COLLEGE OF ENGINEERING, PUNE – 5
(An Autonomous Institute of Government of Maharashtra)
Autumn Semester
End Semester Examination
(MT401) Design and Selection of Materials

Programme: **Final Year B.Tech. (Metallurgical Engineering)** Year: **2013-14**
Duration: **3 Hours** Max. Marks: **60**

Instructions:
1) Answer ***any five*** questions.
2) Draw neat figures wherever required.
3) Figures to the right indicate full marks.
4) Assume suitable data if required.
5) Use of non-programmable calculators is allowed.
6) Write clearly question numbers. In case a question is solved on different pages, indicate clearly the page number where remaining part of answer is continued.

Q.1 Draw the material property chart of fracture toughness (K_{IC}) *versus* yield strength (σ_f) from the following data. Label the axes and materials appropriately.

Material	K_{IC} (MPa√m)	σ_f, (MPa)
Epoxies	0.4 –2.22	36–71.7
Nylons (PA)	2.22–5.62	50–94.8
Butyl rubber	0.07–0.1	2–3
CFRP	6.1–88	550–1050
Tungsten carbide	2–3.8	3347–6833
Titanium alloys	14–120	250–1245
Cast irons	22–54	215–790
Stainless steels	62–280	170–1000

What do the unit slope lines with changing ratios of (K_{IC}/σ_f) indicate? 8

Q.2 (a) Using a flow chart explain the stages involved in design process. Explain how the nature of material data needed changes in every stage? 4

(b) What are the four main steps involved in the strategy for material selection? Explain the steps in not more than 3 lines each. 6

Q.3 (a) Write the 'need statements' for designing following objects
i. Kick lever of a motorcycle
ii. Valve of a four stoke engine
iii. Screw driver
iv. Steel rule 4

(b) Recommend suitable materials for slender, solid cylindrical legs of a table? Explain the process of selection sequentially. Given : Equation for mass of leg m

$$m = \left(\frac{4F}{\pi}\right)^{1/2} (L)^2 \left[\frac{\rho}{E^{1/2}}\right]$$

Equation for radius of leg, r

$$r = \left(\frac{4F}{\pi^3}\right)^{1/4} (L)^{1/2} \left[\frac{1}{E}\right]^{1/4}$$

where, F is load on the leg, L is length of leg, ρ is density and E elastic modulus of the material.
Indicate the material search region on elastic modulus- density chart. 6

Q.4 (a) Flywheels are designed with any one of the requirements:

i. storing maximum energy per unit weight or
ii. storing maximum energy per unit volume

Which of these requirements is applicable for a flywheel of an automobile engine?
Derive the material indices for flywheels of these two requirements using following data.
The flywheel has thickness t, outside radius R, mass m, volume V, density ρ, and angular velocity ω. The energy U stored in the flywheel is

$$U = \frac{1}{2} J\omega^2$$

where 'polar moment of inertia' of the disk, $J=(\pi/2)\rho R^4 t$.
The maximum principal stress σ_{max} in a spinning disk of uniform thickness is

$$\sigma_{max} \approx \frac{1}{2}\rho R^2 \omega^2$$

....6

(b) Write the design requirements for the following applications:

i. Heat sink for microchips
ii. Light tie rod
iii. Boating oar

In which case(s), the constraints are not coupled with objectives? 6

Q.5 (a) State the different attributes used in selection of processes for manufacturing. Which process sounds to be the most flexible? 4

(b) What are the dangers of specifying high performance in terms of strength, precision and surface finish? 3

(c) What are the different inputs to a cost model? Which of these inputs are taken as variable costs and overhead costs at the beginning of a setup? 3

Q.6 (a) Draw a typical graph showing relationship between relative cost per component and the number of components produced. When do the tooling costs and material costs dominate? 4

(b) How are the materials selected quantitatively for an application by using 'weighted property method'? Draw a flow chart for the stages. 3

(c) What do you understand by 'superalloy'? Give some applications of nickel base superalloys. 3

-@-@-@-