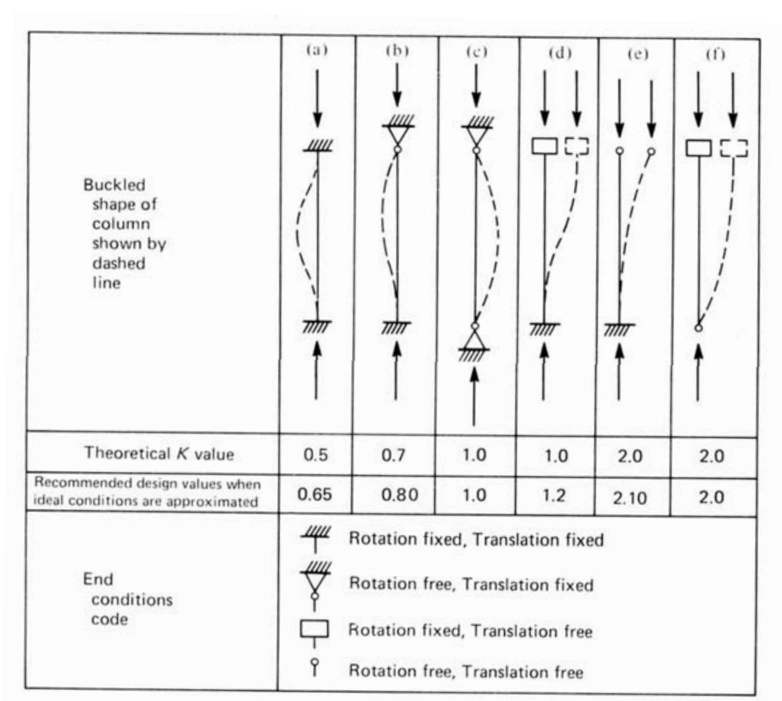
Reference Formulas

$\sum F_x = 0$	$C^2 = A^2 + B^2 - 2AB\cos\gamma$	$\hat{x} = \frac{\Sigma \bar{x} A}{\Sigma A}$
$\sum F_y = 0$	$\frac{A}{\sin\alpha} = \frac{B}{\sin\beta} = \frac{C}{\sin\gamma}$	$Q_y = \bar{x}A = \sum_{i=1}^{n} \bar{x}_i A_i$
$\sum M = 0$	$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$	$\hat{y} = \frac{\Sigma \bar{y} A}{\Sigma A}$
$F_x = F\cos\theta$	$p = 2\pi r = \pi d$	$Q_x = \bar{y}A = \sum_{i=1}^{n} \bar{y}_i A_i$
$F_y = F\sin\theta$	$A = W \cdot l = t \cdot d$	$I = \bar{I} + Ad^2$
$F = \sqrt{F_x^2 + F_y^2}$	$A = \pi r^2 = \frac{\pi d^2}{4}$	$I = \sum I_c + \sum Ad^2$
$\tan\theta = \frac{F_y}{F_x}$	$M = Fd$	$r = \sqrt{\frac{I}{A}}$
$g = 9.81\, m/s^2$	$F = mg$	$S = \frac{I}{c}$
$\frac{dV}{dx} = -w$	$y = mx + b$	$J = \frac{\pi c^4}{2}$
$\frac{dM}{dx} = V$	$m = \frac{y_2 - y_1}{x_2 - x_1}$	$J = \frac{\pi\left(c_o^4 - c_i^4\right)}{2}$
$Pa = N/m^2$	$N = kg \cdot m/s^2$	$\pi(radians) = 180°$
$1\, kPa = 1{,}000\ Pa$	$psi = lb/in^2$	$ksi = kip/in^2$
$1\, kPa = 1\, kN/m^2$	$1\, kip = 1000\ lb$	$12\ in = 1\ ft$
$1\, MPa = 10^6\ Pa$	$1\, GPa = 10^9\ Pa$	$1\, m = 1000\ mm$
$f_c = \frac{P}{A}$	$F.S = \frac{ultimate}{allowable}$	$\varepsilon = \frac{\delta}{L}$
$f_t = \frac{P}{A}$	$f_v = \frac{P}{A}$	$f_v = \frac{P}{2A}$
$f_p = \frac{P}{A}$	$\tau = \frac{T\rho}{J}$	$f_p = \frac{P}{A} = \frac{P}{td}$
$f_y = \frac{My}{I}$	$f_{v-ave} = \frac{VQ}{Ib}$	$f = E\varepsilon$
$f_{b-max} = \frac{Mc}{I} = \frac{M}{S}$	$f_{v-max} = \frac{3V}{2A}$ for a rectangle	$\delta = \frac{PL}{AE}$
$S_{req} \ge \frac{M}{F_b}$	$f_{v-\max} \cong \frac{V}{A_{web}} = \frac{V}{t_w d}$ for an I beam	$\delta_T = \alpha(\Delta T)L$
$V_{longitudinal} = \frac{V_T Q}{I}\Delta x$	$\varepsilon_y = \varepsilon_z = -\frac{\mu f_x}{E}$	$\varepsilon_T = \alpha(\Delta T)$

