BITS, PILANI - DUBAI CAMPUS
Knowledge Village, Dubai
I Semester 2006-07

Course No: ME UC392
Course title: Advanced Mechanics of Solids & Kinematics
Date: 12.11.06
Max Marks: 20
Test 2- Regular – Open Book
Duration: 50 Min
Weightage: 20%

Note: Assume any missing data.

Q1. For the cantilever beam shown in Fig. Q1, determine the maximum absolute value of flexural stress. P=1960 N.

[6]

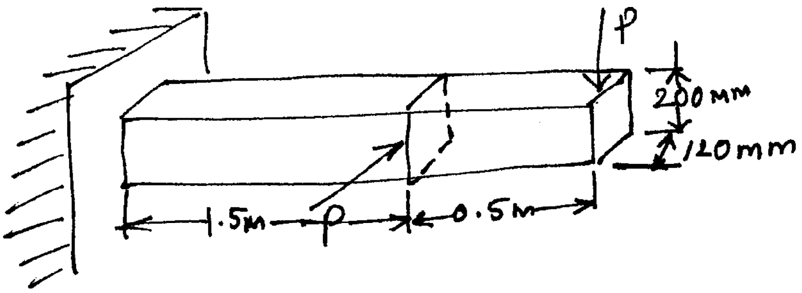

Fig Q1

Q2. For the channel section shown in the Fig. Q2, determine the
(i) moment of inertia of cross section
(ii) shear center
(iii) average and maximum value of shear stress in the web due to the force F_3.

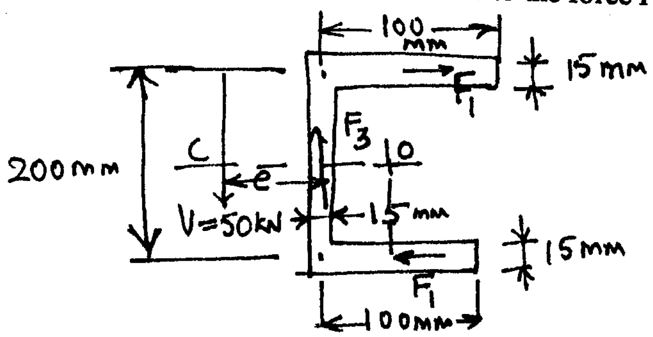

Fig Q2

[4]

Q3. Determine the ratio of the absolute value of σ_{max} and σ_{min} for a curved bar of rectangular cross section in pure bending if R=100 mm, and c-a=40 mm.

[4]

Q4. The curved beam in Fig. Q4 has a 50 mm square cross section and a radius of curvature R=50 m. The beam is (made of steel for which E=200 GPa) is subjected to a force P=5 kN. Determine the deflection of the free end of the curved beam in the direction of P.

[6]

Strain energy must include consideration of curvature.

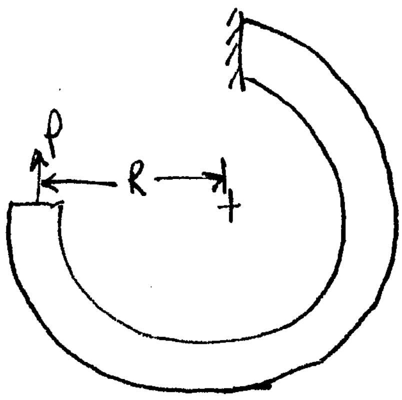

Fig Q4

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Knowledge Village, Dubai
I Semester 2006-07

A

Course No: ME UC392
Date: 02.11.06
Max Marks: 10

Course title: Advanced Mechanics of Solids & Kinematics
Quiz 2 - Regular

Duration: 30 Min
Weightage: 10%

Note: All questions carry equal marks

Name: **ID No:** **Section:**

Q1. A beam has a square cross section shown in Fig. Q1. The allowable flexural stress is σ_{zz}= *100 MPa.* The magnitude of elastic section modulus (S_x=I_x/y_{max}) is 177x10^3 mm^3. The maximum allowable bending moment M_x is ______

