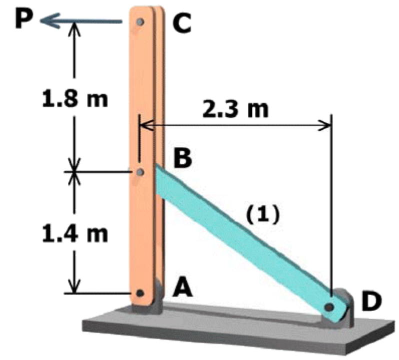
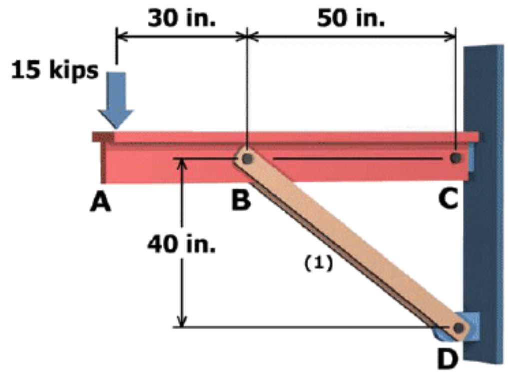
1. If the applied load P = 10 kN, determine the axial force in member (1).



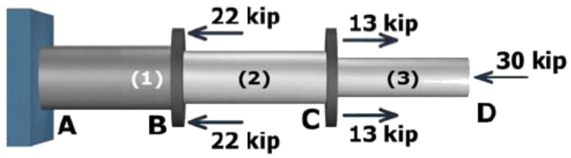
N_1 = ___________ kN

2. If the axial force in member (1) is 38,420 lb, determine the resultant force at joint C.



C = ___________ lb

3. Determine the normal force in segments (1), (2) and (3), and circle whether they are in tension (T) or compression (C).

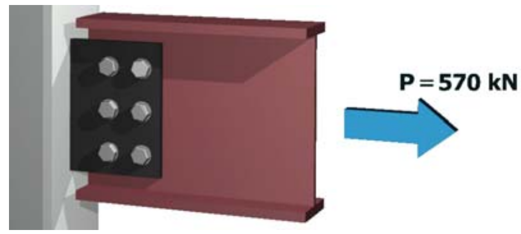


(a) N_1 = ___________ kip (T or C)

(b) N_2 = ___________ kip (T or C)

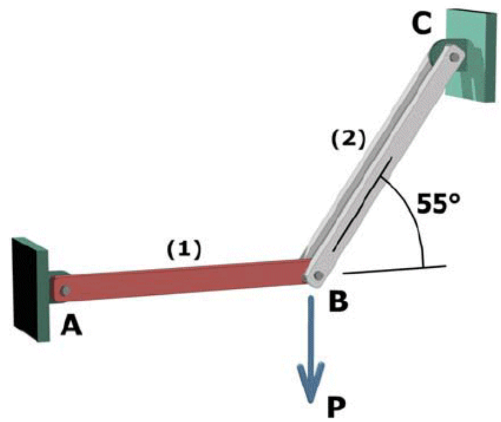
(c) N_3 = ___________ kip (T or C)

4. The single shear connection consists of six 26-mm-diameter bolts. If the ultimage strength of the bolts is 720 MPa, determine the factor of safety for the connection at an applied load of P = 570 kN.



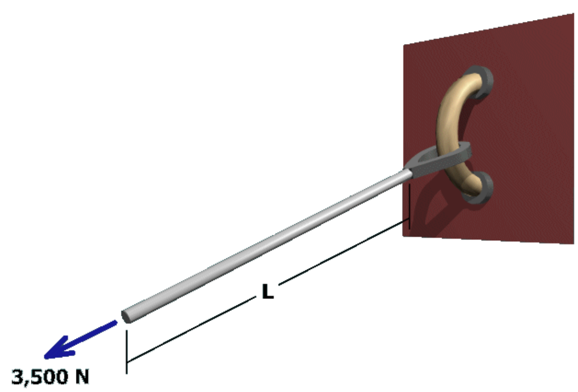
FS = __________

5. Member (1) is a steel bar with a cross-sectional area of 1.75 in^2 and a yield strength of 50 ksi. Member (2) is a pair of aluminum bars having a combined cross-sectional area of 4.50 in^2 and a yield strength of 40 ksi. Having already done the statics and knowing that the axial load in the members is $N_1 = 0.7P$ and $N_2 = 1.22P$, determine the maximum allowable load P that may be applied to the structure.