$nF_{connector} \geq \frac{VQ_{connected\ area}}{I} \cdot p$	$f_v = \tau = G \cdot \frac{\rho\phi}{L}$	$\gamma = \frac{\rho\phi}{L}$
$\tau_{max} = \frac{T}{c_1 ab^2}$	$\phi = \frac{TL}{c_2 ab^3 G}$	$\phi = \frac{TL}{JG}$
$\tau_{max} = \frac{T}{\frac{1}{3} ab^2}$	$\phi = \frac{TL}{\frac{1}{3} ab^3 G}$	$\tau_{max} = \frac{Tt_{max}}{\frac{1}{3} \Sigma b_i t_i^3}$
$\tau_{max} = \frac{T}{2ta}$	$\phi = \frac{TL}{4ta^2} \sum_i \frac{s_i}{t_i}$	$\phi = \frac{TL}{\frac{1}{3} G \Sigma b_i t_i^3}$
$\frac{1}{\rho} = \frac{M}{EI} = \frac{1}{R}$	$\Delta = \int\int \frac{M(x)}{EI} dx$	$2n = b + 3$
$P_U = P_L \gamma_L + P_D \gamma_D \leq \phi P_n$	AISC-LRFD: P_U : 1.4D	$M_u \leq \phi_b M_n = 0.9 F_y Z$
$L_e = Kl$	P_U : 1.2D + 1.6L + 0.5(Lr or S or R)	$M_{ult} = M_p = f_y \Sigma A_i y_i = f_y Z$
$P_{cr} = \frac{\pi^2 EI}{(L_e)^2} = \frac{\pi^2 EA}{\left(L_e/r\right)^2}$	P_U : 1.2D + 1.6(Lr or S or R) + (0.5L or 0.8W)	$k = Z/S$; $Z = \frac{M_p}{f_y}$
$f_{cr} = \frac{\pi^2 E}{\left(L_e/r\right)^2}$	P_U : 1.2D + 1.3W + 0.5L + 0.5(Lr or S or R)	$P_u \leq \phi_c F_{cr} A_g \quad \phi_c = 0.85$
	$V_u \leq \phi_v (0.6 F_{yw} A_w) \quad \phi_v = 0.9$	$\lambda_c = \frac{Kl}{r\pi}\sqrt{\frac{F_y}{E}}$
Wood: $F' = C_D C_M C_F \ldots \times F_{tabulated}$	$\lambda_c \leq 1.5 \qquad F_{cr} = \left(0.658^{\lambda_c^2}\right) F_y$	
$F'_c = F_c^* C_p = (F_c C_D) C_p$	$\lambda_c > 1.5 \qquad F_{cr} = \left[\frac{0.877}{\lambda_c^2}\right] F_y$	
$F_{cE} = \frac{K_{cE} E}{\left(l_e/d\right)^2}$ K_{cE} = 0.3 sawn, 0.418 glulam	$\frac{P_u}{\phi_c P_n} \geq 0.2: \qquad \frac{P_u}{\phi_c P_n} + \frac{8}{9}\left(\frac{M_{ux}}{\phi_b M_{nx}} + \frac{M_{uy}}{\phi_b M_{ny}}\right) \leq 1.0$	
$\left[\frac{f_c}{F'_c}\right]^2 + \frac{f_{bx}}{F'_{bx}\left[1 - f_c/F_{cEx}\right]} \leq 1.0$	$\frac{P_u}{\phi_c P_n} < 0.2: \qquad \frac{P_u}{2\phi_c P_n} + \left(\frac{M_{ux}}{\phi_b M_{nx}} + \frac{M_{uy}}{\phi_b M_{ny}}\right) \leq 1.0$	
$f_{max} = \frac{P}{A} + \frac{Mc}{I}$	$P_u \leq \phi_t F_y A_g \quad \phi_t = 0.9$	$P_u \leq \phi_t F_u A_e \quad \phi_t = 0.75$
$\frac{f_a}{F_a} + \frac{f_b}{F_b} \leq 1.0$	$f_{max} = \frac{P}{A} + \frac{M_1 y}{I} + \frac{M_2 z}{I}$	$\frac{f_a}{F_a} + \frac{f_{bx}}{F_{bx}} + \frac{f_{by}}{F_{by}} \leq 1.0$

