

## AM07 Axial Loading &amp; Stress

1	$\sigma = \begin{cases} (47.5 - 20.0x) \text{ MPa} & (0 < x \leq 0.5\text{m}) \\ (32.5 - 20.0x) \text{ MPa} & (0.5 < x \leq 1.25\text{m}) \end{cases}$
2	$\sigma_{\text{ave}} = \frac{P}{A} \sin^2 \theta \quad \tau_{\text{ave}} = \frac{P}{2A} \sin 2\theta$
3	$\theta \approx 63.6^\circ \approx 1.11 \text{ rad} \quad \sigma_{AB} = \sigma_{BC} = 316 \text{ MPa}$
4	$\sigma_{a-a} = 12.2 \text{ MPa} \quad \tau_{a-a} = 0 \quad \sigma_{b-b} = 4.41 \text{ MPa} \quad \tau_{b-b} = 5.88 \text{ MPa}$

## AM08 Elastic Deformation of Axially Loaded Bars

1	$\delta_B = 2.20 \text{ mm} \quad \delta_A = 2.517 \text{ mm}$
2	$\delta_F = 2.23 \text{ mm}$
3	$\delta_{A/B} = -1.03 \text{ mm}$
4	$\delta = \frac{PL}{\pi E r_1 r_2}$

## AM09 Mechanical Behavior &amp; Strength Check

1	$\nu = 0.300$
2	$\varepsilon_e = 0.00207 \text{ mm/mm} \quad \varepsilon_p = 0.0729 \text{ mm/mm}$
3	$P_{\text{max}} = 11.3 \text{ kN}$
4	$d_{AB} = 3.54 \text{ mm} \quad d_{AC} = 3.23 \text{ mm} \quad L_{AB\text{-final}} = 750.49 \text{ mm}$

## AM10 Pin Shearing &amp; Bearing Stresses

1	$\sigma_b = 48.3 \text{ MPa} \quad \tau_{\text{ave}} = 18.4 \text{ MPa}$
2	$d = 28 \text{ mm} \quad b = 62.3 \text{ mm} \quad h = 34.3 \text{ mm}$
3	$\tau_{\text{ave}} = 80.8 \text{ MPa} \quad \sigma_b = 126.95 \text{ MPa} \quad \sigma_b = 203 \text{ MPa}$

## AM11 Torsional Stresses

1	$\tau_{AB\text{max}} = 1.04 \text{ MPa} \quad \tau_{BC\text{max}} = 3.11 \text{ MPa}$
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2	$ \tau _{\max} = 33.0 \text{ MPa}$ at the fixed end $ \tau _{\min} = 0$ at 0.7m from the fixed end
3	$t_0 = 133 \text{ N} \cdot \text{m/m}$ $\tau_A = 0.255 \text{ MPa}$ $\tau_B = 0.141 \text{ MPa}$
4	$r' = \frac{1}{\sqrt[4]{2}} r$

## AM12 Torsional Deformation

1	percent increase in shear stress = 6.67% percent increase in angle of twist per unit length = 6.67%
2	$d_{\min} = 201 \text{ mm}$ $\phi = 0.0576 \text{ rad} = 3.30^\circ$
3	$t_{\min} = 1.60 \text{ mm}$
4	$T_B = \frac{1}{2} t_0 L + T_A$ $\phi_{A/B} = \frac{2L(t_0 L + 3T_A)}{3\pi G(r_0^4 - r_i^4)}$

## AM13 Bending Internal Forces - Diagrams

a	$A_y = 815.63 \text{ N} \uparrow$ $B_y = 1484.38 \text{ N} \uparrow$
b	$A_y = \frac{M_0}{3a} \downarrow$ $B_y = \frac{M_0}{3a} \uparrow$
c	$A_y = 0$ $M_A = mL \uparrow \downarrow$
d	$A_y = 10 \text{ kN} \uparrow$ $B_y = 130 \text{ kN} \uparrow$
e	$A_y = 16.5 \text{ kN} \uparrow$ $B_y = 0.5 \text{ kN} \downarrow$
f	$A_y = 65 \text{ kN} \uparrow$ $B_y = 5 \text{ kN} \downarrow$
g	$A_y = 82.5 \text{ kN} \uparrow$ $B_y = 37.5 \text{ kN} \uparrow$
h	$A_y = 180 \text{ kN} \uparrow$ $M_A = 535 \text{ kN} \cdot \text{m} \downarrow \uparrow$