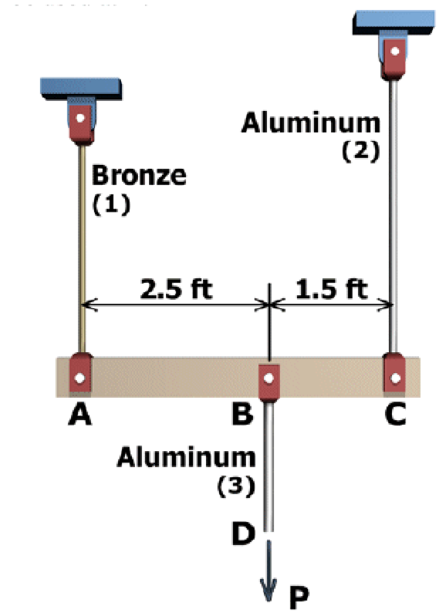
P_{max} = __________ lb

6. A 8-mm-diameter wire (E = 60 GPa) supports a tension load of 3,500 N. If the total elongation of the wire must not exceed 10 mm, determine the maximum allowable length L of the wire.



L = __________ m

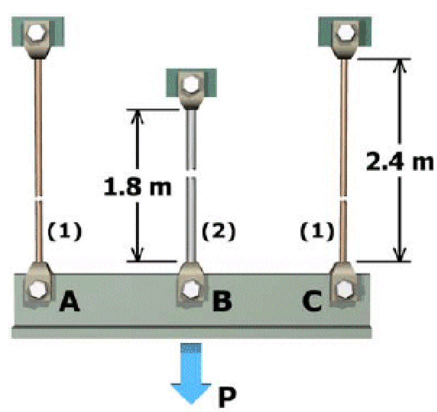
7. Rigid bar *ABC* is supported by bronze bar (1) and aluminum rod (2). A concentrated load *P* is applied the free end of aluminum rod (3). Bronze rod (1) has a diameter of $d_1 = 0.375$ in. Aluminum rods (2) and (3) have a diameter of $d_2 = 0.625$ in. and $d_3 = 1.0$ in. The yield strength of the bronze is 50 ksi, and the yield strength of the aluminum is 36 ksi. Having already done the statics and knowing that the axial load in bars (1) and (2) is $N_1 = 0.375P$ and $N_2 = 0.625P$, determine the magnitude of load *P* that can safely be applied to the structure if a minimum factor of safety of 1.5 is required.



P_{max} = __________ lb

8. *Fill in the missing pieces of the following derivation. Numbers should be in meters and Newtons. Do NOT solve for* N_1 *or simplify your numbers.*

A load of $P = 170$ kN is supported by a structure consisting of rigid bar *ABC*, two identical solid bronze [$E = 100$ GPa] rods, and a solid steel [$E = 200$ GPa] rod. The bronze rods (1) each have a diameter of 20 mm, and they are symmetrically positioned relative to the center rod (2) and the applied load *P*. Steel rod (2) has a diameter of 24 mm. All bars are unstressed before the load *P* is applied; however, there is a 3-mm clearance in the bolted connection at *B*. Determine the axial load in the bronze bars.



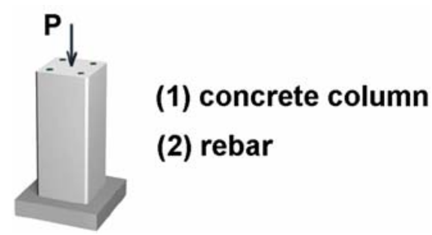
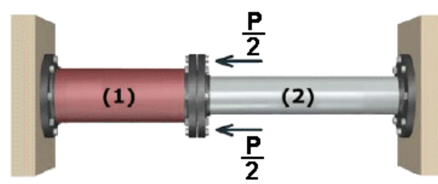
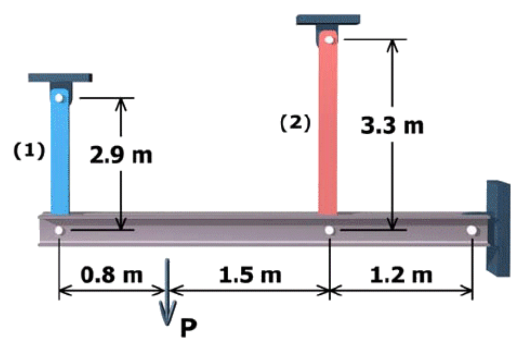
$N_1 + N_2 = 170{,}000$

