Course Title	Mechanical Vibrations and Machine Dynamics				
Course Code	ME323				
Course Type	Compulsory				
Level	BSc (Level 1)				
Year / Semester	3rd (Fall)				
Teacher's Name	Assoc. Prof. Marios Lestas				
ECTS	6	Lectures / week	3	Laboratories/week	1
Course Purpose	The aim of the course is to familiarize the students with the concepts and the principles of mechanical vibrations analysis so that they become competent in formulating and solving machine vibration problems. Building on the mathematical tools of Newtons Laws, Laplace Transforms, Transfer Functions, eigenvalues and eigenvectors, the students are aimed to address practical problems such as vibration of beams on elastic vibrations, lumped mass systems and rotor dynamics. The theoretical analysis is also aimed to be validated using practical lab experiments.				
Learning Outcomes	By the end of the course, students must be able to: 1. Formulate and solve machinery vibrations problems. 2. Solve common machinery vibration problems using Matlab. 3. Solve problems regarding the vibration of beams on elastic foundations. 4. Solve problems regarding the stability of rotors on elastic shafts. 5. State the physical principles of natural vibration and analyse how a system responds to a harmonic excitation and a non-harmonic excitation. 6. Develop competence in using the Laplace Transform to derive transfer functions for mechanical systems and use these transfer functions to derive the frequency response of mechanical systems. Identify the significance of the frequency response in the design of vibration absorbers. 7. Implement modal analysis to decouple systems with multiple degrees of freedom, explain how damping can be implemented to the modal analysis and implement in Matlab numerical methods to plot the response of a system and solve the eigenvalue/eigenvector problem. 8. Explain the use of transfer matrices and their application to vibration analysis. 9. Describe the dynamics of a rotor on a flexible shaft and compute the				

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<tr><td></td><td colspan="3">rotating unbalance as well as the critical speed.
10. Apply vibration analysis in the time and frequency domain explaining the time and frequency domain signal processing procedures.</td></tr>
<tr><td>Prerequisites</td><td>ME114, AMAT204</td><td>Corequisites</td><td>None</td></tr>
<tr><td>Course Content</td><td colspan="3">Natural and forced vibration: review physical principles of natural vibration, undamped and dumped systems, natural frequency, damping ratio, log decrements, response to non-harmonic excitation, harmonic excitation, homogeneous and particular solutions, resonance.

Equivalent Systems: Energy methods, Series and Parallel interconnection of mechanical elements, Rod and Beam Vibrations

Transmissibility: Review of Laplace Transforms and Complex Numbers, Transfer Functions, Frequency Response.

Approximate and numerical methods: Transfer matrices and their application to vibration analysis, finite elements method.

Lumped mass systems: eigenvalue/eigenvector problem and solution, natural frequency of multiples degree of freedom systems, modal analysis.

Rotor dynamics: dynamics of a rotor on a flexible shaft, rotating unbalance and the critical speed, gyroscopic effects are how they affect the rotor dynamics, viscous and hysteretic damping effects, behaviour of rotors that are mounted on flexible bearings, rotor stability.

Vibrating systems design: General design problem in vibrating systems, motion balancing.

Machinery vibration: monitoring and diagnosis, vibration analysis in the time and frequency domain, time and frequency domain signal processing procedures.

Laboratory work: Individual and small group experiments are performed with the use of the Rectilinear Control System experimental setup available in the Control Systems Laboratory. Experiments include identification of plant parameters such as, mass, spring and damping parameters in a classical two spring-mass configurations and measuring the response of the application of excitation signals, in an attempt to validate the material taught in lectures.</td></tr>
<tr><td>Teaching Methodology</td><td colspan="3">Students are taught the course through lectures (3 hours per week) in classrooms or lectures theatres, by means of traditional tools or using computer demonstration.

Auditory exercises, where examples regarding matter represented at the lectures, are solved and further, questions related to particular open-ended topic issues are compiled by the students and answered, during the lecture or assigned as homework.</td></tr>
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	Topic notes are compiled by students, during the lecture which serve to cover the main issues under consideration and can also be downloaded from the e-learning platform or the lecturer's webpage. Students are also advised to use the subject's textbook or reference books for further reading and practice in solving related exercises. Tutorial problems are also submitted as homework and these are solved during lectures or privately during lecturer's office hours. Furthermore, design projects may be assigned to the students, where literature search is encouraged to identify a specific problem related to some issue, gather relevant scientific information about how others have addressed the problem, implement to implement the design and report the results in written or orally. Where appropriate, taught material as well as examples and design problems are drawn from the recent research activities of the lecturer or other faculty members. Laboratory experiments are caried out in small groups and lab reports are required two weeks after the laboratory class resulting in a cumulative mark.
Bibliography	**(a) <u>Textbooks:</u>** • S. S. Rao, **Mechanical Vibrations**, Prentice Hall, 5th edition, 2010.. **(b) <u>References:</u>** • D. J. Inman, **Engineering Vibration**, Prentice Hall, 4th edition, 2013 • J. H. Ginsberg, **Mechanical and Structural Vibrations: Theory and Applications**, John Wiley & Sons, Inc., 2001.
Assessment	The Students are assessed via continuous assessment throughout the duration of the Semester, which forms the Coursework grade and the final written exam. The coursework and the final exam grades are weighted 40% and 60%, respectively, and compose the final grade of the course. Various approaches are used for the continuous assessment of the students, such as mid-term written exam, oral exam, quizzes, design assignments, design projects and laboratory experiments. The assessment weight, date and time of each type of continuous assessment is being set at the beginning of the semester via the course outline. An indicative weighted continuous assessment of the course is shown below: • Assignments 10% • Homework 10% • Mid-Term written exams 30% • Design Project 20% • Laboratory Work 20% • Quizzes 10% Students are prepared for final exam, by revision on the matter taught, problem solving and concept testing and are also trained to be able to deal with time constrains and revision timetable. The criteria considered for the assessment of each type of the continuous assessment and the final exam of the course are: (i) the comprehension of the fundamental concepts and theory of each topic, (ii) the application of the

	theory in solving related problems and (iii) the ability to apply the above knowledge in more complex design problems. The above criteria are weighted 30%, 40% and 30%, respectively. The final assessment of the students is formative and summative and is assured to comply with the subject's expected learning outcomes and the quality of the course
Language	**English**