THE OPEN UNIVERSITY OF SRI LANKA
FACULTY OF ENGINEERING TECHNOLOGY
FINAL EXAMINATION -2005

MEU3302- APPLIED MECHANICS AND STRENGTH OF MATERIALS

DATE : 12 TH MARCH 2006
TIME : 0930 – 1230 HRS
DURATION : THREE HOURS

033

ANSWER ANY FIVE (05) QUESTIONS. ALL QUESTIONS CARRY EQUAL MARKS.

QUESTION 01

Fig. Q1 shows a link mechanism in which the link OA rotates about the fixed point O in an anticlockwise direction at 10 rad/s and the link ABC pivots about the fixed point B. The lengths of the various links are, OA = 75 mm, OB = BC = 150 mm, CD = 300 mm. For the position shown:

(a) Draw the configuration diagram to a suitable scale.

(b) Draw the velocity diagram and determine the angular velocity of link ABC, and the velocity of the slider D.

(c) Draw the relevant portion of the acceleration diagram and determine the angular acceleration of link ABC.

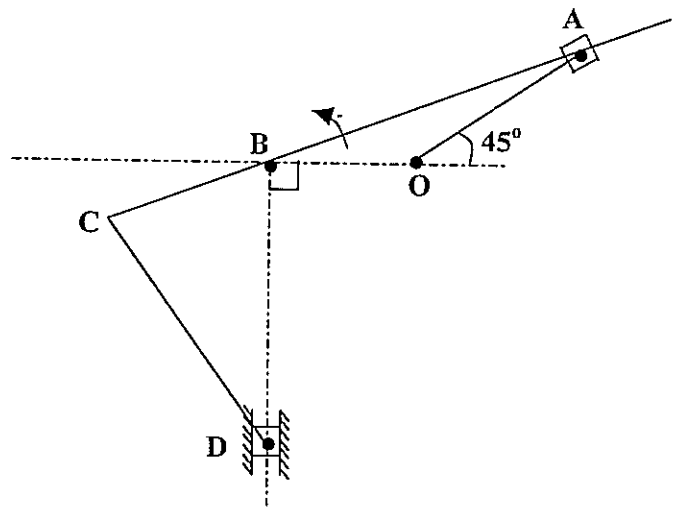


Fig. Q1

QUESTION 02

Starting from first principles show that the gyroscopic couple (C) acting on a disc rotating about an axis normal to the plane of the disc and precessing about a perpendicular axis can be expressed as

$$C = I\,\omega\,\Omega$$

where I – moment of inertia of the disc about the axis of rotation
ω – angular velocity of rotation of the disc
Ω – angular velocity of precession.

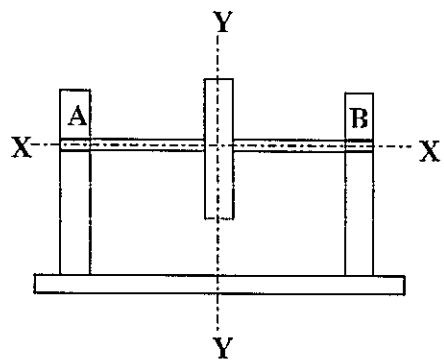


Fig. Q2

A circular disc of mass 10 kg and radius of gyration 120 mm is attached at the mid span of a shaft, which is mounted in bearings A and B as shown in Fig. Q2. The disc spins about its axis XX (horizontal) with a constant angular velocity of 1200 rev/min in a clockwise direction when viewed from the left bearing A. The shaft precesses uniformly about the vertical axis YY at an angular velocity of 100 rev/min in an anticlockwise direction when viewed from top. If the distance between the bearings is 225 mm, find the magnitude and direction of resultant reaction at each bearing.

QUESTION 03

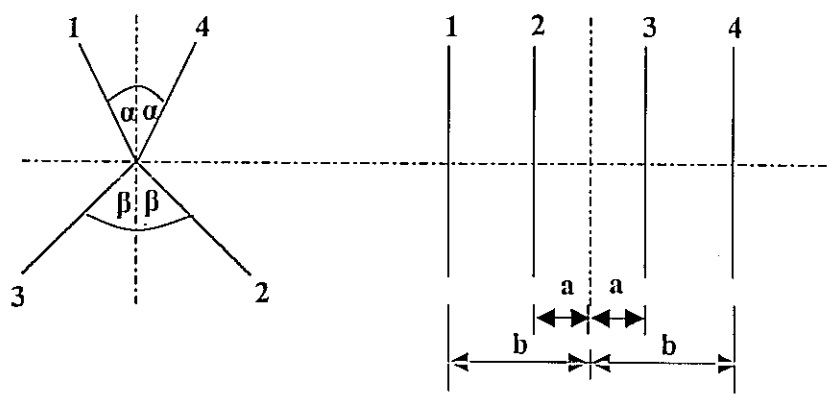


Fig. Q3

The crank arrangement of a vertical four cylinder in-line engine is shown in Fig. Q3. The reciprocating mass at each of the outer cylinders 1 and 4 is 10 kg and that at each of the inner cylinders 2 and 3 is 12 kg. All cylinders have identical crank radii and their connecting rods too are of the same length. Determine the angles α, β and the ratio (b/a) if the engine is balanced for primary forces, secondary forces and secondary moments.

