El-Mansoura University | Final Exam., Jan. 2012
Faculty of Engineering | B. SC. Students
Dept. of Prod.and Mech. Design | Elective Course 3 (Design Methods)

Time Allowed: 3 Hours

⇒ *ATTEMPT ALL PROBLEMS*
⇒ *MISSING DATA MAY BE ASSUMED*
⇒ *NO BOOKS, NO NOTES, NO MOBILES*
⇒ *TOTAL MARKS : 100 POINTS*

PROBLEM 1 :(20 points)

Write technical notes on the following, in relation to mechanical design:

1) Design steps & design phases.
2) High-temperature environments.
3) Reliability & causes of unreliability in design.
4) Repeated loading.

PROBLEM 2 :(35 points)

Acrobatic synchronous water jumping is one of the most elegant athletic events. The material of the jumping board, which is a cantilever beam subjected to a concentrated load at its free end as shown in **Figure1**, must be selected properly so that necessary design requirements must be satisfied. The board must be designed for one or two persons.

It is required to show the following :

a) A statement of the problem
b) Problem analysis
c) Stress analysis
d) Material selection (use Table below)
e) Final dimensions (***L, b, t***)
f) Fixation methodology (make a sketch)

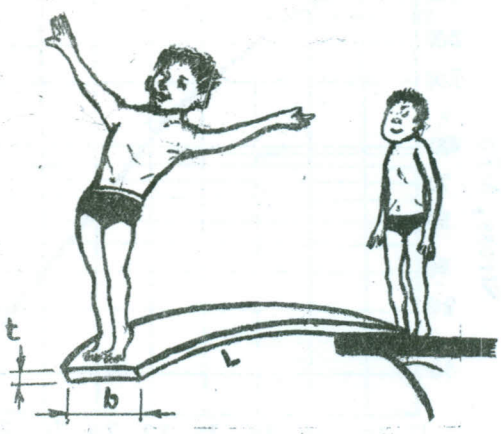


Figure 1

Properties / Material	ρ (kg m^{-3})	E (GPa)	P ($ t^{-1})	FL (MPa)	σ_u (MPa)
▪ Low alloy steel	7800	200	210	320	650
▪ 2014 Al alloy	2796	73	2500	200	450
▪ S glass fiber-reinforced epoxy resin	1997	56	5000	300	1400
▪ Carbon fiber-reinforced epoxy resin	1661	138	130,000	530	800

ρ = Density , kg /m^3, E = Mod. of Elasticity, GPa, P = Price , $ /ton ,
FL = Fatigue Limit after 10^6 cycles, MPa , σ_u = Ultimate Strength, MPa

PROBLEM 3 :(20 points)

A component is made of a steel for which the plain strain fracture toughness, K_{IC} , is 45 MPa $m^{1/2}$. Cracks in this steel grow under fatigue loading according to the equation :

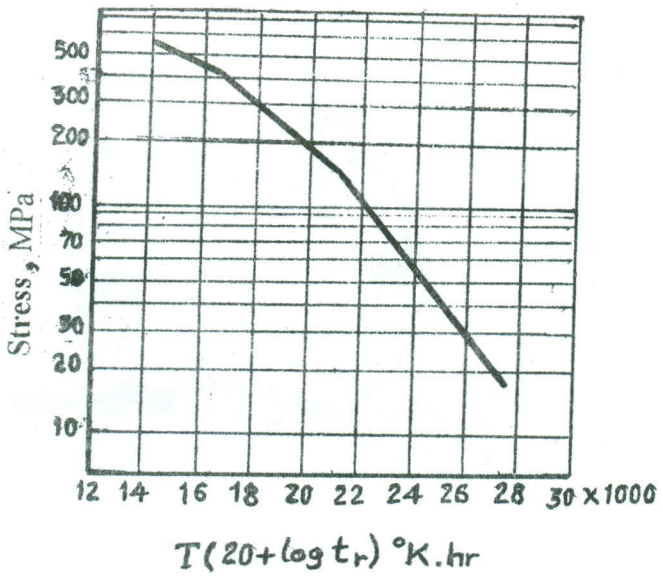
$(dc/dN) = 4.0 \times 10^{-13} (\Delta K_I)^4$ m /cycle

The component is subject to an alternating stress of a range, $\Delta\sigma$, of 180 MPa. The material of the component is found to contain cracks of length, **C**, of 0.15 mm. Given that :$\Delta K_I = \Delta\sigma\sqrt{\pi c}$,
what is the number of loading cycles that would produce failure?
What would you do to double the life of this component?
Give your answer in explicit numbers.

PROBLEM 4 :(25 points)

Figure 2 represents creep design curve for components made of 18-8 Mo stainless steel subjected to tensile loads under high temperatures. It is required to :

Figure 2



a) Give a technical analysis of the curve and its importance to the design engineer

b) If a circular rod made of 18-8 Mo S.S is exposed to a tensile load of 100 Kn at a temperature of 527 °C, calculate the required diameter for a rupture life-time, t_r, of 5 years

c) If, for the component with the calculated diameter, it is required to increase its life to 10 years under the same temperature;
what is the design parameter which should be changed?
What should be its magnitude?

Useful Equations

$$\sigma = F/A \; ; \; \sigma = MY/I \; ; \; \tau = Tr/J \; ; \; K = Y \; \sigma\sqrt{\pi a} \; ; \; (da/dN) = A(\Delta K)^m \; ;$$

$$N_f = [\, a_f^{((-m/2)+1)} - a_0^{((-m/2)+1)}] \, / \, [((-m/2)+1) \, A \, (\Delta\sigma)^m \, \pi^{m/2} \, Y^m]$$

With my best wishes

Prof. Dr. M. Shabara