

KATHMANDU UNIVERSITY  
End Semester Examination  
February, 2025

Marks Scored:

Level : B.E.

Year : IV

Exam Roll No. :

Time: 30 mins.

Course : MEPP 436

Semester : I

F. M. : 20

Registration No.:

Date 04 FEB 2025

SECTION "A"

[20Q. × 1 = 20 marks]

Choose the most appropriate answer and **mark [X]**.

1. What is the purpose of a factor of safety in machine design?  
 To increase the weight of the product  
 To compensate for uncertainties in material properties and loading conditions  
 To reduce the cost of manufacturing  
 To improve the aesthetic appeal of the machine
2. In the design of shafts, which failure criterion is commonly used for ductile materials?  
 Maximum Principal Stress Theory       Maximum Principal Strain Theory  
 Maximum Shear Stress Theory       Maximum Strain Energy Theory
3. A hollow shaft of inner diameter 15 mm and outer diameter 30 mm is subjected to a torque of 100 N.m. What is the stress acting on the outer surface of the shaft?  
 8.74 MPa       20.120 MPa       40.240 MPa       50.260 MPa
4. What is the main advantage of composite materials in engineering design?  
 Low manufacturing cost  
 High strength-to-weight ratio and tailored properties  
 Uniformity in mechanical properties  
 Easy recyclability
5. Which material property is most important when selecting a material for high-temperature applications?  
 Hardness       Thermal conductivity  
 Creep resistance       Fatigue strength
6. Which of the following is not a mode of application of force for crack propagation?  
 Opening mode       Sliding mode       Tearing mode       Rolling mode
7. Which of the following is **NOT** the characteristics of crack in fracture mechanics?  
 Crack length       Crack surface roughness  
 Crack tip radius       Crack orientation
8. In fracture mechanics, what does the term "fatigue crack growth rate" refer to?  
 The rate at which a crack propagates under cyclic loading  
 The time it takes for a crack to reach critical length  
 The resistance of a material to crack initiation  
 The ability of a material to withstand dynamic loading conditions

9. What is the primary mechanism responsible for fatigue failure in materials?  
 Creep deformation  Dislocation movement  
 Crack propagation  Plastic deformation
10. A specimen undergoes cyclic loading between  $\sigma_{\min} = 50$  MPa and  $\sigma_{\max} = 250$  MPa. What is the stress amplitude?  
 100 MPa  150 MPa  200 MPa  250 MPa
11. A material part follows the Basquin equation:  $S = aN^{-0.15}$ , where  $S$  is the stress amplitude (MPa) and  $N$  is the number of cycles to failure. The part is expected to last for  $10^5$  cycles under a cyclic stress of 400 MPa. What would be the estimated stress for a fatigue life of  $10^6$  cycles?  
 250 MPa  280 MPa  320 MPa  380 MPa
12. A mild steel plate with edge crack is loaded under a constant amplitude cyclic load with  $\Delta\sigma = 0$  MPa to 260 MPa.  $K_{IC} = 165$  MPa $\sqrt{m}$ , what is the critical length of crack?  
 82.3 mm  68.6 mm  71.9 mm  102.2 mm
13. Approximately how much of the cost of product development and manufacture is determined at the design stage?  
 40-50%  50-70%  70-80%  75-85%
14. What role does Design for Assembly (DFA) play in DFM?  
 It focuses on optimizing the assembly process for efficiency  
 It emphasizes designing parts with complex geometries  
 It ensures the product meets aesthetic requirements  
 It determines the material properties required for production
15. Which of the following is NOT a typical approach to enhance product reliability?  
 Redundancy  Design simplification  
 Increasing component complexity  Improved quality control
16. The reliability of a ball bearing is represented by Weibull distribution with  $m = 0.7$  and  $\theta = 7500$ . What is the probability of it to last more than 1450 hours?  
 24.31 %  27.5 %  75.69 %  72.8 %
17. What does the term "safety factor" refer to in Design for Safety?  
 The ratio of actual load to the design load  
 The maximum allowable stress before failure  
 The number of redundant components in the system  
 The level of compliance with safety regulations
18. Anthropometric human factors in design are related to the \_\_\_\_\_.  
 human sensation and feel of operator  physical size of human body  
 psychological condition of operator  man-machine interaction
19. Which of the following factor is not applicable for DFR of electrical appliances?  
 Derating  Redundancy  Simplicity  Safety
20. Which type of display is most effective for presenting rapidly changing quantitative information?  
 Digital numerical display  Analog dial display  
 Symbolic display  Text-based display

KATHMANDU UNIVERSITY  
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Level : B.E.  
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Time : 2 hrs. 30mins.

