontal surface and a push force P is applied on the block. The coefficients of static and kinetic friction are 0.3 and 0.25 respectively. Find out the value of friction force generated between the contact surfaces when P = 2000 N and when P = 3500 N respectively.

(a) 2000 N and 2500 N (b) 3000 N and 2500 N
(c) 600 N and 875 N (d) 500 N and 1050 N

[Turn over

(iv) A rectangular block weighing 25 N is placed on a rough inclined plane of inclination 20 degree. The coefficient of static friction between the contacting surfaces is 0.25. Comment on the stability of the block.

(a) The block is in static equilibrium position.

(b) The block is in motion up the inclined plane.

(c) The block is in motion down the inclined plane.

(d) None of the above.

(v) For a homogeneous solid body symmetrical about its centroidal axes, _____. [Fill in the blanks]

(a) the Mass Centre and Centre of Gravity are the same point.

(b) the Mass Centre lies above the Centre of Gravity.

(c) the Mass Centre lies below the Centre of Gravity.

(d) the position of Mass Centre and Centre of Gravity is not collinear.

(vi) What is the position of Centroid for the plane area with respect to the y and x axes respectively as shown in Fig. 1?

(a) 70 mm and 50 mm (b) 50 mm and 50 mm

(c) 50 mm and 70 mm (d) 70 mm and 90 mm

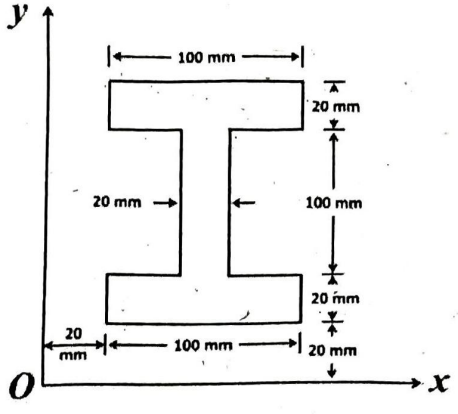


Figure – 1

(vii) For an Actual lifting machine, the values of Mechanical Advantage (MA) and Velocity Ratio (VR) are found to be 5 and 15 respectively. What would be the respective values of MA and VR if the same lifting machine were an Ideal lifting machine?

(a) 5 and 15 (b) 15 and 5

(c) 15 and 15 (d) 5 and 5

(viii) An actual lifting machine is defined by the equation $P = 0.33W + 5$, where P is the effort applied to lift a load W and both are in Kilo Newtons. How much load can be lifted when an effort of 350 Newton has been applied on the machine?

(a) 1045.45 N (b) 14.09 N

(c) 1045.45 kN (d) None of the above

(ix) A uniform ladder AB of length 5 m and weighing 20 N is resting against a smooth vertical wall and a rough horizontal floor with its lower end A situated 4 m away from the wall. If you are asked to find out the normal reaction forces offered by the floor and the wall at the points of contact with the ladder ends A and B respectively (N_A and N_B) using the Principle of Virtual Work, will you be able to find it out?

(a) NO. This cannot be calculated.

(b) YES, $N_A = 20$ N and $N_B = 13.33$ N

(c) YES, $N_A = 13.33$ N and $N_B = 20$ N

(d) YES, $N_A = 20$ N and $N_B = 13.33$ N when $\theta = 36.87$ degrees with the floor.

(x) Determine the force necessary to produce an acceleration of 4 m/s² in a mass of 250 kg.

