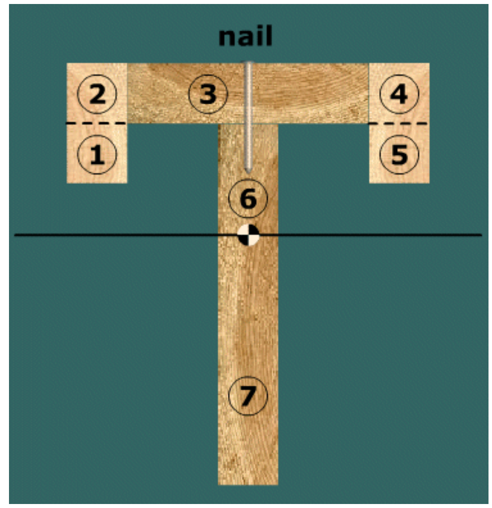
1. In calculating the shear flow associated with the nail shown, which areas should be included in the calculation of Q? (3 points)

   ______ Areas (1) and (5)

   ______ Areas (1) through (5)

   ______ Areas (2), (3) and (4)

   ______ Areas (1), (2), (4) and (5)



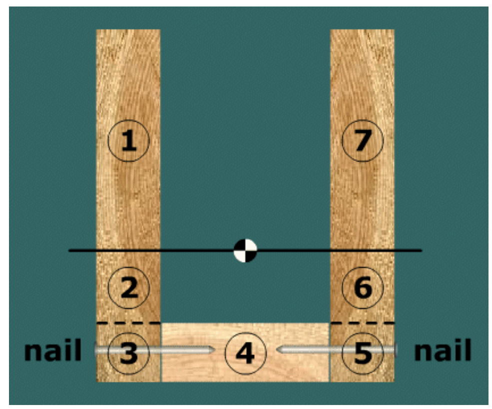
2. In calculating the shear flow associated with the two nails shown, which areas should be included in the calculation of Q? (3 points)

   ______ Areas (2) through (6)

   ______ Areas (2), (3), (5) and (6)

   ______ Area (4)

   ______ Areas (3), (4) and (5)



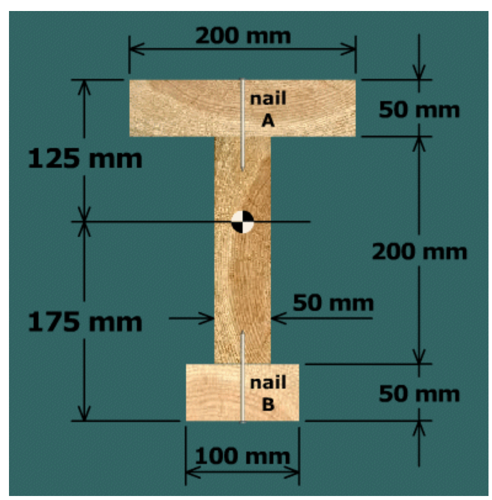
3. What is the value of Q needed to determine the shear force acting on nail B? (6 points)

   ______ 390,625 mm^3

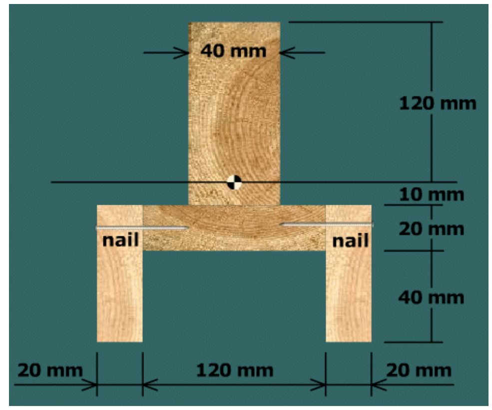
   ______ 1,140,625 mm^3

   ______ 875,000 mm^3

   ______ 750,000 mm^3



4. What is the value of Q needed to determine the shear force acting on the two nails shown? (6 points)



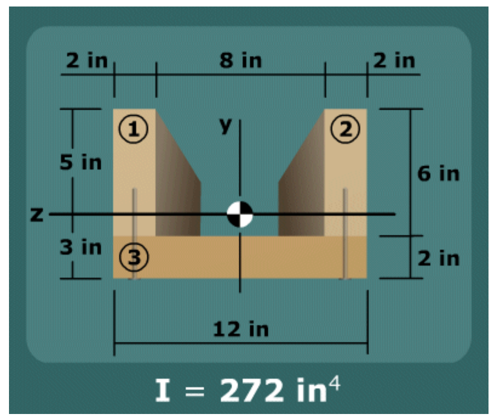
______ 480,000 mm^3

______ 3,200 mm^3

______ 96,000 mm^3

______ 144,000 mm^3

5. If boards (1) and (2) were glued to board (3) instead of nailed, what would be the shear stress in the glue if V = 1,125 lb? (6 points)



