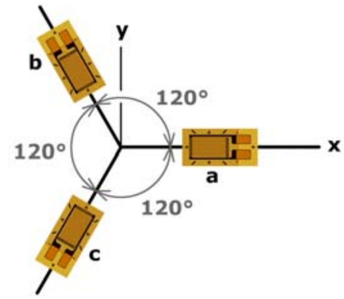
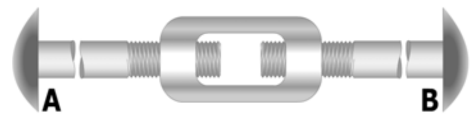
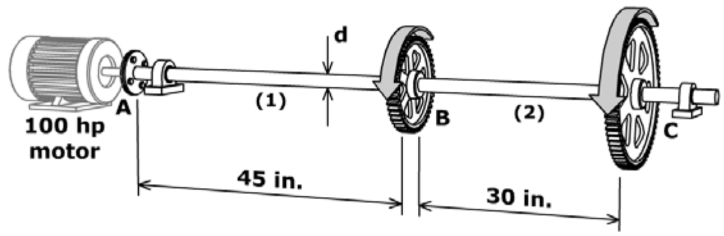


1. The following strains were measured from the strain gage rosette shown:
   ε_a = -555 με ε_b = +925 με ε_c = +740 με
   If Poisson's ratio is ν = 0.3,
   (a) Determine the principal strains. [ε_1 = 1,301 με, ε_2 = -561 με]
   (b) Determine the maximum shearing strain [γ_{max} = 1,862 μrad]
   (c) Determine the angle from the x axis to the largest tensile principal strain. [θ = 86.7° cw]

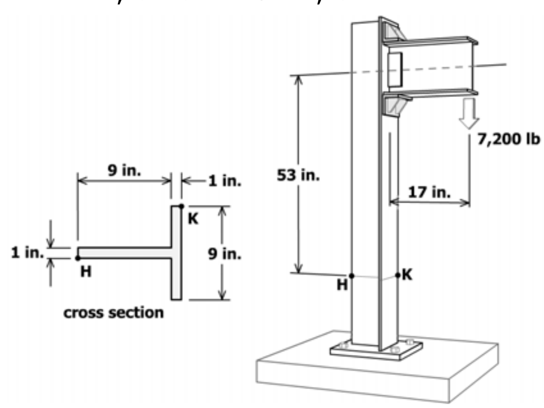
2. A steel tie rod [E = 200 GPa; α = 11.9×10^{-6}/°C] containing a rigid turnbuckle is attached to rigid walls. During the summer when the temperature was 30°C, the turnbuckle was tightened to produce a tension stress in the tie rod of 15 MPa. The elastic strength for the steel is 250 MPa and the ultimate strength is 450 MPa. A factor of safety of 2 is required with respect to the elastic strength, and a factor of safety of 4 is required with respect to the ultimate strength. Is the tie rod overstressed in the winter when the temperature is –10°C? Show justification for your answer. [σ = 110.2 MPa; $FS_{elastic}$ = 2.27; FS_{ult} = 4.08; not overstressed]



3. A motor delivers 100 hp at 600 rpm to the end of a shaft. The gears at B and C take out 40 hp and 60 hp, respectively. Determine the minimum diameter **d** required for the shaft if the allowable shear stress is 7,000 psi and the angle of twist between the motor and gear C is limited to 2°. Assume G = 12 × 10^{6} psi. [Note: 1 hp = 550 lb-ft/s]
   [T_1 = 875.35 lb-ft; T_2 = 525.21 lb-ft; based on shear stress, d_{min} = 1.970 in.; based on angle of twist, d_{min} = 2.003 in.; therefore, d_{min} = 2.00 in.]

