Student Name:

Student ID:

<u>Question 1</u> *{3 marks}*

A circular specimen of MgO is loaded using a three-point bending mode. Compute the minimum possible radius of the specimen, given that it can be loaded with 425 N without fracture, the flexural strength is 105 MPa, and the separation between load points is 50 mm.

<u>Solution:</u>

We are asked to calculate the maximum radius of a circular specimen of MgO that is loaded using three point bending. Solving for *R* from Equation 12.7b

$$R = \left[\frac{F_f L}{\sigma_{fs}\pi}\right]^{1/3}$$

which, when substituting the parameters stipulated in the problem statement, yields

$$R = \left[\frac{(425\text{ N})\left(50 \times 10^{-3}\text{ m}\right)}{\left(105 \times 10^{6}\text{ N/m}^2\right)(\pi)}\right]^{1/3}$$

$$= 4.0 \times 10^{-3}\text{ m} = 4.0\text{ mm} \ \ (0.16\text{ in.})$$

<u>Question 2</u> *{7 marks}*

The density and associated percent crystallinity for two polytetrafluoroethylene materials are as follows:

ρ (g/cm^3)	crystallinity (%)
2.144	51.3
2.215	74.2

(a) Compute the densities of totally crystalline and totally amorphous polytetrafluoroethylene.

(b) Determine the percent crystallinity of a specimen having a density of 2.26 g/cm^3.

<u>Solution</u>

$$C = \frac{\rho_c(\rho_s - \rho_a)}{\rho_s(\rho_c - \rho_a)}$$

Rearrangement of this expression leads to

$$\rho_c(C\rho_s - \rho_s) + \rho_c\rho_a - C\rho_s\rho_a = 0$$

For the two conditions given, we can generate two equations and solve them simultaneously to find the densities of totally crystalline and totally amorphous polytetrafluoroethylene, that is

$$\rho_c(C_1\rho_{s1} - \rho_{s1}) + \rho_c\rho_a - C_1\rho_{s1}\rho_a = 0$$

$$\rho_c(C_2\rho_{s2} - \rho_{s2}) + \rho_c\rho_a - C_2\rho_{s2}\rho_a = 0$$

Therefore, the density of the totally amorphous material is

$$\rho_a = \frac{\rho_{s1}\rho_{s2}(C_1 - C_2)}{C_1\rho_{s1} - C_2\rho_{s2}} = \frac{(2.144\text{ g/cm}^3)(2.215\text{ g/cm}^3)(0.513 - 0.742)}{(0.513)(2.144\text{ g/cm}^3) - (0.742)(2.215\text{ g/cm}^3)} = 2.000\text{ g/cm}^3$$

And that of the totally crystalline material is

$$\rho_c = \frac{\rho_{s1}\rho_{s2}(C_2 - C_1)}{\rho_{s2}(C_2 - 1) - \rho_{s1}(C_1 - 1)}$$

$$= \frac{(2.144 \text{ g/cm}^3)(2.215 \text{ g/cm}^3)(0.742 - 0.513)}{(2.215 \text{ g/cm}^3)(0.742 - 1) - (2.144 \text{ g/cm}^3)(0.513 - 1)} = 2.301 \text{ g/cm}^3$$

(b) Now we are to determine the % crystallinity for 7*s* = 2.26 g/cm3. So, using Equation 14.8

$$\text{\% crystallinity} = \frac{\rho_c(\rho_s - \rho_a)}{\rho_s(\rho_c - \rho_a)} \times 100$$

$$= \frac{(2.301 \text{ g/cm}^3)(2.260 \text{ g/cm}^3 - 2.000 \text{ g/cm}^3)}{(2.260 \text{ g/cm}^3)(2.301 \text{ g/cm}^3 - 2.000 \text{ g/cm}^3)} \times 100$$

$$= 87.9\%$$