04 FEB 2025

Course : MEPP 436  
Semester : I  
F. M. : 55

SECTION "B"

Attempt ALL the questions. Assume suitable data if necessary.

1.
  - a. Explain three-dimensional stress state and its tensor notation. For the three-dimensional stress and strain field, define generalized Hooke's law. [2+3=5]
  - b. Ceramics are considered as linear elastic material with no plasticity. Draw an illustrative stress-strain diagram for ceramic material. [2]
  - c. Define material selection chart and explain how it helps in product design. [3]
  - d. State Tresca criteria for failure of ductile materials. Draw a two-dimensional Tresca yield surface in terms of principal stresses. [2+2=4]
2.
  - a. Define cohesive stress and explain its significance in fracture process. [3]
  - b. Define the Energy Release rate (G) and state the Energy Release rate criteria for crack propagation. [3]
  - c. A cantilever beam of thickness 5 mm has a crack of 2 mm as shown in Figure 1. The fracture toughness and yield stress of the beam material are  $30 \text{ MPa}\sqrt{\text{m}}$  and  $300 \text{ MPa}$  respectively. Assume nominal stress at the crack as  $M/Z$  where  $M$  is the bending moment and  $Z$  is the section modulus =  $400 \text{ mm}^3$ .

For the edge crack, Stress Intensity Factor ( $K_I$ ) =  $1.12 \sigma\sqrt{\pi a}$ .

- i. Calculate the failure load  $P$  assuming fracture to take place by propagation to the crack. [2]
- ii. Calculate the failure load  $P$  assuming yielding of the beam at the fix end. [2]
- iii. Predict the mode of failure for the given beam. [1]

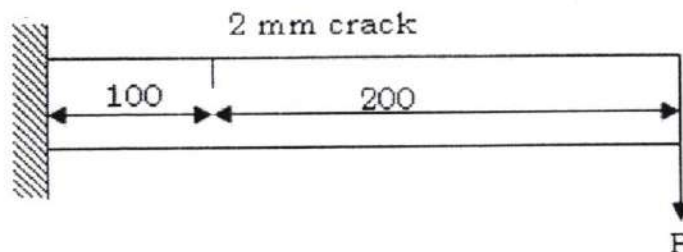


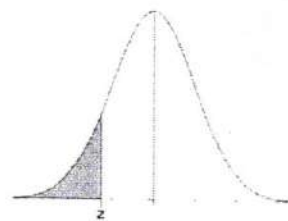
Figure 1

P.T.O.

- 3.
- a. Define High Cycle Fatigue (HCF) and Low Cycle Fatigue (LCF). Explain the major difference in terms of failure mechanism in HCF and LCF. [1+2=3]
  - b. How does residual stresses affect fatigue strength and fatigue life of a material? [2]
  - c. A large low carbon steel plate having an initial edge crack of length 30 mm is subjected to a cyclic fatigue load range of 0 MPa to 180 MPa. For the safety purpose, the crack is not allowed to exceed half of the critical crack length corresponding to  $K_{IC} = 150 \text{ MPa} \sqrt{\text{m}}$ . Use the Paris' law with  $C = 7.2 \times 10^{12} \text{ MPa}^{-3} \text{ m}^{1/2}$  and  $m=3.0$ . Determine the fatigue crack propagation life. [4]
  - d. Explain Damage-tolerance fatigue design strategies. [2]
- 4.
- a. List and briefly describe three key aspects of DFX that are commonly used in engineering design. [3]
  - b. Discuss how the implementation of DFMA can improve supply chain efficiency and reduce lead times in mass production industries such as automotive or consumer electronics. State any four guidelines for DFMA approach with suitable examples and illustrations. [3+4=7]
  - c. The mean life of a certain ball bearing can be modelled using a Normal distribution with a mean of six years and a standard deviation of one year.  
Determine:
    - i. The probability that a ball bearing will fail before 7 years of service [1.5]
    - ii. The reliability of the ball bearing for 7 years of service [1]
    - iii. The service life that will provide a failure probability of 10 percent. [1.5]
  - d. Explain Man as an important part of effective Man-Machine system with suitable example. Discuss the design guidelines for ergonomic design of controls in Man-machine system. [2+3=5]

