Civil Engineering Department
Mechanics of materials (61207)
Second Exam

Instructor Name: 
Academic Year: 2013/2014
Semester: Summer
Credit Hours: 3
Date: Monday, July 14, 2014
Exam Duration:

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Student Grade

Good Luck.
Q1) The torques shown are exerted on pulleys B, C, and D. Knowing that the entire shaft is made of aluminum \((G = 27 \text{ GPa})\), determine

a) The max shear stress in the system
b) the angle of twist \(D\) with respect to \(B\).

\[ T_1 = 400 \text{ N} \cdot \text{m} \]

\[ J_1 = \frac{\pi (15)^4}{2} = 79521.5 \text{ mm}^4 \]

\[ T_2 = 500 \text{ N} \cdot \text{m} \]

\[ J_2 = \frac{\pi (18)^4}{2} = 164895.9 \text{ mm}^4 \]

\[ \tau_1 = \frac{T_1}{J_1} = \frac{400 \text{ (1500)} 15}{79521.5} = 75.4 \text{ MPa} \]

\[ \tau_2 = \frac{T_2}{J_2} = \frac{500 \text{ (1800)} 18}{164895.9} = 54 \text{ MPa} \]

\[ \phi_1 = \frac{T_1 \cdot L}{G J_1} = \frac{400 \text{ (1500)} (800)}{27 \times 10^3 \text{ (79521.5)}} = 0.149 \text{ rad} \]

\[ \phi_2 = \frac{T_2 \cdot L}{G J_2} = \frac{500 \text{ (1800)} (1000)}{27 \times 10^3 \text{ (164895.9)}} = 0.112 \text{ rad} \]

\[ \phi_{D/B} = 0.149 - 0.112 = 0.0366 \text{ rad} \]
Q2) Draw the shear force, and the Bending Moment Diagrams for the following Beam.

\[ \Sigma M_A = 0 \quad (4.8 \times 5) + (12 \times 14) - R_B \cdot 8 - (16 \times 4) = 0 \]

\[ R_B = 64 \, kN \]

\[ R_A = 24 \, kN \]
Q3) using the given beam and cross section, determine

1) The max tensile stress in the section at support B,
2) The max compressive stress in the section between AB

\[ M = -250 \text{kN.m} \]

\[ G = \frac{My}{I} \]

\[ T = \frac{(250 \times 10^6) \times 54}{28.55 \times 10^6} = 54 \text{ mm}^4 \]

\[ \sigma = \frac{250 \times 10^6 \times 90}{28.55 \times 10^6} = 7.88 \text{ MPa} \]
Q4) For the beam and loading shown, determine (a) the equation of the elastic curve for portion BC of the beam, (b) the slope at B

EI = 4000 kN.m²

\[ M_1 = \frac{6}{2} \left(2 - x_1\right)^2 \]
\[ M_2 = -3 \left(2 - x_1\right)^2 \]
\[ M_3 = -3 \left(4 - 2x_1 + x_1^2\right) \]
\[ M_4 = -12 + 6x_1 - 3x_1^2 \]

\[ M_2 = \frac{6}{2} \left(2 + x_1\right)^2 + 32x \]
\[ M_3 = 32x - 3 \left(4 + x_1 + x_1^2\right) \]
\[ M_4 = 32x - (12 - 6x_1 - 3x_1^2) \]
\[ M_5 = -3x_1^2 + 26x - 12 \]

\[ K_2 = 0 \quad y_2 = 0 \quad K_3 = 6 \quad y_3 = 6 \]

\[ E = \frac{1}{l^2} \left[ -K_3^3 + 13K_2^2 - 12K_1 + C_1 \right] \]
\[ y_3 = \frac{l}{C_4} \left[ -\frac{x_1^4}{4} + \frac{13}{3} x_1^3 - 6 x_1^2 + 6 x_1 + C_2 \right] \]
\[ C_2 = 0 \quad C_1 = 66 \]

\[ y_3 = \frac{1}{E_0} \left[ -\frac{K_3^3}{4} + \frac{13}{3} K_2^2 - 6 K_1^2 + 66 K_1 \right] \]