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: 2015

Date: October 3, 2015 Time: 13.30 – 16.30

Subject: 238-502 Adv. Mat. Proc. and Mat. Select. Room: Robot

Instructions

1. There are 4 problems (11 pages including cover page). Please do all of them. Write your answers in the space provided.
2. Textbook and course notes are not allowed.
3. Dictionary and calculator are allowed.
4. This mid-term exam is accounted for 25 % of total grade of this course.

Asst. Prof. 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 (20 points)

1.1 Explain the three basic stages in a design process; identify main activities which are performed in each stages of the design process and how the materials selection involves in each stages. (10 points)

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1.2 What is the Material Index, *M*? (5 points)

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1.3 What is the Ashby's materials selection chart? (5 points)

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Problem 2 (40 points)

Deriving Material Index for C-clamp

A C-clamp shown in Figure 2 is used for processing of electronic components.

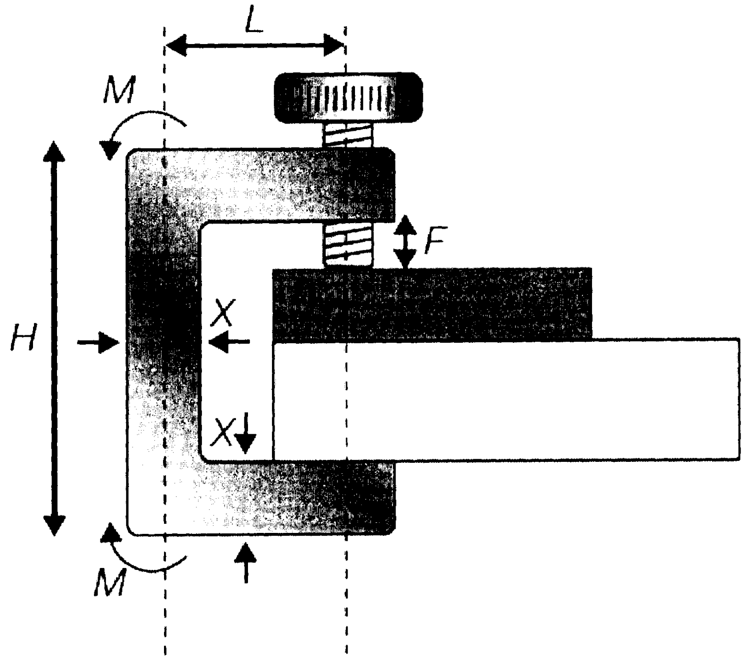

Figure 2

The clamp has a square cross-section of width x and given depth b. It is essential that the clamp has low thermal inertia so that it reaches temperature quickly. The time t it takes a component of thickness x to reach thermal equilibrium when the temperature is suddenly changed (a transient heat flow problem) is

$$t \approx \frac{x^2}{2a}$$

where the thermal diffusivity $a = \lambda / \rho C_p$ and λ is the thermal conductivity, ρ the density, and C_p the specific heat. The time to reach thermal equilibrium is reduced by making the section x thinner, but it must not be so thin that it fails in service. Use this constraint to eliminate x in the equation above, thereby **deriving a material index for the clamp.** Use the fact that the clamping force F creates a moment on the body of the clamp of $M = FL$, and that the peak stress in the body is given by

$$\sigma = \frac{x}{2}\frac{M}{I}$$

where $I = bx^3/12$ is the second moment of area of the body. The table summarizes the requirements.

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Function	C-clamp of low thermal inertia
Constraints	Depth b specified Must carry clamping load F without failure
Objective	Minimize time to reach thermal equilibrium
Free variables	Width of clamp body x Choice of material

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Problem 3 (20 points)

One criterion for design of a safe pressure vessel is that it should leak before it breaks: The leak can be detected and the pressure released. This is achieved by designing the vessel to tolerate a crack of length equal to the thickness t of the pressure vessel wall, without failing by fast fracture. The safe pressure p is then

$$p \le \frac{4}{\pi}\frac{1}{R}\left(\frac{K_{1C}^2}{\sigma_f}\right)$$

where σ_f is the elastic limit, K_{1C} is the fracture toughness, and R is the vessel radius. The pressure is maximized by choosing the material with the greatest value of

$$M = \frac{K_{1C}^2}{\sigma_f}$$

Use the $K_{1C} - \sigma_f$ chart shown in Figure 3 to identify three alloys that have particularly high values of M. Please show your work how to get the answer.

