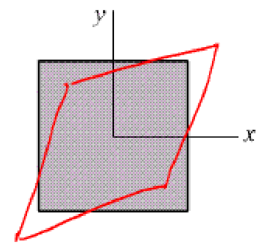
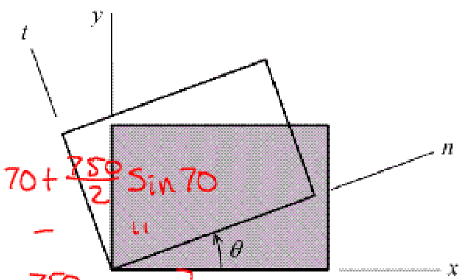
IDE 110 W08 Test 4 Name: Key

1. The strain components $\varepsilon_x = 520$ με, $\varepsilon_y = -650$ με, and $\gamma_{xy} = 750$ μrad are given for a point in a body subjected to plane strain.

a. (4 points) Sketch the deformed shape on the element to the right.



b. (9 points) Determine the strain components ε_n, ε_t, and γ_{nt} at the point if the nt-axes are rotated with respect to the xy-axes by $\theta = 35°$, as illustrated in the figure. Do not sketch the deformed shape of the element.



$\varepsilon_n =$ 487.5 με $= \frac{520-650}{2} + \frac{520+650}{2} \cos 70 + \frac{750}{2} \sin 70$

$\varepsilon_t =$ -617.5 με $=$ " $-$ " $-$ "

$\gamma_{nt} =$ -842.9 μrad $= 2\left[-\frac{520+650}{2} \sin 70 + \frac{750}{2} \cos 70\right]$

c. (14 points) Determine the angles θ_p and θ_s, principal strains, and maximum in-plane shear strain at the point. Do not sketch the deformed shapes of the element.

$\theta_p =$ 16.33 deg $= \frac{1}{2} \tan^{-1}\left(\frac{750}{520+650}\right)$

$\theta_s =$ -28.67 deg $= \theta_p \pm 45°$

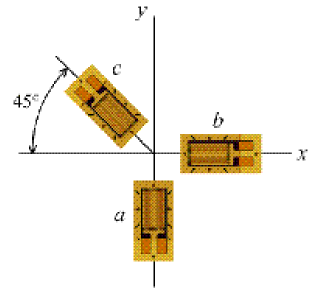
$\varepsilon_1 =$ 629.9 με

$\varepsilon_2 =$ -759.9 με

$\left.\right\} = \frac{520-650}{2} \pm \sqrt{\left(\frac{520+650}{2}\right)^2 + \left(\frac{750}{2}\right)^2}$

$\gamma_{max} =$ 1390 μrad $= 2\sqrt{\left(\frac{520+650}{2}\right)^2 + \left(\frac{750}{2}\right)^2}$

2. (10 points) The strain rosette shown in the figure was used to obtain normal strain data at a point on the free surface of a machine part. ε_a = 550μ, ε_b = -730μ, and ε_c = -375μ. Determine the strain components ε_x, ε_y, and γ_{xy} at the point.



ε_x = -730 με

ε_y = 550 με

γ_{xy} = 570 μrad

$$-375 = \frac{-730+550}{2} - \frac{730-550}{2}\overset{0}{\cancel{\cos}}\,-90 + \frac{\gamma_{xy}}{2}\overset{-1}{\cancel{\sin}}\,-90$$

3. (8 points) The strain components ε_x = 390μ, ε_y = 820μ, and γ_{xy} = -560μ are given for a point on the free surface of a machine component. The modulus of elasticity for the material is E = 73 GPa and the Poisson's ratio is ν = 0.30. Determine the stresses σ_x and τ_{xy} at the point.

σ_x = 51.02 MPa $= \frac{73E9}{1-.3^2}\left(390E{-6}+.3(820E{-6})\right)$

τ_{xy} = -15.72 MPa $= \frac{73E9}{2(1+.3)}(-560E{-6})$

4. (5 points) A spherical gas-storage tank with an inside diameter of 12 m is being constructed to store gas under an internal pressure of 1.75 MPa. The tank will be constructed from structural steel that has a yield strength of 250 MPa. If a factor of safety of 3.0 with respect to the yield strength is required, determine the minimum wall thickness required for the spherical tank.

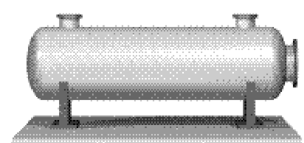
t_{min} = ___63___ mm

$$\sigma = \frac{1.75E6(6)}{2t} \le \frac{250E6}{3}$$

5. (5 points) A cylindrical boiler with an outside diameter of 3.60 m and a wall thickness of 40 mm is made of a steel alloy that has a yield stress of 415 MPa. Determine the maximum normal stress produced by an internal pressure of 2 MPa.

