THE UNIVERSITY OF IOWA
Department of Mechanical Engineering

Fracture Mechanics	**Homework #3**	**Assigned: March 02, 2020**
ME:5159	**Total Points: 20**	**Due: March 11, 2020**

The design team of an aerospace company discovered cracks, approximately 4 mm (0.16 inch) long, emanating from each side of a circular rivet hole (Hole No. 6, see figure below) in a fuselage lap joint of a Boeing 747 aircraft. The fuselage skin is 2024-T651 aluminum with a plane strain fracture toughness of 40 MPa√m (36.4 ksi√in). From linear-elastic stress analysis, the membrane stress (σ_m), the fastener load (P), the local bending stress (σ_b) can be related to fuselage pressure, p, fuselage radius, R_F, skin thickness, t_s, and hole spacing, s by the following equation:

$$\sigma_m(p) = \frac{A_1 p R_F}{t_s}, \quad P(p) = \frac{A_2 p R_F s}{t_s}, \quad \text{and} \quad \sigma_b(p) = \frac{A_3 p R_F}{t_s^{\,2}}$$

Following a linear-elastic finite element analysis, the proportionality factors, A_1, A_2, and A_3 are calculated to be 9.35×10^{-1}, 3.44×10^{-4} m, and 4.72×10^{-4} m, respectively, for Hole No. 6. Also given are the following geometric parameters:

Hole Diameter, $D = 4.572\times10^{-3}$ m (0.18 inch)
Fuselage Radius, $R_F = 1.905$ m (75 inches)
Hole Spacing, $s = 25.4\times10^{-3}$ m (1 inch)
Skin Thickness, $t_s = 7.62\times10^{-4}$ m (0.03 inch)
Fuselage Pressure, $p = 0.0586$ MPa (8.5 psi)

1. Are these cracks going to propagate under the given loading condition? What is the factor of safety of the current design against the propagation of these cracks?

2. For design of a new aircraft with the same materials and service loads (and same crack size), what changes in the skin thickness (t_s) have to be made to maintain a safety factor of 2?