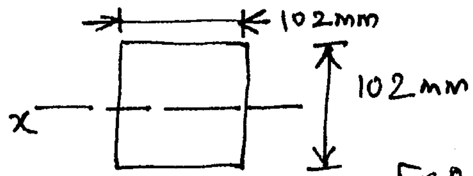


Fig Q1

Q2. The T section beam shown in Fig. Q2 is subjected to a positive bending moment M_x=1000 Nmm. The maximum tensile and compressive flexural stresses for the member are ______

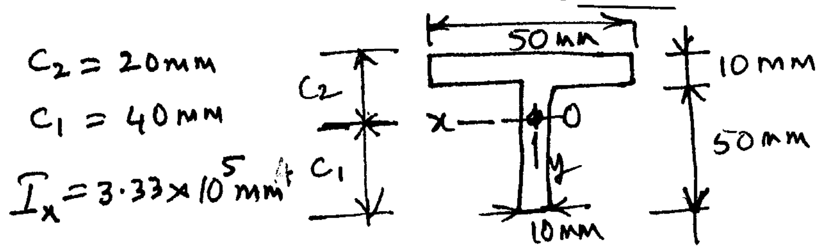


Fig Q2

Q3. For the problem in Q2, sketch the *distribution* of flexural stress σ_{zz} .

Q4. A cantilever beam shown in Fig. Q4 has a circular cross section of diameter 100 mm. The maximum flexural stress in the beam is ______

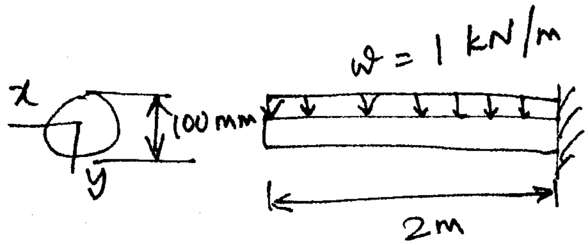
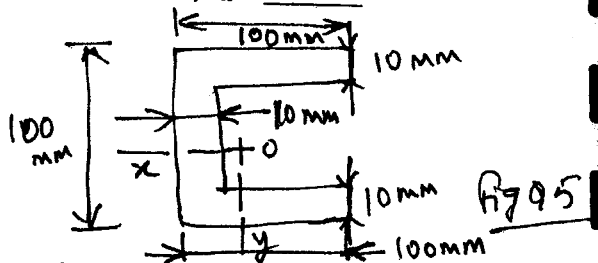


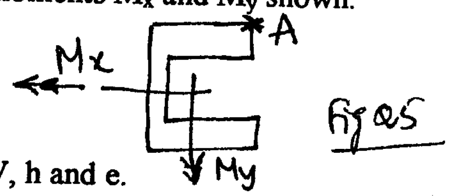
Fig Q4

Q5. A beam has a cross section shown in Fig. Q5. The moment of inertia, I_x= ______

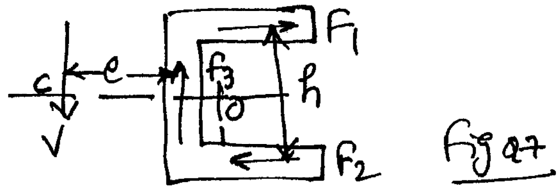


Q6. Indicate the nature of flexural stresses (tensile or compressive) occurring at the point A on the beam cross section shown in Fig. Q5, due to positive bending moments M_x and M_y shown.

Dimensions are same as shown in Q5.

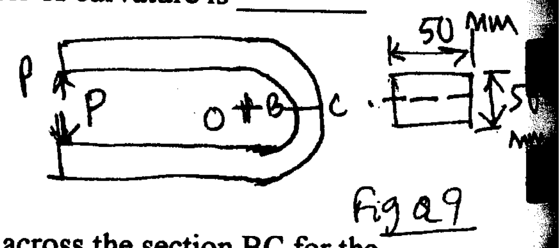


Q7. Locate the shear center for the Fig. Q7, in terms of F_1, F_2, F_3, V, h and e.