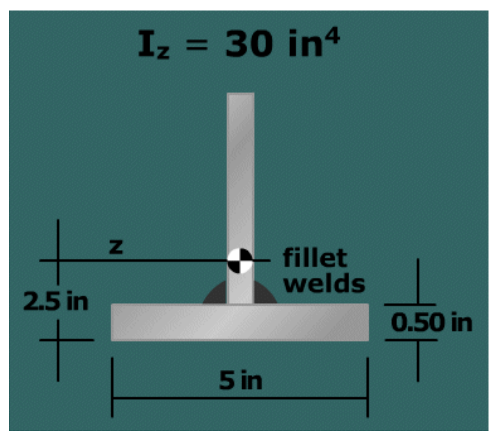
______ 16.5 psi

______ 49.6 psi

______ 99.3 psi

______ 198.5 psi

6. The allowable load for each weld is 2.4 kip/inch in the longitudinal direction. What is the maximum allowable shear force V? (8 points)



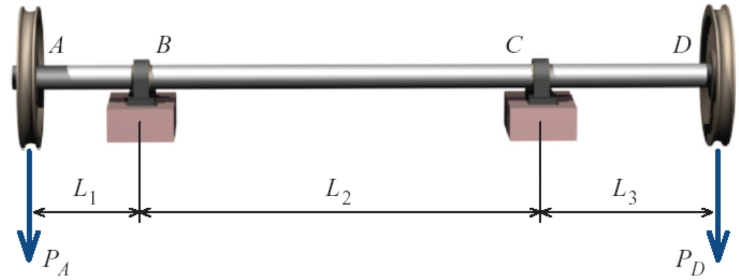
______ 10.5 kips

______ 12.8 kips

______ 20.9 kips

______ 25.6 kips

7. A 1.00-inch-diameter solid steel shaft supports loads $P_A = 300$ lb and $P_D = 500$ lb. Assume $L_1 = 5$ in., $L_2 = 16$ in., and $L_3 = 8$ in. Determine the values for V, Q, I, and b that would be used in the maximum horizontal shear stress anywhere in the shaft. (20 points)



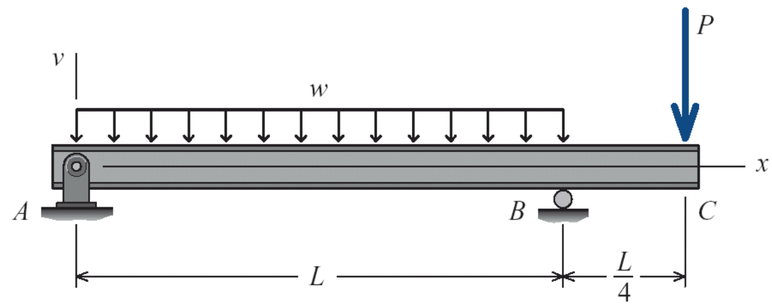
V= __________ lb

Q= __________ in.^{3}

I= __________ in.^{4}

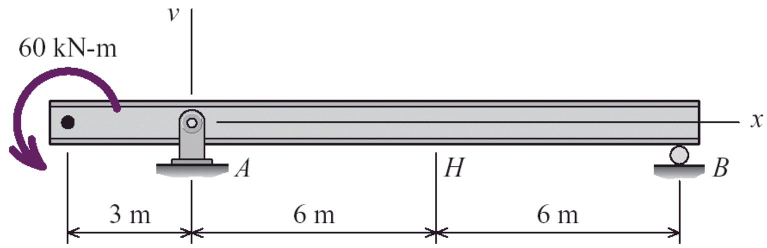
b= __________ in.

