B.Tech.

(SEM. II) EVEN THEORY EXAMINATION 2012-13

ENGINEERING MECHANICS

Time : 3 Hours

Total Marks : 100

Note :– (1) This paper contains three Sections. Section A carries 20 marks, Section B carries 30 marks and Section C carries 50 marks.

(2) Attempt all questions. Marks are indicated against each question.

(3) Assume any missing data suitably.

SECTION–A

1. Attempt all questions : (10\times2=20)

(a) Explain the difference between a couple and a moment.

(b) A force of 1 kN inclined upward at an angle of 55° with horizontal axis acts at a point (2m, 3m). Find the moment of the force about the origin.

(c) A circular arc of radius 1 m has a central angle of 45°. Locate its centroid.

(d) Distinguish between the moment of inertia of an area and its polar moment of inertia.
(e) If the instantaneous center of a rigid body lies at infinity, what conclusion can be drawn about the velocities at any two points of the body?

(f) What is the meaning of inertia force in D'Alembert's principle? How does it lead to the concept of dynamic equilibrium?

(g) What is a zero force member in a truss? Write two rules to identify it.

(h) What are the implications of sudden changes of (a) shear force and (b) bending moment for a simply supported beam?

(i) A 25 mm square cross-section bar of length 300 mm carries an axial compressive load of 50 kN. Determine the stress in the bar and its change of length when the load is applied. For the bar material $E = 200$ GPa.

(j) A solid steel shaft A of 50 mm diameter rotates at 250 RPM. Find the greatest power that can be transmitted for a limiting shearing stress of 60 MPa in the steel.

SECTION-B

2. Attempt any three of the following: $(10 \times 3 = 30)$

(a) A log of wood 3 m long and 25 cm x 25 cm in cross section and specific gravity 0.78 floats in water. Determine the load that should be placed centrally on the log so that the log is just completely immersed in the water. Also draw shear force and bending moment diagram for the log.
(b) A load of 100 kN is supported by a crane as shown in Figure. DAE is the cable which passes over a smooth pulley at A. Draw a free body diagram of the pulley A and hence find the forces in the cable, the tie AC and the jib AB of the crane. (Assume that the diameter of the pulley and the weight of the jib are both negligible.)

(c) A cantilever type cast-iron machine part is acted upon by the 3 kN.m couple at the free end in the counterclockwise direction. If the modulus of elasticity for the material is 165 GPa, determine (a) the maximum tensile and compressive stresses in the casting, (b) the radius of curvature of the casting. The cross section of the machine part is given in the figure.
(d) A crank OA of a reciprocating engine is 150 mm long and rotates at 200 rpm. The connecting rod is 700 mm long. Determine the angular velocity of the connecting rod and the velocity of the piston when the crank angle is $45^\circ$ with horizontal.

(e) Calculate the polar moment of inertia of the shaded area about point O.

SECTION–C

3. Attempt any two of the following: (5×2=10)

(a) A square plate shown in figure is in equilibrium. Find the values of $F_1$, $F_2$ and $\theta$. 
(b) Determine the force $P$ required to move the uniform 800 N plank from its position of rest as shown in figure, if the coefficient of friction at both contact locations is 0.4.

(c) A wedge is used to level a structure. All contact surfaces have coefficients of static and kinetic friction of 0.3 and 0.25, respectively, and $W = 500$ N. Assume the dimensions of the wedge are small. Determine the value of $P$ to cause impending motion of the wedge to the left.

4. Attempt any two of the following: \hspace{1cm} (5 \times 2=10)

(a) Locate the centroid of area under curve $x = ky^3$ from $x = 0$ to $x = a$. 

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(b) Determine the area moment of inertia for the given triangular area about x axis.

(c) Determine the mass moment of inertia of a right circular cone about its longitudinal axis.

5. Attempt any one of the following: (10×1=10)

(a) Determine the force in each member of the truss and state if the member is in tension or compression. Take P = 5 kN.

(b) Develop the shear force and bending moment diagram from the simply supported beam shown in figure. Also calculate the shear force and bending moment at point C.
6. Attempt any two of the following: \((5 \times 2 = 10)\)

(a) A slender bar 5 m long is rotated in a horizontal plane about vertical axis through one end. It accelerates uniformly from 800 rpm to 1200 rpm in 4 s. What is the linear velocity of its midpoint at the beginning and end of time interval? Determine the normal and tangential acceleration of the midpoint of the bar 3 s after the commencement of the acceleration.

(b) Using D'Alembert's principle determine the tension in the string and acceleration of the blocks A and B weighing 1200 N and 400 N connected by a string as shown. Assume pulleys are frictionless.

(c) A wagon weighing 90 kN moving at 18 kmph strikes a pair of buffer springs. If the stiffness of each spring is 600 kN/m, determine the maximum compression of the spring before the wagon comes to rest.
7. Attempt any two of the following: 

(a) Two solid cylindrical rods AB and BC are welded together at B and loaded as shown. If the average normal stress must not exceed 175 MPa in rod AB and 150 MPa in rod BC, determine the smallest allowable values of \( d_1 \) and \( d_2 \).

(b) Stating the assumptions used in simple bending theory derive the expression for the bending of a beam having circular cross section of diameter \( d \).

(c) A hollow shaft has to transmit 16 kW at 150 rev/min. The maximum allowable stress is not to exceed 60 MPa nor the angle of twist 0.3° per meter length of shaft. If the outside diameter of the shaft is 300 mm find the minimum thickness of the hollow shaft to satisfy the above conditions. Take \( G = 80 \) GPa.