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:

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

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

respectively, where $E = 182.7$ GPa, $\sigma_0 = 155$ MPa, $\alpha = 8.1$, $n = 3.8$, $J_{IC} = 0.5$ 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 $\sigma_f$ is the average of yield and ultimate strengths calculate also (3) the net-section-collapse moment $M_{nc}$ for this pipe.
Problem 2:
Consider a pipe with a circumferential, constant-depth, internal part-through surface crack of total angle $2\theta$ 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 $\sigma_f$ 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),

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

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

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

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

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