(a) 500 Newton (b) 1500 Newton

(c) 1000 Newton (d) 2000 Newton

2. (a) Two forces of equal magnitude P act at an angle θ to each other. What will be their resultant? (5)

(b) A uniform rod AB of 1000 cm length and 1 kg mass is suspended from its ends as shown in Fig. 2. Outline the free body diagram for the given problem statement and find the amount of tension T_1 and T_2 that would be induced in the strings when a mass of 5 kg is suspended from a point D on the rod? Take acceleration due to gravity equal to 10 m/sec² if required. (10)

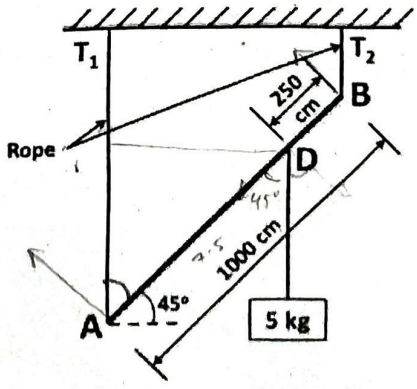


Figure – 2

3. (a) What do you mean when a truss is referred to as a Prefect, Redundant and Deficient truss? Also mention the correlations between the number of members and the number of joints for each of these three types of trusses. $(6 \times 0.5 = 3)$

(b) What do you mean by a Plane Truss and a Space Truss? (1+1=2)

(c) A cantilever truss is loaded as shown in Fig. 3. Use the method of sections to find the forces in the members AB, AE and EF of the truss. (10)

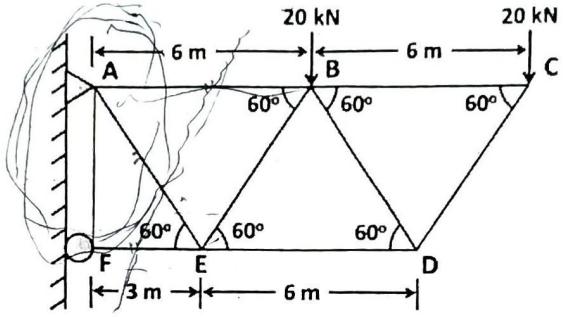


Figure – 3

Or

(d) A plane truss is loaded at Joints E and D and supported at Joints A and C as shown in Fig. 4. The magnitude and direction of the support reactions are indicated in the figure. Determine the magnitude and nature of forces induced in all the members of the truss using Graphical Method. (10)

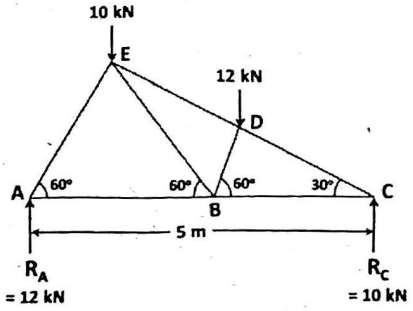


Figure – 4

4. (a) Draw a properly labelled Idealized Plot of Friction force vs. Applied Force / Tractive Force. (5)

(b) A rectangular block weighing 50 N is placed on a rough inclined plane of inclination 20° with the horizontal and it is acted upon by a push force P as shown in Fig. 5. Find the value of this push force P and comment whether this push force P is actually required for the block to move down the inclined plane? Take coefficient of static friction between the contacting surfaces to be 0.25. (10)

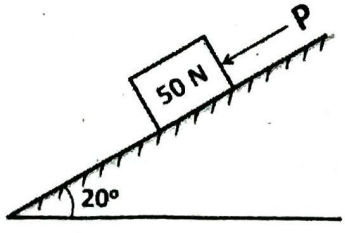
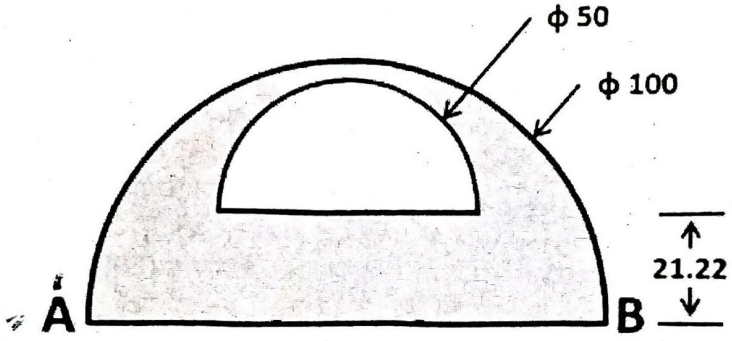


