Outline

Examples on:

- Fracture Mechanics
- Fatigue
- Wear rate
- Electrochemical cell
- Materials selection

Example 1: *Fracture Mechanics*

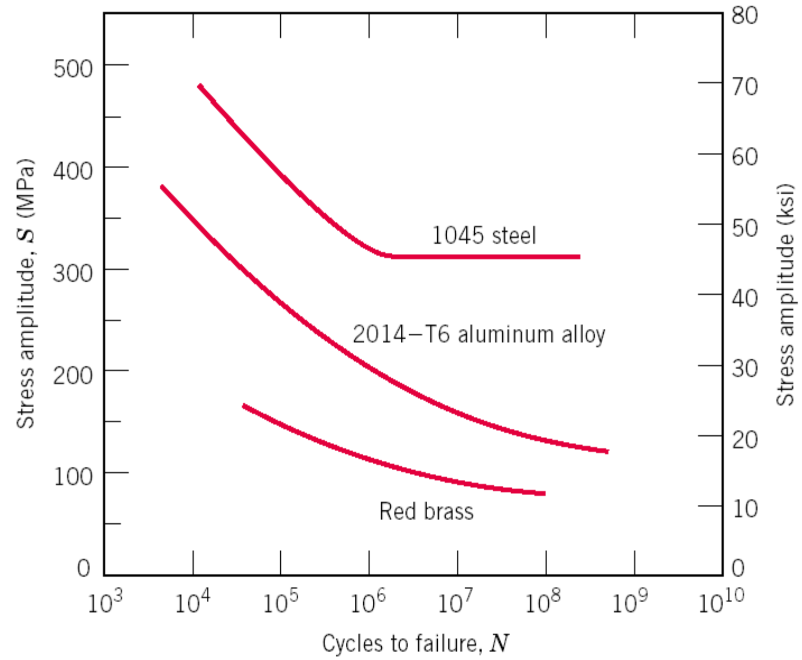
A sharp penny-shaped crack with a diameter of 2.5-cm is completely embedded in a solid. Catastrophic fracture occurs when a stress of 700 MPa is applied.

(a) What is the fracture toughness for the material? (*Assume that this value is for plane-strain conditions. The value of Y in this configuration is 2/π*).

(b) If a sheet (0.75 cm thick) of this same material is prepared for fracture-toughness testing (width B = 0.75 cm), would the fracture-toughness value measured be a valid number for plane strain fracture-toughness (K_{IC}) or not? If not, what would be the minimum thickness for valid K_{IC} determination? *The yield strength of the material is 1100 MPa.*

Example 2: *Fatigue*

Consider the 2014-T6 aluminum alloy the S-N behaviour for which is shown in the accompanying figure. A 0.505 in. diameter cylindrical rod fabricated from this alloy is subjected to a repeated tension-compression loading along its axis. Determine the fatigue life if the maximum and mean loads are 8,000 lb_f and 2,000 lb_f, respectively. Assume that the stress plotted on the vertical axis is stress amplitude and that the curve was generated for a mean stress corresponding to a mean load of 2,000 lb_f.



Example 3: *Wear*

Wear in metals is sometimes rapid at first but then appears to lessen as the time in service increases. How this non-uniform wear rate might occur?

Example 4: *Electrochemical Cell*

An electrochemical cell is composed of pure copper and pure lead electrodes immersed in solutions of their respective divalent ions. For a $6 \times 10^{-3} M$ concentration, of Cu^{2+}, the lead electrode is oxidized yielding a cell potential of 0.4 V. Calculate the concentration of Pb^{2+} ions if the temperature is 50°C.

Table 18.1 The Standard emf Series *5th ed.*

	Electrode Reaction	Standard Electrode Potential, V^0 (V)
↑	$Au^{3+} + 3e^- \longrightarrow Au$	+1.420
	$O_2 + 4H^+ + 4e^- \longrightarrow 2H_2O$	+1.229
	$Pt^{2+} + 2e^- \longrightarrow Pt$	~+1.2
	$Ag^+ + e^- \longrightarrow Ag$	+0.800
Increasingly inert (cathodic)	$Fe^{3+} + e^- \longrightarrow Fe^{2+}$	+0.771
	$O_2 + 2H_2O + 4e^- \longrightarrow 4(OH^-)$	+0.401
	$Cu^{2+} + 2e^- \longrightarrow Cu$	+0.340
	$2H^+ + 2e^- \longrightarrow H_2$	0.000
	$Pb^{2+} + 2e^- \longrightarrow Pb$	−0.126
	$Sn^{2+} + 2e^- \longrightarrow Sn$	−0.136
	$Ni^{2+} + 2e^- \longrightarrow Ni$	−0.250
	$Co^{2+} + 2e^- \longrightarrow Co$	−0.277
	$Cd^{2+} + 2e^- \longrightarrow Cd$	−0.403
	$Fe^{2+} + 2e^- \longrightarrow Fe$	−0.440
Increasingly active (anodic)	$Cr^{3+} + 3e^- \longrightarrow Cr$	−0.744
	$Zn^{2+} + 2e^- \longrightarrow Zn$	−0.763
	$Al^{3+} + 3e^- \longrightarrow Al$	−1.662
	$Mg^{2+} + 2e^- \longrightarrow Mg$	−2.363
	$Na^+ + e^- \longrightarrow Na$	−2.714
↓	$K^+ + e^- \longrightarrow K$	−2.924

