Concordia University

Faculty of Engineering and Computer Science
ENGR 244 Mechanics of Materials Midterm (12.5%)
Saturday, February 9, 2013 11:00 AM to 12:30 PM
Drs. Ahmed (Sec. T), Bhowmick (Sec. X), El Baky (Sec. M) and Rajalingham (Secs. V and LL)

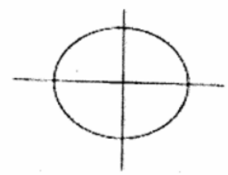
Special Instructions:

Answer all 3 questions. All Questions carry equal marks. Total Marks (75 pts.) Show all your work. In order to qualify for partial grade you must present your work neatly with explanations. Provide complete answer in the space provided with units.

Name: Midterm Test #1 SOLUTION ID:__________ Section: __________

Midterm Formulas

* $\sigma = \dfrac{P}{A}$
* $\tau = \dfrac{V}{A}$
* $\sigma = \dfrac{P}{A}\cos^2\theta$
* $\tau = \dfrac{P}{A}\cos\theta\sin\theta$
* $FS = \dfrac{ultimate}{allowable}$
* $\varepsilon = \dfrac{\partial}{L}$
* $E = \dfrac{\sigma}{\varepsilon}$
* $\partial = \dfrac{PL}{AE}$
* $G = \dfrac{E}{2(1+\upsilon)}$
* $\nu = -\dfrac{\varepsilon_y}{\varepsilon_x} = -\dfrac{\varepsilon_z}{\varepsilon_x}$
* $G = \dfrac{\tau}{\gamma}$
* $\tau = \dfrac{Tc}{J}$
* $\phi = \dfrac{TL}{JG}$
* $J = \frac{1}{2}\pi c^4$
* $P = 2\pi f T$
* $\tau_{Tx} = \dfrac{Ty}{\Sigma(x^2+y^2)A}$
* $\tau_{Ty} = \dfrac{Tx}{\Sigma(x^2+y^2)A}$
* $I = \frac{1}{12}bh^3$
* $\sigma = -\dfrac{My}{I} = \dfrac{|M|c}{I} = \dfrac{|M|}{S}$

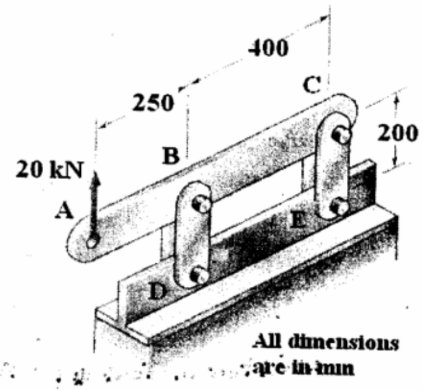


Material	Density (kg/m³)	Ultimate Strength			Yield Strength		Modulus of Elasticity (GPa)	Modulus of Rigidity (GPa)
		Tension (MPa)	Compression (MPa)	Shear (MPa)	Tension (MPa)	Shear (MPa)		
Steel	7860	400	400	400	250	145	200	77.2
Aluminum	2719	110	110	70	95	55	70	26

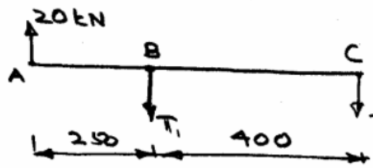
Question # 1 (25 pts)

A 20 kN vertical force is applied at A of a rigid beam ABC as shown in Figure. Each of the four vertical links BD and CF has a 30 mm x 10 mm rectangular cross section. Each of the four pins B, C, D and E has 15 mm diameter. Determine the followings:

(a) the maximum tensile stress in the links. (7 pts)
(b) the maximum compressive stress in the links. (6 pts)
(c) the maximum shearing stress in the pins. (6 pts)
(d) the maximum bearing stress between the links and the pins. (6 pts)



Forces on ABC:



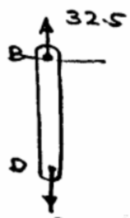
c) $-20 \times 625 + T_1 \times 400 = 0$

② $T_1 = 32.5$ kN (BD is in tension)

↑ $20 - T_1 - T_2 = 0$

② $T_2 = -12.5$ kN (CE is in compression)

(a)



BD is in tension

Weak section:

① Force = 32.5 kN

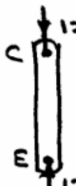
② Area = 2(30 − 15)(10) mm^2.

$\therefore \sigma_T = \frac{32.5 \times 10^3}{2(30-15)(10)}$

③ $= 108.3$ MPa.

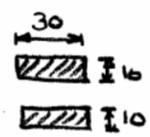
(Maximum tensile stress)

(b)



CE is in compression

Cross-section



① Force = 12.5 kN

① Area = $2 \times 30 \times 10$ mm^2

$\sigma_C = \frac{12.5 \times 10^3}{2 \times 30 \times 10}$

② $= 20.83$ MPa ⟸

(Nominal compressive stress).

(c) Maximum shear force on pin

= max (32.5, 12.5) = 32.5 kN ②

Pins are in double shear. ①

Area of Cross-section } $= \frac{\pi}{4} \times 15^2$ mm^2. ①