TEACHING PLAN: ADVANCED MACHINE DESIGN M.Tech. 2nd SEM.

SCHOOL OF ENGINEERING AND TECHNOLOGY		ACADEMIC SESSION: 2022-23		FOR STUDENTS' BATCH: 2022-2024	
1	Course code	MMED-201			
2	Course Title	ADVANCED MACHINE DESIGN.			
3	Credits	4			
4	Learning Hours	Contact Hours: 3 Practical Teaching: 0 Project, Tutorial, and Assessment: 1 Total hours: 4			
5	Course Objective	1. Understand different modes of failures, application of theories of failures. 2. Life estimation, stress calculation of component subjected to finite and infinite life. 3. Introduction to fracture mechanics and stress intensity factor. 4. Understand different damage tolerant theories used to estimate life for variable amplitude fatigueloading. 5. Types of surface failures, stresses for different type of contacts.			
6	Course Outcomes	Upon successful completion of the course, students should be able to 1. Apply knowledge of failure theories appropriately to solve problems of practical interest with a variety of loading situations. 2. Analyze and calculate stress/strain distributions for 2D problems of elasticity using stress function approach and evaluate using IT tools like ANSYS, etc. 3. Describe stress strain measurement through experimental technique, and stress-strain relation of composite materials. 4. Describe various equipment required to perform the experimental stress-strain analysis. 5. Apply knowledge of surface failures, stresses for different type of contacts.			
7	Outline syllabus: Introduction and fatigue of materials, Stress-life (S-N) approach and strain-life (ε-N) approach, LEFM approach: LEFM concepts, Fatigue from variable amplitude loading, Surface failure.				
7.01	Paper Code	Unit	Introduction	Reference number	Teaching methods
	MMED-201	I	**Introduction and fatigue of materials:** Role of failure prevention analysis in mechanical design, Modes of mechanical failure, Review of failure theories for ductile and brittle materials including Mohr's theory and modified Mohr's theory, Numerical examples. Introductory concepts, High cycle and low cycle fatigue, Fatigue design models, Fatigue design methods, Fatigue design criteria, Fatigue testing, Test methods and standard test specimens, Fatigue fracture surfaces and	R. I. Stephens, A. Fatemi, R. R. Stephens, H. Fuchs, Metal Fatigue in Engineering	White Board, PPT

			macroscopic features, Fatigue mechanisms and microscopic features.		
		II	**Stress-life (S-N) approach and strain-life (ε-N) approach:** S-N curves, Statistical nature of fatigue test data, General S-N behavior, Mean stress effects, Different factors influencing S-N behavior, S-N curve representation and approximations, Constant life diagrams, Fatigue life estimation using S-N approach. Monotonic stress-strain behavior, Strain controlled test methods, Cyclic stress-strain behavior, Strain based approach to life estimation, Determination of strain life fatigue properties, mean stress effects, Effect of surface finish, Life estimation by S-N approach.	R. I. Stephens, A. Fatemi, R. R. Stephens, H. Fuchs, Metal Fatigue in Engineering	White Board, PPT
		III	**LEFM approach:** LEFM concepts, Crack tip plastic zone, Fracture toughness, Fatigue crack growth, Mean stress effects, Crack growth life estimation. Definitions of types of fracture and failure, Introduction to stress intensity factor and strain energy release rate, stress intensity approach, Notch strain analysis and the strain – life approach, Neuber’s rule, Glinka’s rule, Paris law. **Residual Stress:** Introduction, production of residual stresses & fatigue resistance, relaxation of residual stresses, measurement of residual stresses, stress intensity factors for residual stresses, applications.	R. I. Stephens, A. Fatemi, R. R. Stephens, H. Fuchs, Metal Fatigue in Engineering.	White Board, PPT
		IV	**Fatigue from variable amplitude loading:** Spectrum loads and cumulative damage, Damage quantification and the concepts of Damage fraction and accumulation, Cumulative damage theories, Load interaction and sequence effects, Cycle counting methods, Life estimation using stress life approach.	R. I. Stephens, A. Fatemi, R. R. Stephens, H. Fuchs, Metal Fatigue in Engineering	White Board, PPT
		V	**Surface failure:** Introduction, Surface geometry, Mating surface, Friction, Adhesive wear, Abrasive wear, Corrosion wear, Surface fatigue spherical contact, Cylindrical contact, General contact, Dynamic contact stresses, Surface fatigue strength.	R. I. Stephens, A. Fatemi, R. R. Stephens, H. Fuchs, Metal Fatigue in Engineering.	White Board, PPT