8. For the beam and loading shown, use the integration method to determine the equation of the elastic curve for segment *AB* of the beam. Do NOT solve for the integration constants. (8 points)



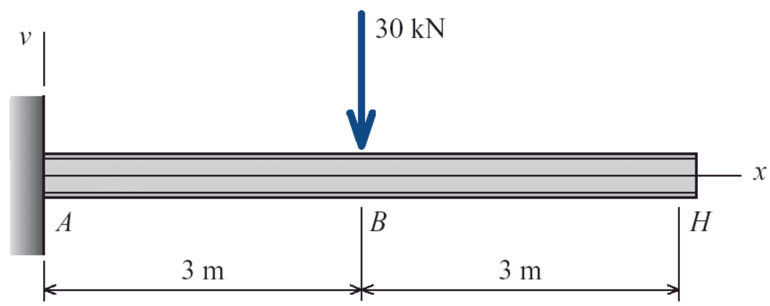
9. List the boundary, continuity, and/or symmetry conditions that could be used to solve the integration constants in the previous problem. (6 points)

10. Determine the beam deflection at point H. Assume that $EI = 40{,}000$ kN-m^2 is constant for the beam. (6 points)



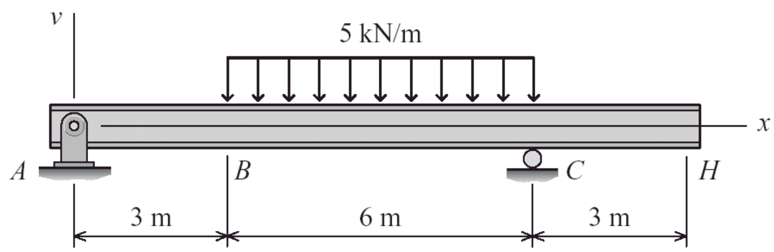
$v_H =$ ___________ mm

11. Determine the beam deflection at point H. Assume that $EI = 40{,}000$ kN-m^2 is constant for the beam. (10 points)



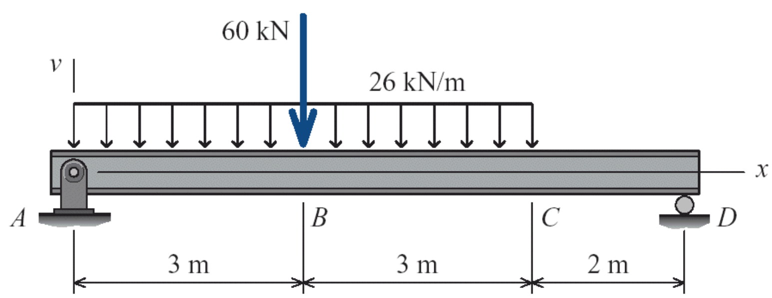
$v_H =$ ___________ mm

12. Determine the beam deflection at point *H*. Assume that $EI = 40{,}000$ kN-m^2 is constant for the beam. (8 points)



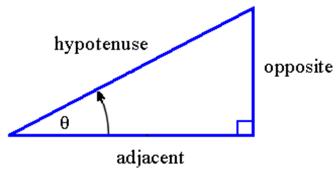
$v_H =$ __________ mm

13. Determine the beam deflection at point *C*. Assume that $EI = 40{,}000$ kN-m^2 is constant for the beam. (10 points)



$v_C =$ __________ mm

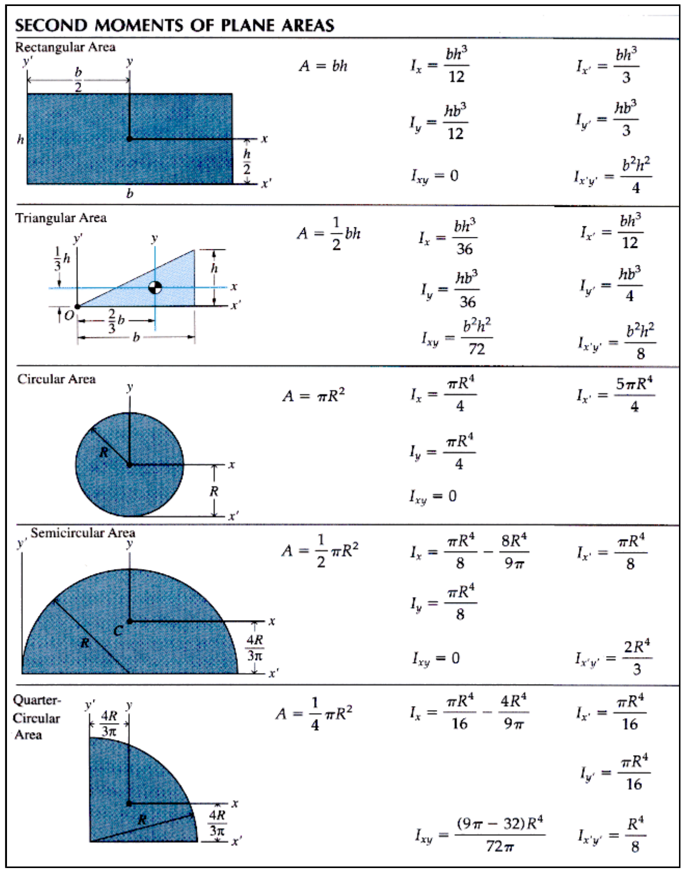
TRIGONOMETRY



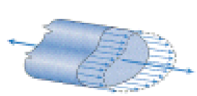
$\sin\theta = \text{opp} / \text{hyp}$
$\cos\theta = \text{adj} / \text{hyp}$