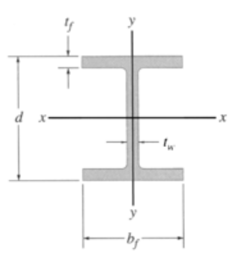


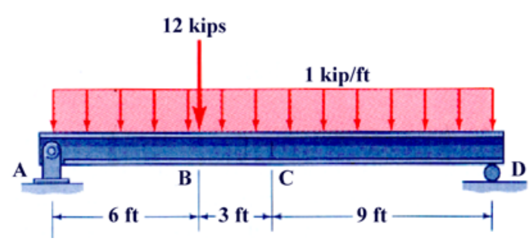
4. The tee-shaped column supports the loading shown. Determine the normal stresses at points H and K. [centroid is located 3 in. to the left of point K; moment of inertia = 174 in^4; area = 18 in^2; distance from centroid to 7,200 lb force is 20 in.; moment at section of interest is (7,200 lb)(20 in.) = 144,000 lb-in; axial force at section of interest is 7,200 lb (C).
   At point H, bending stress is 5,793 psi (T) and axial stress is 400 psi (C); therefore, normal stress at H = 5,393 psi (T).
   At point K, bending stress is 2,483 psi (C) and axial stress is 400 psi (C); therefore, normal stress at K = 2,883 psi (C).]



Wide-Flange Sections or W Shapes

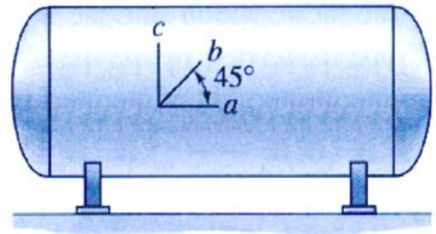
Designation	Area A	Depth d	Web thickness t_w	Flange width b_f	Flange thickness t_f	x–x axis I	x–x axis S	x–x axis r	y–y axis I	y–y axis S	y–y axis r
in. × lb/ft	in^2	in.	in.	in.	in.	in^4	in^3	in.	in^4	in^3	in.
W14 × 53	15.6	13.92	0.370	8.060	0.660	541	77.8	5.89	57.7	14.3	1.92
W14 × 43	12.6	13.66	0.305	7.995	0.530	428	62.7	5.82	45.2	11.3	1.89
W14 × 38	11.2	14.10	0.310	6.770	0.515	385	54.6	5.87	26.7	7.88	1.55
W14 × 34	10.0	13.98	0.285	6.745	0.455	340	48.6	5.83	23.3	6.91	1.53
W14 × 30	8.85	13.84	0.270	6.730	0.385	291	42.0	5.73	19.6	5.82	1.49
W14 × 26	7.69	13.91	0.255	5.025	0.420	245	35.3	5.65	8.91	3.54	1.08
W14 × 22	6.49	13.74	0.230	5.000	0.335	199	29.0	5.54	7.00	2.80	1.04





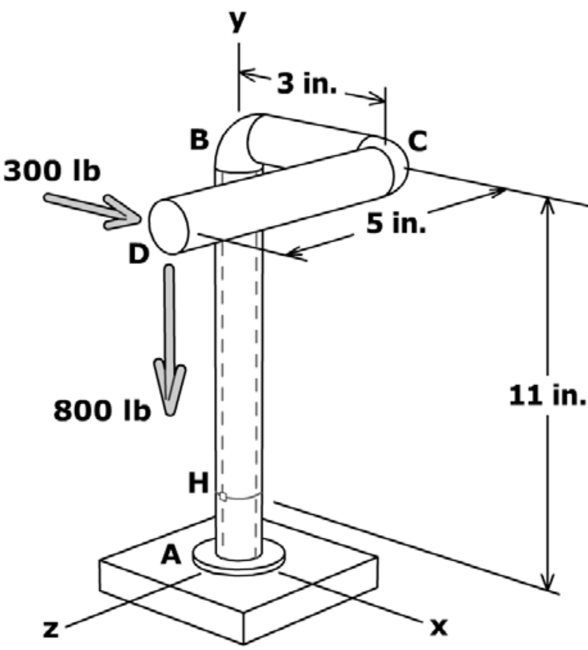
5. A W14×53 wide-flange beam supports the distributed load and concentrated load shown. Consider location B on the beam, which is located **just to the left** of the 12 kip concentrated load. At the junction between the top flange and the beam web, determine:
   (a) The bending stress σ
   (b) The shear stress τ.
   [V = 11 kips; M = +84 kip-ft; I = 541 in^4; y = +6.30 in.; σ = -11,738 psi = 11,738 psi (C); Q = 35.2689 in^3; t = t_w = 0.370 in.; τ = 1,938 psi (downward on right face of stress element)]

