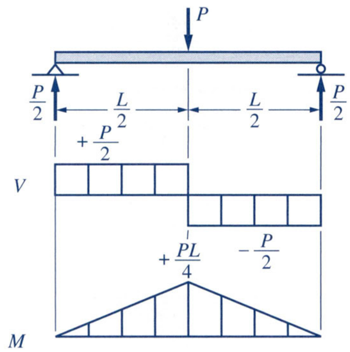
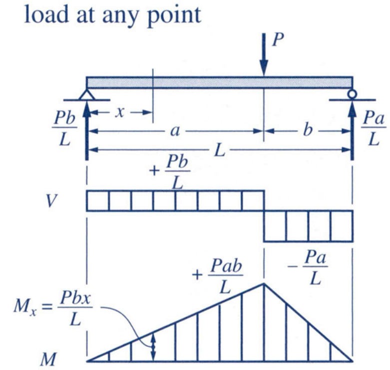
13-9
Shear and Moment Formulas

TABLE 13–1 Shear and Moment Formulas for Some Simple Loadings

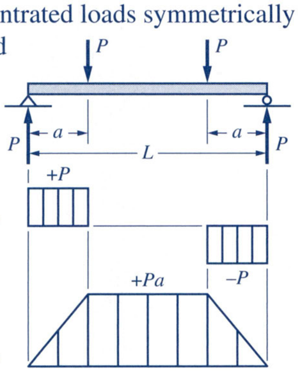
1. Simple beam with a concentrated load at the center



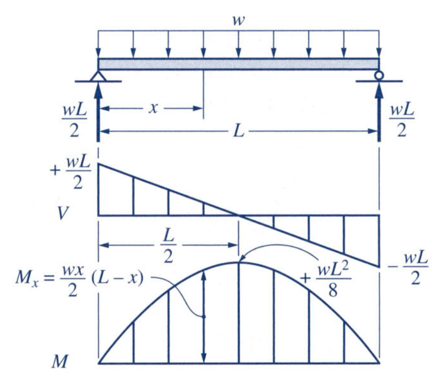
2. Simple beam with a concentrated load at any point



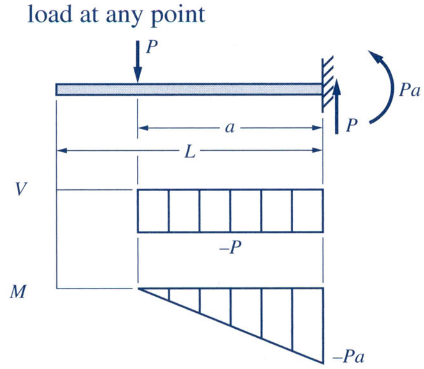
3. Simple beam with two equal concentrated loads symmetrically placed



4. Simple beam with a uniform load



5. Cantilever beam with a concentrated load at any point



6. Cantilever beam with a uniform load

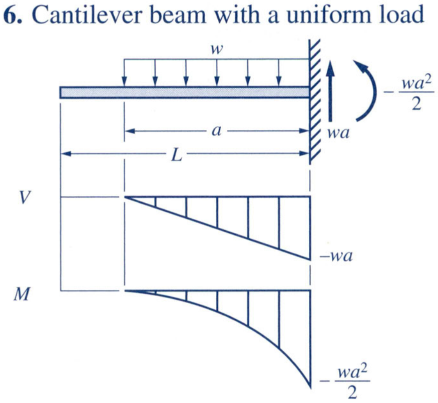


TABLE 15–2 Allowable Stresses for Timber

Species	Extreme Fiber in Bending psi (kPa)	Tension Parallel to Grain psi (kPa)	Longitudinal Shear psi (kPa)	Compression	
				Perpendicular to Grain psi (kPa)	Parallel to Grain psi (kPa)
Douglas fir	1450 (10 000)	625 (4310)	95 (660)	385 (2650)	1050 (7240)
Eastern hemlock	1350 (9310)	925 (6380)	80 (550)	360 (2480)	950 (6550)
Southern pine	1600 (11 000)	825 (5690)	90 (620)	410 (2830)	1250 (8620)
Ponderosa pine	1100 (7580)	725 (5000)	65 (450)	235 (1620)	750 (5170)
California redwood	1350 (9310)	650 (4480)	100 (690)	270 (1860)	1050 (7240)