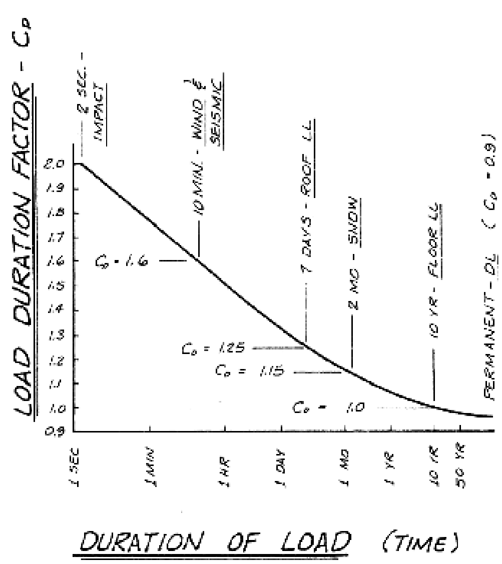
AISC – ASD: $C_m = 0.6 - 0.4\left(\frac{M_1}{M_2}\right)$	$\frac{l_e}{r} \geq C_c \qquad F_a = \frac{f_{critical}}{F.S.} = \frac{12\pi^2 E}{23\left(\frac{Kl}{r}\right)^2}$
$C_c = \sqrt{\frac{2\pi^2 E}{F_y}}$	$\frac{l_e}{r} < C_c \qquad F_a = \left[1 - \frac{\left(\frac{Kl}{r}\right)^2}{2C_c^2}\right]\frac{F_y}{F.S.}$
$F_b = 0.66F_y$ (braced)	$F.S. = \frac{5}{3} + \frac{3}{8}\cdot\frac{\frac{L_e}{r}}{C_c} - \frac{1}{8}\cdot\left(\frac{\frac{L_e}{r}}{C_c}\right)^3$
$F_b = 0.60F_y$ (unbraced)	
$F_v = 0.40F_y$	
$F_v = 0.30F_{weld}$	
$F_t = 0.60F_y$ (gross)	$\frac{f_a}{F_a} + \frac{C_{mx} f_{bx}}{\left(1 - \frac{f_a}{F'_{ex}}\right)F_{bx}} + \frac{C_{my} f_{by}}{\left(1 - \frac{f_a}{F'_{ey}}\right)F_{by}} \leq 1.0$
$F_t = 0.5F_u$ (net)	
$F_t = 0.45F_y$ (pinned)	
$F_t = 0.33F_u$ (threaded)	

Reference Diagrams



Allowable Strength of Fillet Welds per inch of weld

Weld Size (in.)	E60XX (k/in.)	E70XX (k/in.)
3/16	2.39	2.78
¼	3.18	3.71
5/16	3.98	4.64
3/8	4.77	5.57
7/16	5.57	6.94
½	6.36	7.42
5/8	7.95	9.27
¾	9.55	11.13