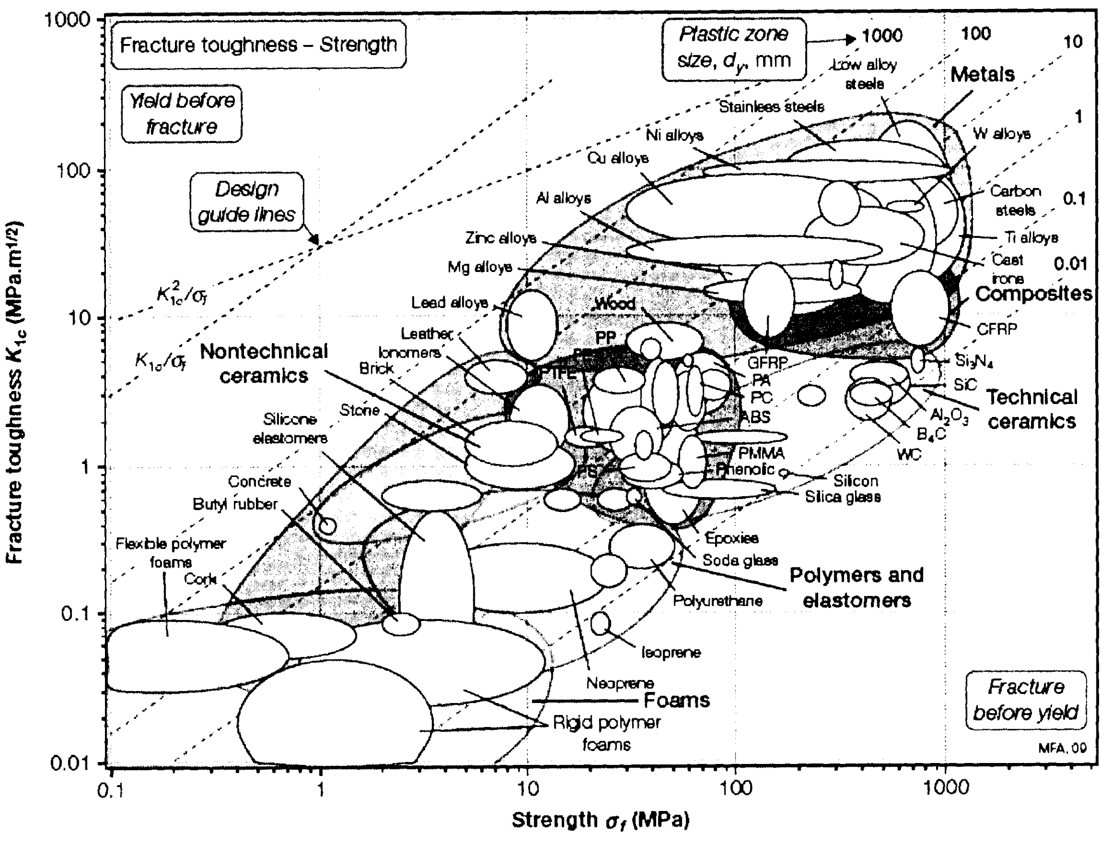

Figure 3 Fracture toughness – Strength chart.

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Problem 4 (20 points)

4.1 Estimate the shape factor ϕ_B^e for a beam loaded in bending. The beam is a closed circular tube of outer radius *5t* and wall thickness *t* shown in Figure 4. (10 points)

