(21)

Program: B. Sc. Engg. (IPE) **Date: 03 October 2023**
Semester: 7th **Time: 02.30 pm to 04.00 pm (afternoon)**

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)

ORGANISATION OF ISLAMIC COOPERATION (OIC)

DEPARTMENT OF MECHANICAL AND PRODUCTION ENGINEERING

Mid-Semester Examination **Winter Semester: 2022-2023**
Course Number: IPE 4709 **Full Marks: 75**
Course Title: Product Design II **Time: 1 hour and 30 mins**

Answer all the 3 (three) questions below. The distribution of marks and the CO-PO mapping are given in brackets. Necessary formula and table are attached.

Q1. (a) A cellphone company is planning to launch a new series of cellphone in the next year. The company is now generating horizontal and vertical prototypes to achieve the fidelity of the final product. Answer the following questions. **[6+2+3+4]** (CO3, PO2)

i) What does fidelity of prototype mean? Discuss briefly the different dimensions of fidelity.

ii) When the cellphone prototype is just a paper prototype at the initial stage, what are the fidelity of the prototype for the different dimensions?

iii) What could be the possible arrangements as horizontal and vertical prototypes for the cellphone?

iv) How can the storyboarding tool be used for low-fi and high-fi prototypes of the cellphone?

(b) A part of a machine, which has a shiny outer surface, needs to be reverse engineered. The laboratory has a noncontact scanner and Fused Deposition Modeling (FDM) and Selective Laser Sintering (SLS) additive manufacturing technologies. **[5+5]** (CO3, PO2)

i) Describe with a schematic representation the scanning method used in such a scenario.

ii) Write down five differences between the FDM and SLS methods.

Q2. (a) Describe seven principles of Design For Assembly (DFA). Draw the necessary schematic diagrams for illustration. **[14]** (CO1, PO1)

(b) The useful life of the product can be extended with a proper Design For Disassembly (DFD). Illustrate and discuss the self-replenishing loops for DFD. **[6]** (CO1, PO1)

Q3. (a) A company is planning to buy a machine. There are two alternatives of buying it. The following information of the alternatives have been provided. **[12]** (CO3, PO1)

Alternative 1: Machine A has an initial cost of $18,000, an annual operating cost of $3,000, and an expected salvage value of $3,000 at the end of its 5-year service life.

Alternative 2: Machine B costs $10,000 initially. With an economic life of 3 years and no salvage value, it has an annual operating cost of $4,000.

If the required rate of return is 15%, state which alternative is preferred when the alternatives are compared with

- Present worth
- Annual cost

(b) A section of a 25 mm diameter solid shaft shown in Figure 1 below is drawn from AISI 1080 (quenched and tempered at 800◦C) carbon steel for which the ultimate tensile strength becomes 615 MPa. During service, the shaft encounters a bending moment that varies from –8 to 40 Nm. For a reliability of 98.5% and no thermal or miscellaneous effects, determine the safety factor using the Goodman line. Assume that the fatigue stress concentration factor = 1 due to the unnotched shaft. **[18]** (CO3, PO3)

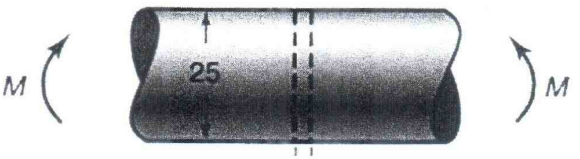

Figure 1. For Problem 3b.

Tables and Formulas

Table 1. Discrete cash flow: compound interest factors for 15%

	Single Payments		Uniform Series Payments				Arithmetic Gradients	
n	F/P Compound Amount	P/F Present Worth	A/F Sinking Fund	F/A Compound Amount	A/P Capital Recovery	P/A Present Worth	P/G Gradient Present Worth	A/G Gradient Uniform Series
1	1.1500	0.8696	1.00000	1.0000	1.15000	0.8696		
2	1.3225	0.7561	0.46512	2.1500	0.61512	1.6257	0.7561	0.4651
3	1.5209	0.6575	0.28798	3.4725	0.43798	2.2832	2.0712	0.9071
4	1.7490	0.5718	0.20027	4.9934	0.35027	2.8550	3.7864	1.3263
5	2.0114	0.4972	0.14832	6.7424	0.29832	3.3522	5.7751	1.7228
6	2.3131	0.4323	0.11424	8.7537	0.26424	3.7845	7.9368	2.0972

Table 2: Surface finish factor

Manufacturing process	Factor a	Exponent f
Grinding	1.58	-0.085
Machining or cold drawing	**4.51**	**-0.265**
Hot rolling	57.7	-0.718
As forged	**272.0**	**-0.995**

High cycle fatigue limits:

Lower limit ($N \approx 10^3$): for bending, $S_t' = 0.9S_u$;
for axial loads, $S_t' = 0.75S_u$;
for torsion, $S_t' = 0.72S_u$.

Upper limit ($N \approx 10^6$ or 10^7): $S_e' = 0.5S_u$;
for axial loads, $S_e' = 0.45S_u$;
for torsion, $S_e' = 0.29S_u$.

Life as a function of stress: $N_t' = \left(S_f' 10^{-C}\right)^{1/b}$

Fatigue Stress Concentrations: $K_f = 1 + (K_t - 1)q_n$

Modified Endurance Limit: $S_e = k_f k_s k_r k_m S_e'$

Surface finish factor: $k_f = aS_{ut}^f$

Size factor:

$$k_s = \begin{cases} 1 & d \le 8 \text{ mm} \\ 1.189d^{-0.112} & 8 \text{ mm} < d \le 250 \text{ mm} \end{cases}$$

Temperature factor: $k_t = \dfrac{S_{ut}}{S_{ut,rt}}$

Reliability factor: $k_r = 0.512\left[\ln\left(\dfrac{1}{R}\right)\right]^{0.11} + 0.508.$

Effect of Nonzero Mean Stress:

Gerber parabola: $\dfrac{K_f n_s \sigma_a}{S_e} + \left(\dfrac{n_s \sigma_m}{S_{ut}}\right)^2 = 1$

Goodman line: $\dfrac{K_f \sigma_a}{S_e} + \dfrac{\sigma_m}{S_{ut}} = \dfrac{1}{n_s}$