

FLORIDA INTERNATIONAL UNIVERSITY  
Mechanical and Materials Engineering Department

Fall 2018

Mechanical Vibrations

EML4220

Instructor: Professor Cesar Levy (levyez@fiu.edu)

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<b>COURSE OBJECTIVES</b>
Understand Undamped SDOF systems $d^2x/dt^2 + \omega^2x = 0$ and its relation to a vibrating system
Understand Damped SDOF systems-viscous (underdamped, critically damped and overdamped) and coulomb friction and their differences
Understand Forced Motion due to harmonic force
Understand Forced Motion due to rotating unbalance
Understand forced motion due to oscillating support and its application--how vibrometers, velometers and accelerometers work
Understand forced motion due to a general periodic force (Chapter 4)
Understand forced motion due to a general nonperiodic force (Chapter 4)
Understand forced motion for two degree of freedom systems
Understand how to derive Eqs. Of Motion for two degree of freedom systems or higher
Understand how to find frequencies using Rayleigh and Dunkerley Methods

<b>MME Program Educational Objectives</b>
Broad and in-depth knowledge of engineering science and principles in the major fields of MME for effective engineering practice, professional growth, and as a base for life-long learning.
An adequate background to pursue graduate studies in engineering and other fields.
A sense of professional and social responsibility, including a commitment to protect both occupational and public health and safety, developed through consideration of moral, social, and ethical paradigms related to the engineering profession and practice.

<b>MME Program Outcomes</b>
A. Ability to apply knowledge of mathematics, science, and engineering.
C. Ability to design a system, component, or process to meet desired needs.
E. Ability to identify, formulate, and solve engineering problems.
F. Understanding of professional and ethical responsibility.
I. Recognition of the need for, and an ability to engage in, life long learning.
J. Knowledge of contemporary issues.
K. Ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.
M. Knowledge of mathematics and of basic and engineering science necessary to carry out analysis and design appropriate to M&M Engineer.
N. Ability to apply advanced mathematics through multivariable calculus and differential equations.

## COURSE CONTENT

### Topics

1. What is vibrations and its importance
2. Equivalent Systems and Equations of Motion
3. Free Vibrations of M-K system, Energy Methods

4.	SDOF with damping	
5.	Forced SDOF without damping	Q1
6.	Forced SDOF with damping	
7.	Other Systems-Fluidic, thermal	
8.	Oscillating Base and Force Transmission	
9.	Rotating Unbalance and Relative Motion	Q2
10.	Vibration Measuring Equipment	
11.	Vibration Under General Forcing Function	
12.	Coordinate Coupling 2DOF systems	
13.	Forced Vibration of 2DOF system + Vibration Absorber	Q3
14.	Dunkerley and Rayleigh Methods	

1. Importance of Vibrations; Basic Concepts--period, amplitude, circular frequency, units; Classification of Vibrations-- random, periodic, harmonic, aperiodic; Vibrational Analysis Procedures; Quick Review of Dynamics--Kinetics and Principle of Linear and Angular Motion of a Particle, Mass Center and a System of Particles. (CH.1 and 2)

2. Undamped Free Vibrations for a Single Degree of Freedom (SDOF) System: Spring-Mass System; Equivalent Springs and Masses; Energy Method--KE<->PE transfer. (CH 2)

3. Damped Free Vibrations for an SDOF System; Spring-Mass-Dashpot System; Overdamped, Underdamped, Critically Damped System, damped frequency, damping factor, general solutions, Quick Review of second order linear constant coeff. Diff. Eqs.; Coulomb Damping, frequency displacement decrease, differences between coulomb and viscous damping. (CH 2)

4. Harmonically Forced Vibrations (HFV) of an SDOF System; Undamped and Damped Vibrations--magnification factor, resonance conditions; beats; force transmission; HFV with coulomb damping; eccentric masses; relative motion, base excitation, effect of mass and spring variation applications--velometers, vibrometers, accelerometers (CH 3, 9, 10)

5. General Forcing Conditions and Response; Fourier Analysis; Duhamel's Integral; Response of a Damped System. (CH 4)

6. Two Degree of Freedom (TDOF) Systems; Linear and Torsional Systems; Matrix Notation; Coupling and coupling coefficient; amplitudes, natural frequencies--how to find them (CH 5, 6)

7. Multidegree of Freedom Systems; Stiffness Matrix; Flexibility Matrix; Mass Matrix; Energy Methods. (CH 5, 6)

8. Rayleigh's and Dunkerley's Method. (CH 6, 7)

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Course Prerequisites: EGN3321 (Dynamics), EMA3702 (Mechanics and Materials Science), and any type of computer programming course such as (EML2032)

Textbook: Mechanical Vibrations by S. S. Rao, 4th Edition.

HW's will be assigned but none will be collected for grading. **Some, however, will be collected and graded as a check on learning.** Website will provide solutions to many problems a week after they are assigned. However, it is to your advantage to do it since the more problems you do, the easier will be the material and the method of attack used on the problems.

Important information:

**Your grade will be based upon**

**3 exams (20%, 25%, 25%)**

**1 final, comprehensive (30%)**

Grading Scheme: 90 and above A

87 - 89 A-

83 - 86 B+

80 - 82 B

77 - 79 B-

74 - 76 C+

67 - 73 C

60 - 66 D

Below 60 F

**We will be meeting W 10-1150am in EC1113 and F 11-1150 in EC1114, unless changed.**

THIS IS A PRELIMINARY SCHEDULE--ALL CHANGES WILL BE ANNOUNCED IN CLASS.