Module (Course Syllabus) Catalogue

2023-2024

College/ Institute	Erbil Technical Engineering	
Department	Technical Mechanical and Energy Eng.	
Module Name	Advanced Vibration	
Module Code	ADV104	
Degree	Technical Diploma ☐ Bachler ☐ High Diploma ☐ Master ■ PhD ☐	
Semester	1st	
Qualification	PhD in Mechanical Engineering	
Scientific Title	Lecturer	
ECTS (Credits)	7	
Module type	Prerequisite ☐ Core ■ Assist. ☐	
Weekly hours	3	
Weekly hours (Theory)	(3)hr Class	(36)Total hrs Workload
Weekly hours (Practical)		
Number of Weeks	16	
Lecturer (Theory)	ABDULRAHMAN BAHADDIN SHAKIR	
E-Mail & Mobile NO.	abdulrahman.shakir@epu.edu.iq, 07504748599	
Lecturer (Practical)		
E-Mail & Mobile NO.		
Websites		

Course Book

<table>
<tr><td>Course Description</td><td colspan="5">Advanced vibrations of discrete and continuous systems in mechanical and mechatronics engineering; analytical, computational and experimental analysis tools with which to investigate and predict the performance of systems; oscillatory types include self- and parametrically excited systems.</td></tr>
<tr><td>Course objectives</td><td colspan="5">This course covers advanced vibrations of discrete and continuous systems in mechanical and energy engineering and builds on the knowledge of previous basic dynamic, mechanics and vibration courses. The overarching theme of the course is learning how to predict the performance of oscillating systems as we can observe them in everyday life. Thereby; vibrations will first be classified by mechanisms, followed by learning associated solution approaches for each type of vibration.</td></tr>
<tr><td>Student's obligation</td><td colspan="5">Student's obligation In the Mechanical vibration course is:
• Attendance in the all lectures.
• One or more quizzes in each course.
• Exam in end of first course</td></tr>
<tr><td>Required Learning Materials</td><td colspan="5">- Data show, and PowerPoint program in teaching in computer hall.
- White board.
- Moodle to upload all lecture notes.</td></tr>
<tr><td rowspan="11">Evaluation</td><td colspan="2">Task</td><td>Weight (Marks)</td><td>Due Week</td><td>Relevant Learning Outcome</td></tr>
<tr><td colspan="2">Paper Review</td><td>10</td><td></td><td></td></tr>
<tr><td rowspan="6">Assignments</td><td>Homework</td><td></td><td></td><td></td></tr>
<tr><td>Class Activity</td><td>5</td><td></td><td></td></tr>
<tr><td>Report</td><td></td><td></td><td></td></tr>
<tr><td>Seminar</td><td>5</td><td></td><td></td></tr>
<tr><td>Essay</td><td></td><td></td><td></td></tr>
<tr><td>Project</td><td></td><td></td><td></td></tr>
<tr><td colspan="2">Quiz</td><td>10</td><td></td><td></td></tr>
<tr><td colspan="2">Lab.</td><td></td><td></td><td></td></tr>
<tr><td colspan="2">Midterm Exam</td><td>20</td><td></td><td></td></tr>
<tr><td colspan="2">Final Exam</td><td>50</td><td></td><td></td></tr>
<tr><td colspan="2">Total</td><td>100</td><td></td><td></td></tr>
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Specific learning outcome:	(Vibration course) the student will be able: 1. To construct the equations of motion from free-body diagrams. 2. To solve for the motion and the natural frequency of (1) a freely vibrating single degree of freedom undamped motion and (2) a freely vibrating single degree of freedom damped motion. 3. Model, approximate, analysis and design vibratory systems and their responses. 4. Discern the relevant principles that must be applied to describe or measure the equilibrium or motion of vibratory systems and discriminate between relevant and irrelevant information in the context 5. To solve for the motion and the natural frequency for forced vibration of a single degree of freedom damped or undamped system. 6. To solve vibration problems that contains multiple degrees of freedom. 7. Produce appropriate reports to communicate about technical matters relating to vibration and machine condition monitoring at a professional engineering level.
Course References:	**Key reference:** **1.** Mechanical Vibrations by Sinirseu S. Rao Fifth Edition 2011 **Useful Reference:** 1- Meirovitch, L. Fundamentals of Vibrations, 1st Edition, Waveland Press 2- Mechanical Vibrations theory and applications , S Graham Kelly 3- Theory of Vibration with Application ,W.T. Thomson

Course topics (Theory)	**Week**	**Learning Outcome**
Free vibration of an undamped and a viscously damped single degree of freedom system.	1	
Forced vibration of a single degree of freedom system.	2-3	
Two - degree of freedom system.	4-5	
Multi degree of freedom	6-7	
Determination of Natural Frequencies and Mode Shapes	8-9	

Continuous Systems	10-12	
Nonlinear Vibtaion	13-14	
Practical Topics	**Week**	**Learning Outcome**

Questions Example Design

EXAMPLE :