Figure – 5

5. (a) A 50 mm diameter hole is punched out from a 100 mm diameter thin circular plate. Find out the position of Centroid for the remaining portion of the plate. (5)

(b) A semi-circular hole of diameter 50 mm is punched out from a semi-circular thin plate of diameter 100 mm as shown in Fig. 6. The base of the punched hole is situated at a distance of 21.22 mm from the base AB of the semi-circular plate as indicated in the figure. Calculate the Moment of Inertia for the remaining portion of the plate about AB. (10)



All dimensions in millimeters

Figure – 6

6. (a) Define the following in connection to a simple lifting machine: (3 × 1 = 3)

(i) Mechanical Advantage (MA)

(ii) Velocity Ratio (VR)

(iii) Efficiency (η)

(b) In an actual lifting machine, when an effort P Newton is applied through a distance of y meter, then a load W Newton is raised through a distance of x meter, where $x < y$. Find out the limiting value of efficiency (η) for this lifting machine to achieve self-locking condition. (2)

(c) In an experimental test conducted on a lifting, it has been observed that an effort of 20 kN can lift a load of 90 kN, whereas an effort of 16 kN can lift a load of 70 kN. Take velocity ratio equal to 25 and determine the following: (10)

(i) Law of machine,

(ii) The limiting mechanical advantage,

(iii) The limiting efficiency, and

(iv) The effort required to lift a load of 15 kN. What would be the mechanical advantage and efficiency of the machine at this moment?

7. (a) State the Principle of Virtual Work. (2)

(b) As shown in Fig. 7, a prismatic bar AB is hinged at point O using a smooth pin; and forces P and Q are applied at the ends A and B of the bar. Using the principle of virtual work, find the value of force Q. (3)

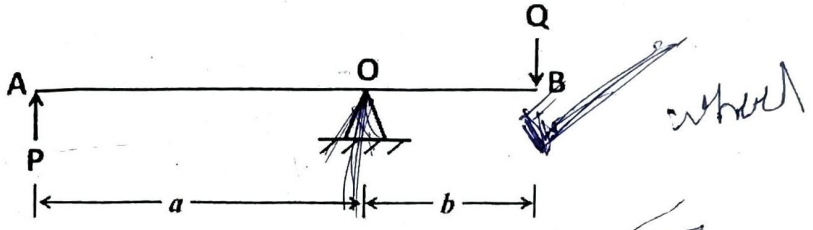


Figure – 7

(c) A Block of weight 1000 N is suspended from a movable pulley using a light inextensible string. Another light inextensible string whose one end is fixed to the ceiling is passing around the circumference of this movable pulley and another fixed pulley as shown in Fig. 8. Assuming no frictional resistance to angular displacement of the pulleys, find the minimum value of the force P that is required to be applied at the free end of the string to hold the system in equilibrium. (10)

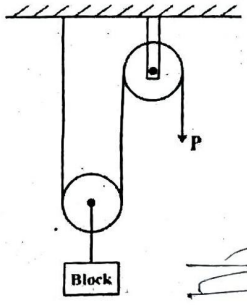


Figure – 8

8. (a) A body of mass 160 kg is made to move with a velocity of 20 meter/second when a force of 80 N acts on it for 60 seconds. Make calculations for the velocity attained by the body when: (5)

(i) The force acts in the direction of motion.

(ii) The force acts in the direction opposite to that of motion.

(b) A hammer of mass 200 kg is made to fall freely from 2 m height on the head of a pile of 1500 kg mass. The pile is driven 5 cm into the ground in one blow. Determine the following: (10)

(i) The common velocity of the pile and hammer after the impact,

(ii) The energy lost in the impact, and

(iii) The average resistance of the ground to penetration.