AERO 309 – MECHANICAL VIBRATIONS

Course Code	Course Name		Semester	
AERO 309	Mechanical Vibrations		Fall ☒ Spring ☐ Summer ☐	
Hours			**Credit**	**ECTS**
Theory	**Practice**	**Lab**	3	5
3	0	0		

Course Details	
Department	Aerospace Engineering
Course Language	English
Course Level	Undergraduate ☒ Graduate ☐
Mode of Delivery	Face to Face ☒ Online ☐ Hybrid ☐
Course Type	Compulsory ☒ Elective ☐
Course Objectives	This course equips students with the concepts of intermediate structural dynamics and educates them to apply this knowledge in the solution of problems related to the vibrations of Aerospace Structures. It also provides the knowledge of vibration behavior of lumped parameter and continuous systems and their characteristics. To provide knowledge about vibration isolation.
Course Content	Free and forced vibrations of single degree-of-freedom undamped linear systems. Types and characteristics of damping and its effects on the response. Two degree-of-freedom systems. Coordinate transformation. Coupling. Free vibration, response to harmonic excitation. Multi degree-of-freedom systems. Eigenvalue problem, modal vectors and orthogonality. Vibration of continuous systems. Transverse vibration of beams. Effects of boundary conditions on the response. Vibration measurement and isolation.
Course Method/ Techniques	Lecture ☒ Question & Answer ☐ Presentation ☐ Discussion ☐
Prerequisites/ Corequisites	
Work Placement(s)	
Textbook/References/Materials	

- Rao SS, () Roseau, M. (2012). Vibrations in mechanical systems: analytical methods and applications. Springer Science & Business Media
- Inman, D.J. (2001). Engineering Vibration. New Jersey: Prentice Hall
- Meirovitch, L. (1967). Analytical Methods in Vibrations. New York: McMillan

Course Category				
Mathematics and Basic Sciences	☒		Education	☐
Engineering	☒		Science	☐
Engineering Design	☒		Health	☐
Social Sciences	☐		Profession	☐

Weekly Schedule

No	Topics	Materials/Notes
1	INTRODUCTION: A brief history of mechanical vibrations, the importance of studying mechanical vibrations, basic concepts of vibrations; vibration, basic elements of vibrations.	1
2	CLASSIFICATION of VIBRATIONS and VIBRATION ANALYSIS PROCEDURE: Forced and free vibrations, damped and undamped vibrations, linear and nonlinear vibrations; Spring element, mass or inertia element, damping element, mass element, harmonic motion, analysis of harmonic motion.	1
3	VIBRATION of SINGLE DEGREE of FREEDOM SYSTEMS: Motion equation of a single degree of freedom undamped free system, solution of the motion equation.	2
4	DAMPED VIBRATIONS: Single degree of freedom damped free systems, logarithmic decrement, vibration of dry friction systems.	2
5	FORCED VIBRATIONS: Motion equation and solution of forced harmonic undamped vibrations, beating, resonance, and natural frequency.	3
6	FORCED VIBRATIONS: Harmonic excitation of a damped system, response of a damped system to a general excitation, convolution integral, response spectrum.	3
7	VIBRATION OF TWO-DEGREE-OF-FREEDOM SYSTEMS: derivation, solution, and interpretation of the motion equation for an undamped two-degree-of-freedom system.	5
8	Midterm Exam	
9	NATURAL FREQUENCIES AND MODE SHAPES: Coordinate coupling and natural coordinates, coordinate transformation, vibration modes. Vibrations of semi-definite systems stability, sample application study.	5
10	VIBRATION OF MULTI-DEGREE OF FREEDOM SYSTEMS: An overview of the vibration of multi-degree of freedom systems,	6
11	VIBRATION OF MULTI-DEGREE OF FREEDOM SYSTEMS:	6

	Modal Analysis,	
12	VIBRATIONS OF CONTINUOUS SYSTEMS: Axial and lateral vibrations of beams.	8
13	VIBRATIONS OF CONTINUOUS SYSTEMS: Axial and lateral vibrations of beams.	8
14	VIBRATION ISOLATION: Passive isolation methods; Operation of the dynamic vibration absorber, undamped dynamic absorber, damped dynamic absorber.	5,9
15	Final Exam	

Assessment Methods and Criteria		
In-term studies	**Quantity**	**Percentage**
Attendance	14	
Lab		
Practice		
Fieldwork		
Course-specific internship		
Quiz/Studio/Criticize		
Homework	4	20%
Presentation / Seminar		
Project		
Report		
Seminar		
Midterm Exam	1	30%
Final Exam	1	50%
	Total	**100%**
Contribution of Midterm Studies to Success Grade		50
Contribution of End of Semester Studies to Success Grade		50
	Total	**100%**

ECTS Allocated Based on Student Workload			
Activities	**Quantity**	**Duration (Hrs)**	**Total Workload**
Course Hours	14	3	42
Lab			
Practice			
Fieldwork			
Course-specific Work Placement			
Out-of-class study time			
Quiz/Studio/Criticize			
Homework	4	8	32
Presentation / Seminar			
Project			
Report			

Midterm Exam and Preparation for Midterm	1	20	20
Final Exam and Preparation for Final Exam	1	30	25
Total Workload			**119**
Total Workload / 25			**4.77**
ECTS Credit			**5**

Course Learning Outcomes	
No	**Outcome**
L1	Obtains the equations of motion of single-degree-of-freedom systems.
L2	Obtaning natural frequency with different method (energy, static deflection, from solution of EoM)
L3	Detailed insight about damping types (viscous, frictional, hysteretic).
L4	Understands free and forced (especially harmonic exitation) vibrations of single-degree-of-freedom systems.
L5	Obtaining to total response of single-degree-of-freedom systems.
L6	Analyzes free vibrations of multi-degree-of-freedom systems.
L7	Applying Modal Analysis
L8	Modelling and understanding of continuous system vibrations and mode shapes
L9	Understanding of vibration isolation techniques

Contribution of Course Learning Outcomes to Program Competencies/Outcomes

Contribution Level: 1: Very Slight, 2: Slight, 3: Moderate, 4: Significant, 5: Very Significant

	P1	**P2**	**P3**	**P4**	**P5**	**P6**	**P7**	**P8**	**P9**	**P10**	**P11**					**Total**
L1	5	5	5	5	2	5	4	3	2	1	3					40/55; 72,7%
L2	5	5	5	5	2	5	4	3	2	1	3					40/55; 72,7%
L3	5	5	5	5	2	5	4	3	2	1	3					40/55; 72,7%
L4	5	5	5	5	2	5	4	3	2	1	3					40/55; 72,7%
L5	5	5	5	5	2	5	4	3	2	1	3					40/55; 72,7%
L6	5	5	5	5	2	5	4	3	2	1	3					40/55; 72,7%
L7	5	5	5	5	2	5	4	3	2	1	3					40/55; 72,7%
L8	5	5	5	5	2	5	4	3	2	1	3					40/55; 72,7%
L9	5	5	5	5	2	5	4	3	2	1	3					40/55; 72,7%
															Total	360/495; 72,7%