ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)
ORGANISATION OF ISLAMIC COOPERATION (OIC)
DEPARTMENT OF MECHANICAL AND PRODUCTION ENGINEERING

Semester Final Examination   **Winter Semester: 2022-2023**
Course Number: IPE 4709   **Full Marks: 150**
Course Title: Product Design II   **Time: 3 hours**

This is an **open book examination**. Only a fresh copy of the book "**Fundamentals of Machine Elements by S. R. Schmid**" is allowed in the examination hall.
Answer all the **6 (six)** questions below. The distribution of marks and the CO-PO mapping are given in brackets.

Q1. (a) There are products A, B and C in the product portfolio, as shown in Figure 1.   **[5]**
With the help of Boston matrix, analyze the importance of balancing the   **(CO3, PO2)**
portfolio at points 1 and 2.

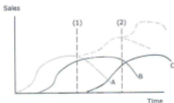*Figure 1*

(b) Mention any five limitations of Boston matrix for the products in Figure 1.   **[7.5]**
                                                                                         (CO3, PO2)

(c) Briefly describe the strategies need to be applied in the different stages of the   **[12.5]**
product life cycle.   **(CO3, PO2)**

Q2. (a) Consider the probability density function (PDF) given by   **[20]**
                                                                                         (CO2, PO1)

$$f(t) = 0.00285t, 0 \le t \le 70$$

Calculate the R(14), the MTTF, the median time and the $B_{2.15}$ life. Find the
probability that a failure will occur after the fifth year.

(b) State any five main reasons for system failure.   **[5]**
                                                             (CO2, PO1)

Q3. (a) Show the relationships between marginal cost and different average costs in a figure and briefly explain the behavior of the costs. **[7]** (CO2, PO1)

(b) Consider a Pizza selling restaurant, which only sells pepperoni pizza. The expenses of the restaurant per month are shown below. **[10]** (CO2, PO1)

Fixed Costs		Variable Costs Per Pizza	
General Labor	$1,500	Flour	$0.50
Rent	$3,000	Yeast	$0.05
Insurance	$200	Water	$0.01
Advertising	$500	Cheese	$3.00
Utilities	$450	Pepperoni	$2.00

If the owner sells 350 pizzas/week at $10.50 each, what will be the profit or loss at the end of the month? What will be the break-even units/week?

(c) The variable cost and the total revenue follow non-linear functions. There are two break-even points within the Q time. Draw the break-even analysis graph and show the profitable zone within the graph. **[6]** (CO2, PO2)

Q4. The rotating solid steel shaft is simply supported by bearings at points B and C and is driven by a gear (not shown) which meshes with the spur gear at D, which has a 150-mm pitch diameter (Figure 2). The force F from the drive gear acts at a pressure angle of $20°$ (The shaft transmits a torque to point A of $T_A = 340$ N-m. The shaft is machined from steel with $S_y = 420$ MPa and $S_{ut} = 560$ MPa. Assume there is no notch that can produce a stress concentration. Using a factor of safety of 2.5, determine the minimum allowable diameter of the 250-mm section of the shaft based on (i) a static yield analysis using the distortion energy theory and (ii) a fatigue-failure analysis. Assume there is no notch that can produce a stress concentration. Also, provide a free-body diagram as well as moment and torque diagrams. **[25]** (CO3, PO3)
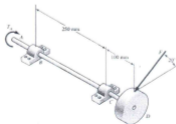

Figure 2

Q5. (a) In a gear train used in manufacturing machine parts, a pinion having 30 teeth, a module of 2 mm, and rotating at 2000 rpm is to drive a gear rotating at 500 rpm. Determine the diametral pitch, number of teeth in the gear, and the center distance. **[10]** (CO1, PO1)

(b) For a deep-groove ball bearing, the width-to-length ratio of the contact area is given by the race conformity. Calculate the race conformity for both the inner- and outer-race contacts when the ball diameter is 17 mm and the radii of curvature in the axial direction are 8.840 mm for the inner race and 9.180 mm for the outer race. Also, calculate the free contact angle, the shoulder heights and the endplay when the diametral clearance is 0.15 mm. **[15]** (CO1, PO1)

Q6. (a) A cone clutch has a major diameter of 328 mm and a minor diameter of 310 mm, is 50 mm wide, and transfers 250 N-m of torque. The clutch uses hard steel on smooth cast iron. Using the assumptions of uniform pressure and uniform wear, determine the actuating force and the contact pressure. **[15]** (CO1, PO1)

(b) List the advantages and disadvantages of (i) rigid couplings; (ii) helical couplings; (iii) Schmidt couplings; (iv) fluid couplings. **[10]** (CO1, PO1)