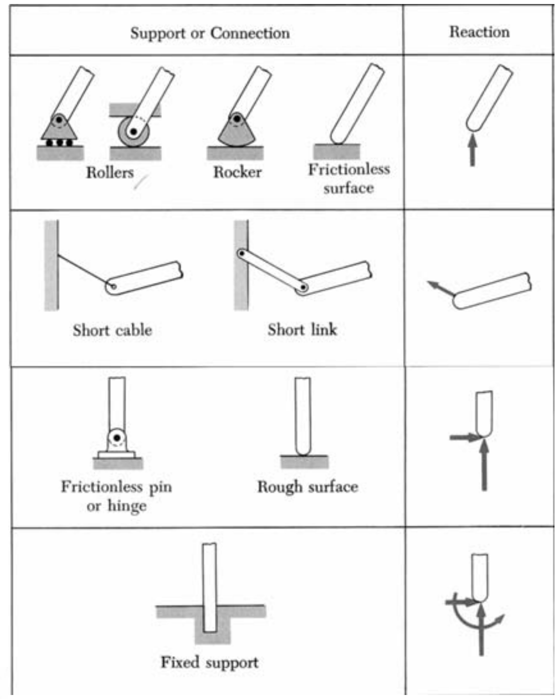


Reference Diagrams

BOLTS, THREADED PARTS AND RIVETS
Allowable Shear in kips

TABLE SHEAR

	ASTM Designation	Connection Type[a]	Hole Type[b]	F_v ksi	Loading[c]	5/8	3/4	7/8	1	1 1/8	1 1/4	1 3/8	1 1/2
						Nominal Diameter d, in.							
						Area (Based on Nominal Diameter) in.^{2}							
						.3068	.4418	.6013	.7854	.9940	1.227	1.485	1.767
Bolts	A307	—	STD NSL	10.0	S	3.1	4.4	6.0	7.9	9.9	12.3	14.8	17.7
					D	6.1	8.8	12.0	15.7	19.9	24.5	29.7	35.3
	A325	SC[a] Class A	STD	17.0	S	5.22	7.51	10.2	13.4	16.9	20.9	25.2	30.0
					D	10.4	15.0	20.4	26.7	33.8	41.7	50.5	60.1
			OVS, SSL	15.0	S	4.60	6.63	9.02	11.8	14.9	18.4	22.3	26.5
					D	9.20	13.3	18.0	23.6	29.8	36.8	44.6	53.0
			LSL	12.0	S	3.68	5.30	7.22	9.42	11.9	14.7	17.8	21.2
					D	7.36	10.6	14.4	18.8	23.9	29.4	35.6	42.4
		N	STD, NSL	21.0	S	6.4	9.3	12.6	16.5	20.9	25.8	31.2	37.1
					D	12.9	18.6	25.3	33.0	41.7	51.5	62.4	74.2
		X	STD, NSL	30.0	S	9.2	13.3	18.0	23.6	29.8	36.8	44.5	53.0
					D	18.4	26.5	36.1	47.1	59.6	73.6	89.1	106.0



BOLTS, AND THREADED PARTS
Allowable Bearing load in kips

TABLE BEARING
Slip-critical and Bearing-type Connections

Material Thickness	F_u = 58 ksi Bolt dia. 3/4	7/8	1	F_u = 65 ksi Bolt dia. 3/4	7/8	1	F_u = 70 ksi Bolt dia. 3/4	7/8	1	F_u = 100 ksi Bolt dia. 3/4	7/8	1
1/8	6.5	7.6	8.7	7.3	8.5	9.8	7.9	9.2	10.5	11.3	13.1	15.0
3/16	9.8	11.4	13.1	11.0	12.8	14.6	11.8	13.8	15.8	16.9	19.7	22.5
1/4	13.1	15.2	17.4	14.6	17.1	19.5	15.8	18.4	21.0	22.5	26.3	30.0
5/16	16.3	19.0	21.8	18.3	21.3	24.4	19.7	23.0	26.3	28.1	32.8	37.5
3/8	19.6	22.8	26.1	21.9	25.6	29.3	23.6	27.6	31.5	33.8	39.4	45.0
7/16	22.8	26.6	30.5	25.6	29.9	34.1	27.6	32.2	36.8		45.9	52.5
1/2	26.1	30.5	34.8	29.3	34.1	39.0	31.5	36.8	42.0			60.0
9/16	29.4	34.3	39.2	32.9	38.4	43.9		41.3	47.3			
5/8	32.6	38.1	43.5		42.7	48.8		45.9	52.5			
11/16		41.9	47.9		46.9	53.6			57.8			
3/4		45.7	52.2			58.5						
13/16			56.6									
7/8			60.9									
15/16												
1	52.2	60.9	69.6	58.5	68.3	78.0	63.0	73.5	84.0	90.0	105.0	120.0