## AM14 Bending Internal Forces - Applications

1	$A_y = F_y = 1 \text{ kN} \uparrow$ $C_y = D_y = 3.6 \text{ kN} \uparrow$
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2	$a = \frac{L}{\sqrt{2}}$
3	$a = \frac{\sqrt{3}}{2}L$
4	$a = 0.207L$

## AM15 Bending Normal Stresses

1	$P_{\max} = 1.67 \text{ kN}$
2	$\sigma_{\text{smaller}} = 74.7 \text{ MPa}$ percent decrease in stress = 53.0%
3	$b_{\min} = 53.1 \text{ mm}$
4	$a_{\min} = 160 \text{ mm}$

## AM16 Bending Shearing Stresses &amp; Rational Design of Beams

1	$b_{\min} = 211 \text{ mm}$ $h_{\min} = 264 \text{ mm}$
2	$a = L/4$ $\tau_{\max} = \frac{3wL}{8bd}$
3	$\tau_{\max} = 14.7 \text{ MPa}$ at cross-section $B$
4	$d = d_0 \sqrt{\frac{x}{L}}$

## AM17 Bending Deflections by Integration

1	$w_1 = \frac{P}{6EI} [-3x_1(L-a)^2 + 3a(L-a)^2 + 2(L-a)^3] \downarrow \quad 0 < x_1 \leq a$ $w_2 = \frac{P}{6EI} [-x_2^3 + 3(L-a)x_2^2] \downarrow \quad 0 < x_2 \leq L-a$
2	$w = \frac{M_0}{6EIL} (-3Lx^2 + x^3 + 2L^2x) \downarrow \quad \theta_A = \frac{M_0L}{3EI} \uparrow \downarrow$ $w_{\max} = \frac{0.0642M_0L^2}{EI} \downarrow \quad \text{at } x = \left(1 - \frac{1}{\sqrt{3}}\right)L$

3	$w_1 = \frac{M_0}{6EI} (x_1^3 - L^2 x_1) \downarrow \quad w_2 = \frac{M_0}{6EI} (3Lx_2^2 - 8L^2 x_2 + 5L^3) \downarrow$ $\theta_c = \frac{4M_0 L}{3EI} \uparrow \downarrow \quad w_c = \frac{5M_0 L^2}{6EI} \downarrow$
4	$w_1 = \frac{w}{24EI} (x_1^4 - 4ax_1^3 + 6a^2 x_1^2) \downarrow \quad w_2 = \frac{wa^3}{24EI} (4x_2 - a) \downarrow$ $\theta_B = \frac{wa^3}{6EI} \uparrow \downarrow \quad w_B = \frac{wa^3}{24EI} (4L - a) \downarrow$

## AM18 Bending Deflections by Integration &amp; Applications

1	$w_1 = \frac{Px_1}{12EI} (x_1^2 - L^2) \downarrow \quad w_2 = \frac{P}{24EI} (4x_2^3 - 7L^2 x_2 + 3L^3) \downarrow$ $w_{\max} = w(x_2 = 0) = \frac{PL^3}{8EI} \downarrow$
2	$w_1 = \frac{P}{6EI} (x_1^3 - 3a(a+b)x_1 + a^2(2a+3b)) \downarrow \quad w_3 = \frac{Pax_3}{2EI} (x_3 - b) \downarrow$ $\theta_A = -\frac{Pab}{2EI} \uparrow \downarrow \quad w(x_3 = b/2) = -\frac{Pab^2}{8EI} \downarrow$
3	$\sigma_{\max} = 582 \text{ MPa}$
4	$F = 1.375 \text{ N}$

## AM19 Bending Deflections by Superposition

1	$M_0 = \frac{Pa}{6}$
2	$I = 40b$
3	$w_D = \frac{9.11 \times 10^5}{EI} \text{ N} \cdot \text{m}^3 \downarrow$
4	$w_A = \frac{308}{EI} \text{ kN} \cdot \text{m}^3 \downarrow \quad \theta_A = \frac{79.7}{EI} \text{ kN} \cdot \text{m}^2 \uparrow \downarrow$

## AM20 Bending Deflections by Moment-Area Theorems

1	$\theta_C = \frac{5Pa^2}{2EI} \uparrow \downarrow \quad w_B = \frac{25Pa^3}{6EI} \downarrow$
2	$\theta_B = -\frac{7wa^3}{12EI} \uparrow \downarrow \quad w_C = \frac{25wa^4}{48EI} \downarrow$

