BIOINSPIRED MATERIALS AND STRUCTURES - SINGAPORE

TRANSLATING BIOLOGICAL PRINCIPLES INTO ENGINEERING APPLICATIONS

The purpose of this course is to introduce bio-inspired principles as a source of engineering design and functionality and to inspire multidisciplinary thinking and inter-cultural perspective as a tool for working in diverse and international settings.

In addition to course activities, lectures, and case studies students will experience cultural and fun events:

- Night Safari, China Town, Changi Jewel, Half-day City tour, ArtScience Museum, Clarke Quay, Little India and much more!

Open to all engineering students sophomore through seniors! Students must be in good academic standing.

May 18- June 1, 2024

Earn 3 credits for ME 49700. This is a Tech Elective for ME students. Students in other majors must check with their academic advisor to see how this course can be used in their plan of study.

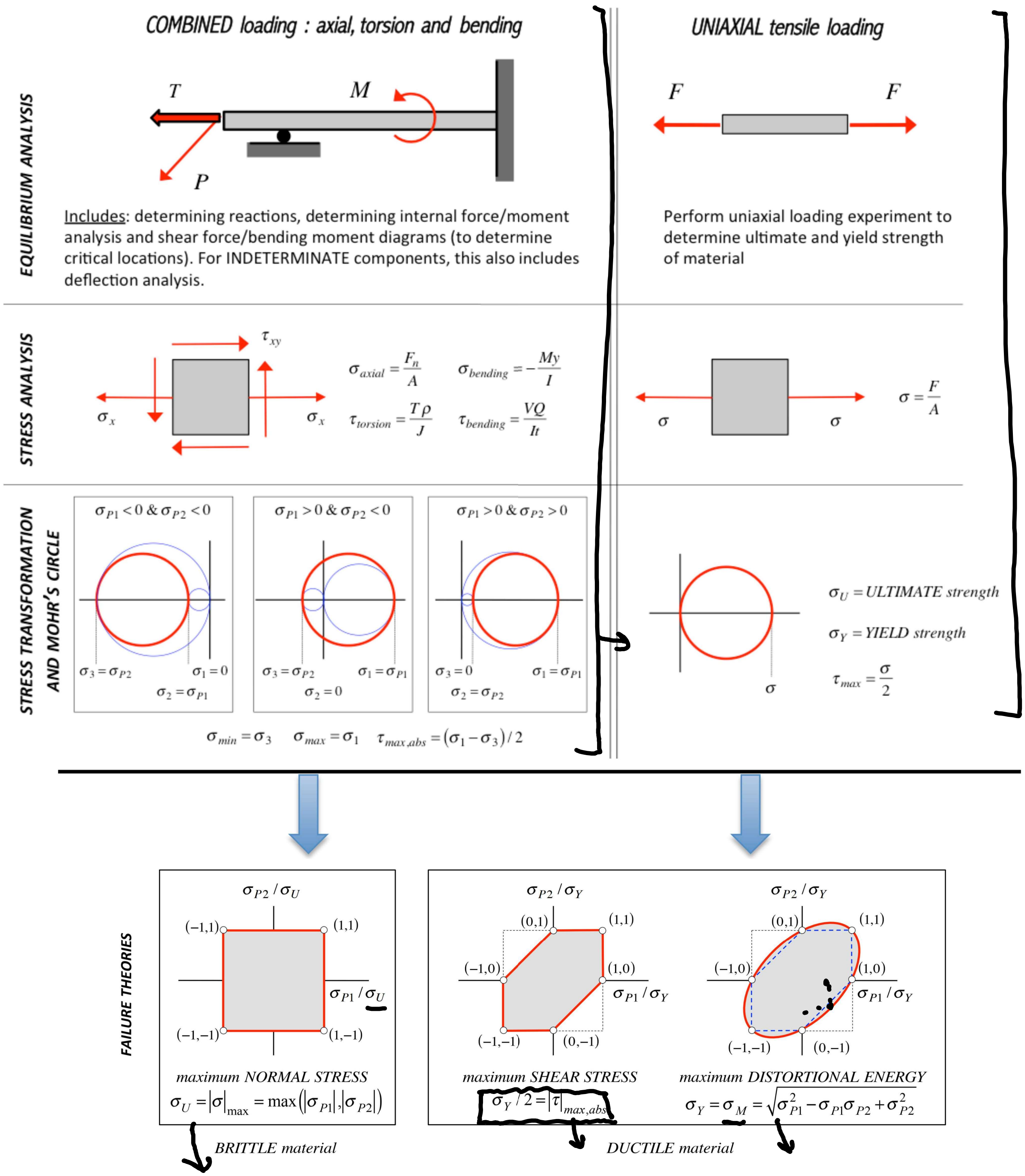
Estimated cost is $4,300 which includes: academic credits, all housing, ground transportation, airport pickup in Singapore, all activities on the itinerary, daily breakfast, Welcome and Farewell meals, and international health insurance. Additional costs: Passport, airfare, visa (if needed), and personal spending money.