4.2 Explain the meaning of the value of shape factor obtained from 4.1 (10 points)

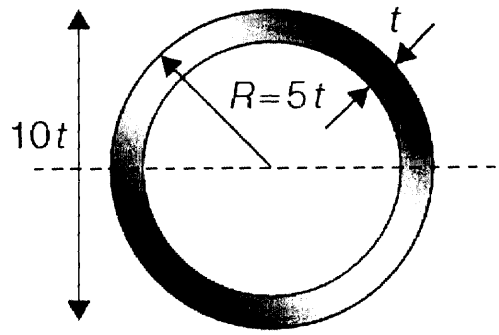

Figure 4

Hint:

$$\phi_B^e = \frac{S}{S_0} = \frac{EI}{EI_0} = \frac{12I}{A^2}$$

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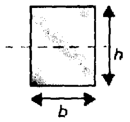
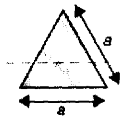
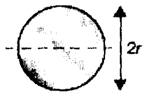
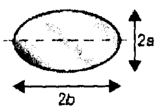
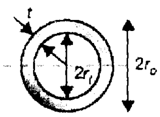
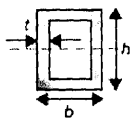
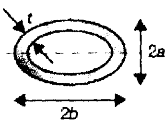
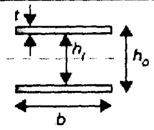
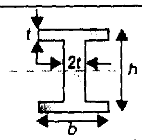
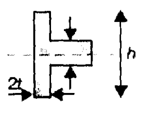
Section Shape	Area A m^2	Moment I m^4	Moment K m^4	Moment Z m^3	Moment Z_p m^3
	bh	$\frac{bh^3}{12}$	$\frac{bh^3}{3}(1-0.58\frac{b}{h})$ $(h>b)$	$\frac{bh^2}{6}$	$\frac{bh^2}{4}$
	$\frac{\sqrt{3}}{4}a^2$	$\frac{a^4}{32\sqrt{3}}$	$\frac{\sqrt{3}a^4}{80}$	$\frac{a^3}{32}$	$\frac{3a^3}{64}$
	πr^2	$\frac{\pi}{4}r^4$	$\frac{\pi}{2}r^4$	$\frac{\pi}{4}r^3$	$\frac{\pi}{3}r^3$
	πab	$\frac{\pi}{4}a^3b$	$\frac{\pi a^3b^3}{(a^2+b^2)}$	$\frac{\pi}{4}a^2b$	$\frac{\pi}{3}a^2b$
	$\pi(r_o^2-r_i^2)$ $\approx 2\pi rt$	$\frac{\pi}{4}(r_o^4-r_i^4)$ $\approx \pi r^3t$	$\frac{\pi}{2}(r_o^4-r_i^4)$ $\approx 2\pi r^3t$	$\frac{\pi}{4r_o}(r_o^4-r_i^4)$ $\approx \pi r^2t$	$\frac{\pi}{3}(r_o^3-r_i^3)$ $\approx \pi r^2t$
	$2t(h+b)$ $(h, b >> t)$	$\frac{1}{6}h^3t(1+3\frac{b}{h})$	$\frac{2tb^2h^2}{(h+b)}(1-\frac{t}{h})^4$	$\frac{1}{3}h^2t(1+3\frac{b}{h})$	$bht(1+\frac{h}{2b})$
	$\pi(a+b)t$ $(a, b >> t)$	$\frac{\pi}{4}a^3t(1+\frac{3b}{a})$	$\frac{4\pi(ab)^{5/2}t}{(a^2+b^2)}$	$\frac{\pi}{4}a^2t(1+\frac{3b}{a})$	$\pi abt(2+\frac{a}{b})$
	$b(h_o-h_i)$ $\approx 2bt$ $(h, b >> t)$	$\frac{b}{12}(h_o^3-h_i^3)$ $\approx \frac{1}{2}bth_o^2$	-	$\frac{b}{6h_o}(h_o^3-h_i^3)$ $\approx bth_o$	$\frac{b}{4}(h_o^2-h_i^2)$ $\approx bth_o$
	$2t(h+b)$ $(h, b >> t)$	$\frac{1}{6}h^3t(1+3\frac{b}{h})$	$\frac{2}{3}bt^3(1+4\frac{h}{b})$	$\frac{1}{3}h^2t(1+3\frac{b}{h})$	$bht(1+\frac{h}{2b})$
	$2t(h+b)$ $(h, b >> t)$	$\frac{t}{6}(h^3+4bt^2)$	$\frac{t^3}{3}(8b+h)$	$\frac{t}{3h}(h^3+4bt^2)$	$\frac{th^2}{2}\{1+\frac{2t(b-2t)}{h^2}\}$

Figure 5 Moment of Sections.