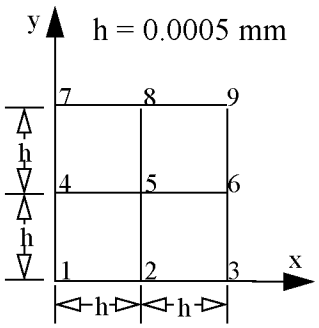
EXAM 1 MEEM 4150 Feb. 24, 2015

1.

(i) The displacement field in an elastic body is given by: $u = 0$ $v = Kx(y^2 - z^2) + Kaxz$ $w = -2Kxyz - Kaxy$ where u, v, and w are displacements in the x, y, and z directions, respectively. Determine the shear strain γ_{yz} at $x = 2a$ in terms of K, a, y, and z.

(ii) The displacements u and v in the x and y directions respectively were measured by Moire' interferometry. Displacements of 9 points on the body and are as given below. Determine the shear strain γ_{xy} at point 6.

Point	u (μmm)	v (μmm)	Point	u (μmm)	v (μmm)
1	0.000	0.000	6	-0.080	0.240
2	-0.112	0.144	7	0.128	0.384
3	-0.128	0.256	8	-0.048	0.336
4	0.112	0.176	9	0.128	0.384
5	-0.032	0.224			



To answer parts *(iii)* through *(v)*, use modulus of elasticity of 30,000 ksi, Poisson's ratio of 0.25, and angle of the seam The as 30° to the axis of the shaft.

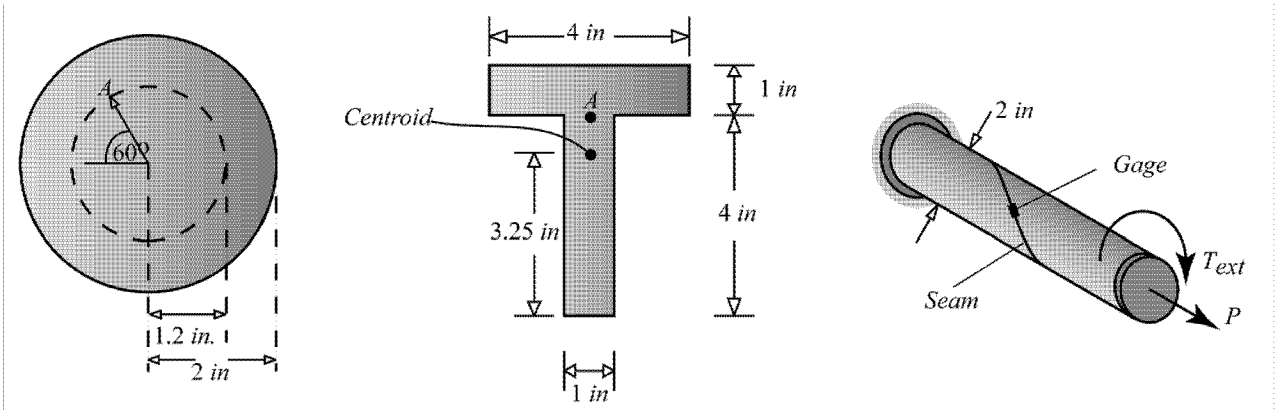


Figure (*a*) Figure (*b*) Figure (*c*)

(iii) In Figure (*a*), the maximum torsional shear *strain* on the solid circular cross-section was found to be 0.0015. Determine the torsional shear *stress* at point A.

(iv) In Figure (*b*), the bending normal *strain* at point A on the cross-section of a beam was found to be 0.00015. Determine the maximum bending normal *stress* in the cross-section.

(v) In Figure (*c*), for $P = 9\pi$ kips and $T_{ext} = 12\pi$ in-kips, determine the *strain* recorded by the strain gage.

2.

The stress matrix at a point, the three principal stresses of the matrix, and material property are given below. Use this information to answer parts (i) through *(vi)*.

$$\begin{bmatrix} 17.5 & -10.607 & -12.5 \\ -10.607 & 5 & -10.607 \\ -12.5 & -10.607 & \sigma_{zz} \end{bmatrix} \text{ ksi}$$

$\sigma_1 = 30$ ksi(T)
$\sigma_2 = 20$ ksi(T)
$\sigma_3 = 10$ ksi(C)

Modulus of Elasticity = 30,000 ksi
Poisson's ratio=0.25
Yield Stress = 60 ksi
Critical stress intensity factor =22 ksi$\sqrt{\text{in.}}$

(i) The third stress invariant is ----------

(ii) The stress σ_{zz} is ----------

(iii) The principal *strain* one is ----------

(iv) The factor of safety to avoid yielding using maximum shear stress theory is ----------

(v) The factor of safety to avoid yielding using maximum octahedral shear stress theory is ----------

(vi) The critical crack length in Mode I is ----------

In parts *(vii)* through *(xi)* **circle** the correct answer.

(vii) Stress components have opposite signs on the two surfaces of an imaginary cut.

TRUE / FALSE

(viii) In Lagrangian strain, the original geometry is used as reference geometry.

TRUE / FALSE

(ix) The normal strain will be positive if the left end of a rod moves more than the right end in the negative x direction.

TRUE / FALSE

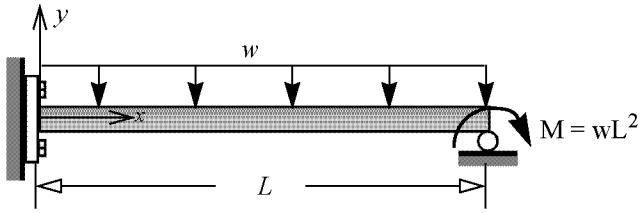
(x) The most general anisotropic material needs 36 independent constants to relate the six independent stress components to the six independent strain components at a point.

TRUE / FALSE

(xi) Principal directions for stress and strain are same for orthotropic material.

TRUE / FALSE

3. (*i*) For the beam and loading shown, *write the boundary value problem* for determining the deflection v(x). (*ii*) Determine the slope at $x = L$. (*iii*) The direction and value of reaction force and moment at $x = 0$. Report your answers in terms of w, L, E and I.



ANSWERS

1. (i) $\gamma_{yz} = -8Kaz$; (ii) $\gamma_{xy} = 288\ \mu$; (iii) $\tau_A = 10.8$ ksi (iv) $\sigma_{max} = 19.5$ ksi (C) (v) $\varepsilon_{gage} = -660\ \mu$

2. (i) $I_3 = -6000$ ksi^3 ; (ii) $\sigma_{zz} = 17.5$ ksi (T) ; (iii) $\varepsilon_1 = 916.7\ \mu$; (iv) $K = 1.5$; (v)$K = 1.66$; (vi) $2a = 0.342$ inch ; (vii) FALSE; (viii) TRUE ; (ix) TRUE (x) FALSE; (xi) FALSE

3. $\frac{dv}{dx}(x = L) = -\left(\frac{11wL^3}{48EI}\right)$; $R_{wall} = (7wL)/8$ DOWN; $M_{wall} = (3wL^2)/8\ CW$;