ELIZADE UNIVERSITY, ILARA-MOKIN,
ONDO STATE, NIGERIA
DEPARTMENT OF MECHANICAL ENGINEERING

SECOND SEMESTER EXAMINATIONS

2017/2018 ACADEMIC SESSION

COURSE: MEE 312 – Mechanical Engineering Design I (3 Units)

CLASS: 300 Level Mechanical Engineering

TIME ALLOWED: 3 Hours

INSTRUCTIONS: Answer question **ONE (1)** and any other **THREE (3)** questions

HOD'S SIGNATURE

Date: July/August, 2018

Question 1 (15 MARKS)

(a) Identify the critical location in a shaft.
(b) What is the distortion energy failure theory?
(c) What is the shaft loading factor k_c for torsional and axial loading?
(d) What type of screw thread is this MJF14 x 1.5 x 80? Define each of the values indicated.
(e) State the formula you will use to calculate the threading length of the screw in question 1(d) and why?
(f) What is Mechanical Fastener? State the two main categories.
(g) Form the regression equation ($FL^{1/a} = constant$) used for tests of various kinds of bearings, what is the value of 'a' for ball bearings as well as roller bearing?
(h) Enumerate four different types of standardized bearing.
(i) Define *catalog load rating.*
(j) What is lubrication?
(k) What is Newton's viscous effect?
(l) The phenomenon of bearing friction was first explained by Petroff on the assumption that the shaft is concentric. True/False
(m) The Sommerfield number is very important in lubrication analysis because it contains many of the parameters that are specified by the designer. True/False

Question 2 (15 MARKS)

(*a*) With the aid of a well labelled sketch, show the different terminologies used in the design of screw thread. Define four of the terms.
(*b*) Derive the Goodman equation for shaft design.

Question 3 (15 MARKS)

As shown in the Figure Q3 below, two plates are clamped by washer-faced MJC 12 x 1.75 bolts each with a standard ½ N steel plain washer outside diameter (OD) 19.05 mm.

(*a*) Determine the member spring rate k_m if the top plate is copper and the bottom plate is aluminum.

(*b*) Using the method of conical frusta, determine the member spring rate k_m if both plates are copper.

(*c*) Using exponential curve-fit, determine the member spring rate k_m if both plates are copper. Compare the results with part (*b*).

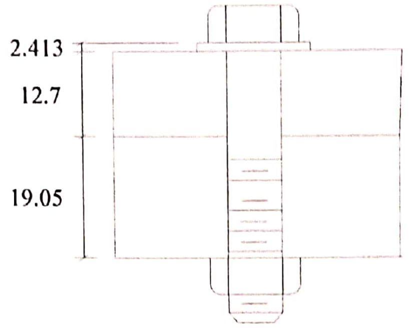

Figure Q3

Direction of predominant pattern made by mark tool.

Question 4 (15 MARKS)

(a) What is 'lay' in surface finish? Explain the 5 different types.

(b) With the aid of a diagram explain 'fit' and the 3 different types.

Question 5 (15 MARKS)

(a) List and explain four different forms of lubrication that you know.

(b) At a machined shaft shoulder the small diameter d is 27.94 mm, the large diameter D is 41.91 mm, and the fillet radius is 2.8 mm. The alternating bending moment is 142.361 kNmm and the steady midrange torsional moment is 124.283 kNmm. The heat-treated steel shaft has an ultimate strength of S_{ut} = 0.724 GPa and a yield strength of S_y = 0.565 GPa. The reliability goal is 0.99. Use Figure Q5a & b below:

(i) Determine the fatigue factor of safety (n) of the design using the Goodman equation.

(ii) Determine the yielding factor of safety.

Take $K_t = 1.68$, $K_{ts} = 1.42$, $K_e = 0.814$, $S_e = 0.202$ GPa

Question 6 (15 MARKS)

(a) What are the four essential parts of a bearing? Mention the part mostly omitted from low-priced bearings and what is its function.

(b) Derive an expression for the catalog load rating (C_{10}) of a bearing.

(c) The design load on a ball bearing is 1840 N and an application factor of 1.2 is appropriate. The speed of the shaft is to be 300 rev/min, the life is to be 30 kh with a reliability of 0.99. What is the C_{10} catalog entry to be sought (or exceeded) when searching for a deep-groove bearing in a manufacturer's catalog on the basis of 10^6 revolutions for rating life?