$\tan\theta = \text{opp} / \text{adj}$

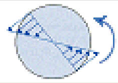
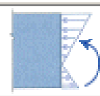
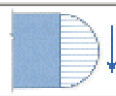
STATICS

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



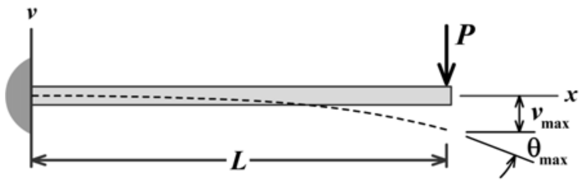
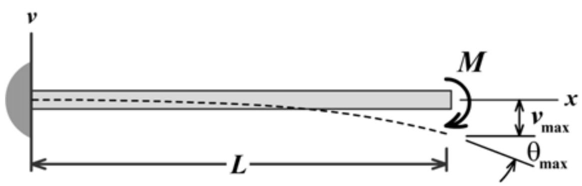
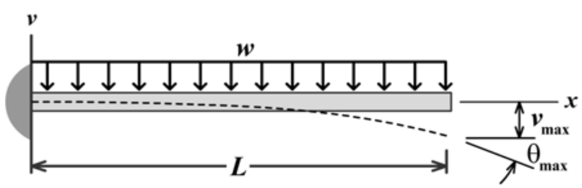
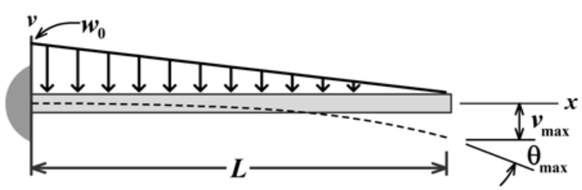
MECHANICS OF MATERIALS

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	$\delta = NL_o/EA + \alpha\Delta TL_o$	in, m
	α, alpha	coefficient of thermal expansion (CTE)		in/inF, m/mC
	F.S.	factor of safety	F.S. = actual strength / design strength	

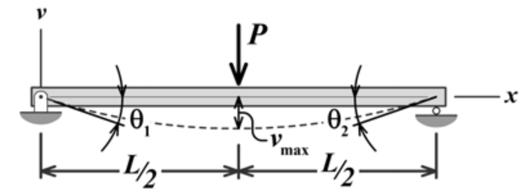
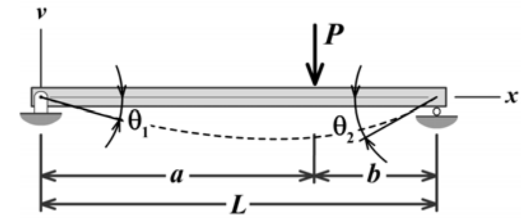
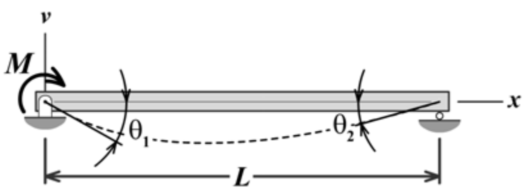
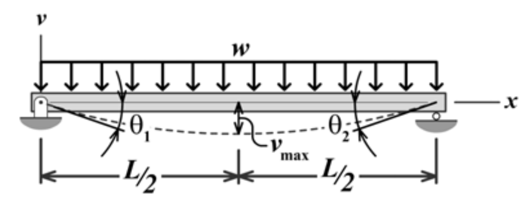
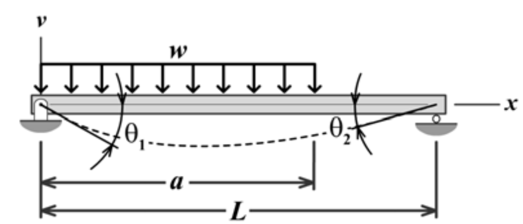
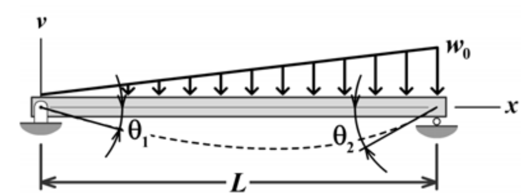
Topic	Symbol	Meaning	Equation		Units
torsion	τ, tau	shear stress 	$\tau_{torsion} = Tc/J$		psi, Pa
	ϕ, phi	angle of twist	$\phi = TL/GJ$		rad, degrees
	θ, theta	angle of twist per unit length, rate of twist	$\theta = \phi / L$		rad/in, rad/m
	P	power	$P = T\omega$	$r_2T_1 = r_1T_2$ $r_1\omega_1 = r_2\omega_2$	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