17.1 in the 6th ed.

Example 5: *Materials Selection*

Select from this list the one metal or alloy that is best suited for each of the following applications, and cite at least one reason for your choice:

(a) The base for a milling machine.

(b) The walls of a steam boiler.

(c) High-speed aircraft.

(d) Drill bit.

(e) Cryogenic (i.e., very low temperature) container.

(f) As a pyrotechnic (i.e., in flares and fireworks).

(g) High-temperature furnace heating elements to be used in oxidizing atmospheres.

Below is a list of metals and alloys:

- *Plain carbon steel*
- *Magnesium*
- *Brass*
- *Zinc*
- *Tungsten*
- *Gray cast iron*
- *Tool steel*
- *Platinum*
- *Aluminum*
- *Titanium alloy*
- *Stainless steel*

Example 6: *Materials Selection*

The connecting rod of an internal combustion engine is essentially a column loaded in compression.

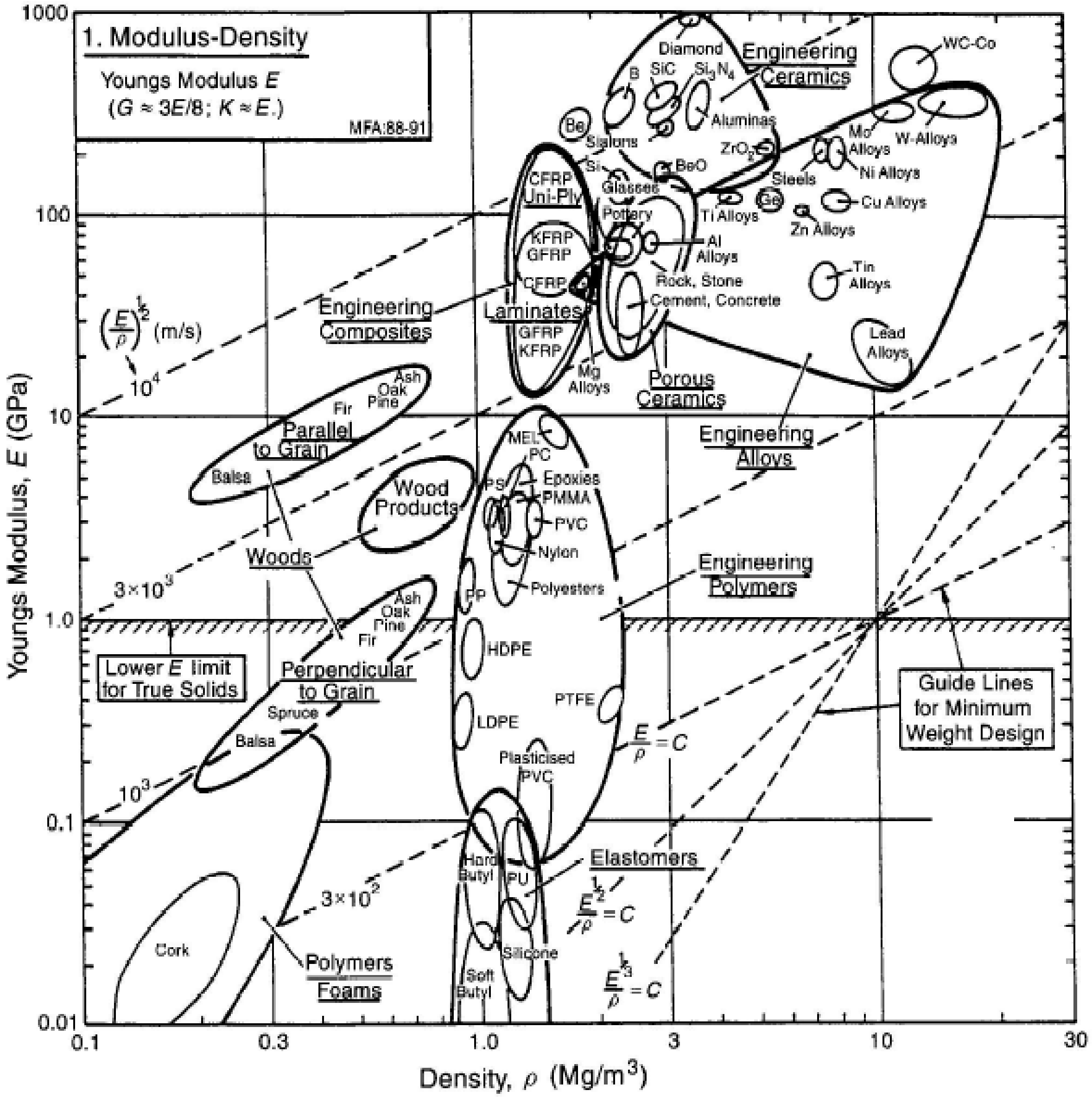
a) Ignoring elevated temperature concerns, derive the material indices to minimize mass while simultaneously avoiding plastic yielding and buckling.

