Ministry of Higher Education&
Scientific Research
University of Technology
Materials Engineering Department
Subject: Materials Selection
Examiner: Dr. Ahmed Ameed
Allowed time: 3 hours

Final Exam (2014-2015)

وزارة التعليم العالي والبحث العلمي
الجامعة التكنولوجية
قسم هندسة المواد

Class: 4th Grade
Signature :
Date: / / 2015

Note: Answer four question including Q1 is oblige

Q1: a) In a Formula-1 Car Disc-brake Caliper, cost is not an objective to reduce, the objectives is Minimize Mass and Maximize Heat Transfer. The Structure is Fixed Beam with central load and heat flow as shown in Fig 1. Constraints: Stiffness must be more than S_o, Length and Depth are constant, thickness of caliper wall 'h' free variable. Use the following useful equations in your calculation:

$$mass(m) = \rho bLh \ , \quad \text{Heat Flux per unit area } (q) = \lambda\left(\frac{\Delta T}{h}\right) \quad , \ S_o = \frac{4Ebh^3}{L^3}$$

- Write the penalty function equation for this design.
- Derive the minimizing objective function P_{min} and calculate the value of the constants in the (minimizing) objective equations using the given values : b: 0.1 m, L: 0.3 m, ΔT=300°C, S_o=150 GPa

b) For completely different design, I have made a linear-linear tradeoff plot (Fig. 2), by drawing two tangent lines from Epoxy/Glass Fiber Composite to the outside edge of two neighboring candidate materials on right and left of Epoxy/Glass Fiber Composites; determine the value of the exchange constant. **(25 marks)**

Q2: a) I made the coupling selection chart below using CES for a design problem for which the coupling equation is:

$$\frac{M_2}{M_1} = \frac{\left(\frac{E^{1/3}}{C\rho}\right)}{\left(\frac{\sigma_f}{C\rho}\right)} = \frac{1}{F_T}\left(\frac{48L^2b^2F_B}{\pi^2}\right)^{1/3} \quad , \qquad M_2 \ Units = \frac{GPa^{1/3}.kg.m^3}{US\$.Mg} , \qquad M_1 \ Units = \frac{MPa.kg.m^3}{US\$.Mg}$$

Where $F_T = 2 \times 10^6 N, L = 2.5m, b = 0.02m, \ F_B = 3 \times 10^6 N$

Calculate the value of the coupling constant and plot the value of the coupling line on the coupling chart Fig. 3

(25marks)

Q3: a) For certain design; we have the following performance metrics:

$$P_{MAX1} = \frac{\sigma_f^{2/3}}{E}\left(\frac{3bL^3F}{8}\right)^{1/2} \qquad P_{MAX2} = \frac{W\sigma_f^2}{2E\rho}$$

Use the active constraint approach to rank the materials listed below.

Design Parameters

b (m): 0.3 , L (m): 3.6 , F (N): 1500 , W (kg) : 18

Material	*Young's Modulus (GPa)*	*Yield Strength (MPa)*	*Density (Mg/m^3)*
Polyurethane	0.016	38	1.14
Ethylene-Probylene	1.35×10^{-3}	13.7	0.85
Epoxy / Fiber glass composites	30	625	1.75

b) Differentiate between value, price and cost? Is there any relation connected the last two terms? Which one you think is higher? **(25 marks)**

Q4: a) Look at Ashby's selection chart for fracture toughness versus Young's modulus (Fig. 4). A straight line on this chart will describe a selection criterion, M, that involves combinations of these two properties, and all materials on the line will have the same value of M. Determine an EQUATION for a selection criterion, M, for which Boron Carbide (B_4C) perform the same as alloys of Magnesium (Mg alloys).

b) What is the difference between fatigue behavior of ferrous and non-ferrous metals? **(25marks)**

Q5: Answer two branches only:

a) Discuss briefly the following statements

1. "Reduction in mechanical properties like strength may notice as the cross section increase".
2. The price of materials is subjected to change due to short and long term trends.
3. The polymer is economically sold per unit volume more than per unit weight.

b) Explain the difference between each case in the figure (5)? What material do you think it behave for each case?

c) Explain briefly with aids of sketch the friction stir welding process, for which material category are best fit?

(25 marks)

..................GOOD LUCK................