$\delta_1 = \delta_2 + .003$

$$\frac{N_1}{\_\_\_\_\_\_\_\_} = \frac{(170{,}000 - N_1)}{\_\_\_\_\_\_\_\_} + .003$$

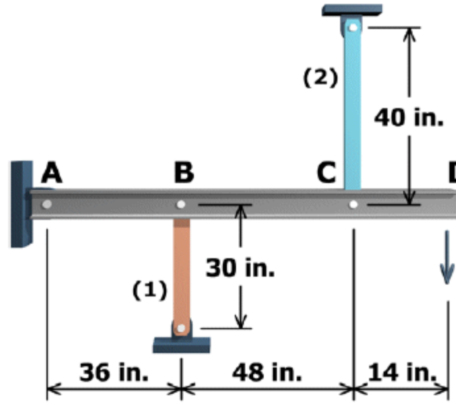
→ $N_1 =$ # # # #

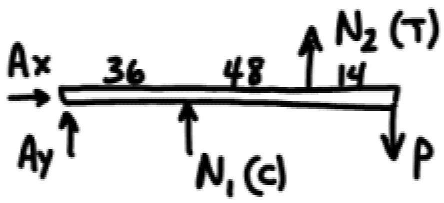
9. Write the statics and compatibility relationships for the following structures.

Statics: write a formula relating *P*, N_1 and N_2 and state whether N_1 and N_2 are in tension or compression	**Compatibility:** write a formula relating δ_1 and δ_2	
N_1 (T or C) *N2* (T or C)		
N_1 (T or C) *N2* (T or C)		
N_1 (T or C) *N2* (T or C)		

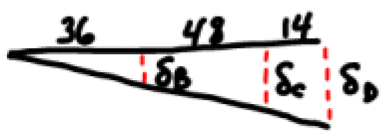
10. *Fill in the missing pieces of the following derivation. Numbers should be in inches and pounds. Do NOT solve for N_1 or simplify your numbers.*

Rigid bar ABCD is supported by a pin connection at A and by two axial bars (1) and (2). Bar (1) is a 30-in.-long bronze [E = 15,000 ksi, α = 9.4x10-6/°F] bar with a cross-sectional area of 1.25 in^2. Bar (2) is a 40-in.-long aluminum alloy [E = 10,000 ksi, α = 12.5x10^{-6}/°F] bar with a cross-sectional area of 2.00 in.^{2} Both bars are unstressed before the load P is applied. If a concentrated load of P = 27 kips is applied to the rigid bar at D and the temperature is decreased by 100°F, determine the axial force in bar (1).





$$\Sigma M_A : 98P = 36N_1 + 84N_2$$



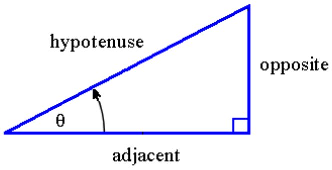
$$\frac{\delta_1}{36} = -\frac{\delta_2}{84}$$

$$\frac{\_\_\_\_\_\_\_\_}{36} + \frac{9.4\times10^{-6}(-100)(30)}{36}$$

$$= -\left[\frac{\frac{1}{84}[98(27000)-36N_1](40)}{84(10\times10^6)(2)} + \frac{\_\_\_\_\_\_\_\_}{84}\right]$$