04 FEB 2025

### Standard Normal Cumulative Probability Table



Cumulative probabilities for NEGATIVE z-values are shown in the following table:

z	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
-3.4	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0002
-3.3	0.0005	0.0005	0.0005	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0003
-3.2	0.0007	0.0007	0.0006	0.0006	0.0006	0.0006	0.0006	0.0005	0.0005	0.0005
-3.1	0.0010	0.0009	0.0009	0.0009	0.0008	0.0008	0.0008	0.0008	0.0007	0.0007
-3.0	0.0013	0.0013	0.0013	0.0012	0.0012	0.0011	0.0011	0.0011	0.0010	0.0010
-2.9	0.0019	0.0018	0.0018	0.0017	0.0016	0.0016	0.0015	0.0015	0.0014	0.0014
-2.8	0.0026	0.0025	0.0024	0.0023	0.0023	0.0022	0.0021	0.0021	0.0020	0.0019
-2.7	0.0035	0.0034	0.0033	0.0032	0.0031	0.0030	0.0029	0.0028	0.0027	0.0026
-2.6	0.0047	0.0045	0.0044	0.0043	0.0041	0.0040	0.0039	0.0038	0.0037	0.0036
-2.5	0.0062	0.0060	0.0059	0.0057	0.0055	0.0054	0.0052	0.0051	0.0049	0.0048
-2.4	0.0082	0.0080	0.0078	0.0075	0.0073	0.0071	0.0069	0.0068	0.0066	0.0064
-2.3	0.0107	0.0104	0.0102	0.0099	0.0096	0.0094	0.0091	0.0089	0.0087	0.0084
-2.2	0.0139	0.0136	0.0132	0.0129	0.0125	0.0122	0.0119	0.0116	0.0113	0.0110
-2.1	0.0179	0.0174	0.0170	0.0166	0.0162	0.0158	0.0154	0.0150	0.0146	0.0143
-2.0	0.0228	0.0222	0.0217	0.0212	0.0207	0.0202	0.0197	0.0192	0.0188	0.0183
-1.9	0.0287	0.0281	0.0274	0.0268	0.0262	0.0256	0.0250	0.0244	0.0239	0.0233
-1.8	0.0359	0.0351	0.0344	0.0336	0.0329	0.0322	0.0314	0.0307	0.0301	0.0294
-1.7	0.0446	0.0436	0.0427	0.0418	0.0409	0.0401	0.0392	0.0384	0.0375	0.0367
-1.6	0.0548	0.0537	0.0526	0.0516	0.0505	0.0495	0.0485	0.0475	0.0465	0.0455
-1.5	0.0668	0.0655	0.0643	0.0630	0.0618	0.0606	0.0594	0.0582	0.0571	0.0559
-1.4	0.0808	0.0793	0.0778	0.0764	0.0749	0.0735	0.0721	0.0708	0.0694	0.0681
-1.3	0.0968	0.0951	0.0934	0.0918	0.0901	0.0885	0.0869	0.0853	0.0838	0.0823
-1.2	0.1151	0.1131	0.1112	0.1093	0.1075	0.1056	0.1038	0.1020	0.1003	0.0985
-1.1	0.1357	0.1335	0.1314	0.1292	0.1271	0.1251	0.1230	0.1210	0.1190	0.1170
-1.0	0.1587	0.1562	0.1539	0.1515	0.1492	0.1469	0.1446	0.1423	0.1401	0.1379
-0.9	0.1841	0.1814	0.1788	0.1762	0.1736	0.1711	0.1685	0.1660	0.1635	0.1611
-0.8	0.2119	0.2090	0.2061	0.2033	0.2005	0.1977	0.1949	0.1922	0.1894	0.1867
-0.7	0.2420	0.2389	0.2358	0.2327	0.2296	0.2266	0.2236	0.2206	0.2177	0.2148
-0.6	0.2743	0.2709	0.2676	0.2643	0.2611	0.2578	0.2546	0.2514	0.2483	0.2451
-0.5	0.3085	0.3050	0.3015	0.2981	0.2946	0.2912	0.2877	0.2843	0.2810	0.2776
-0.4	0.3446	0.3409	0.3372	0.3336	0.3300	0.3264	0.3228	0.3192	0.3156	0.3121
-0.3	0.3821	0.3783	0.3745	0.3707	0.3669	0.3632	0.3594	0.3557	0.3520	0.3483
-0.2	0.4207	0.4168	0.4129	0.4090	0.4052	0.4013	0.3974	0.3936	0.3897	0.3859
-0.1	0.4602	0.4562	0.4522	0.4483	0.4443	0.4404	0.4364	0.4325	0.4286	0.4247
0.0	0.5000	0.4960	0.4920	0.4880	0.4840	0.4801	0.4761	0.4721	0.4681	0.4641

