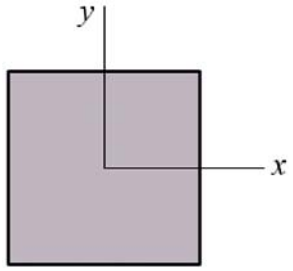
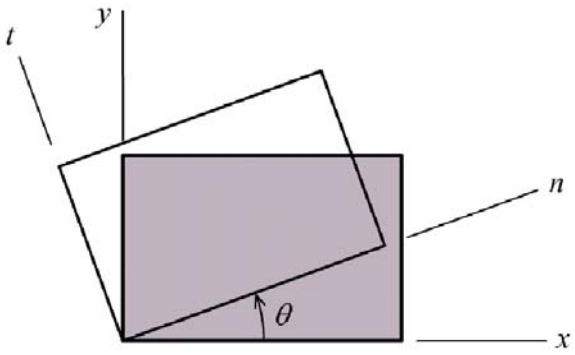
1. The strain components $\varepsilon_x = 520\ \mu\varepsilon$, $\varepsilon_y = -650\ \mu\varepsilon$, and $\gamma_{xy} = 750\ \mu\text{rad}$ are given for a point in a body subjected to plane strain.

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.



ε_n = _____ με

ε_t = _____ με

γ_{nt} = _____ μrad

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.

θ_p = _____ deg

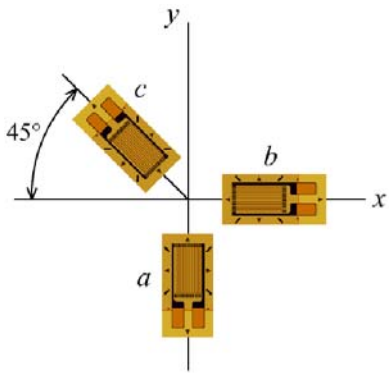
θ_s = _____ deg

ε_1 = _____ με

ε_2 = _____ με

γ_{max} = _____ μrad

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 = _____ με

ε_y = _____ με

γ_{xy} = _____ μrad

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 = _____ MPa

τ_{xy} = _____ MPa

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} = _____ mm

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} = _____ MPa

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:

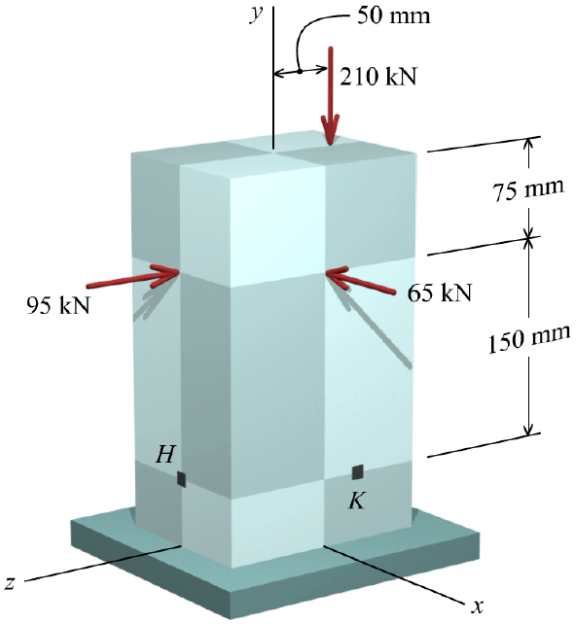
a. (4 points) the absolute maximum shear stress on the outer surface of the cylinder.

$\tau_{abs\ max}$ = _____ ksi

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

$\tau_{abs\ max}$ = _____ 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 = _____ kN

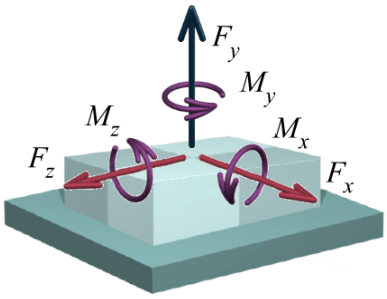
F_y = _____ kN

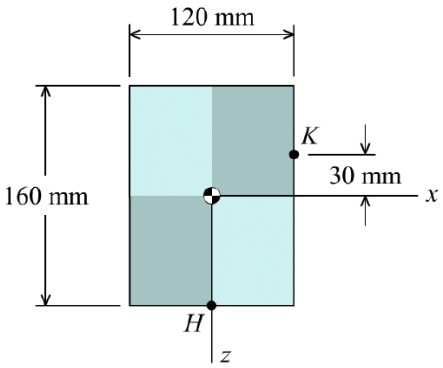
F_z = _____ kN

M_x = _____ kN-m

M_y = _____ kN-m

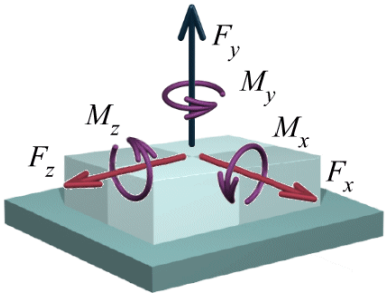
M_z = _____ kN-m





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

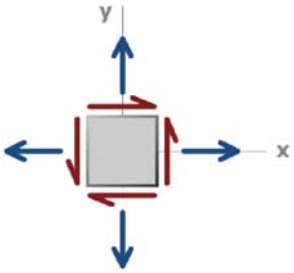
F_x = 48 kN
F_y = 0 kN
F_z = 73 kN
M_x = 3 kN-m
M_y = 0 kN-m
M_z = -2.5 kN-m



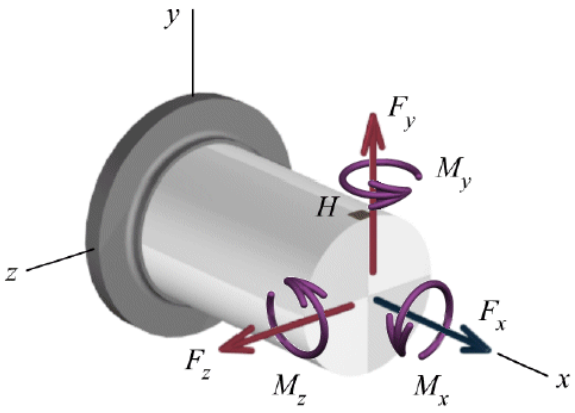
σ_x = _____ MPa

σ_y = _____ MPa

τ_{xy} = _____ MPa



8. (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

$\sigma_x =$ _____ MPa

$\sigma_z =$ _____ MPa

$\tau_{xz} =$ _____ MPa