Table 1: Stiffness Parameters of Various Member Materials

Material Used	Poisson Ratio	Elastic GPa	Modulus Mpsi	A	B
Steel	0.291	207	30.0	0.787 15	0.628 73
Aluminum	0.334	71	10.3	0.796 70	0.638 16
Copper	0.326	119	17.3	0.795 68	0.635 53
Gray cast iron	0.211	100	14.5	0.778 71	0.616 16
General expression				0.789 52	0.629 14

Table 2: Diameters and Areas of Coarse-Pitch and Fine-Pitch Metric Threads

Nominal Major Diameter d mm	Coarse-Pitch Series Pitch p mm	Coarse-Pitch Series Tensile-Stress Area A_t mm²	Coarse-Pitch Series Minor-Diameter Area A_r mm²	Fine-Pitch Series Pitch p mm	Fine-Pitch Series Tensile-Stress Area A_t mm²	Fine-Pitch Series Minor-Diameter Area A_r mm²
1.6	0.35	1.27	1.07			
2	0.40	2.07	1.79			
2.5	0.45	3.39	2.98			
3	0.5	5.03	4.47			
3.5	0.6	6.78	6.00			
4	0.7	8.78	7.75			
5	0.8	14.2	12.7			
6	1	20.1	17.9			
8	1.25	36.6	32.8	1	39.2	36.0
10	1.5	58.0	52.3	1.25	61.2	56.3
12	1.75	84.3	76.3	1.25	92.1	86.0
14	2	115	104	1.5	125	116
16	2	157	144	1.5	167	157
20	2.5	245	225	1.5	272	259
24	3	353	324	2	384	365
30	3.5	561	519	2	621	596
36	4	817	759	2	915	884
42	4.5	1120	1050	2	1260	1230
48	5	1470	1380	2	1670	1630
56	5.5	2030	1910	2	2300	2250
64	6	2680	2520	2	3030	2980
72	6	3460	3280	2	3860	3800
80	6	4340	4140	1.5	4850	4800
90	6	5590	5360	2	6100	6020
100	6	6990	6740	2	7560	7470
110				2	9180	9080

Table 3: Parameters for Marin Surface Modification Factor.

Surface Finish	Factor a S_{ut}, kpsi	Factor a S_{ut}, MPa	Exponent b
Ground	1.34	1.58	−0.085
Machined or cold-drawn	2.70	4.51	−0.265
Hot-rolled	14.4	57.7	−0.718
As-forged	39.9	272.	−0.995