bitly

PURDUE UNIVERSITY | College of Engineering

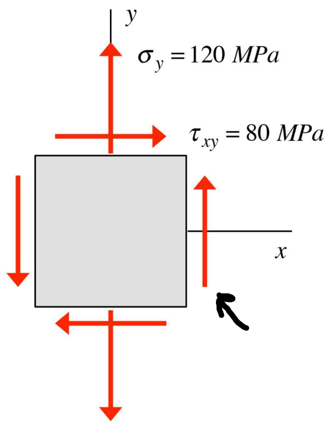
GLOBAL ENGINEERING
SHAH FAMILY GLOBAL INNOVATION LAB

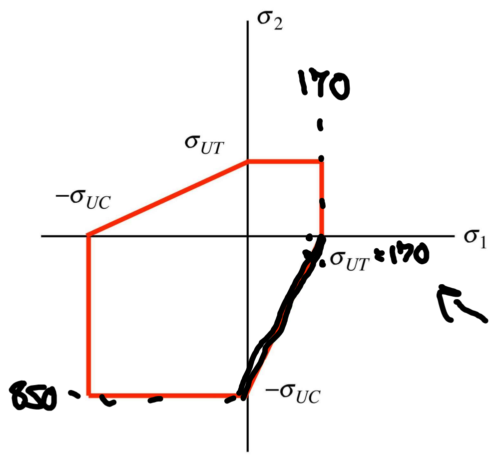
Summary: failure analysis *(what the whole course of ME 323 leads up to…)*



Example 15.7

Consider the state of stress shown below that exists at a location within a component made up of a *brittle* material, where this brittle material has tensile and compressive ultimate strengths of $\sigma_{UT} = 170\ MPa$ and $\sigma_{UC} = 850\ MPa$, respectively. Has the material failed at this location in the component?





$$\sigma_{avg} = \frac{\sigma_y}{2} = 60\ MPa$$

$$R = \sqrt{\left(\frac{120}{2}\right)^2 + 80^2} = 100\ MPa.$$

$$\sigma_{p1} = 160\ MPa$$

$$\sigma_{p2} = -40\ MPa.$$

Mohr's criterion

$$\frac{\sigma_{p1}}{\sigma_{UT}} = \frac{\sigma_{p2}}{\sigma_{UC}} + 1$$

$$\boxed{\frac{\sigma_{p1}}{\sigma_{UT}} - \frac{\sigma_{p2}}{\sigma_{UC}} > 1 \Rightarrow \text{fail}}$$

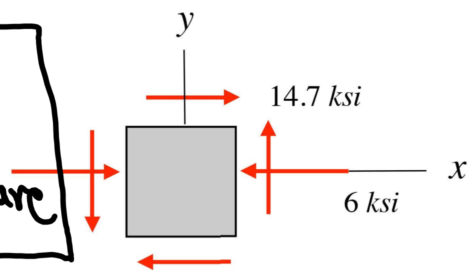
$$\frac{160}{170} - \frac{(-40)}{850} = 0.9882 \Rightarrow \text{safe}$$

Example 15.2

Consider the state of stress shown below in a component made up of a ductile material with a shear strength of $\sigma_Y = 36 ksi$. Does the maximum shear stress theory predict failure for the material? Does the maximum distortional energy theory predict failure of the material?

