M. E. 7206 Dynamics of Rotating Machinery

Term:	Spring 2004
Instructor:	Dr. "Nat" C. Nataraj
Classes:	Wednesdays, 3:30 – 6:00
Office:	Tolentine 113B, 519-4994
Office Hours:	By appointment
E-mail:	nataraj@villanova.edu
Web page:	http://www.homepage.villanova.edu/c.nataraj/

Course Description

This course will deal with the problems of dynamics and vibration associated with most kinds of rotating machinery. Examples include turbomachines (steam turbines, gas turbines, pumps, compressors), electric machines (motors, generators), and machines with rotating components such as centrifuges.

The aspects of modeling such rotor-disk-bearing assemblies will be explored in detail. Since fluid-film bearings are in wide use, the effect of these bearings on the dynamics of rotors will be studied. Apart from detailed analysis of some simplified models, general methods of modeling and analysis such as finite element and transfer matrix approaches will be discussed. Other aspects to be included in the course are, the effect of internal damping on the stability of the system, the phenomenon of oil whirl, the theory and practice of balancing of rotating components, and the influence of nonlinearities on the vibrational response of the system.

Prerequisites

Undergraduate vibration, numerical analysis.

Texts

There will be no required text. Suggested reference material is as follows. A draft of a text by the instructor is likely to be available by the first class, and can be purchased in class for a nominal amount.

- Dimentberg, F. M., 1961, *Flexural Vibrations of Rotating Shafts*, Butterworths, London.
- Tondl, A., 1965, *Some Problems of Rotor Dynamics*, Chapman and Hall, London.

- Lund, J. W., 1979, *Dynamics of Machines*, Ossolineum, Denmark.
- Rao, J. S., 1983, *Rotor Dynamics*, Wiley Eastern, New Delhi.
- Dimorogonas, A. D., and Paipetes, S. A., 1983, *Analytical Methods in Rotor Dynamics*, Applied Science Publishers.
- Adams, M. L., 2001, *Rotating Machinery Vibration*, Marcel-Dekker, Inc.
- Vance, J. M., 1988, *Rotordynamics of Turbomachinery*, Wiley Inter-Science.
- Nelson, H. D., Preliminary draft of *Rotor Dynamics*.
- Nataraj, C., Research Notes.
- Numerous technical publications.

Grading:

Homework will be assigned every week and should be submitted promptly for grading and subsequent discussion. In addition, small computer projects will be assigned.

An individual term project will be required of each student. The project topic may be either selected by the student, with approval, or be specified by the instructor. It is initiated at the mid-term date and is due in the last class week.

The semester grade is based on the following relative weights.

Homework	15%
Quizzes (two)	20%
Computer projects	40%
Final Exam (comprehensive)	25%

Grades:

F $<$ 65% C- $<$ 70% $<$ C $<$ 75% $<$ C+ $<$ 80%$<$ B- $<$ 82% $<$ B $<$ 85% $<$ B+ $<$ 87% $<$ A- $<$ 90% $<$ A

Course Syllabus[1]

- Objectives of Rotordynamic Analysis
- Coordinate systems and kinematics of rotor motion
- Critical speeds
- Jeffcott rotor equations: free and forced response, stability
- Rigid rotor equations, forward and backward modes
- Onset of Instability
- Transient Response
- Hydrodynamic bearings and Reynolds equation
- Unbalance response
- Flexible MDOF systems - finite element modeling
- Balancing procedures
- Instability mechanisms
- Nonlinear effects due to bearings, couplings, cracks, etc.
- Troubleshooting from vibration measurement

Demonstration Setup

If time permits, a Bently Nevada rotating machinery setup will be used to demonstrate whirling of shafts, balancing procedures, and oil whirl due to fluid–film bearings.

[1]This a little optimistic!