Name..Student I.D.............................

Department of Mining and Materials Engineering

Faculty of Engineering

Prince of Songkla University

Mid-term Exam for Semester: 1 Academic Year: 2005

Date: 2 August 2005 Time: 13.30-16.30

Subject: 237-405 Materials and Process Selection Room: A200

Instruction

1. There are 4 problem sets. Please do all of them and write your answers in the space provided after each problem set.
2. Textbooks and course notes are not allowed.
3. Dictionary and calculator are allowed.
4. This mid-term exam is accounted for 30% of total grade.

Dr. Thawatchai Plookphol

Problem No.	Full Score (points)	Student's Score (points)
1.	20	
2.	40	
3.	20	
4.	20	
Total	100	

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Problem 1

Describe the general design process and identify main activities performed in each stages of the process. (20 points)

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Problem2

2.1 Derive the material index (*M*) for a light weight and strong shaft, specified

Transmitting load (Torque) *T*,

Solid circular section with length *l*, and

Design against yield failure

The diameter (*d*) of shaft is not specified (i.e. *d* is free). (30 points)

2.2 What kind of material selection chart (Ashby's chart) will represent your material index and what is the slope of selection guide line? Please show your work. (10 points)

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Problem 3

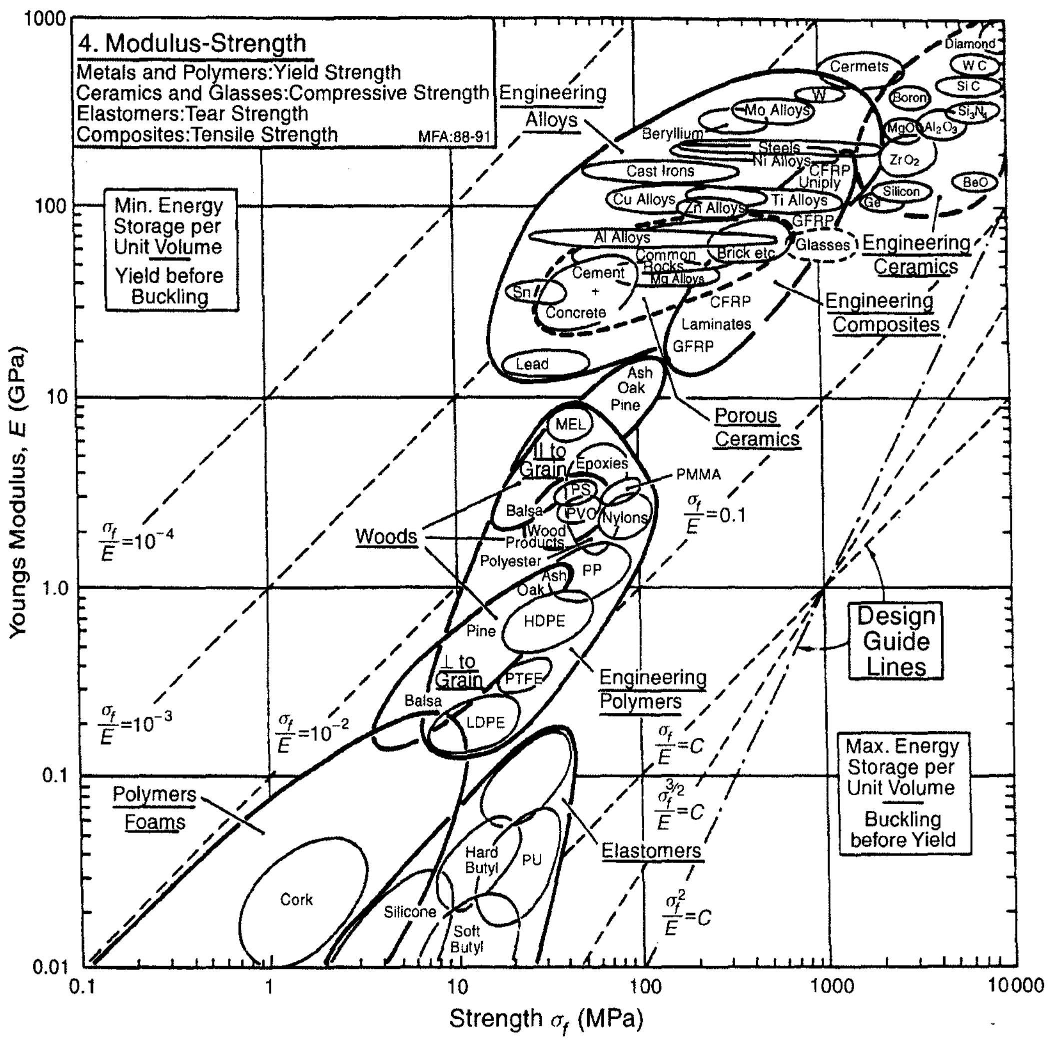
Use the Modulus-Strength Chart below to identify a subset of materials may be used for making elastic seal with

