Take Home Exam03AB2: Modes of Fracture & the Energy Approach

Assigned: 03/08/2022 (Tuesday)

Due (as pdf by email) 03/11/2022 (Friday)

HW 03AB2.1

Show that the units in Eq. (6) are balanced.

You may submit your answers in one of two ways:

(i) •For typed answers: as a .docx file (as is) or converted into a pdf file. (DO NOT SEND GOOGLE DOC)

•For handwritten answers: Please scan as images, and group together into one pdf file. Or you may hand them manually to my office (ECME-212)

(ii) Please send your submission via email starting with HWExam03AB2 in the subject line.

$$2\gamma_F = \frac{P^2}{2}\frac{dS}{dc}$$ (Eq. 6 from notes)

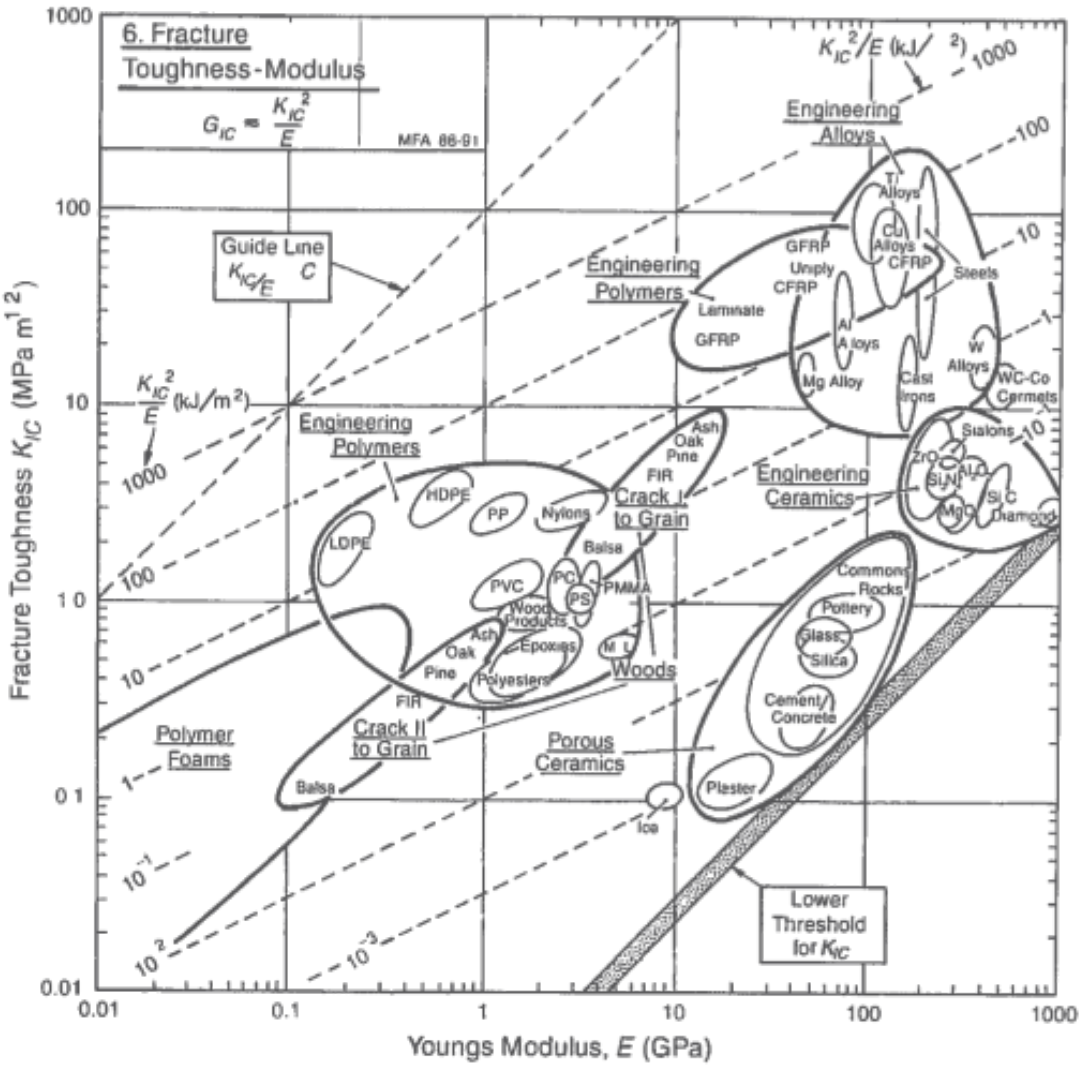
HW 03AB.2

Consider the map of fracture toughness plotted against the Youngs Modulus for different classes of materials.

What is the reason that the fracture toughness of polymers is significantly (more than one order of magnitude) lower than for metals, even though the work of fracture for polymer is nearly the same (as pointed out in the original lecture -- see website)?

Hint: the answer is related to the equation

$$2\gamma_F = \frac{K_{IC}^2}{E}$$



HW 03AB.3

The fracture toughness of graphite-fiber-polymer composites lies in the range of 20 to 80 MPa $m^{1/2}$, and that for polymers on their own between 0.5 and 5 MPa $m^{1/2}$.

The dotted lines in the map stand for a constant value of the work of fracture as given by $2\gamma_F = \frac{K_{IC}^2}{E}$. Broadly speaking, given the wide spread in the data we may say that $2\gamma_F$ for composites lies in the range of 10 to 100 J m^{-2}, and for the high density polymers, which are used to construct the composites, the work of fracture is approximately 10 J m^{-2}, that is not so very different from the work of fracture for the composites.

Why is that the difference between the fracture toughness of the composites and the polymers is much greater than the difference between the work of fracture of the composites and the polymers.

Consider the schematic given below to illustrate fracture in composites vs. the polymer.