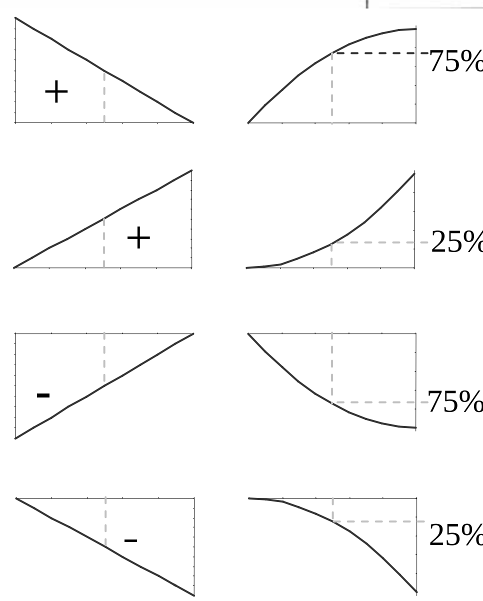
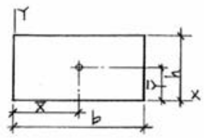
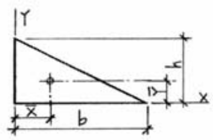
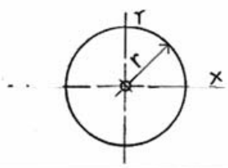
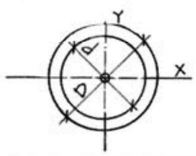
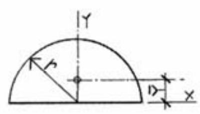
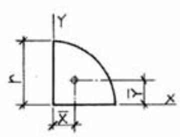
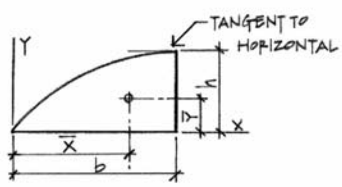
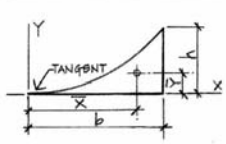


TABLE 3.1. Coefficients for Rectangular Bars in Torsion

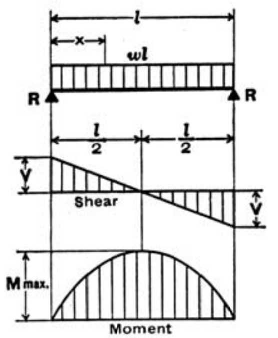
a/b	c_1	c_2
1.0	0.208	0.1406
1.2	0.219	0.1661
1.5	0.231	0.1958
2.0	0.246	0.229
2.5	0.258	0.249
3.0	0.267	0.263
4.0	0.282	0.281
5.0	0.291	0.291
10.0	0.312	0.312
∞	0.333	0.333

Reference Geometry

Shape	Drawing	$\bar{x}$	$\bar{y}$	Area	Moment of Inertia (I_x)
Rectangle		$b/2$	$h/2$	bh	$I_x = \frac{bh^3}{12}$
Triangle		$b/3$	$h/3$	$bh/2$	$I_x = \frac{bh^3}{36}$
Circle		0	0	πr^2	$I_x = \frac{\pi r^4}{4} = \frac{\pi d^4}{64}$
Hollow Circle		0	0	$\frac{\pi(D^2 - d^2)}{4}$	$I_x = \frac{\pi(D^4 - d^4)}{64}$
Semicircle		0	$4r/3\pi$	$\pi r^2/2$	$I_x = I_y = \frac{\pi r^4}{8}$
Quarter Circle		$4r/3\pi$	$4r/3\pi$	$\pi r^2/4$	$I_x = I_y = \frac{\pi r^4}{16}$
Parabolic Segment		$5b/8$	$2h/5$	$2bh/3$	$I_x = \frac{8h^3b}{175}$
Complement of a Parabolic Segment		$3b/4$	$3h/10$	$bh/3$	$I_x = \frac{37h^3b}{2100}$

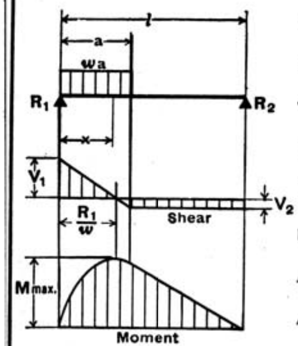
Reference Beam Diagrams

1. SIMPLE BEAM—UNIFORMLY DISTRIBUTED LOAD



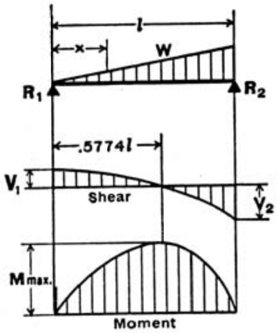
Total Equiv. Uniform Load		$= wl$
$R = V$		$= \frac{wl}{2}$
V_x		$= w\left(\frac{l}{2} - x\right)$
M max.	(at center)	$= \frac{wl^2}{8}$
M_x		$= \frac{wx}{2}(l - x)$
Δmax.	(at center)	$= \frac{5wl^4}{384EI}$
Δx		$= \frac{wx}{24EI}(l^3 - 2lx^2 + x^3)$

