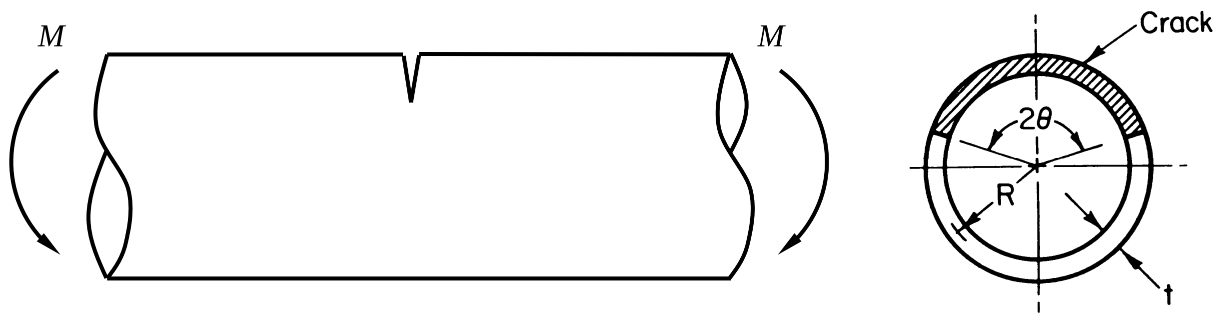
THE UNIVERSITY OF IOWA
Department of Mechanical Engineering

Fracture Mechanics	**Homework #5**	**Assigned: April 13, 2020**
ME:5159	**Total Points: 20**	**Due: April 20, 2020**

Problem 1:
Consider a pipe with a circumferential through-wall crack that is subjected to pure bending, as shown in the figure below.



The pipe has outer diameter D_o = 457.2 mm, wall thickness t = 21.77 mm, and initial crack size $\theta_0/\pi = 0.2$. The material is Type 304 stainless steel and has the stress-strain curve and *J-R* curve which can be conveniently modeled by Ramberg-Osgood and power-law equations:

$$\frac{\varepsilon}{\varepsilon_0} = \frac{\sigma}{\sigma_0} + \alpha\left(\frac{\sigma}{\sigma_0}\right)^n \quad \text{and}$$

$$J_R = J_{Ic} + C\left(\Delta a\right)^m,$$

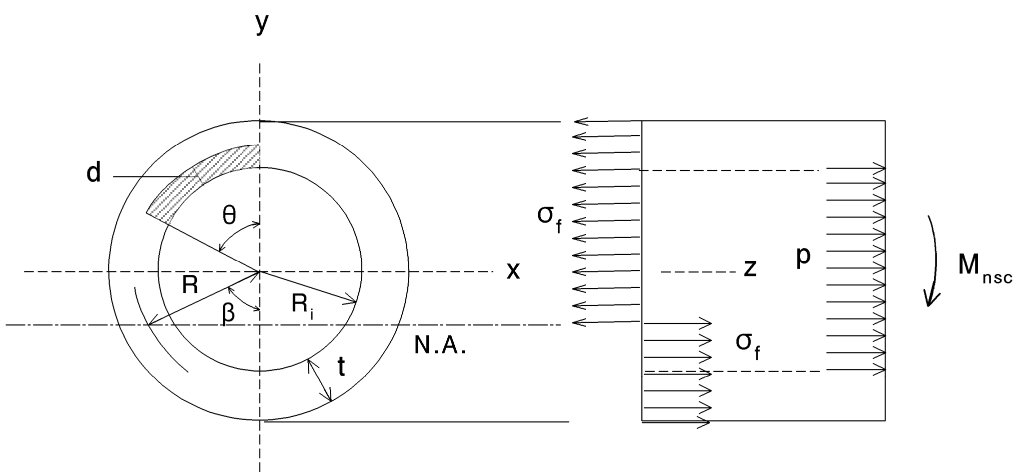
respectively, where E = 182.7 GPa, σ_0 = 155 MPa, α = 8.1, n = 3.8, J_{Ic} = 0.5 MJ/m^2, C = 3.5, and m = 0.5. Also, S_y = 155 MPa and S_u = 443 MPa.

Using the GE/EPRI EPFM method and the closed-form $F(\theta/\pi, R/t)$ and $h_1(\theta/\pi, n, R/t)$ functions (see *Engineering Fracture Mechanics* paper, Vol. 52, No. 2, 1995), calculate (1) the initiation moment M_i and (2) the maximum moment M_{max} for this cracked pipe. Assuming that the flow stress σ_f is the average of yield and ultimate strengths calculate also (3) the net-section-collapse moment M_{nsc} for this pipe.

Problem 2:

Consider a pipe with a circumferential, constant-depth, internal part-through surface crack of total angle 2θ and depth d, as shown in the figure (note: the crack is symmetrical about y-axis and only half of crack is shown). The pipe and crack geometry parameters are defined in the figure. The pipe is subjected to combined bending and longitudinal tension, $P = \pi R_i^2 p$ with p representing the internal pipe pressure. If σ_f is the flow stress of the material, show that the net-section-collapse moment M_{nsc} is:

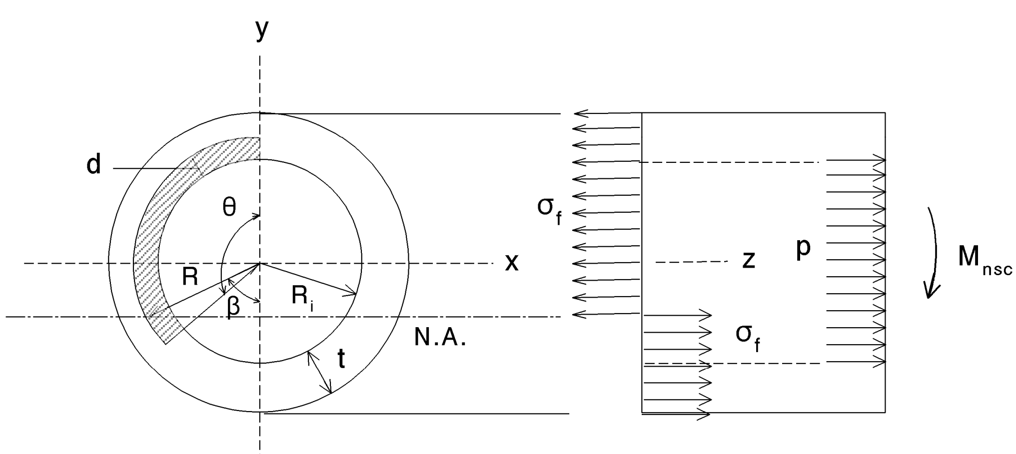
(a) For $\theta < \pi - \beta$ (Entire Crack in Tension Zone),



$$M_{nsc} = 2R^2 t\sigma_f\left[2\sin\beta - \frac{d}{t}\sin\theta\right]$$

$$\beta = \frac{\pi - \theta(d/t)}{2} - \frac{\pi R_i^2 p}{4R\sigma_f t}$$

(b) For $\theta \geq \pi - \beta$ (Part of Crack in Compression Zone),



$$M_{nsc} = 2R^2 t\sigma_f\left[2 - \frac{d}{t}\right]\sin\beta$$

$$\beta = \frac{\pi}{2-(d/t)}\left[1-(d/t) - \frac{R_i^2 p}{2R\sigma_f t}\right]$$