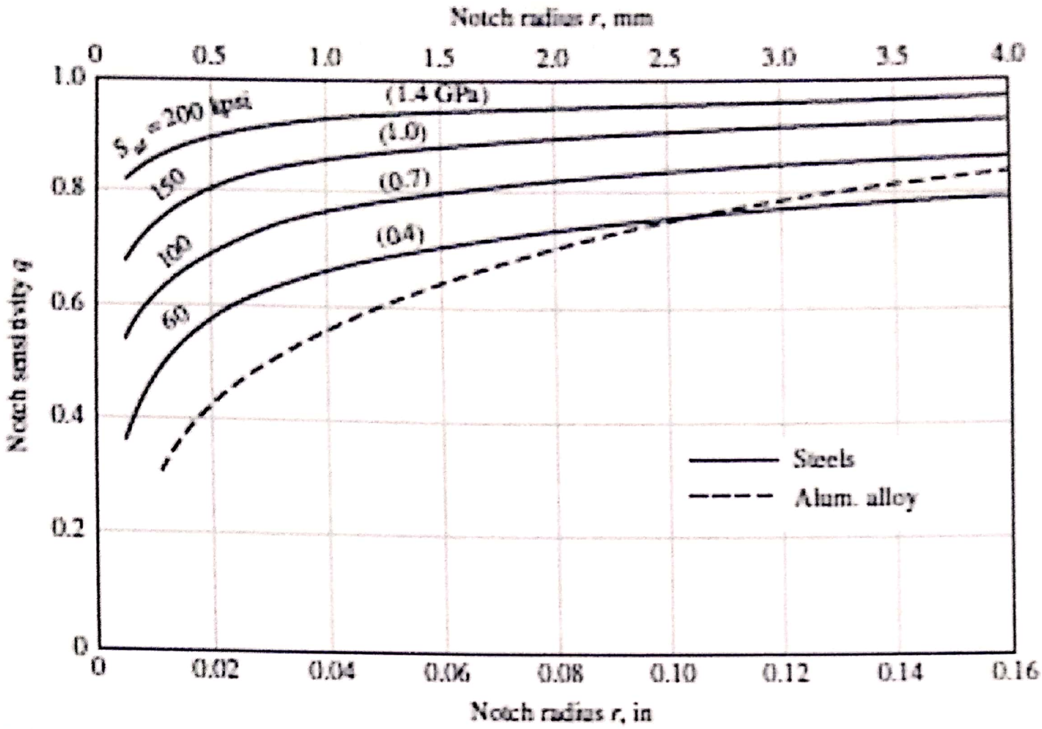

Figure 5a: Notch-sensitivity charts for steels and UNS A92024-T wrought aluminum alloys

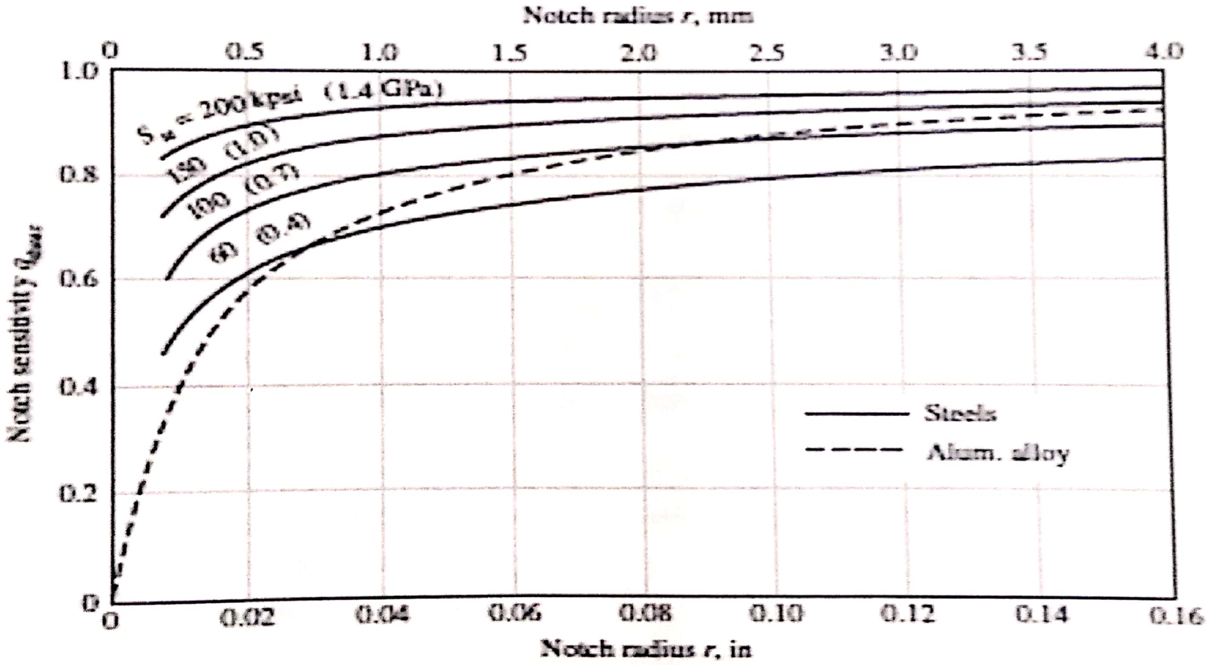

Figure 5b: Notch-sensitivity curves for materials in reversed torsion.

$$\frac{16}{\pi d^3}\left\{\frac{4}{Se}\cdot\left[(K_f M_a)^2+3(K_{fs}T_a)^2\right]^{1/2}+\frac{4}{Sut}\left[(K_f M_m)^2+3(K_{fs}T_m)^2\right]^{1/2}\right\}$$