Q8. Justify your answer for the following statement: For bending of a beam by a concentrated force and for which the shear stresses are negligible, the line of action of the force must pass through the shear center of a cross section of the beam.

Q9. The frame shown in Fig. Q9 has a 50 mm by 50 mm square cross section. The load P=10 kN is located 100 mm from the center of curvature of the curved beam portion of the frame. The radius of curvature of the inner surface of the curved beam is 30 mm. For the curved beam portion of the frame, the distance of the neutral axis from the center of curvature is ______



Q10. Sketch the *distribution* of circumferential stress distribution across the section BC for the frame shown in Fig. 9.

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Knowledge Village, Dubai
I Semester 2006-07

B

Course No: ME UC392
Date: 21.09.06
Max Marks: 10
Note: All questions carry equal marks

Course title: Advanced Mechanics of Solids & Kinematics
Quiz 1 - Regular
Duration: 30 Min
Weightage: 10%

Name: ID No: Section:

Q1. Consider the displacements given by the following relations: $u=C_1x^2$, $v=C_2y^2$, $w=C_3z^2$, where (u, v, w) denote the (x,y,z) components of the displacement of P (x=1, y=1, z=2) to P*(x*=1.004, y*=1.002, z*=1.996). The magnitudes of C_1, C_2, C_3 are:

C_1= ____________,

C_2= ____________,

C_3= ____________

Q2. For the problem given in Q1, normal strain components at the point P in the direction of (x, y, z) axes are:

ε_{xx}= __________,

ε_{yy}= __________,

ε_{zz}= __________,

Q3. Consider a prismatic bar subjected to the following state of stress relative to the (x, y, z) axes, with the z axis directed along the longitudinal axis of the bar: $\sigma_{xx}= 0$, $\sigma_{yy}= 0$, $\sigma_{zz}= \sigma$, $\sigma_{xy}= 0$, $\sigma_{xz}= 0$, $\sigma_{yz}= 0$. The state of stress in the bar is one of simple tension. The normal strain components in the direction of (x, y, z) axes in terms of Young's modulus of elasticity and Poisson's ratio are:

ε_{xx}= __________,

ε_{yy}= __________,

ε_{zz}= __________,

Q4. For an isotropic material

1. principal axes of stress are coincident with principal axes of strain.

2. If the (x, y, z) axes are directed along the principal axes of strain, then $\varepsilon_{xy} = \varepsilon_{xz} = \varepsilon_{yz} = 0$, and $\sigma_{xy} = \sigma_{xz} = \sigma_{yz} = 0$

a) 1 is true, 2 is false

b) 1 is false, 2 is true

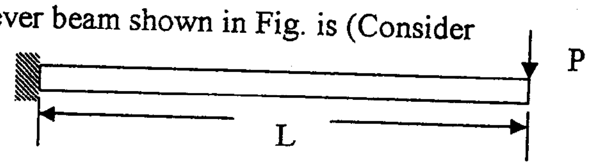
c) both 1 and 2 are true

d) none of the above

Ans. ________

Q5. The force – elongation relation for the spring carrying a weight W is $F=kx^2$. The displacement (q) of the weight W is ________

Q6. The deflection under load P of the cantilever beam shown in Fig. is (Consider only the strain energy resulting from the bending of the beam)



____

Q7. Consider the results of a simple tension test of a circular cylindrical bar that is subjected to an axial load.

1. $\varepsilon_t = \ln(1+\varepsilon)$

2. $\varepsilon_t = \ln\left(\frac{D_o}{D_t}\right)$

where ε_t=true strain, ε=engineering strain, D_o= initial diameter of the bar, D_t= true diameter of the bar.

a) 1 is true, 2 is false

b) 1 is false, 2 is true

c) both 1 and 2 are true

d) none of the above

Ans. ________

Q8. The stress components at a point are: σ_{xx}= 100 MPa, σ_{yy}= - 100 MPa, σ_{zz}= 0, σ_{xy}= 50 MPa, σ_{xz}= 0, σ_{yz}= 0. The normal stress on the plane defined by unit normal **N**: $(l=\frac{1}{\sqrt{2}}, m=\frac{1}{\sqrt{2}}, n=0)$ is ___________

