ME 370 – Vibration of Mechanical Systems
Section 1, Fall 2018
www.mne.psu.edu/chang/me370

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Prerequisites: E Mch 212 and 213, Math 251 and 220, CMPSC 200
Text: Vibrations of Mechanical Systems by A Sinha, Cambridge, 2010

	Lecture topics	Reading materials	Exams
I.	Fundamentals of mechanical vibration	1.1-1.3	
II.	Single degree-of-freedom vibration		
	• Free vibration of undamped systems	1.4	
	• Free vibration of damped systems	1.5	
	• Harmonically excited vibration,	2.3	
	design considerations	2.4-2.6	
	• Vibration with periodic excitations	3.1	Midterm, Wednesday Oct. 31, 7:45-9:45pm 26 Holser
III.	Multiple degree-of-freedom vibration		
	• Free vibration and principal modes	4.1-4.3	
	• The eigenvalue problem		
	• Forced vibration	4.6, 4.7	
IV.	Vibration reduction in engineering design		
	• Vibration isolation	2.4-2.6	
	• Vibration absorption	4.7	
	• Balancing		Final exam

Grading:

Homework*	50%
Exams	50%

Grading by exams alone:
>94 = A, 90~94 = A-
85~89 = B+, 80~84 = B, 76~79 = B-
73~75 = C+, 70~72 = C

Minimum exam-scores requirements: *For C or better, the average in the exams must be above 45% or not 20 points below the class exam-average*

*Homework may be done in a group of two students.
Group members will receive the same credits.

LEARNING OBJECTIVES OF THE COURSE

I. Fundamentals of mechanical vibrations

1. *Acquire the concepts and techniques to develop and simplify a geometric model of a vibratory system, including model schematic, model parameters, degree of freedom, equivalent elements/systems and energy methods.*
2. *Draw free-body diagrams and write elemental equations for elements of a vibratory system.*

II. Single degree-of-freedom vibrations

3. *Develop the governing equation of a single degree-of-freedom vibratory system from its elemental equations.*
4. *Determine the natural frequency and damping ratio of a single degree-of-freedom model.*
5. *Obtain analytical solutions for a single degree-of-freedom model, including free and forced vibrations of undamped and damped systems.*
6. *Make use of the results from the single degree-of-freedom models to study various design implications of vibratory systems.*

III. Multiple degree-of-freedom vibrations

7. *Develop governing equations of a multiple degree-of-freedom vibratory system from its elemental equations.*
8. *Determine the natural frequencies and modes shapes of a multiple degree-of-freedom model.*
9. *Obtain analytical solutions for a multiple degree-of-freedom model, including free (undapmed) and forced vibration responses.*

IV. Vibration control in engineering design

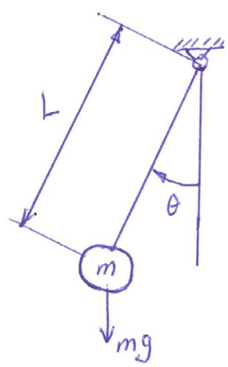
10. *Make use of the theory and results of the single and multiple degree-of-freedom models in various vibration-control design calculations, including vibration isolation and absorption and balancing of machine elements.*

The study of mechanical vibrations makes use of what you learned from earlier courses including:

PHYS 211 – Mechanics
EMCH 211 – Statics (free-body diagram)
EMCH 212 – Dynamics (equation of motion)
EMCH 213 – Strength of materials
MATH 251 – Ordinary differential equations
MATH 220 – Matrix algebra
CMPSC 200 – Programming in Matlab

See if you can solve/comprehend the following problem:

A simple pendulum is schematically shown below:



Can you use what you learned in PHYS 211 and/or EMCH 212 to obtain the following 2nd-order differential equation describing the swing of the pendulum?

$$L\ddot{\theta} + g\sin\theta = 0$$

where $\ddot{\theta}$ is the angular acceleration of the pendulum swing and g is the gravitational constant. For small-angle swing of the pendulum, the equation of motion can be simplified to:

$$L\ddot{\theta} + g\theta = 0$$

Suppose the pendulum is displaced from its bottom equilibrium position by a small angle θ_o and is released from rest (ie. $\dot{\theta}(0) = 0$). Can you use what you learned in MATH 251 to determine which expression below correctly describes the pendulum swing after it is released?

a) $\theta(t) = \theta_o \sin \omega_n t$
b) $\theta(t) = \theta_o \cos \omega_n t$
c) $\theta(t) = \theta_o (\sin \omega_n t + \cos \omega_n t)$

where $\omega_n = \sqrt{g/L}$ is the natural frequency of the pendulum with a unit of rad/s.

Can you use the basic physics and algebra to determine the length of the pendulum, so that it will swing with a period of about 1.0 second?

a) $L = 0.52$ meter
b) $L = 0.25$
c) $L = 9.81$
d) $L = 2\pi$

If you can solve and/or reasonably comprehend the above problem physically, you have sufficient background for the course and would likely enjoy it. Otherwise, you should prepare to commit more efforts to enhance your earlier basics before it is too late into the course.