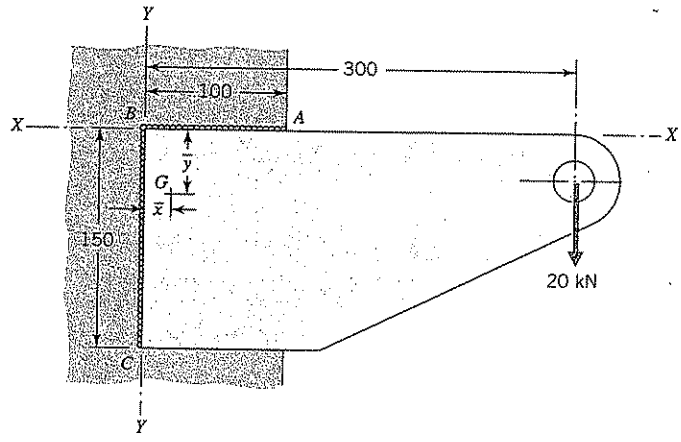
ME 325 Machine Design
Exam 3 – April 29, 2009

1. *(50 pts.)* Knowing that in the figure below the weld height is $h = 12$ mm, determine the stress in the weld at point B. All dimensions are in mm.



2. *(50 pts.)* A helical coil spring with $D = 50$ mm and $d = 5.5$ mm is wound with a pitch (distance between corresponding points of adjacent coils) of 10 mm. The material is ASTM A277 cold-drawn carbon steel. If the spring is compressed solid, would you expect it to return to its original free length when the force is removed?

(1)