$\longrightarrow N_1 =$ ######

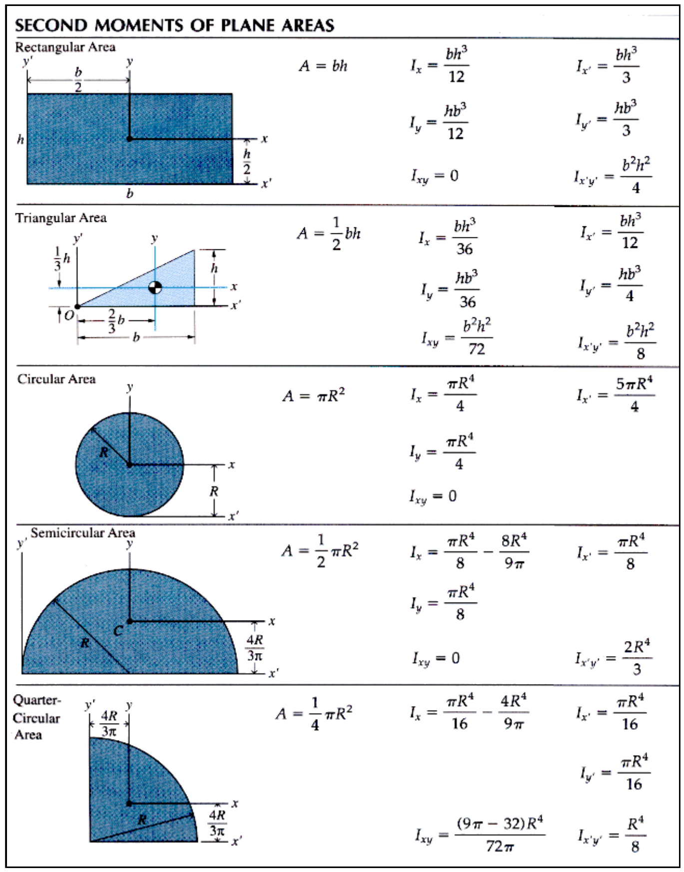
TRIGONOMETRY



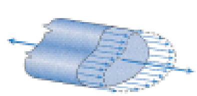
$\sin\theta$ = opp / hyp
$\cos\theta$ = adj / hyp
$\tan\theta$ = opp / adj

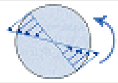
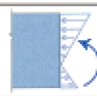
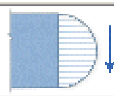
STATICS

Symbol	Meaning	Equation	Units
$\bar{x}, \bar{y}, \bar{z}$	centroid position	$\bar{y} = \Sigma \bar{y}_i A_i / \Sigma A_i$	in, m
I	moment of inertia	$I = \Sigma(I_i + d_i^2 A_i)$	in^4, m^4
J	polar moment of inertia	$J_{\text{solid circular shaft}} = \pi d^4/32$ $J_{\text{hollow circular shaft}} = \pi(d_o^4 - d_i^4)/32$	in^4, m^4
N	normal force		lb, N
V	shear force	$V = \int -w(x)\,dx$	lb, N
M	bending moment	$M = \int V(x)\,dx$	in-lb, Nm
equilibrium		$\Sigma\mathbf{F} = \mathbf{0}$ $\Sigma\mathbf{M}_{\text{(any point)}} = \mathbf{0}$	lb, N in-lb, Nm



MECHANICS OF MATERIALS

Topic	Symbol	Meaning	Equation	Units
axial	σ, sigma	normal stress 	$\sigma_{axial} = N/A$ $\tau_{cutting} = V/A$ $\sigma_{bearing} = F_b/A_b$	psi, Pa
	ε, epsilon	normal strain	$\varepsilon_{axial} = \Delta L/L_o = \delta/L_o$ $\varepsilon_{transverse} = \Delta d/d$	in/in, m/m
	γ, gamma	shear strain	γ = change in angle, $\gamma = c\theta$	rad
	E	Young's modulus, modulus of elasticity	$\sigma = E\varepsilon$ (one-dimensional only)	psi, Pa
	G	shear modulus, modulus of rigidity	$G = \tau/\gamma = E / 2(1+\nu)$	psi, Pa
	ν, nu	Poisson's ratio	$\nu = -\varepsilon'/\varepsilon$	
	δ, delta	deformation, elongation, deflection	$\delta = NL_o/EA + \alpha\Delta T L_o$	in, m
	α, alpha	coefficient of thermal expansion (CTE)		in/inF, m/mC
	F.S.	factor of safety	F.S. = actual strength / design strength	

Topic	Symbol	Meaning	Equation	Units
torsion	τ, tau	shear stress 	$\tau_{torsion} = Tc/J$	psi, Pa
	ϕ, phi	angle of twist	$\phi = TL/GJ$	rad, degrees
	θ, theta	angle of twist per unit length, rate of twist	$\theta = \phi / L$	rad/in, rad/m
	P	power	$P = T\omega$ $r_2T_1 = r_1T_2$ $r_1\omega_1 = r_2\omega_2$	watts = Nm/s hp=6600 in-lb/s
	ω, omega	angular speed, speed of rotation		rad/s
	f	frequency	$\omega = 2\pi f$	Hz = rev/s
	K	stress concentration factor	$\tau_{max} = KTc/J$	psi, Pa
flexure	σ, sigma	normal stress 	$\sigma_{beam} = -My/I$	psi, Pa
	σ, sigma	composite beams, $n = E_B/E_A$	$\sigma_A = -My / I^T$ $\sigma_B = -nMy / I^T$	psi, Pa
	τ, tau	shear stress 	$\tau_{beam} = VQ/Ib$ where $Q = \Sigma(y_{bar\ i} A_i)$	psi, Pa
	q	shear flow	$q = V_{beam}Q/I = nV_{fastener}/s$	
	v or y	beam deflection	$v = \iint M(x)\, dx^2 / EI$	in, m

