





**Fayoum University** 



Faculty of Engineering Mechanical Engineering Dept.

### Lecture (1)

on

# Introduction to Vibration Engineering

By

### Dr. Emad M. Saad

Mechanical Engineering Dept. Faculty of Engineering Fayoum University

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## **Course Description and Outline**

#### **Course Description**

This course is designed for 3<sup>rd</sup> year students. It covers the vibrations of discrete systems and continuous structures, and an introduction to the computational dynamics of linear engineering systems.

#### **Course Outline**

- Harmonic motion.
- One-degree-of-freedom free vibration systems.
- One-degree-of-freedom forced vibration systems.
- Two-degree-of-freedom vibration systems.
- Approximate and numerical methods
- Multi-degree-of-freedom systems.
- Applications on vibration systems.
- Unbalanced vibration systems cases.
- Rotor dynamics.
- Vibration isolation.
- Vibration measurements devices.





## **Course Prerequisites and Objectives**

#### **Course Prerequisites**

- Dynamics.
- Basic knowledge of linear algebra and ODEs.
- General Physics (Waves).
- Basic knowledge on structural analysis.
- Microsoft Excel.
- MATLAB (recommended but not required).

#### **Course Objectives**

- 1. To present the fundamentals and applications of vibration theory.
- 2. Students will demonstrate the ability to model and analyze free and forced vibration of multi-degree of freedom systems.
- 3. Students will be able to apply vibration principles for the design of engineering systems and devices.
- Students will demonstrate the ability to use experimental as well as theoretical vibration analysis for system parameter identification and vibration trouble shooting.
- 5. Enhance a team work spirit and report writing.





## **Text Books and References**

Text Books		
Will be assigned by instructor		
References		
<ul> <li>S.S. Rao, "Mechanical Vibrations", Addison Wesley, fifth Edition.</li> <li>S. G. Kelly, "Mechanical Vibrations – Theory and Applications", Cengage Learning.</li> <li>C. M. Harris and A. G. Piersol, "Harris's Shock and Vibration Handbook ", McGraw-HILL, fifth Edition.</li> </ul>		

 P. Girdhar and C. Scheffer, "Practical Machinery Vibration Analysis and Predictive Maintenance", ELSEVIER.





### **Course Outcomes**

#### **Course Outcomes**

- 1. Students will be able to draw a free-body and kinetic diagrams for dynamic configurations.
- Students will be able to formulate the dynamic equations of motion of problems in vibrations using Newton's second law, energy equations and influence coefficients.
- 3. Students will have the ability to obtain the solutions to vibration problems that contain two- and multi-degree-of freedom systems. This includes the determination of natural frequencies and mode shapes and the evaluation of time response of systems under free and forced conditions.
- Students shall become familiar with the design of vibration isolators for harmonic and shock loading.
- 5. Select the appropriate parameters for the vibration absorbers.
- 6. Students will be able to identify major faults in rotating machinery components using vibration signal analysis.
- 7. Students shall become familiar with vibration isolation.
- 8. Students will be able to use the vibration measurements devices.





## **Students' Evaluation and Exam Method**







### Contact

Professor:	Facebook:	DrEmad Elasid
	Website:	http://www.fayoum.edu.eg/emad
	Email:	<u>emadsaad@fayoum.edu.eg</u>
	Office Hours:	Tuesday: 10:00 - 15:30 Wednesday: 09:00 - 15:30 or by Appointment



#### **Importance of the Study of Vibration**

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## What is the Vibration?

A vibration is the oscillating motion of a body or system of connected bodies displaced from a position of equilibrium.







## **Vibration in our Daily lives**





### Human body resonance frequencies





## **Engineering Applications of Vibration**

- 1. Machine design,
- 2. Foundations,
- 3. Structures,
- 4. Engines,
- 5. Turbines,
- 6. Control systems.





## **Undesirable Effects of Vibration**

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- 1. Excessive noise,
- 2. Material fatigue of structure or machine component
- 3. Rapid wear of machine parts
- 4. High power consumption
- 5. Low products quality,
- 6. Over control scheme.





Tacoma Narrows Bridge Collapse; The first Tacoma Narrows Bridge was built between November 23, 1938, and July 1, 1940, at a cost of approximately \$6,400,000.





## **Desirable Effects of Vibration**

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- Vibratory equipment; vibratory conveyors, hoppers, sieves, compactors, washing machines, electric toothbrushes, drills, clocks, alerts, and electric massaging units.
- 2. Pile driving
- 3. Simulation of geological activities; earthquakes
- 4. Vibratory finishing processes,









#### **Importance of the Study of Vibration**



## **Desirable Effects of Vibration**

- 4. Electronic circuits to filter out the unwanted frequencies
- 5. Improve the efficiency of certain machining, casting, forging, and welding processes.
- 6. Improve the efficiency of certain thermal processes.
- 7. Vibratory testing of materials and machines,
- 8. Conduct studies in the design of nuclear reactors.





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### **Desirable Effects of Vibration**







### **Vibration Categories According to Main Parameters**

- 1. Free and forced
- 2. Damped and undamped
- 3. Linear and nonlinear
- 4. Deterministic and random
- 5. Steady state and transient





### **Free and Forced Vibration**

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### **Free and Forced Vibration**

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## **Linear and nonlinear Vibration**

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### **Nonlinear and linear springs**





## **Steady State and Transient Vibration**

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## **Deterministic and Random Vibration**

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#### A deterministic (periodic) excitation

A random excitation



**Mechanical Vibrations – 3rd year** 



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The minimum number of independent coordinates required to determine completely the position of all parts of a system at any instant of time defines the degree of freedom of the system.

Number of degrees of freedom = of the system	Number of masses in the system
	number of possible types of motion of each mass











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Human hand has 27 DOF



Ship has 6 DOF