b) Use the materials indices derived in (a) in conjunction with the appropriate materials selection chart to propose the best materials for the connecting rod.

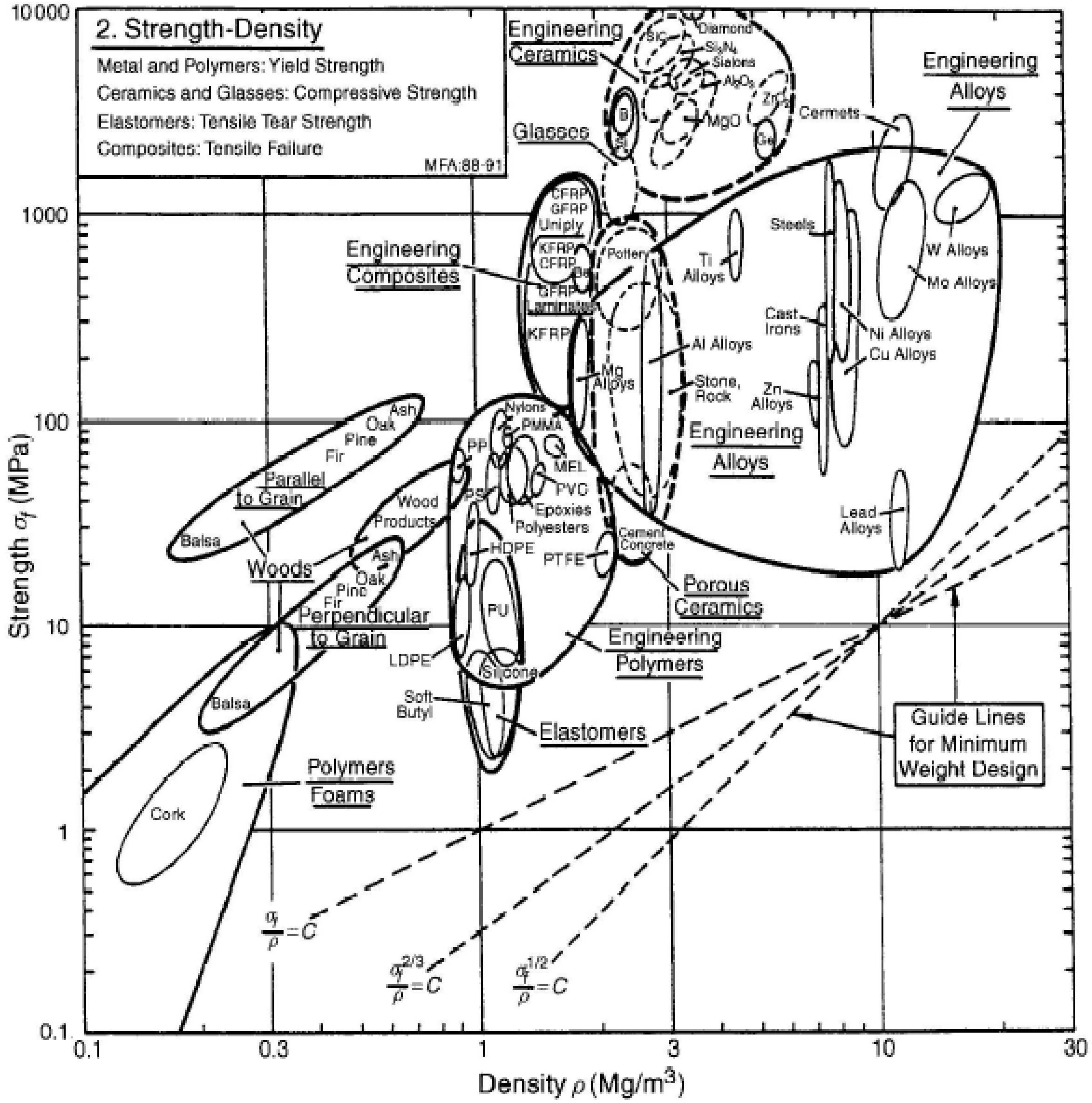
c) List (at least) two material properties that do not enter into the above analysis but that would be important to the overall design.

d) If a limit is imposed such that the fracture toughness of the material must be greater than 10 Mpa.m$^{-0.5}$ how does this change your answer?