Q9. The stress invariants are of the form:

$$I_1 = \sigma_1 + \sigma_2 + \sigma_3$$

$$I_2 = \sigma_1\sigma_2 + \sigma_2\sigma_3 + \sigma_3\sigma_1$$

$$I_3 = \sigma_1\sigma_2\sigma_3$$

The octahedral shear stress τ_{oct}= __________

Q10. The principal stresses at a point are σ_1= 100 MPa, σ_2= 0, σ_3= - 100 MPa. The maximum shear stress is ________

BITS PILANI DUBAI CAMPUS
Knowledge Village, Dubai
I Semester 2006-07

Course No: ME UC392
Course title: Advanced Mechanics of Solids & Kinematics
Date: 01.10.06 **Test 1- Regular** **Duration: 50 Min**
Max Marks: 20 **Weightage: 20%**

Q1. The known stress components at a point in a body, relative to the (x,y,z) axes, are σ_{xx}= *18 MPa*, σ_{yy}= *- 50 MPa*, σ_{zz}= *32 MPa*, σ_{xz}= *24 MPa*, σ_{xy}= σ_{yz}= *0*. Determine
(a) normal and shear stresses on a plane whose normal has the direction cosines: $l = m = n = \frac{1}{\sqrt{3}}$.
(b) the stress invariants I_1, I_2, I_3 relative to (x,y,z) axes and the principal stresses

[3+3]

Q2. Consider the displacement field given by the following relations: $u = C_1 y^2$, $v = C_2 yz$, $w = C_3 x^2$, where (*u, v, w*) denote the (*x,y,z*) components of the displacements and C_1 =0.01, C_2=0.03, C_3=0.06. When the body is deformed, the particle at P: (*x=1,y=0,z=2*) passes to the point P*: (*x*,y*,z**). Determine
(a) coordinates of the point P*.
(b) the strain components for the state of strain at point P.
(c) the normal strain at P in the direction of line PQ having direction cosines: $l = 0.6, m = 0, n = 0.8$

[1+3+1]

Q3. A plate in the side of a ship is made of an isotropic steel (E=200 GPa, and ν=0.3). The plate is subjected to a uniform state of stress (σ_{xx}= *100 MPa*, σ_{yy}= *- 20 MPa*, $\sigma_{zz}=\sigma_{xz}=\sigma_{xy}=\sigma_{yz}$= *0*). Determine
(a) the principal stresses and principal strains
(b) the maximum shear stress and maximum shear strain

[3+2]

Q4. The semicircular cantilever beam in Fig. Q4 has a radius of curvature R. It is subjected to load of magnitude P at B. Determine the vertical deflection at B in terms of P, modulus of elasticity E, radius of curvature R, and moment of inertia of cross section I. Neglect the strain energy due to axial and shear loads.

[4]

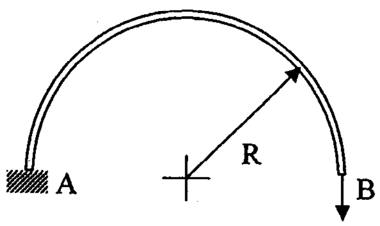


Fig. Q4

BITS, PILANI - DUBAI CAMPUS

First Semester 2006-07

COMPREHENSIVE EXAMINATION (CLOSED BOOK)

Course Name: Advanced Mechanics of Solids & Kinematics **Course No: ME UC392**
Date: 26.12.2006 **Weightage: 40%**
Max Marks: 40 **Duration: 3Hrs**

Q1. The displacements of a machine part are given by the following relations: $u = 0.00133xyz$, $v = 0.00066xyz$, $w = -0.00133xyz$, where u,v,w are the x, y, z components of displacements. What is the displaced position of a point P on the machine part originally at $x=1m$, $y=1m$, $z=2m$. Determine the state of strain $\varepsilon_{xx}, \varepsilon_{yy}, \varepsilon_{zz}, \gamma_{xy}, \gamma_{xz}, \gamma_{yz}$ at the point P. [4]