5. SIMPLE BEAM—UNIFORM LOAD PARTIALLY DISTRIBUTED AT ONE END



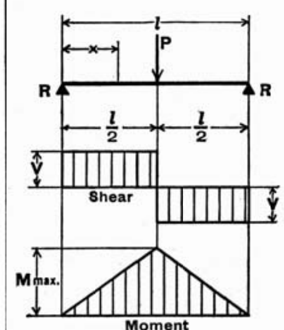
$R_1 = V_1$ max.		$= \frac{wa}{2l}(2l - a)$
$R_2 = V_2$		$= \frac{wa^2}{2l}$
V_x	(when $x < a$)	$= R_1 - wx$
M max.	(at $x = \frac{R_1}{w}$)	$= \frac{R_1^2}{2w}$
M_x	(when $x < a$)	$= R_1x - \frac{wx^2}{2}$
M_x	(when $x > a$)	$= R_2(l - x)$
Δx	(when $x < a$)	$= \frac{wx}{24EIl}\left(a^2(2l-a)^2 - 2ax^2(2l-a) + lx^3\right)$
Δx	(when $x > a$)	$= \frac{wa^2(l-x)}{24EIl}(4xl - 2x^2 - a^2)$

2. SIMPLE BEAM—LOAD INCREASING UNIFORMLY TO ONE END



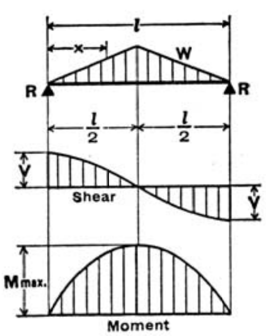
Total Equiv. Uniform Load		$= \frac{16W}{9\sqrt{3}} = 1.0264W$
$R_1 = V_1$		$= \frac{W}{3}$
$R_2 = V_2$ max.		$= \frac{2W}{3}$
V_x		$= \frac{W}{3} - \frac{Wx^2}{l^2}$
M max.	(at $x = \frac{l}{\sqrt{3}} = .5774l$)	$= \frac{2Wl}{9\sqrt{3}} = .1283\,Wl$
M_x		$= \frac{Wx}{3l^2}(l^2 - x^2)$
Δmax.	(at $x = l\sqrt{1 - \sqrt{\frac{8}{15}}} = .5193l$)	$= .01304\,\frac{Wl^3}{EI}$
Δx		$= \frac{Wx}{180EIl^2}(3x^4 - 10l^2x^2 + 7l^4)$

7. SIMPLE BEAM—CONCENTRATED LOAD AT CENTER



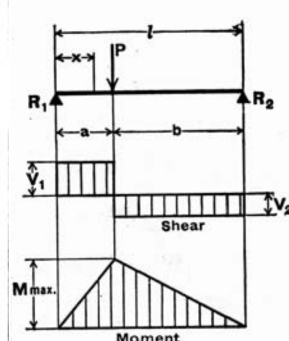
Total Equiv. Uniform Load		$= 2P$
$R = V$		$= \frac{P}{2}$
M max.	(at point of load)	$= \frac{Pl}{4}$
M_x	(when $x < \frac{l}{2}$)	$= \frac{Px}{2}$
Δmax.	(at point of load)	$= \frac{Pl^3}{48EI}$
Δx	(when $x < \frac{l}{2}$)	$= \frac{Px}{48EI}(3l^2 - 4x^2)$

3. SIMPLE BEAM—LOAD INCREASING UNIFORMLY TO CENTER



Total Equiv. Uniform Load		$= \frac{4W}{3}$
$R = V$		$= \frac{W}{2}$
V_x	(when $x < \frac{l}{2}$)	$= \frac{W}{2l^2}(l^2 - 4x^2)$
M max.	(at center)	$= \frac{Wl}{6}$
M_x	(when $x < \frac{l}{2}$)	$= Wx\left(\frac{1}{2} - \frac{2x^2}{3l^2}\right)$
Δmax.	(at center)	$= \frac{Wl^3}{60EI}$
Δx	(when $x < \frac{l}{2}$)	$= \frac{Wx}{480EIl^2}(5l^2 - 4x^2)^2$