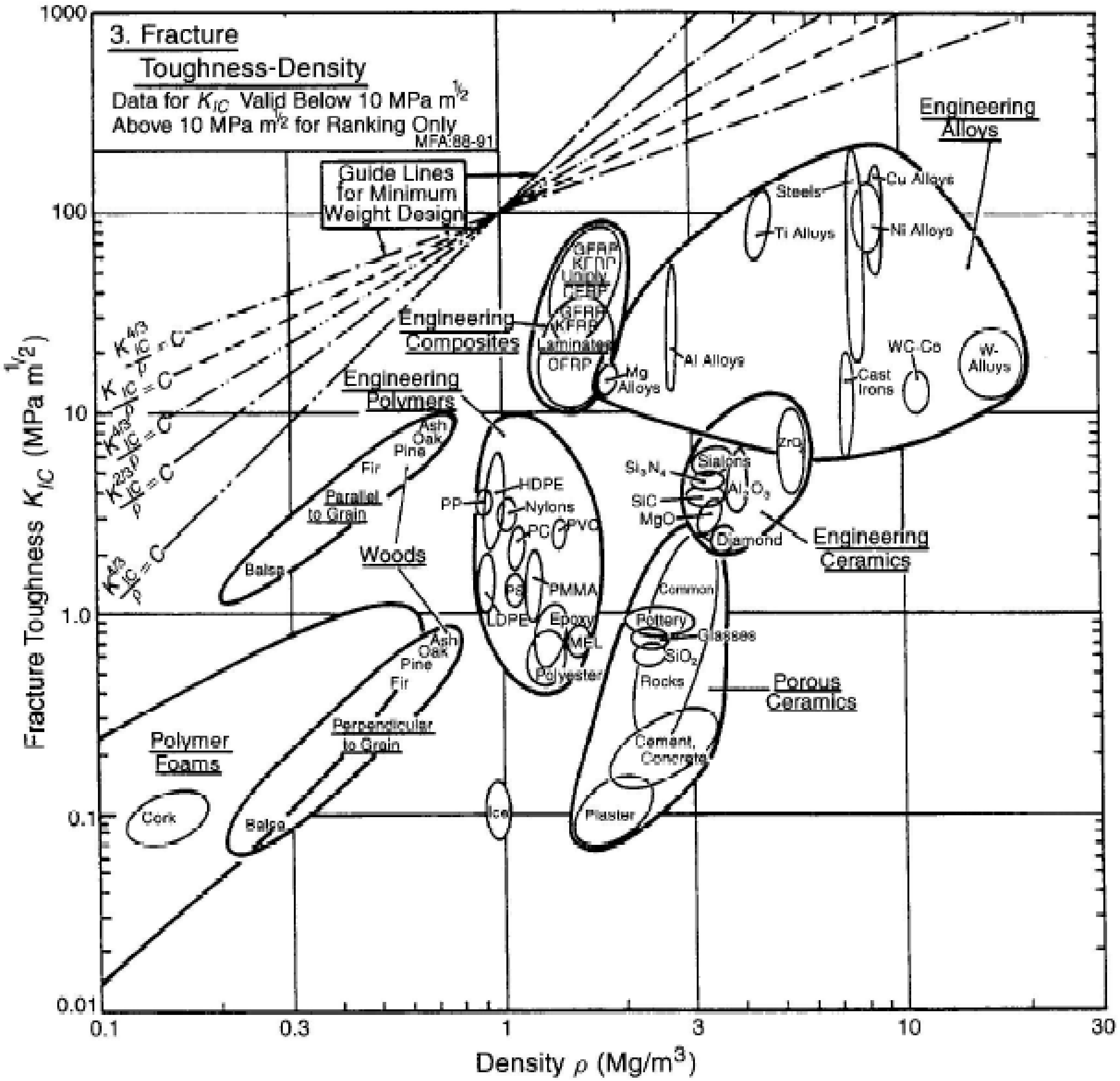
Example 6: *Materials Selection*



Example 6: *Materials Selection*



Example 6: *Materials Selection*



Thanks for listening

Good luck in your exams