$$M_1 = \frac{\sigma_f}{E} = 0.05$$

$$M_2 = \sigma_f \leq 100 \text{ MPa}$$

3.1 Draw the M_1 and M_2 lines and label search region (14 points)

3.2 Identify a subset of three materials in the search region (6 points)



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Problem 4

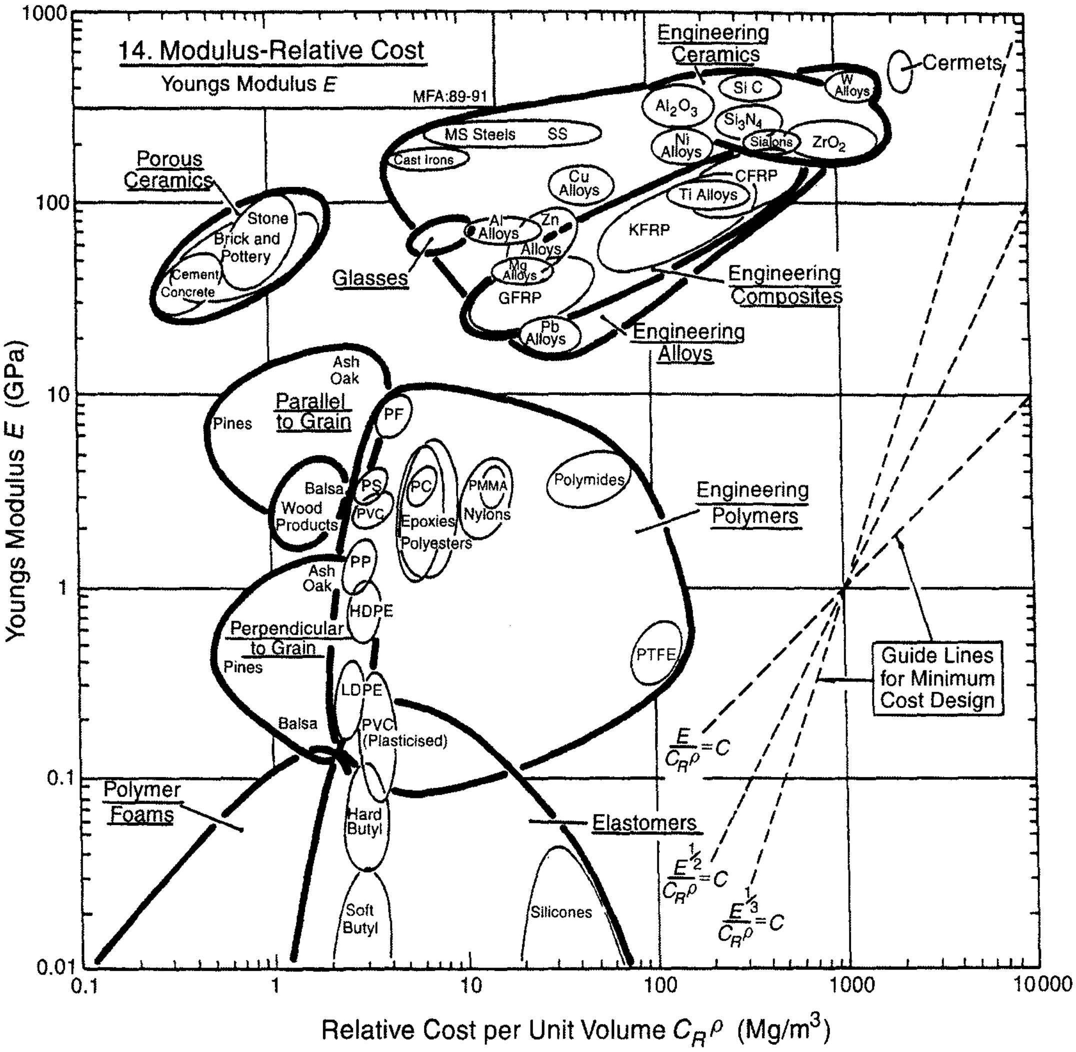
The cheapest material for a column which will not buckle under a given load is that with the greatest value of the material index