CANTILEVER BEAMS

Beam	Slope	Deflection	Elastic Curve
	$\theta_{\max} = -\dfrac{PL^2}{2EI}$	$v_{\max} = -\dfrac{PL^3}{3EI}$	$v = -\dfrac{Px^2}{6EI}(3L - x)$
	$\theta_{\max} = -\dfrac{ML}{EI}$	$v_{\max} = -\dfrac{ML^2}{2EI}$	$v = -\dfrac{Mx^2}{2EI}$
	$\theta_{\max} = -\dfrac{wL^3}{6EI}$	$v_{\max} = -\dfrac{wL^4}{8EI}$	$v = -\dfrac{wx^2}{24EI}(6L^2 - 4Lx + x^2)$
	$\theta_{\max} = -\dfrac{w_0L^3}{24EI}$	$v_{\max} = -\dfrac{w_0L^4}{30EI}$	$v = -\dfrac{w_0x^2}{120LEI}(10L^3 - 10L^2x + 5Lx^2 - x^3)$

SIMPLY SUPPORTED BEAMS

Beam	Slope	Deflection	Elastic Curve
	$\theta_1 = -\theta_2 = -\dfrac{PL^2}{16EI}$	$v_{\max} = -\dfrac{PL^3}{48EI}$	$v = -\dfrac{Px}{48EI}(3L^2 - 4x^2)$ for $0 \le x \le L/2$
	$\theta_1 = -\dfrac{Pb(L^2 - b^2)}{6LEI}$ $\theta_2 = +\dfrac{Pa(L^2 - a^2)}{6LEI}$	$v\big\|_{x=a} = -\dfrac{Pba}{6LEI}(L^2 - b^2 - a^2)$	$v = -\dfrac{Pbx}{6LEI}(L^2 - b^2 - x^2)$ for $0 \le x \le a$
	$\theta_1 = -\dfrac{ML}{3EI}$ $\theta_2 = +\dfrac{ML}{6EI}$	$v_{\max} = -\dfrac{ML^2}{9\sqrt{3}EI}$ @ $x = L\left(1 - \dfrac{\sqrt{3}}{3}\right)$	$v = -\dfrac{Mx}{6LEI}(2L^2 - 3Lx + x^2)$
	$\theta_1 = -\theta_2 = -\dfrac{wL^3}{24EI}$	$v_{\max} = -\dfrac{5wL^4}{384EI}$	$v = -\dfrac{wx}{24EI}(L^3 - 2Lx^2 + x^3)$
	$\theta_1 = -\dfrac{wa^2}{24LEI}(2L - a)^2$ $\theta_2 = +\dfrac{wa^2}{24LEI}(2L^2 - a^2)$	$v\big\|_{x=a} = -\dfrac{wa^3}{24LEI}(3a^2 - 7aL + 4L^2)$	$v = -\dfrac{wx}{24LEI}(a^4 - 4a^3L + 4a^2L^2 + 2a^2x^2 - 4aLx^2 + Lx^3)$ for $0 \le x \le a$ $v = -\dfrac{wa^2}{24LEI}(-a^2L + 4L^2x + a^2x - 6Lx^2 + 2x^3)$ for $a \le x \le L$
	$\theta_1 = -\dfrac{7w_0L^3}{360EI}$ $\theta_2 = +\dfrac{w_0L^3}{45EI}$	$v_{\max} = -0.00652\dfrac{w_0L^4}{EI}$ @ $x = 0.5193L$	$v = -\dfrac{w_0x}{360LEI}(7L^4 - 10L^2x^2 + 3x^4)$