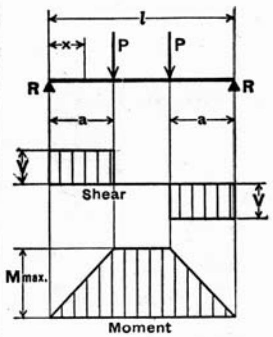
8. SIMPLE BEAM—CONCENTRATED LOAD AT ANY POINT



Total Equiv. Uniform Load		$= \frac{8Pab}{l^2}$
$R_1 = V_1$	(max. when $a < b$)	$= \frac{Pb}{l}$
$R_2 = V_2$	(max. when $a > b$)	$= \frac{Pa}{l}$
M max.	(at point of load)	$= \frac{Pab}{l}$
M_x	(when $x < a$)	$= \frac{Pbx}{l}$
Δmax.	(at $x = \sqrt{\frac{a(a+2b)}{3}}$ when $a > b$)	$= \frac{Pab(a+2b)\sqrt{3a(a+2b)}}{27EIl}$
Δa	(at point of load)	$= \frac{Pa^2b^2}{3EIl}$
Δx	(when $x < a$)	$= \frac{Pbx}{6EIl}(l^2 - b^2 - x^2)$

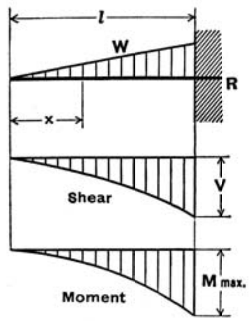
Reference Beam Diagrams

9. SIMPLE BEAM—TWO EQUAL CONCENTRATED LOADS SYMMETRICALLY PLACED



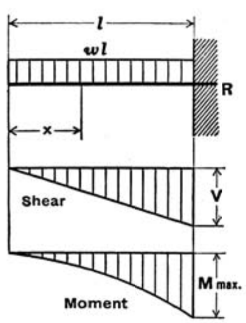
Total Equiv. Uniform Load	$= \frac{8\,Pa}{l}$
R = V	= P
M max. (between loads)	= Pa
M_x (when x < a)	= Px
Δmax. (at center)	$= \frac{Pa}{24EI}(3l^2 - 4a^2)$
Δx (when x < a)	$= \frac{Px}{6EI}(3la - 3a^2 - x^2)$
Δx (when x > a and < (l − a))	$= \frac{Pa}{6EI}(3lx - 3x^2 - a^2)$

18. CANTILEVER BEAM—LOAD INCREASING UNIFORMLY TO FIXED END



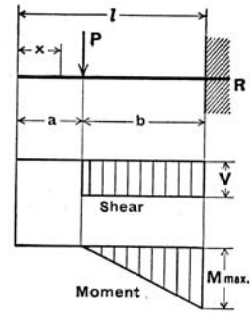
Total Equiv. Uniform Load	$= \frac{8}{3}W$
R = V	= W
V_x	$= W\frac{x^2}{l^2}$
M max. (at fixed end)	$= \frac{Wl}{3}$
M_x	$= \frac{Wx^3}{3l^2}$
Δmax. (at free end)	$= \frac{Wl^3}{15EI}$
Δx	$= \frac{W}{60EIl^2}(x^5 - 5l^4x + 4l^5)$

19. CANTILEVER BEAM—UNIFORMLY DISTRIBUTED LOAD



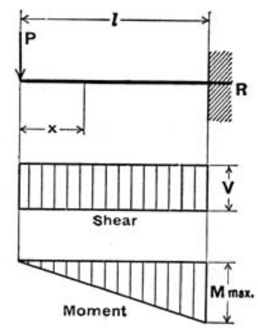
Total Equiv. Uniform Load	$= 4wl$
R = V	$= wl$
V_x	$= wx$
M max. (at fixed end)	$= \frac{wl^2}{2}$
M_x	$= \frac{wx^2}{2}$
Δmax. (at free end)	$= \frac{wl^4}{8EI}$
Δx	$= \frac{w}{24EI}(x^4 - 4l^3x + 3l^4)$

21. CANTILEVER BEAM—CONCENTRATED LOAD AT ANY POINT



Total Equiv. Uniform Load	$= \frac{8Pb}{l}$
R = V	= P
M max. (at fixed end)	= Pb
M_x (when x > a)	= P (x − a)
Δmax. (at free end)	$= \frac{Pb^2}{6EI}(3l - b)$
Δa (at point of load)	$= \frac{Pb^3}{3EI}$
Δx (when x < a)	$= \frac{Pb^2}{6EI}(3l - 3x - b)$
Δx (when x > a)	$= \frac{P(l-x)^2}{6EI}(3b - l + x)$