$$M = \frac{E^{1/2}}{C_m \rho}$$

where E is the modulus, ρ the density and C_m the cost per kilogram of the material.

4.1 Use the Modulus-Relative Cost Chart below and draw three selection guide lines of which $M = 10$, $M = 1$, and $M = 0.1$ $\frac{GPa^{1/2}}{Mg/m^3}$. (16 points)

4.2 Identify a subset of four materials which have the value of $M = 1$ (4 points)



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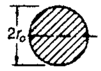
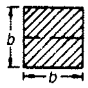
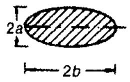
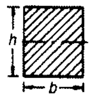
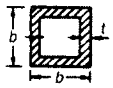
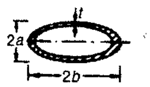
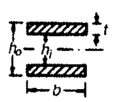
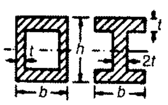
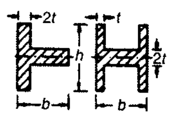
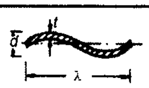
Tables and Charts

Moments of sections

Section Shape	$A(m^2)$	$I_{xx}(m^4)$	$K(m^4)$	$Z(m^3)$	$Q(m^3)$
	πr^2	$\frac{\pi}{4}r^4$	$\frac{\pi}{2}r^4$	$\frac{\pi}{4}r^3$	$\frac{\pi}{2}r^3$
	b^2	$\frac{b^4}{12}$	$0.14b^4$	$\frac{b^3}{6}$	$0.21b^3$
	πab	$\frac{\pi}{4}a^3b$	$\frac{\pi a^3b^3}{(a^2+b^2)}$	$\frac{\pi}{4}a^2b$	$\frac{\pi a^2b}{2}$ $(a < b)$
	bh	$\frac{bh^3}{12}$	$\frac{b^3h}{3}\left(1-0.58\frac{b}{h}\right)$ $(h > b)$	$\frac{bh^2}{6}$	$\frac{b^2h^2}{3h+1.8b}$ $(h > b)$
	$\frac{\sqrt{3}}{4}a^2$	$\frac{a^4}{32\sqrt{3}}$	$\frac{a^4\sqrt{3}}{80}$	$\frac{a^3}{32}$	$\frac{a^3}{20}$
	$\pi(r_o^2-r_i^2)$ $\approx 2\pi rt$	$\frac{\pi}{4}(r_o^4-r_i^4)$ $\approx \pi r^3t$	$\frac{\pi}{2}(r_o^4-r_i^4)$ $\approx 2\pi r^3t$	$\frac{\pi}{4r_o}(r_o^4-r_i^4)$ $\approx \pi r^2t$	$\frac{\pi}{2r_o}(r_o^4-r_i^4)$ $\approx 2\pi r^2t$
	$4bt$	$\frac{2}{3}b^3t$	$b^3t\left(1-\frac{t}{b}\right)^4$	$\frac{4}{3}b^2t$	$2b^2t\left(1-\frac{t}{b}\right)^2$
	$\pi(a+b)t$	$\frac{\pi}{4}a^3t\left(1+\frac{3b}{a}\right)$	$\frac{4\pi(ab)^{5/2}t}{(a^2+b^2)}$	$\frac{\pi a^2t}{4}\left(1+\frac{3b}{a}\right)$	$2\pi t(a^3b)^{1/2}$ $(b > a)$
	$b(h_o-h_i)$ $\approx 2bt$	$\frac{b}{12}(h_o^3-h_i^3)$ $\approx \frac{1}{2}bth_o^2$	—	$\frac{b}{6h_o}(h_o^3-h_i^3)$ $\approx bth_o$	—
	$2t(h+b)$	$\frac{1}{6}h^3t\left(1+\frac{3b}{h}\right)$	I: $\approx \frac{2tb^2h^2}{h+b}$; □: $\frac{2}{3}bt^3\left(1+\frac{4h}{b}\right)$	$\frac{h^2t}{3}\left(1+\frac{3b}{h}\right)$	I: $2tbh$; □: $\frac{2}{3}bt^2\left(1+\frac{4h}{b}\right)$
	$2t(h+b)$	$\frac{t}{6}(h^3+4bt^2)$	H: $\frac{t^3}{3}(8b+h)$; ⊢: $\frac{2}{3}ht^3\left(1+\frac{4b}{h}\right)$	$\frac{t}{3h}(h^3+4bt^2)$	H: $\frac{t^2}{3}(8b+h)$; ⊢: $\frac{2}{3}ht^2\left(1+\frac{4b}{h}\right)$
	$t\lambda\left(1+\frac{\pi^2d^2}{4\lambda^2}\right)$	$\frac{t\lambda d^2}{8}$	—	$\frac{t\lambda d}{4}$	—