3	$\theta_B = \frac{3Pa^2}{4EI} \uparrow \downarrow \quad w_C = \frac{13Pa^3}{12EI} \downarrow$
4	$F = \frac{P}{4}$

## AM21 Bending Deflections by Singular Functions

1	$w = \frac{1}{EI} \left[ 0.25x^4 - 0.208\langle x-1.5 \rangle^3 - 0.25\langle x-1.5 \rangle^4 - 4.625\langle x-4.5 \rangle^3 - 25.1x + 36.4 \right] \text{ kN} \cdot \text{m}^3 \downarrow$
2	$w(x=7\text{m}) = \frac{835}{EI} \text{ kN} \cdot \text{m}^3 \downarrow \quad \theta_A = \frac{279}{EI} \text{ kN} \cdot \text{m}^2 \uparrow \downarrow$
3	$\theta = \frac{1}{EI} \left[ -2.25x^2 + 0.5x^3 - 5.25\langle x-5 \rangle^2 - 0.5\langle x-5 \rangle^3 + 3.125 \right] \text{ kN} \cdot \text{m}^2 \uparrow \downarrow$ $w = \frac{1}{EI} \left[ -0.75x^3 + 0.125x^4 - 1.75\langle x-5 \rangle^3 - 0.125\langle x-5 \rangle^4 + 3.125x \right] \text{ kN} \cdot \text{m}^3 \downarrow$
4	$w = \frac{w}{EI} \left[ \frac{1}{24}x^4 - \frac{1}{4}L\langle x-L \rangle^3 - \frac{1}{24}\langle x-L \rangle^4 - \frac{1}{3}L^3x + \frac{7}{24}L^4 \right] \downarrow \quad w_C = \frac{7wL^4}{24EI} \downarrow$

## AM22 Statically Indeterminate Problems – Axially Loaded Members

1	$\sigma_{\text{steel}} = 65.9 \text{ MPa} \quad \sigma_{\text{concrete}} = 8.24 \text{ MPa}$
2	$\sigma_{AB} = \frac{7}{12} \frac{P}{A} \quad \sigma_{CD} = \frac{1}{3} \frac{P}{A} \quad \sigma_{EF} = \frac{1}{12} \frac{P}{A}$
3	$F_{AB} = F_{EF} = 1.85 \text{ kN} \quad F_{CD} = 3.70 \text{ kN}$
4	$F = \frac{1}{2} \alpha AE (T_B - T_A)$

## AM23 Statically Indeterminate Problems – Torque Loaded Members

1	$\tau_{AC\text{-max}} = 9.55 \text{ MPa} \quad \tau_{CB\text{-max}} = 6.37 \text{ MPa}$
2	$T_A = 55.6 \text{ N} \cdot \text{m} \quad T_B = 222 \text{ N} \cdot \text{m}$
3	$T_A = \frac{3}{4} t_0 L \quad T_B = \frac{7}{12} t_0 L$

## AM24 Statically Indeterminate Problems – Beams

1	$A_y = C_y = \frac{1}{10} w_0 L \uparrow \quad B_y = \frac{4}{5} w_0 L \uparrow$
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2	$F_{AC} = \frac{3E_2 A_2 w L_1^4}{8(E_2 A_2 L_1^3 + 3E_1 I_1 L_2)}$
3	$A_y = \frac{57}{128} wL \uparrow \quad M_A = -\frac{9}{128} wL^2 \uparrow\downarrow \quad B_y = \frac{7}{128} wL \uparrow$
4	$F_{\text{spring}} = \frac{5wkL^4}{4(6EI + kL^3)} \uparrow$

## AM25 Stress Transformation &amp; Mohr's Circle

1	$\sigma_x = -193 \text{ MPa} \quad \sigma_y = -357 \text{ MPa} \quad \tau_{xy} = 102 \text{ MPa}$
2	$\sigma_{x'} = 49.7 \text{ MPa} \quad \tau_{x'y'} = -34.8 \text{ MPa}$
3	$\sigma_1 = 88.1 \text{ MPa} \quad \sigma_2 = -13.1 \text{ MPa} \quad \theta_p = 40.7^\circ$ $\tau_{\max} = 50.6 \text{ MPa} \quad \sigma_{\text{ave}} = 37.5 \text{ MPa} \quad \theta_s = 4.27^\circ$
4	$\sigma_1 = 150 \text{ MPa} \quad \sigma_2 = 137 \text{ MPa} \quad \sigma_3 = -46.8 \text{ MPa} \quad \tau_{\max} = 98.4 \text{ MPa}$