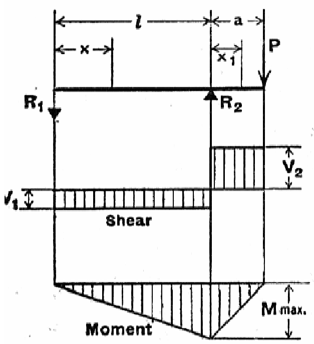
22. CANTILEVER BEAM—CONCENTRATED LOAD AT FREE END



Total Equiv. Uniform Load	= 8P
R = V	= P
M max. (at fixed end)	= Pl
M_x	= Px
Δmax. (at free end)	$= \frac{Pl^3}{3EI}$
Δx	$= \frac{P}{6EI}(2l^3 - 3l^2x + x^3)$

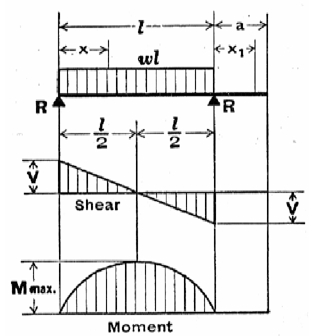
Reference Beam Diagrams

26. BEAM OVERHANGING ONE SUPPORT—CONCENTRATED LOAD AT END OF OVERHANG



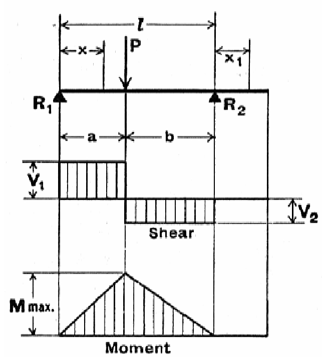
$R_1 = V_1$		$= \frac{Pa}{l}$
$R_2 = V_1 + V_2$		$= \frac{P}{l}(l + a)$
V_2		$= P$
M max.	(at R_2)	$= Pa$
M_x	(between supports)	$= \frac{Pax}{l}$
M_{x_1}	(for overhang)	$= P(a - x_1)$
Δmax.	(between supports at $x = \frac{l}{\sqrt{3}}$)	$= \frac{Pal^2}{9\sqrt{3}EI} = .06415\frac{Pal^2}{EI}$
Δmax.	(for overhang at $x_1 = a$)	$= \frac{Pa^2}{3EI}(l + a)$
Δx	(between supports)	$= \frac{Pax}{6EIl}(l^2 - x^2)$
Δx_1	(for overhang)	$= \frac{Px_1}{6EI}(2al + 3ax_1 - x_1^2)$

27. BEAM OVERHANGING ONE SUPPORT—UNIFORMLY DISTRIBUTED LOAD BETWEEN SUPPORTS



Total Equiv. Uniform Load		$= wl$
$R = V$		$= \frac{wl}{2}$
V_x		$= w\left(\frac{l}{2} - x\right)$
M max.	(at center)	$= \frac{wl^2}{8}$
M_x		$= \frac{wx}{2}(l - x)$
Δmax.	(at center)	$= \frac{5wl^4}{384EI}$
Δx		$= \frac{wx}{24EI}(l^3 - 2lx^2 + x^3)$
Δx_1		$= \frac{wl^3x_1}{24EI}$

28. BEAM OVERHANGING ONE SUPPORT—CONCENTRATED LOAD AT ANY POINT BETWEEN SUPPORTS



Total Equiv. Uniform Load		$= \frac{8Pab}{l^2}$
$R_1 = V_1$	(max. when $a < b$)	$= \frac{Pb}{l}$
$R_2 = V_2$	(max. when $a > b$)	$= \frac{Pa}{l}$
M max.	(at point of load)	$= \frac{Pab}{l}$
M_x	(when $x < a$)	$= \frac{Pbx}{l}$
Δmax.	(at $x = \sqrt{\frac{a(a+2b)}{3}}$ when $a > b$)	$= \frac{Pab(a+2b)\sqrt{3a(a+2b)}}{27EIl}$
Δa	(at point of load)	$= \frac{Pa^2b^2}{3EIl}$
Δx	(when $x < a$)	$= \frac{Pbx}{6EIl}(l^2 - b^2 - x^2)$
Δx	(when $x > a$)	$= \frac{Pa(l - x)}{6EIl}(2lx - x^2 - a^2)$
Δx_1		$= \frac{Pabx_1}{6EIl}(l + a)$