

Instructor: Professor George G. Adams, 203 SN, T: 617-373-3826, F: 617-373-2921,
Email: adams@coe.neu.edu

Web-Site: http://www.coe.neu.edu/~adams_g/mim3630.html

Prerequisites: Admission to the Graduate School of Engineering.

Conference Hours: Tuesday 10:30-11:35; 5:30-5:50;
Wednesday 10:30-11:35;
Thursday 4:05-5:00, 5:30-5:50;

Text: Meirovitch, L., *Fundamentals of Vibrations*, McGraw-Hill Book Company, Inc., New York, 2001.

Reserve: Den Hartog, J.P., *Mechanical Vibrations*, Dover Publications reprint (1985) of the 4th edition, McGraw-Hill Book Company, New York, 1956.

Dimarogonas, A.D., and Haddad, S.D., *Vibration Engineering*, Prentice-Hall, Englewood Cliffs, New Jersey, 1992.

Graff, K.F., *Wave Motion in Elastic Solids*, Ohio State University Press, 1975.

Inman, D.J., *Engineering Vibrations*, Prentice-Hall, Englewood Cliffs, New Jersey, 1994.

Kelly, S. Graham, *Mechanical Vibrations*, Schaum's Outline Series, McGraw-Hill Book Company, Inc., New York, 1996.

Meirovitch, L., *Analytical Methods in Vibrations*, Macmillan Company, New York, 1967.

Meirovitch, L., *Elements of Vibration Analysis*, McGraw-Hill Book Company, Inc., New York, New York, Second Edition, 1986.

Meirovitch, L., *Principles and Techniques of Vibration*, Prentice-Hall, Inc., New Jersey, 1997.

Thomson, W.T., and Dahleh, M.D., *Theory of Vibration with Applications*, Prentice-Hall, Englewood Cliffs, New Jersey, Fifth Edition, 1998.

Tongue, B.H., *Principles of Vibration*, Oxford University Press, New York, 1996.

Weaver Jr., W., Timoshenko, S.P., and Young, D.H., *Vibration Problems in Engineering*, John Wiley & Sons, Inc., New York, Fifth Edition, 1990.

Goals: To understand fundamental and advanced concepts of mechanical vibrations. To model simple mechanical systems and determine natural frequencies, damping ratios, and response to periodic and aperiodic forcing functions. To model multi-degree-of freedom and continuous systems and determine natural frequencies, mode shapes, and forced response. To understand the use of numerical methods in the solution of vibrations problems.

Exams and Grading :

2 Exams 30% each; Final Exam 40%

First Exam: Thurs., April 24; **Second Exam:** Thurs., May 22; **Final Exam:** Tues., June 4.

No class on: Tues., May 6

An Incomplete Grade (I Grade) will only be given in very unusual circumstances at the discretion of the instructor.

Class	TOPIC	PROBLEMS
ONE-DEGREE-OF-FREEDOM SYSTEMS (1-DOF)		
1	Introduction (1-1.10,1.14). Free Vibrations (2-2.6).	2.3, 2.6, 2.11, 2.22, 2.29
2	Forced Vibration at a Single Frequency (1.11-1.12, 3-3.3, 3.10). Response to Periodic Forcing Functions (3.9, 3.11).	3.3, 3.18 ¹
3	Support Motion (3.5, 3.6). Response to General Forcing Functions (4-4.4). Self-Excited Oscillations and Instabilities (1.13).	3.14, SP3.1, 4.4, 4.5
4	Laplace Transform Method (4.6-4.7, Appendix B), Nonlinear Vibration.	SP4.1, SP4.2
MULTIPLE-DEGREE-OF-FREEDOM SYSTEMS (N-DOF)		
5	Free Vibrations of Two DOF Systems (5-5.4, 5.7, 5.12).	5.1, 5.12, 5.18
6	Coordinate Coupling, Orthogonality (5.5, 5.6). Forced Vibrations, Vibration Absorber (5.8, 5.9). Summary (5.15)	5.24, 5.26
7	Influence Coefficients (7-7.3), Review of Linear Algebra (Appendix C)	7.2 ² , 7.12, 7.14 ³ , SP7.1
8	Eigenvalue Problem for Free Undamped Vibration (7.5-7.9) MatLab Solutions (7.18).	7.22, 7.30
9	Response to Initial Conditions (7.10, 7.19). Response to Excitations – Direct Method (7.14). Forced Vibrations Using Modal Analysis (7.15).	7.31, 7.34
10	(7.15) Continued, Frequency Response Functions.	SP 10.1, SP 10.2
11	Linear Damping, Complex Modes (7.16). Summary (7.21).	SP 11.1
VIBRATION OF CONTINUOUS SYSTEMS (∞-DOF)		
12	Wave Propagation in Strings (8, 8.1, 8.12).	SP 12.1
13	Vibration in Strings, Differential Eigenvalue Problem, Orthogonality (8,8.1,8.4, 8.5). (Read parts related to strings).	SP 13.1
14	Axial Vibrations of Bars and Torsional Vibrations of Shafts, Response to Initial Conditions and to External Excitations (8.9-8.11).	8.3, 8.11, 8.36
15	Vibration of Beams (8.3–8.5, 8.9–8.11)	8.14, 8.16
APPROXIMATE METHODS		
16	Rayleigh's Quotient (7.13, 8.8), Rayleigh's Principle (9.5), Rayleigh-Ritz Method (9.6), Assumed Mode Method (9.8)	7.42 ⁴ , 9.15 ⁵

¹ Plot the result with $m = 1$ kg, $k_1 = k_2 = 5000$ N/m, $c = 20$ Ns/m, $A = 10$ mm, $B = 0$. The cam rotates at 500 rpm.

² Use the method of stiffness influence coefficients.

³ Use $EI_1 = EI_2 = EI_3 = EI$ and $L_1 = L_2 = L_3 = L$.

⁴ Estimate the lowest natural frequency only.

⁵ Estimate lowest natural frequency; do not compare with other methods.