Q2. A plate (modulus of elasticity=200 GPa and Poisson's ratio=0.29) is subjected to plane strain ($\varepsilon_{zz} = \gamma_{xz} = \gamma_{yz} = 0$). If $\sigma_{xx} = \sigma_1 = 500$ MPa and $\varepsilon_{xx} = 2\varepsilon_{yy}$, determine the magnitude of $\sigma_{yy} = \sigma_2$, $\sigma_{zz} = \sigma_3$, assuming linearly elastic conditions. [4]

Q3. A curved beam shown in Fig. Q3 has a radius of curvature R and circular cross section of diameter d. It is subjected to load of magnitude P at B. Determine the deflection in the direction of P in terms of P (load), E (modulus of elasticity), R (radius of curvature), and I (moment of inertia of cross section). [5]

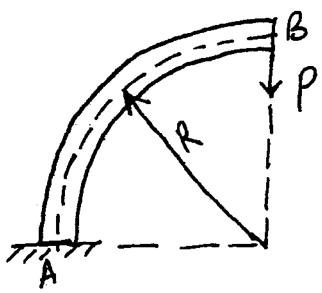


Fig. Q 3

Q4. A cantilever beam of rectangular cross section shown in Fig. Q4 is subjected to a load of 2000 N at the mid span, which is inclined at an angle of 30° to the vertical. What is the stress due to bending at the point D near its built in end? [4]

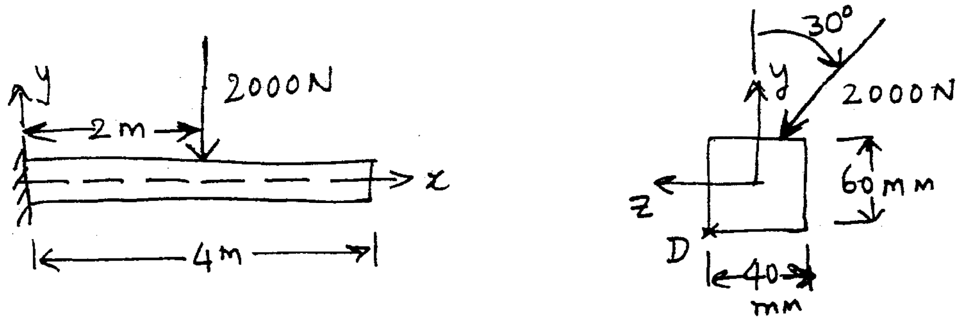


Fig Q4

Q5. The frame shown in Fig. Q5 has a 60 mm by 60 mm square cross section. The load P is located 120 mm from the center of curvature of the curved beam portion of the frame. The radius of curvature of the inner surface of the curved beam is a=40 mm. For P=10 kN, determine the values for the maximum tensile and compressive stresses in the frame.

[5]

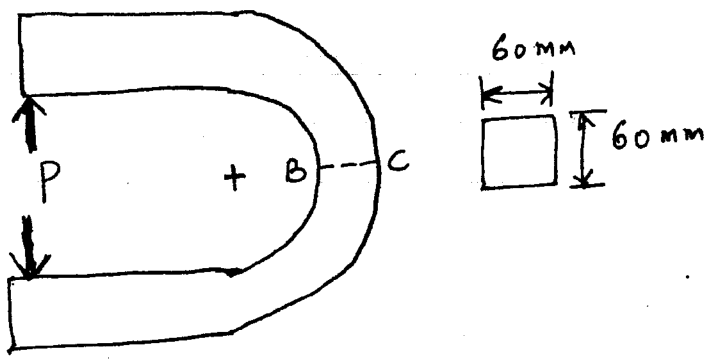


Fig Q5

Q6. A thick-wall cylinder is made of steel (modulus of elasticity=200 GPa and Poisson's ratio=0.29), has an inside diameter of 20 mm and an outside diameter of 80 mm. The cylinder is subjected to an internal pressure of 200 MPa. Determine the stress components σ_{rr} and $\sigma_{\theta\theta}$ at r=a=10 mm, and r=b=40 mm. [4]

