Solution to Problem 410A:

The potential flow around a sphere yields a surface velocity of $3U(\sin\theta)/2$ where U is the free stream velocity and the angle, θ, is measured from the front stagnation point. We seek the cavitation inception number for this flow if the liquid can withstand a tension of $(0.2\rho_L U^2)$ where ρ_L is the liquid density.

It follows that the liquid will cavitate when the pressure reaches a value of $p = p_V - 0.2\rho_L U^2$ where p_V is the vapor pressure. But, by Bernoulli's equation, the pressure on the surface of the sphere is a minimum at $\theta = \pi/2$ and that minimum pressure, p_{min}, is given by

$$p_{min} \;=\; p_\infty + \frac{1}{2}\rho_L U^2 \left(1 - \frac{9}{4}\right) \;=\; p_\infty - \frac{5}{8}\rho_L U^2 \quad (1)$$

and therefore cavitation will occur at $\theta = \pi/2$ when

$$p_\infty - \frac{5}{8}\rho_L U^2 \;=\; p_V - 0.2\rho_L U^2 \quad (2)$$

or

$$p_\infty - p_V \;=\; \frac{5}{8}\rho_L U^2 - 0.2\rho_L U^2 \;=\; 0.425\rho_L U^2 \quad (3)$$

and therefore the cavitation inception number, σ_i, would be

$$\sigma_i \;=\; \frac{2(p_\infty - p_V)}{\rho_L U^2} \;=\; 0.85 \quad (4)$$