8	**Course Evaluation**	
8.10	**CA: 20%**	
8.1	**Attendance**	10%
8.12	**Homework**	10%
8.13	**Quizzes**	-
8.14	**Projects**	-
8.15	**Presentation**	-
8.16	**Any other**	-
8.2	**MTE(IA)**	20%
8.3	**End-term examination: 60%**	
9	**Text Books & References**	
9.1	**Text books**	1. R. I. Stephens, A. Fatemi, R. R. Stephens, H. Fuchs, Metal Fatigue in Engineering, John Wiley New york, 2nd edition, 2001. 2. J. A. Collins, J Wiley, Failure of Materials in Mechanical Design, New york, 1992. 3. R. L. Norton, Machine Design, Pearson Education India, 2000.
9.2	**References**	1. S. Suresh, Fatigue of Material, Cambridge University Press, 1998. 2. J. A. Benantine, Fundamentals of Metal Fatigue Analysis, Prentice Hall, 1990. 3. Fatigue and Fracture, ASM Hand Book, Vol 19, 2002.
9.3	**Video References**	https://nptel.ac.in/courses/112106286 https://www.youtube.com/watch?v=qGpIyQgZdHI

Mapping of Outcomes v. Topics

Course Outcome	Program Outcome												PSO			
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
CO1	3	3	3	3	3	3	2	1	3	2	2	3	3	3	3	2
CO2	3	3	3	3	3	3	2	1	2	2	2	3	3	3	3	2
CO3	3	3	3	3	3	2	2	1	2	2	2	3	3	3	3	2
CO4	3	3	3	3	3	3	3	1	2	2	2	3	3	3	3	2
CO5	3	3	3	3	3	3	3	1	2	3	2	3	3	3	3	2

QUESTION BANK

1. With the help of Mohr's circles drawn for compression and tension tests, explain clearly the differences between 'even' and 'uneven' materials. Draw the failure envelope of an uneven material according to modified Mohr's theory.
2. What do you mean by 'synergistic failure mode'? Explain with an example.

3. A differential element is subjected to the following stresses: ax = 68 MPa, ay = -136 MPa and "txy = -136 MPa. The material of this element has an ultimate tensile strength of 340 MPa and ultimate compressive strength of 612 MPa. Calculate the factor of safety by using an appropriate theory of failure. Draw the failure locus.
4. Explain the following: i) High cycle fatigue, ii) Low cycle fatigue.
5. Explain the effect of the following on S-N behavior: i) Microstructure ii) Surface finish iii) Size
6. Sketch a family of S-N-P curves and explain the utility of such curves.
7. Sketch and explain direct stre s fatigue testing machine.
8. How are constant fatigue life diagrams drawn? Using constant life diagrams superimposed with yield criterion, explain the effect of tensile and compressive mean stress.
9. As forged 50 mm diameter 1040 steel rod has S, = 689 MPa and S, = 516 MPa. It is subjected to constant amplitude cyclic bending. Determine the following values using appropriate fatigue models: i) Fully reversed bending fatigue strength at 106 cycles. ii) Sa and Smfor 106 cycles if R = O. iii) Sa and Sillfor 10 4 cycles if R = O
10. Explain the effect of: i) Surface finish and (ii) Mean stress on E-N behaviour of materials. Also explain SWT parameter.
11. What do you mean by plane train fracture toughness? Explain the effect of the following on plane strain fracture toughness: i) Temperature ii) Crack length iii) Stress applied.
12. A very wide plate 60 mm thick made of mill annealed Ti-6AI-4V with a through thickness central crack of length 15 mm is subjected to a nominal stress of 700 MPa normal to the crack plane. Determine: i) The applied stress intensity level. ii) If the plate was cyclically loaded between Smin = 0 and Smax = 725 MPa, determine the total number of cycles needed to failure. Take A = 2.3 X 10- 11 m/cycle, n = 3.2, K]c = 123 MPa J;; ,s, = 1090 MPa.
13. Sketch and explain a Haigh diagram for a notched part. Also sketch a modified Goodman' s diagram for a notched part.
14. Explain the following: i) Nueber's rule ii) Glinka's rule.
15. A stepped shaft shown in Fig.Q6(c) is made of alloy steel with an ultimate tensile strength of 700 MPa. It is subjected to a constant amplitude rotating bending. Estimate the magnitude of the bending moment which can be applied such that failure does not occur in LOb cycles. Take notch sensitivity index as 0.9.
16. Explain the Palmgren-Miner hypothesis.
17. Derive an expression for the pressure distribution in a spherical contact and show the pressure distribution schematically.
18. Justify the need for contact stress analysis in mechanical engineering design.
19. Enumerate the precautions that a designer has to take to minimize the chances of surface failure.
20. Name the major fatigue life methods used in design and analysis. What is common in all the three methods? Explain any one lethed in detail.
21. Explain contact stresses in design per Hertz's mathematical model of stress field, write down the condition regarding the shear stress at the contact zone.
22. Define creep How the log-time creep lest is performed while designing for creep? Explain with the help of neat diagram.
23. How computer can aid in the design process through CAD? List various merits and demerits of using CAD in design.
24. What do you mean by fracture mechanics approach to design? Explain in detail with the help of suitable example and neat sketches.