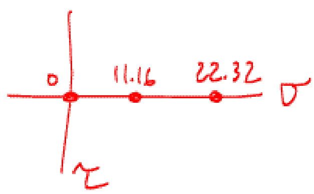
σ_{max} = ___88___ MPa $= \dfrac{2E6(1.76)}{.04}$

6. A closed cylindrical vessel contains a fluid at a pressure of 720 psi. Assume σ_{hoop} = 22.32 ksi and σ_{axial} = 11.16 ksi. Determine:



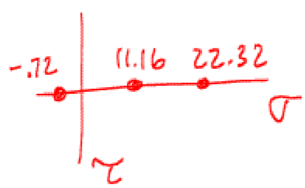
a. (4 points) the absolute maximum shear stress on the outer surface of the cylinder.

τ $\cancel{\sigma}_{abs\ max}$ = ___11.16___ ksi

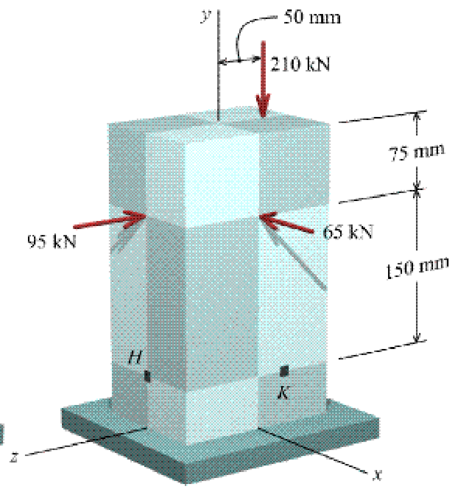


b. (4 points) the absolute maximum shear stress on the inner surface of the cylinder.

τ $\cancel{\sigma}_{abs\ max}$ = ___11.52___ ksi



7. (9 points) Three loads are applied to the short rectangular post. The cross-sectional dimensions of the post are shown.



a. Using the positive sign convention shown, determine the following internal forces and moments acting on a *x*-*z* plane through points *H* and *K*.

F_x = -65 kN

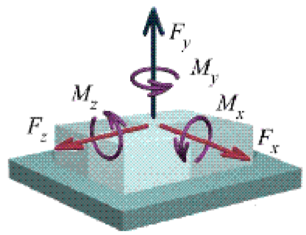
F_y = -210 kN

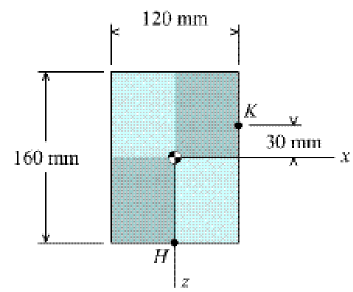
F_z = -95 kN

M_x = -24.75 kN-m

M_y = 0 kN-m

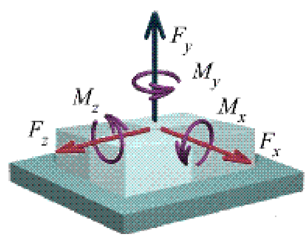
M_z = 9.75 kN-m





b. (14 points) For the following loadings, determine the normal and shear stresses at point *H*.

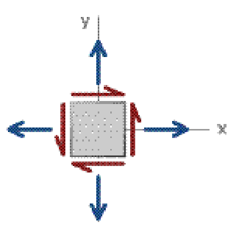
F_x = 48 kN
F_y = 0 kN
F_z = 73 kN
M_x = 3 kN-m
M_y = 0 kN-m
M_z = -2.5 kN-m



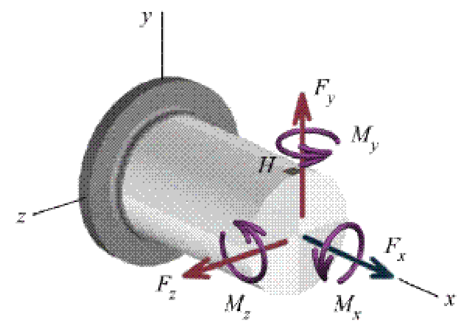
σ_x = 0 MPa

σ_y = -5.859 MPa $= \dfrac{-3000(.08)}{.12(.16)^3/12}$

τ_{xy} = 3.75 MPa $= \dfrac{48{,}000(.03)(.06)(.16)}{\frac{.16(.12)^3}{12}(.16)}$



9. (14 points) A solid steel crank has an outside diameter of 30 mm. For the following loadings, determine the normal and shear stresses on the top surface of the crank at point *H*.



$F_x = 2350$ N
$F_y = -1275$ N
$F_z = 0$ N
$M_x = 204$ Nm
$M_y = 376$ Nm
$M_z = 0$ Nm

σ_x = 3.325 MPa $= \dfrac{2350}{\frac{\pi}{4}(.03)^2}$

σ_z = 0 MPa

τ_{xz} = -38.48 MPa $= \dfrac{-204(.015)}{\frac{\pi}{32}(.03)^4}$