Determine the eigenvalues and eigenvectors of a vibrating system for which

$$[m] = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 2 & 0 \\ 0 & 0 & 1 \end{bmatrix} \quad \text{and} \quad [k] = \begin{bmatrix} 1 & -2 & 1 \\ -2 & 4 & -2 \\ 1 & -2 & 1 \end{bmatrix}$$

Solution:

The eigenvalue equation $[[k] - \lambda[m]]\vec{X} = \vec{0}$ can be written in the form

$$\begin{bmatrix} (1-\lambda) & -2 & 1 \\ -2 & 2(2-\lambda) & -2 \\ 1 & -2 & (1-\lambda) \end{bmatrix} \begin{Bmatrix} X_1 \\ X_2 \\ X_3 \end{Bmatrix} = \begin{Bmatrix} 0 \\ 0 \\ 0 \end{Bmatrix} \qquad (Eq.1)$$

where $\lambda = \omega^2$. The characteristic equation gives

$$|[k] - \lambda[m]| = \lambda^2(\lambda - 4) = 0$$

so

$$\lambda_1 = 0,\ \lambda_2 = 0,\ \lambda_3 = 4$$

Eigenvector for $\lambda_3 = 4$: Using $\lambda_3 = 4$, (Eq. 1) gives

$$\begin{aligned} -3X_1^{(3)} - 2X_2^{(3)} + X_3^{(3)} &= 0 \\ -2X_1^{(3)} - 4X_2^{(3)} - 2X_3^{(3)} &= 0 \\ X_1^{(3)} - 2X_2^{(3)} - 3X_3^{(3)} &= 0 \end{aligned} \qquad \text{(Eq. 2)}$$

If $X_1^{(3)}$ is set equal to 1 , (Eq.2) give the eigenvector $\vec{X}^{(3)}$:

$$\vec{X}^{(3)} = \begin{Bmatrix} 1 \\ -1 \\ 1 \end{Bmatrix}$$

Eigenvector for $\lambda_1 = \lambda_2 = 0$: The value $\lambda_1 = 0$ or $\lambda_2 = 0$ indicates that the system is degenerate Using $\lambda_1 = 0$ in (Eq.1), we obtain

$$\begin{aligned} X_1^{(1)} - 2X_2^{(1)} + X_3^{(1)} &= 0 \\ -2X_1^{(1)} + 4X_2^{(1)} - 2X_3^{(1)} &= 0 \\ X_1^{(1)} - 2X_2^{(1)} + X_3^{(1)} &= 0 \end{aligned} \qquad \text{(Eq. 3)}$$

All these equations are of the form

$$X_1^{(1)} = 2X_2^{(1)} - X_3^{(1)}$$

Thus the eigenvector corresponding to $\lambda_1 = \lambda_2 = 0$ can be written as

$$\vec{X}^{(1)} = \begin{Bmatrix} 2X_2^{(1)} - X_3^{(1)} \\ X_2^{(1)} \\ X_3^{(1)} \end{Bmatrix} \qquad (Eq. 4)$$

If we choose $X_2^{(1)} = 1$ and $X_3^{(1)} = 1$, we obtain

$$\vec{X}^{(1)} = \begin{Bmatrix} 1 \\ 1 \\ 1 \end{Bmatrix}$$

If we select $X_2^{(1)} = 1$ and $X_3^{(1)} = -1$, (Eq.4) gives

$$\vec{X}^{(1)} = \begin{Bmatrix} 3 \\ 1 \\ -1 \end{Bmatrix}$$

As shown earlier in Equation below

$$[D]\left(p\vec{X}^{(1)} + \vec{X}^{(2)}\right) = \lambda\left(p\vec{X}^{(1)} + \vec{X}^{(2)}\right) \qquad (Eq.5)$$

, $\vec{X}^{(1)}$ and $\vec{X}^{(2)}$ are not unique: Any linear combination of $\vec{X}^{(1)}$ and $\vec{X}^{(2)}$ will also satisfy the original (Eq.1). Note that $\vec{X}^{(1)}$ given by (Eq. 4) is orthogonal to $\vec{X}^{(3)}$ of Eq. (E.4) for all values of $X_2^{(1)}$ and $X_3^{(1)}$, since

$$\vec{X}^{(3)T}[m]\vec{X}^{(1)} = \begin{pmatrix} 1 & -1 & 1 \end{pmatrix} \begin{bmatrix} 1 & 0 & 0 \\ 0 & 2 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{Bmatrix} 2X_2^{(1)} - X_3^{(1)} \\ X_2^{(1)} \\ X_3^{(1)} \end{Bmatrix} = 0$$

Extra notes:

External Evaluator

I have reviewed the module catalogue for the postgraduate subject "Advanced Vibration," and I would like to provide feedback on its organization and content:

1- The course objectives are well-defined and align with the standards set by international mechanical engineering organizations.
2- The inclusion of up-to-date references in the module catalogue is commendable.

I can confirm that the module catalogue for "Advanced Vibration" is well-structured and comprehensive. It is designed to meet international engineering standards and equip students with the necessary knowledge and skills. The inclusion of up-to-date references further enhances the quality of education provided.

Dr. Dlair O. Ramadan

21/10/2023