TABLE 16–1 Beam Deflection Formulas

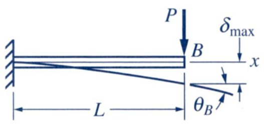
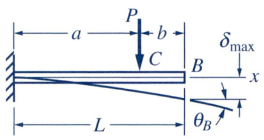
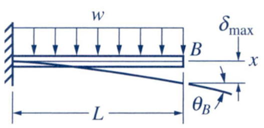
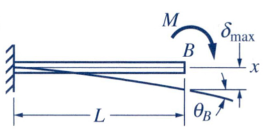
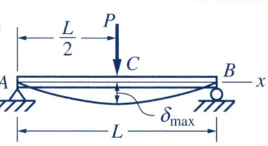
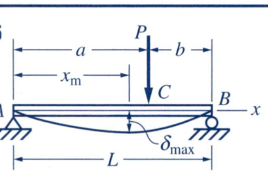
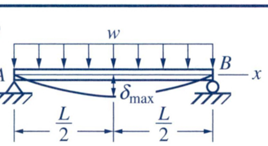
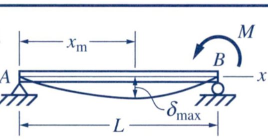
Beam Loading and Deflection	Maximum Deflection	Slope at End(s)	Deflection Equations
1 	$\delta_{max} = \dfrac{PL^3}{3EI}$	$\theta_B = \dfrac{PL^2}{2EI}$	$\delta = \dfrac{Px^2}{6EI}(3L - x)$
2 	$\delta_{max} = \dfrac{Pa^2}{6EI}(3L - a)$	$\theta_B = \dfrac{Pa^2}{2EI}$	$\delta_{AC} = \dfrac{Px^2}{6EI}(3a - x)$ $\delta_{CB} = \dfrac{Pa^2}{6EI}(3x - a)$
3 	$\delta_{max} = \dfrac{wL^4}{8EI}$	$\theta_B = \dfrac{wL^3}{6EI}$	$\delta = \dfrac{wx^2}{24EI}(x^2 - 4Lx + 6L^2)$
4 	$\delta_{max} = \dfrac{ML^2}{2EI}$	$\theta_B = \dfrac{ML}{EI}$	$\delta = \dfrac{Mx^2}{2EI}$
5 	$\delta_{max} = \dfrac{PL^3}{48EI}$	$\theta_A = \theta_B = \dfrac{PL^2}{16EI}$	$\delta_{AC} = \dfrac{Px}{48EI}(3L^2 - 4x^2)$
6 	For $a > b$: $\delta_{max} = \dfrac{Pb(L^2 - b^2)^{3/2}}{9\sqrt{3}EIL}$ at $x_m = \sqrt{\dfrac{L^2 - b^2}{3}}$	$\theta_A = \dfrac{Pb(L^2 - b^2)}{6EIL}$ $\theta_B = \dfrac{Pa(L^2 - a^2)}{6EIL}$	$\delta_{AC} = \dfrac{Pbx}{6EIL}(L^2 - x^2 - b^2)$ $\delta_{CB} = \dfrac{Pb}{6EIL}\left[\dfrac{L}{b}(x - a)^3 + (L^2 - b^2)x - x^3\right]$
7 	$\delta_{max} = \dfrac{5wL^4}{384EI}$	$\theta_A = \theta_B = \dfrac{wL^3}{24EI}$	$\delta = \dfrac{wx}{24EI}(L^3 + x^3 - 2Lx^2)$
8 	$\delta_{max} = \dfrac{ML^2}{9\sqrt{3}EI}$ at $x_m = \dfrac{L}{\sqrt{3}}$	$\theta_A = \dfrac{ML}{6EI}$ $\theta_B = \dfrac{ML}{3EI}$	$\delta = \dfrac{Mx}{6EIL}(L^2 - x^2)$

TABLE 18–1 List of the Fundamental Formulas

Type of Load	*Type of Stress*	*Formula*	*Equation Number*
Axial load	Direct normal stress	$\sigma = \frac{P}{A}$	(9–1)
Internal pressure in thin-walled vessels	Circumferential stress	$\sigma_c = \frac{Pr_i}{t}$	(9–16)
	Longitudinal stress	$\sigma_l = \frac{Pr_i}{2t}$	(9–17)
Beam bending load	Flexural stress	$\sigma = \frac{My}{I}$	(14–3)
		$\sigma_{max} = \frac{Mc}{I}$	(14–2)
		$\sigma_{max} = \frac{M}{S}$	(14–7)
Direct shear load	Direct shear stress	$\tau_{avg} = \frac{P}{A}$	(9–4)
Torque in circular shaft	Torsional shear stress	$\tau = \frac{T\rho}{J}$	(12–2)
		$\tau_{max} = \frac{Tc}{J}$	(12–1)
Beam shear force	Beam shear stress	$\tau = \frac{VQ}{It}$	(14–10)
	Maximum shear stress in rectangular section	$\tau_{max} = 1.5\frac{V}{A}$	(14–11)
	Maximum shear stress in circular section	$\tau_{max} = \frac{4V}{3A}$	(14–12)

18–2 COMBINED AXIAL AND BENDING STRESSES

Many structural and machine members are subjected to axial forces and bending moments exerted simultaneously. Both produce normal stresses along the longitudinal directions. The normal stresses due to each load can be calculated separately and added algebraically to find the combined stresses, as illustrated in the following two examples.

EXAMPLE 18–1

Refer to Fig. E18–1(1). The wide-flange shape W360 × 0.99 is used as a simple beam of 3-m span. The beam is subjected to a uniform load w of 100 kN/m (including the weight of the beam) and an axial tensile force P of 500 kN. Determine the normal stresses at points A and B, and plot the normal stress variation between A and B.