Topic	Equations		Units
stress trans-formation	*planar rotations* $\sigma_u = (\sigma_x+\sigma_y)/2 + (\sigma_x-\sigma_y)/2 \cos(2\theta) + \tau_{xy}\sin(2\theta)$ $\sigma_v = (\sigma_x+\sigma_y)/2 - (\sigma_x-\sigma_y)/2 \cos(2\theta) - \tau_{xy}\sin(2\theta)$ $\tau_{uv} = -(\sigma_x-\sigma_y)/2 \sin(2\theta) + \tau_{xy}\cos(2\theta)$	*principals and max in-plane shear* $\tan(2\theta_p) = 2\tau_{xy} / (\sigma_x-\sigma_y)$, $\theta_s = \theta_p \pm 45^o$ $\sigma_{1,2} = (\sigma_x+\sigma_y)/2 \pm \text{sqrt}\{ [(\sigma_x-\sigma_y)/2]^2 + \tau_{xy}{}^2 \}$ $\tau_{max} = \text{sqrt}\{ [(\sigma_x-\sigma_y)/2]^2 + \tau_{xy}{}^2 \} = (\sigma_1-\sigma_2)/2$ $\sigma_{avg} = (\sigma_x+\sigma_y)/2 = (\sigma_1+\sigma_2)/2$	psi, Pa
strain trans-formation	*planar rotations* $\varepsilon_u = (\varepsilon_x+\varepsilon_y)/2 + (\varepsilon_x-\varepsilon_y)/2 \cos(2\theta) + \gamma_{xy}/2 \sin(2\theta)$ $\varepsilon_v = (\varepsilon_x+\varepsilon_y)/2 - (\varepsilon_x-\varepsilon_y)/2 \cos(2\theta) - \gamma_{xy}/2 \sin(2\theta)$ $\gamma_{uv}/2 = -(\varepsilon_x-\varepsilon_y)/2 \sin(2\theta) + \gamma_{xy}/2 \cos(2\theta)$ $\varepsilon_z = -\nu (\varepsilon_x + \varepsilon_y) / (1-\nu)$	*principals and max in-plane shear* $\tan(2\theta_p) = \gamma_{xy} / (\varepsilon_x-\varepsilon_y)$, $\theta_s = \theta_p \pm 45^o$ $\varepsilon_{1,2} = (\varepsilon_x+\varepsilon_y)/2 \pm \text{sqrt}\{ [(\varepsilon_x-\varepsilon_y)/2]^2 + (\gamma_{xy}/2)^2 \}$ $\gamma_{max}/2 = \text{sqrt}\{ [(\varepsilon_x-\varepsilon_y)/2]^2 + (\gamma_{xy}/2)^2 \}$ $\varepsilon_{avg} = (\varepsilon_x+\varepsilon_y)/2$	psi, Pa in/in, m/m
Hooke's law	*1D strain to stress* $\sigma = E\varepsilon$ *2D strain to stress* $\sigma_x = E(\varepsilon_x+\nu\varepsilon_y) / (1-\nu^2)$ $\sigma_y = E(\varepsilon_y+\nu\varepsilon_x) / (1-\nu^2)$ $\tau_{xy} = G\gamma_{xy} = E\gamma_{xy} / 2(1+\nu)$	*2D stress to strain* $\varepsilon_x = (\sigma_x-\nu\sigma_y) / E$ $\varepsilon_y = (\sigma_y-\nu\sigma_x) / E$ $\varepsilon_z = -\nu(\varepsilon_x+\varepsilon_y) / (1-\nu)$ $\gamma_{xy} = \tau_{xy}/G = 2(1+\nu)\tau_{xy} / E$	psi, Pa in/in, m/m
pressure	$\sigma_{spherical} = pr/2t$ $\sigma_{cylindrical,\ hoop} = pr/t$ $\sigma_{cylindrical,\ axial} = pr/2t$	$\sigma_{radial,\ outside} = 0$ $\sigma_{radial,\ inside} = -p$	psi, Pa
failure theories	*maximum principal stress theory* $\sigma_{1,2} < \sigma_{yp}$	*maximum shear stress theory* $\tau_{max} < 0.5\ \sigma_{yp}$	psi, Pa