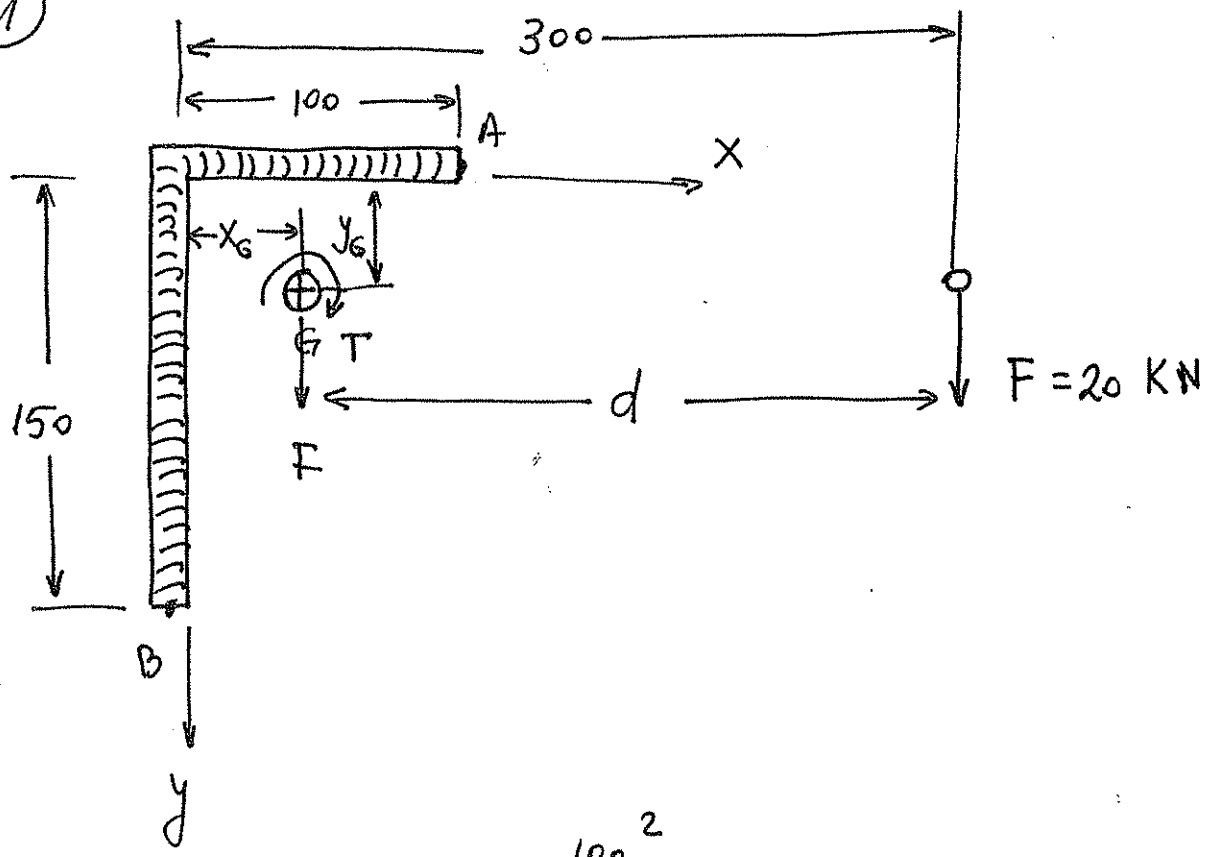


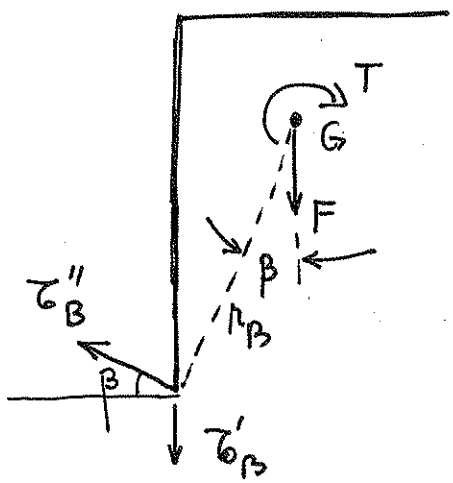
Table 9.-2 :

$$x_G = \frac{100^2}{2(100+150)} = 20 \text{ mm}$$

$$y_G = \frac{150^2}{2(100+150)} = 45 \text{ mm}$$

$$J_u = \frac{(100+150)^4 - 6 \cdot 100^2 \cdot 150^2}{12\,(100+150)} = 8.521 \cdot 10^5 \text{ mm}^3$$

$$A_u = b + d = 250 \text{ mm}$$



$$\tan\beta = \frac{x_G}{150 - y_G} = \frac{20}{150-45} = \frac{20}{105} \Rightarrow$$

$$\Rightarrow \beta = 10.8^\circ$$

$$r_B = \sqrt{20^2 + (150-45)^2} = 107 \text{ mm}$$

$$\tau'_B = \frac{F}{A} = \frac{F}{0.707\, h\, A_u} = \frac{20\cdot 10^3}{0.707(0.012)\cdot 0.25} = 9.43 \text{ MPa}$$

$$\tau''_B = \frac{T\cdot r_B}{J} = \frac{T\cdot r_B}{0.707\, h\, J_u} = \frac{20\cdot 10^3 (300-20)\cdot 10^{-3}\cdot 0.107}{0.707\cdot 0.012\cdot 8.521\cdot 10^5\cdot 10^{-9}} =$$

$$= 82.9 \text{ MPa}$$

$$\tau_{B_x} = \tau''_B \cdot \cos\beta = 82.9\cdot \cos(10.8^\circ) = 81.4 \text{ MPa}$$

$$\tau_{B_y} = \tau''_B \sin(\beta) - \tau'_B = 82.9 \sin(10.8^\circ) - 9.43 = 6.1 \text{ MPa}$$

$$\tau_B = \sqrt{\tau_{B_x}^2 + \tau_{B_y}^2} = \sqrt{81.4^2 + 6.1^2} = 81.6 \text{ MPa}.$$

(2) $L_0 = p \cdot N$ - free length

$L_S = d \cdot N$ - solid length

$\delta = L_0 - L_S = (p-d)\,N$

$F = K \cdot \delta$

$K = \dfrac{d^4 G}{8 D^3 N}$

$\Rightarrow F = \dfrac{d^4 G}{8 D^3 N} \cdot (p-d) N = \dfrac{d^4 G}{8 D^3}(p-d) =$

$$= \frac{(5.5\cdot 10^{-3})^4 \cdot 79.3\cdot 10^9 \cdot (10-5.5)}{8\cdot (50\cdot 10^{-3})^3} = 325\ N$$

$$\tau = K_S \cdot \frac{8FD}{\pi d^3} = 1.055 \cdot \frac{8\cdot 325\cdot 50\cdot 10^{-3}}{\pi (5.5\cdot 10^{-3})^3} = 261\ MPa$$

$$K_S = \frac{2C+1}{2C} = \frac{2\cdot 9.09 + 1}{2\cdot 9.09} = 1.055$$

$$C = \frac{D}{d} = \frac{50}{5.5} = 9.09$$

$$S_{ut} = \frac{A}{d^m} = \frac{1510}{5.5^{0.201}} = 1072\ MPa$$

$$S_{sy} = 0.45 \cdot S_{ut} = 0.45 \cdot 1072 = 482\ MPa$$

$\tau < S_{sy} \Rightarrow$ yielding does <u>not</u> occur; the spring will return to the original dimension