(4)

Programme: B.Sc. in Mechanical Engineering, BSc in Industrial and Production Engineering, BScTE (2 Year Programme), DTE (1 Year Programme)

Semester: Fourth Semester

03 May, 2023 (Morning)

Time: 10:00 AM -1:00 PM

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)

ORGANISATION OF ISLAMIC COOPERATION (OIC)

DEPARTMENT OF MECHANICAL AND PRODUCTION ENGINEERING

FINAL SEMESTER EXAMINATION — SUMMER SEMESTER: 2021-2022

Course Number: ME-4403 — FULL MARKS : 150

Course Name: Mechanics of Materials — TIME : 3.0 Hours

There are **Six** Questions. Answer **All** of them.

Figures in the Right Margin indicate full marks. CO and POs of the corresponding questions are written in the right most margin. (Assume reasonable value of any data missing)

Programmable calculators are not allowed. Do not write on this question paper.

1.	a)	Derive the expression of the critical (buckling) load for one end fixed and the other end hinged column.	(12)	PO1 PO2 CO1 CO2
	b)	A 15 m column with fixed ends supports an axial load of 1500 kN. Determine the slenderness ratio for the long column, the corresponding value of radius of gyration and the moment of inertia if the crushing stress is 240 MPa and modulus of elasticity E=200 GPa.	(13)	PO2 CO2
2.		A material is subjected to two mutually perpendicular strains, $\varepsilon_x = 200 \times 10^{-6}$ and $\varepsilon_y = -56 \times 10^{-6}$, together with an unknown shear strain γ_{xy}. If the principal strain in the material is 244×10^{-6}, determine using Mohr's strain and stress circles: i) The magnitude of that unknown shear strain; ii) The other principal strain; iii) the direction of the principal strain axes; iv) The magnitude of the principal stresses if E=220 GPa and ν=0.3.	(25)	PO2 CO2
3.		A solid circular steel shaft is subjected to a bending moment of 450 Nm and a torque of 250 Nm. Determine the shaft diameter using a) the maximum normal stress theory, b) the maximum shear stress theory and c) the maximum distortion energy theory. Take yield strength of the shaft material is 300 MPa and factor of safety is 2.0 based on yield strength. Finally recommend the value of thickness with explanations from the above results.	(25)	PO3 PO6 CO3
4.		At a certain point in a piece of material there are two planes at right angles to one another on which there are shearing stresses of 150 MN/m^2 together with normal stresses of 300 MN/m^2 tensile on one plane and 150 MN/m^2 tensile on other plane. If the shear stress on the 150 MN/m^2 planes is taken as clockwise in effect determine for the given point using Mohr's circle: i) the magnitudes of principal stresses; ii) the inclinations of the principal planes; iii) the maximum shear stress and the inclinations of the of the planes on which it acts; iv) the normal and shear stress act on the inclination of the plane which is 30^0 counter clockwise from the maximum principal stress.	(25)	PO2 CO2
5.	a)	A steel cylinder of 1 m long of 150 mm internal diameter and plate thickness 5 mm, is subjected to an internal pressure of 7 MPa; the increase in volume owing to the pressure is 16.8×10^{-6} m^3. Determine the values of Poisson's ratio and the modulus of rigidity. Assume E=210 GPa.	(12)	PO2 CO2

b) A spherical vessel of 1.7 m diameter is made from 12 mm thick plate, and it is to be subjected to a hydraulic test. Determine the additional volume of water which it is necessary to pump into the vessel, when the vessel is initially just filled with water, in order to raise the pressure to the proof pressure of 11.6 MPa. The bulk modulus of water is 2.9 GPa. For the material of the vessel, E = 200 GPa, ν =0.3. (13) PO2 CO2

6. a) Derive the relationship between the elastic constants of Young's modulus (E), Modulus of rigidity (G) and Poisson's ratio ν as $E = 2G(1+\nu)$. (10) PO1 CO1

b) Power is transmitted from a solid circular steel shaft AB of diameter 75 mm to a solid circular steel shaft CD of diameter 55 mm through a pair of gears E and F shown in Fig.1. Considering only the stresses due to twisting, determine the maximum torque T that can be transmitted if the maximum shearing stress is limited to 60 MPa for each of the shafts. (15) PO2 CO2

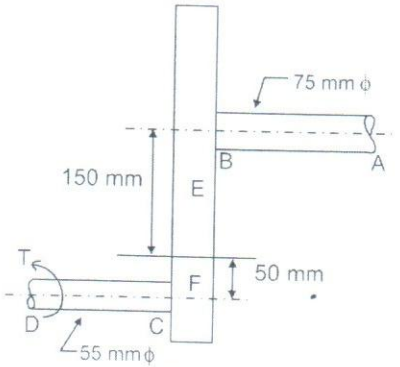

Fig. 1

Related Equations:

Distortion energy theory:

$$(\sigma_1-\sigma_2)^2+(\sigma_2-\sigma_3)^2+(\sigma_3-\sigma_1)^2=2\sigma_y^2$$

Maximum total strain theory:

$$\sigma_1^2+\sigma_2^2+\sigma_3^2-2\nu(\sigma_1\sigma_2+\sigma_2\sigma_3+\sigma_3\sigma_1)=\sigma_y^2$$

Maximum Principal strain theory:

$$\sigma_1-\nu\sigma_2-\nu\sigma_3=\sigma_y$$

Relationship between elastic constants:

$$E=3K(1-2\nu) \qquad E=2G(1+\nu)$$

Principal stresses: σ_1 or σ_2 =

$$=\tfrac{1}{2}(\sigma_x+\sigma_y)\pm\tfrac{1}{2}\sqrt{[(\sigma_x-\sigma_y)^2+4\tau_{xy}^2]}$$

Relationship between Mohr's stress circle and strain circle:

$$\text{stress scale}=\frac{E}{(1-\nu)}\times\text{strain scale}$$

$$\text{radius of stress circle}=\frac{(1-\nu)}{(1+\nu)}\times\text{radius of strain circle}$$

Strain at an inclined angle θ:

$$\varepsilon_\theta=\tfrac{1}{2}(\varepsilon_x+\varepsilon_y)+\tfrac{1}{2}(\varepsilon_x-\varepsilon_y)\cos 2\theta+\tfrac{1}{2}\gamma_{xy}\sin 2\theta$$

Shear strain at an angle θ:

$$\tfrac{1}{2}\gamma_\theta=\tfrac{1}{2}(\varepsilon_x-\varepsilon_y)\sin 2\theta-\tfrac{1}{2}\gamma_{xy}\cos 2\theta$$

Change of volume of thin cylinder and thin sphere are respectively:

$$\frac{pd}{4tE}(5-4\upsilon)V \text{ and } \frac{3pd}{4tE}(1-\upsilon)V$$

Symbols have their usual meanings.