MSS

$\tau_{max,abs} > \frac{\sigma_Y}{2} \Rightarrow$ failure

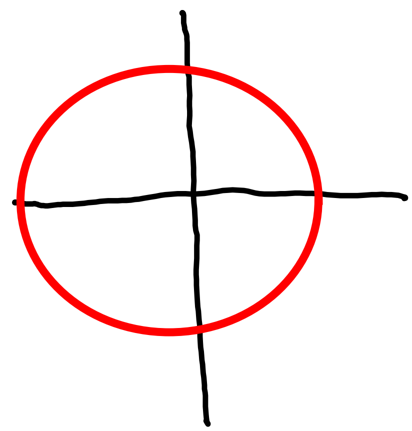


$\sigma_{avg} = \frac{-6}{2} = -3 \text{ ksi}$

$R = \sqrt{\left(\frac{-6}{2}\right)^2 + 14.7^2} = 15 \text{ ksi}$

$\sigma_{p1} = -3 + 15 = 12 \text{ ksi}$

$\sigma_{p2} = -3 - 15 = -18 \text{ ksi}$



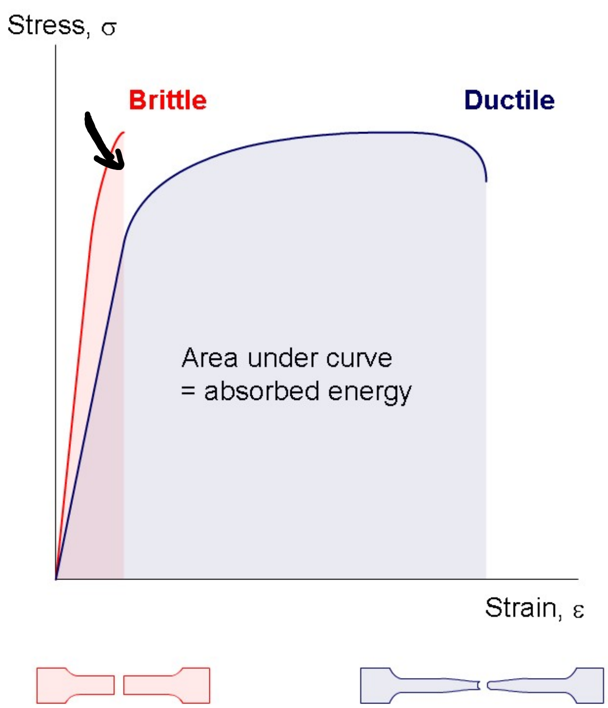
$\tau_{max,abs} = 15 \text{ ksi} < \frac{36}{2} = \frac{\sigma_Y}{2} \Rightarrow$ no failure.

$\sigma_M = \sqrt{\sigma_{p1}^2 - \sigma_{p1}\sigma_{p2} + \sigma_{p2}^2} = 26.2 \text{ ksi}$

$\Rightarrow$ no failure.

Sinking the Titanic

The temperature of the water was below the ductile to brittle transition, causing brittle fracture at low stresses.



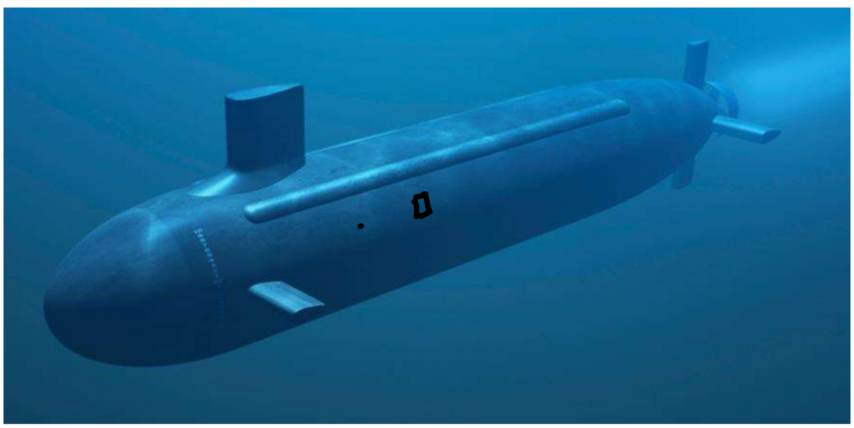
How Deep Can Submarines Dive?

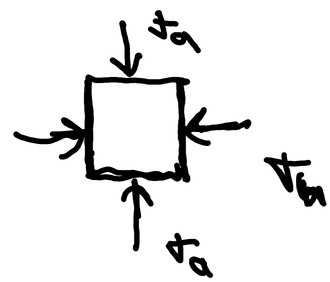
The pressure underwater is ~0.1 MPa/m x depth [m]. The thickness of the hull of a particular submarine is 200 mm and the diameter is 10 m.