## AM26 Generalized Hooke's Law

1	N.A.
2	$\varepsilon_1 = 30.5(10^{-6}) \quad \varepsilon_2 = \varepsilon_3 = -10.7(10^{-6})$
3	$\varepsilon_{x'} = -\varepsilon_{y'} = 2.52(10^{-3})$
4	$\theta = \tan^{-1}\left(\frac{1}{\sqrt{\nu}}\right)$

## AM27 Strength Theory

1	NO.
2	N.A.

3	$(a) \sigma_r = \sqrt{\sigma_x^2 + \sigma_y^2 - \sigma_x \sigma_y + 3\tau_{xy}^2}$ $(b) \sigma_r = \sqrt{(\sigma_x - \sigma_y)^2 + 4\tau_{xy}^2}$
4	<p>Yes according to the maximum shear stress theory</p> <p>No according to the maximum distortion energy</p>

## AM28 Combined Loading

1	$\sigma_x = 11.9 \text{ MPa}$ $\tau_{xy} = \tau_{yx} = -0.318 \text{ MPa}$ all other stress components are zero.
2	$\sigma_E = -1.01 \text{ MPa}$ $\tau_E = 1.96 \text{ MPa}$ all other stress components are zero. $\sigma_F = -27.7 \text{ MPa}$ all other stress components are zero.
3	$\sigma_A = 107 \text{ MPa}$ $\tau_A = 15.3 \text{ MPa}$ all other stress components are zero. $\tau_B = 14.8 \text{ MPa}$ all other stress components are zero.
4	$\sigma_C = -103 \text{ MPa}$ $(\tau_{xy})_C = 3.54 \text{ MPa}$ all other stress components are zero.

## AM29 Core Area of Compression

1	$y = 0.75 - 1.5x$
2	$e_y = r/4$
3	$(\sigma_C)_{\max} = 11.0 \text{ MPa}$ $(\sigma_C)_{\min} = 0$

## AM30 Euler's Formula

1	$P_{cr} = 22.7 \text{ kN}$
2	$P_{cr} = 272 \text{ kN}$
3	$P_{cr} = 1.30 \text{ MN}$

4	$P_{cr} = 42.8 \text{ kN}$
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## AM31 Design of Columns

1	The frame cannot support the load with the required F.S.
2	$P_{cr} = 12.1 \text{ kN}$
3	$d_{AB} = 68.8 \text{ mm}$ $d_{CD} = 40.2 \text{ mm}$
4	Member $AB$ will buckle.

## AM32 Elastic Strain Energy

1	$U = 0.372 \text{ J}$
2	$U = \frac{w_0^2 L^5}{504EI}$
3	$U = 149 \text{ J}$
4	N.A.

## AM33 Work and Energy

1	$(\Delta_C)_h = \frac{2PL}{EA}$
2	$(\Delta_D)_v = \frac{3.50PL}{EA}$
3	$\Delta_B = \frac{PL}{15} \left( \frac{15 \cos^2 \theta}{EA} + \frac{5L^2 \sin^2 \theta}{EI} \right)$
4	$\theta_E = 3.15^\circ$



### AM34 Castigliano's Theorem

1	$(\Delta_D)_h = 4.12 \text{ mm} \rightarrow$
2	$\theta_A = 0.289^\circ$
3	$F_{BC} = P / (1 + 2 \cos^3 \phi)$
4	$F_{sp} = \frac{5wkL^4}{4(6EI + kL^3)}$

### AM35 Method of Virtual Forces

1	$(\Delta_B)_v = 0.01125 \text{ mm}$
2	$(\Delta_E)_v = 0.1167 \text{ mm}$
3	$\theta_A = 0.991(10^{-3}) \text{ rad}$
4	$(\Delta_C)_h = \frac{5wL^4}{8EI}$

### AM36 Dynamic Loading

1	$\sigma_{\max} = 216 \text{ MPa}$
2	$\Delta_{\max} = 23.3 \text{ mm} \quad \sigma_{\max} = 4.89 \text{ MPa}$
3	$\sigma_{\max} = 359 \text{ MPa}$
4	$h_{\max} = \frac{\sigma_{\max} L^2}{3Ec} \left( \frac{\sigma_{\max} I}{W L c} - 2 \right)$