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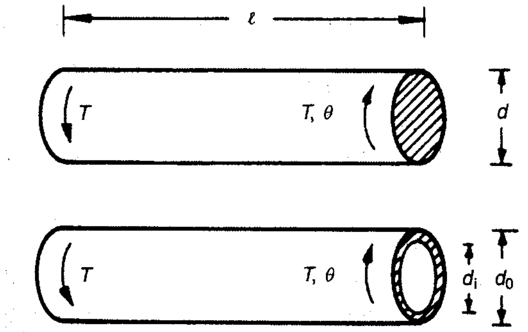
Torsion of shafts



ETC

Elastic deflection

$$\theta = \frac{\ell T}{KG}$$

Failure

$$T_f = \frac{K\sigma_y}{d_0} \text{ (Onset of yield)}$$

$$T_f = \frac{2K\sigma_f}{d_0} \text{ (Brittle fracture)}$$

T = torque (Nm)

θ = angle of twist

G = shear modulus (N/m^2)

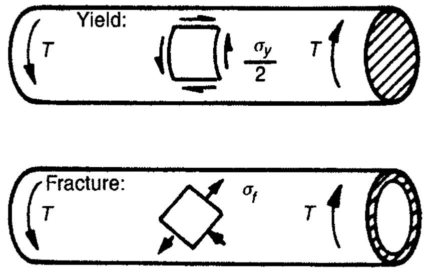
ℓ = length (m)

d = diameter (m)

K = see Table 1 (m^4)

σ_y = yield strength (N/m^2)

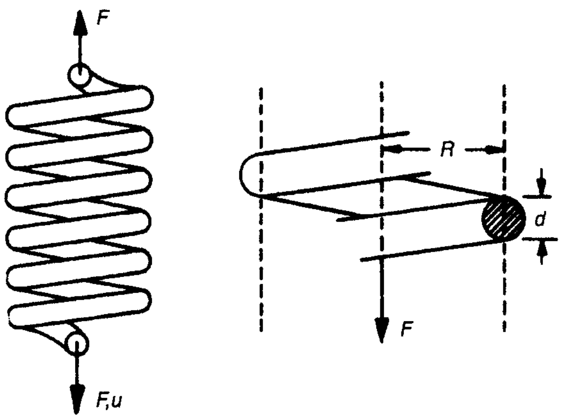
σ_f = modulus of rupture (N/m^2)



Spring deflection and failure

$$u = \frac{64FR^3n}{Gd^4}$$

$$F_f = \frac{\pi}{32}\frac{d^3\sigma_y}{R}$$



F = force (N)

u = deflection (m)

R = coil radius (m)

n = number of turns