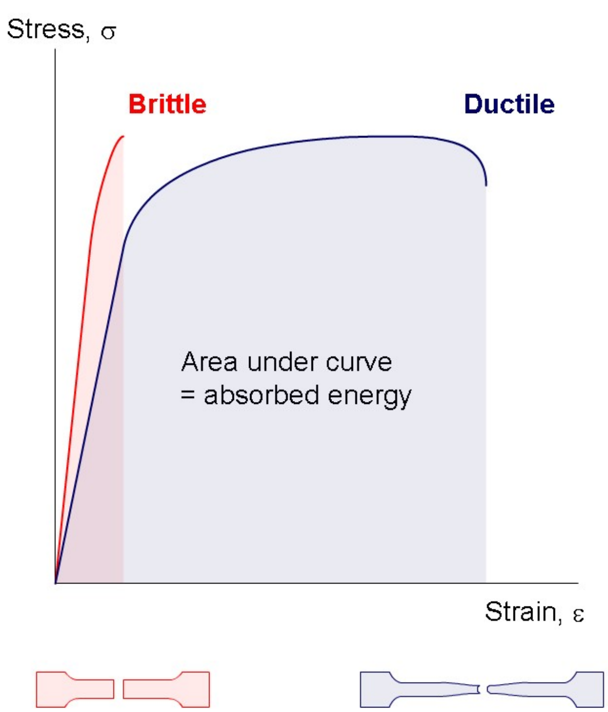
(a) The hull is made from a ductile steel with $\sigma_Y = 500\ MPa$ At what depth does the MSS theory predict failure?

(b) At what depth does the MDE predict failure?

(c) The submarine goes into very cold water so that the steel becomes brittle with $\sigma_{UT} = \sigma_{UC} = 600\ MPa$. At what depth does the hull of the submarine fail?

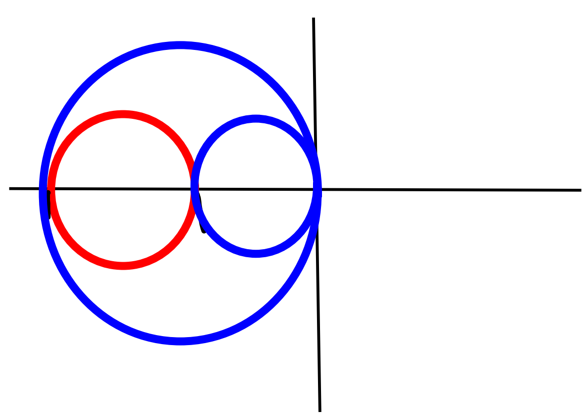






$$\sigma_{avg} = \frac{-\frac{pr}{t} - \frac{pr}{2t}}{2} = \frac{-3pr}{4t}.$$

$$R = \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2} = \sqrt{\left(\frac{pr}{4t}\right)^2} = \frac{pr}{4t}.$$



$$\sigma_{p1} = -\frac{3pr}{4t} + \frac{pr}{4t} = -\frac{pr}{2t} \qquad \sigma_{p2} = -\frac{3pr}{4t} - \frac{pr}{4t} = -\frac{pr}{t}$$

MSS

$$\tau_{max,abs} = \frac{|\sigma_{p2}|}{2} = \frac{pr}{2t} \qquad \frac{\sigma_Y}{2} = \frac{pr}{2t}$$

$$(0.1\times10^6\, d) = \frac{2t\sigma_Y}{2r} \Rightarrow d = 200\,\text{m.}$$

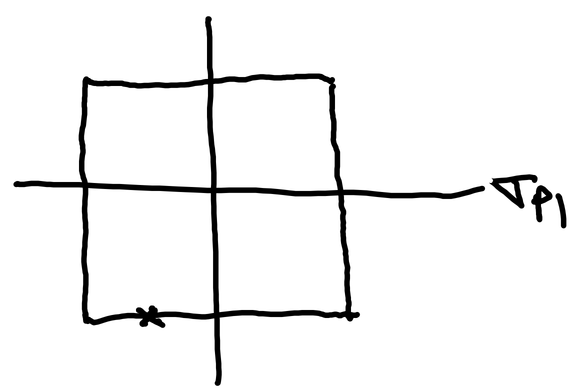
b) $$\sigma_M = \sqrt{\sigma_{p1}^2 - \sigma_{p1}\sigma_{p2} + \sigma_{p2}^2}$$

$$\sigma_M = \sqrt{\left(\frac{pr}{t}\right)^2 - \left(\frac{pr}{t}\right)\left(\frac{pr}{2t}\right) + \left(\frac{pr}{2t}\right)^2} = \frac{pr}{t}\sqrt{\frac{3}{4}} = \sigma_Y$$

$$(0.1\times10^6\, d) = \sqrt{\frac{4}{3}}\,\frac{t}{r}\,\sigma_Y$$

$$d = 231\,\text{m.}$$

c) $\sigma_U = 600$ MPa



$\frac{pr}{t} = 600$ MPa

$\Rightarrow d = 240$ m.

WWI ⇒ 100 m.
WWII ⇒ 200 m.
Now ⇒ 250-350 m.