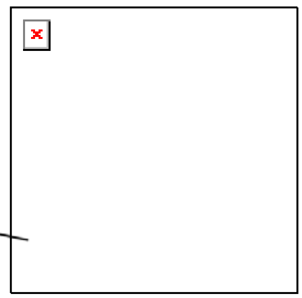
6. A 45° strain gage rosette is attached to a compressed air tank with gage "a" oriented parallel to the long axis of the tank. The tank is made of steel that has a modulus of elasticity of $E = 29\times10^6$ psi and Poisson's ratio of $\nu = 0.3$. The inside diameter of the tank is 40 inches, the wall thickness is 0.375 inches, and the internal pressure is 180 psi. Determine the strain measured by each strain gage: ε_a, ε_b, and ε_c.



[σ_{long} = 4,800 psi; σ_{hoop} = 9,600 psi; note: shear stress is zero on planes perpendicular to the longitudinal direction and to the circumferential directions; use Generalized Hooke's Law to find $\varepsilon_a = \varepsilon_x$ = 66.21 $\mu\varepsilon$ and $\varepsilon_c = \varepsilon_y$ = 281.4 $\mu\varepsilon$; use strain transformation equation to find ε_b = 173.79 $\mu\varepsilon$ at θ = 45°]

7. For the structure shown, determine the normal and shear stresses acting at point H. Show the results on a stress element.



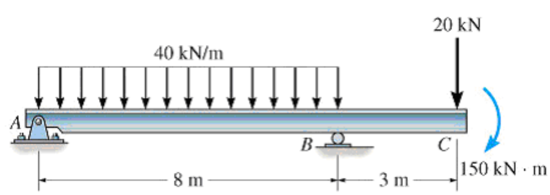


[At the section of interest, the forces are
F_x = 300 lb, F_y = -800 lb, F_z = 0 lb.
The moments are M_x = +4,000 lb-in, M_y = +1,500 lb-in, and M_z = -5,700 lb-in.

Q for the solid circular shape is 0.28125 in^3.

At point H, the axial force (F_y = -800 lb) causes a normal stress of 452.7 psi (C). The shear force in the x direction (F_x = 300 lb) creates a shear stress of 226.4 psi, which acts in the positive x direction on the positive y face of the stress element. The torque at the section of interest (M_y = +1,500 lb-in) creates a shear stress of 2,263.5 psi, which also acts in the positive x direction on the positive y face of the stress element. The bending moment about the x axis (M_x = +4,000 lb-in) creates a compression normal stress at H of 17,202.9 psi (C). The bending moment about the z axis does not create a normal stress at H since H is on the neutral surface for M_z. Altogether, the combined normal stress in the y direction at H is 12,525 psi (C) and the combined shear stress is 2,490 psi, which acts in the positive x direction on the positive y face of the stress element. There is no normal stress in the x direction at H for this structure.]

8. A W305×97 structural steel beam supports the loadings shown. The moment of inertia for the beam is $I = 222 \times 10^6$ mm^4, and the modulus of elasticity is E = 200 GPa. Determine the deflection at the right end of the beam.



[v_C = +0.5631 mm (upward). To solve this problem, consider four cases: two simply supported (SS) cases and two cantilever cases.
SS case 1: Calculate θ at B for 40 kN/m acting on 8 m span. Use θ_B and 3 m overhang to calculate v_C.
SS case 2: Moment at B created by 20 kN load is 60 kN-m. Add the 150 kN-m concentrated moment to find that the total moment required to support the overhang is 210 kN-m. Apply a concentrated moment of 210 kN-m acting clockwise to the 8-m simple span at B and determine θ_B. Use θ_B and 3 m overhang to calculate v_C.
Cantilever case 3: Consider a 20 kN load acting at the tip of a 3-m long cantilever beam and calculate v_C.
Cantilever case 4: Consider a 150 kN-m moment acting clockwise at the tip of a 3-m long cantilever beam and calculate v_C.]