QUESTION 04

A machine of total mass M is mounted on vibration isolators consisting of springs of combined stiffness K connected in parallel with a viscous damper having a damping ratio β. The machine produces a harmonic disturbing force $P \cos \omega t$, where P is the amplitude of the force and ω is the frequency. Show that the amplitude of the force transmitted to the foundation at steady state is

$$P\left[\frac{1+(2\beta r)^2}{(1-r^2)^2+(2\beta r)^2}\right]^{1/2}$$

where $r = \omega/\omega_n$ and $\omega_n = (K/M)^{1/2}$.

If $M = 150$ kg, $\beta = 0.3$ and $\omega = 20$ Hz, what should be the total stiffness of the springs to limit the transmissibility ratio to 0.1.

You may assume that the linear displacement x of the machine at steady state is

$$x = \frac{P}{K}\eta\cos(\omega t - \phi) \text{ where } \eta = \left[(1-r^2)^2 + (2\beta r)^2\right]^{1/2}, \text{ and } \phi = \tan^{-1}\left[2\beta r/(1-r^2)\right]$$

QUESTION 05

Fig. Q5 shows the arrangement of five rotors having moments of inertia I_1, I_2, I_3, I_4 and I_5. The torsional stiffnesses of the corresponding shaft sections are marked as K_1, K_2, K_3, and K_4.

If $I_1 = 10$ kg m^2, $I_2 = 20$ kg m^2, $I_3 = 30$ kg m^2, $I_4 = 40$ kg m^2, $I_5 = 50$ kg m^2,
$K_1 = 1.5 \times 10^4$ Nm/rad, $K_2 = 4.2 \times 10^4$ Nm/rad, $K_3 = 9.2 \times 10^4$ Nm/rad
and the natural frequency of torsional vibration of the system is $(30/\pi)$ Hz, determine the value of K_4 using Holzer method.

If the section of the shaft having stiffness K_4 is a circular shaft of length 125 mm and it is made out of a material having rigidity modulus 80 GN/m^2, determine its diameter in mm.

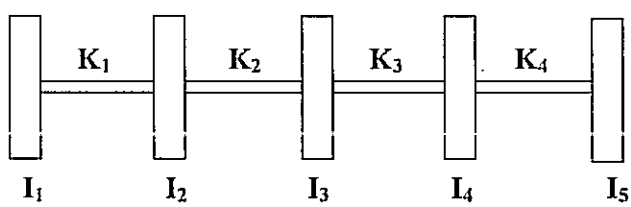


Fig. Q5

QUESTION 06

A circular shaft 0.2m diameter is subjected to combined bending and twisting moments, the bending moment being three times the twisting moment. If the direct tension yield-point of the material is 350 MN/m^2 and the factor of safety on yield is to be 5, calculate the allowable twisting moment by the three following theories of elastic failure; (a) maximum principle stress theory; (b) maximum shearing stress theory; (c) Shear strain energy theory.

QUESTION 07

A thick- walled cylinder 0.2m internal diameters, is to contain fluid at a pressure of 50 MN/m^2. Find the necessary thickness if the maximum shearing stress is not to exceed 100 MN/m^2. What will then be the greatest and least values of the hoop stress in the material?
If the inner surface becomes corroded and the cylinder has to be re-bored, by how much can the inside diameter be increased without raising by more than 5 per cent the maximum shearing stress induced by the same internal pressure?

QUESTION 08

A cantilever consists of a 60mm x 60mm x10 mm angle with the top face AB horizontal, as shown in Fig Q8. It carries a load of 800N at a distance of 1m from the fixed end, the line of action of the load passing through the centroid of the section and inclined at 30^0 to the vertical.

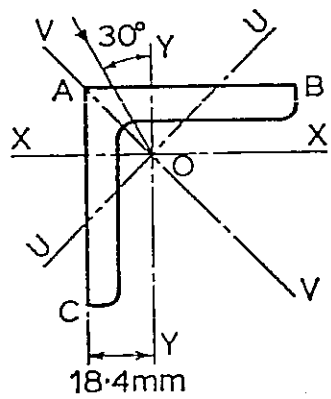


Fig Q8

Determine the stress at the corners A, B and C at the fixed end and also the position of the neutral axis.
For the beam Ixx =Iyy = 0.3488 x 10^{-6} m^4;
Iuu = 0.1472 x 10^{-6} m^4;
Ivv = 0.5506 x 10^{-6} m^4;

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