

**Problem 1.** Linear elastic fracture mechanics (LEFM) can be used to solve fracture problems when two conditions are met: (1) the plastic zone size is small compared to sample dimensions and (2) the sample has to be sufficiently thick to ensure plain strain conditions. If these conditions hold, the contribution of plasticity can be ignored, and the problem can be solved in the elastic framework as a Mode I crack.

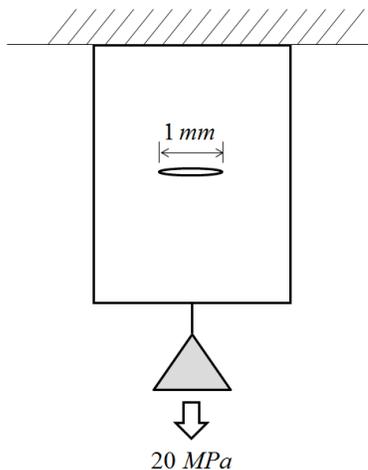
(a) For the two materials whose properties are listed below, Steel 4340 and Steel HSLA, estimate the size of plastic zone ( $r_p$ ) when fracture occurs.

(b) To satisfy condition (2), sample thickness has to be  $\geq 15r_p$ . Estimate the minimum required thickness for each material to satisfy this condition.

Material	Yield strength (MPa)	Ultimate tensile strength (MPa)	Fracture toughness ( $\text{MPa}\sqrt{\text{m}}$ )
Steel 4340	1000	1482	50
Steel HSLA	800	1206	138

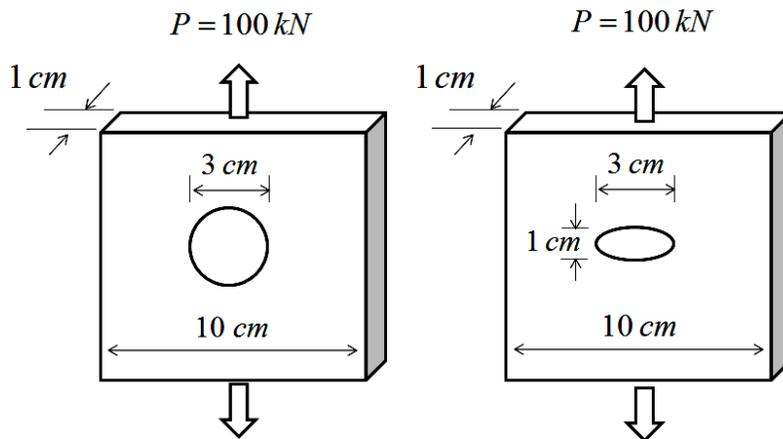
**Problem 2.** The system shown below is subjected to axial tension of 20 MPa. The material is a body-centered cubic crystal, which exhibits a ductile-to-brittle transition at  $-50^\circ\text{C}$ . Based on the Griffith criteria, determine whether this system is safe for the temperatures below and above  $-50^\circ\text{C}$ . The material parameters are listed below.

- Surface energy ( $\gamma_s$ ) =  $1 \text{ J/m}^2$
- Young's modulus ( $E$ ) =  $100 \text{ GPa}$
- Plastic work per unit area of surface created ( $\gamma_p$ ) =  $20 \text{ J/m}^2$



**Problem 3.** Two flat plates are being pulled in tension. The yield strength of the constituent material is 150 MPa. Obtain answers for both circular and elliptical holes.

- Calculate the maximum stress inside the plate.
- Will the material flow plastically?
- Which configuration has a higher stress?



**Problem 4.** The presence of a dislocation in a crystal produces causes lattice distortion and produces a stress field. This stress field would drive another dislocation to move via elastic interactions. Suppose that there is the positive edge dislocation positioned along z-axis and its position is **'fixed'** as shown below. Assume that the temperature is very low, so dislocation climb is disabled. When a negative edge dislocation is placed in the given regions from (1) to (8), guess the motion of the negative dislocation. Regard this problem as the eight separate sets of two edge dislocations (positive and negative), but the draw the resultant configuration on one figure (A negative dislocation will stop at a certain position). Assume that the slip planes of all negative edge dislocations are parallel to the x-z plane.