Q7. Consider two semicircular disks made of steel of different radii pressed against each other. Justify whether the following statement is true or false: The location of maximum shear stress occurs at the center of surface of contact and not just beneath the surface of contact. [2]

Q8. **The four bar linkage shown in Fig. Q8, with all necessary dimensions, is driven by crank 2 at a constant angular velocity of ω_2= 900 rev/min ccw. Find the angular velocities of links 3 and 4 at the position shown.** **[4]**

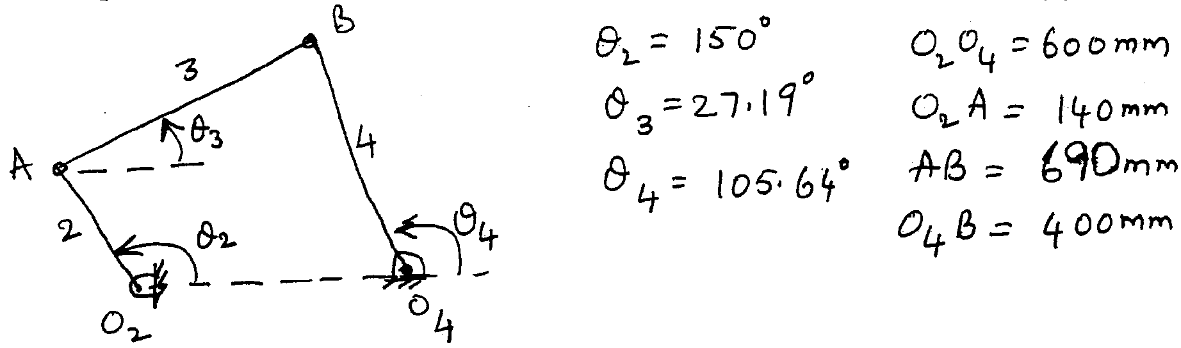


Fig Q8

Q9. **The simple epicyclic gear train is shown in Fig. Q9. Let the angular velocities of sun gear and arm be ω_2= 100 rev/min and ω_3 = 200 rev/min, respectively in both ccw direction. What is the angular velocity of internal ring gear 5?** **[4]**

Q10. **A plate cam with a reciprocating flat face follower is to rise, L=50 mm, with simple harmonic motion in β_1=180° of cam rotation and return with simple harmonic motion in the remaining β_2=180°. Determine the minimum prime circle radius to ensure that the radius of curvature of the cam is everywhere greater than 40 mm. The displacement equation for the full rise simple harmonic motion is:** $y = \frac{L}{2}\left(1 - \cos\frac{\pi\theta}{\beta_1}\right)$ **for** $0 \le \theta \le \beta_1$ **and the displacement equation for the full return simple harmonic motion is:** $y = \frac{L}{2}\left(1 + \cos\frac{\pi\theta}{\beta_2}\right)$ **for** $0 \le \theta \le \beta_2$.

[4]

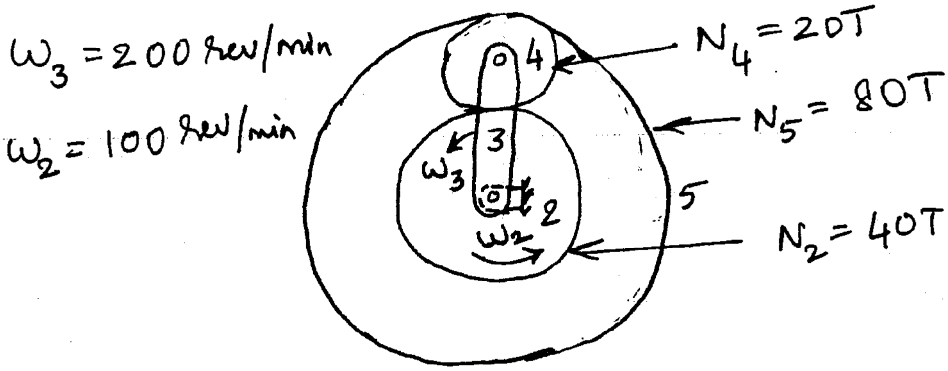


Fig. Q9