VILLANOVA UNIVERSITY
MECHANICAL ENGINEERING DEPARTMENT

ME 8217 Fall 2015
Random Vibration Dr. B.J. Sullivan

COURSE OBJECTIVE

The primary objective of this course is to provide the fundamental concepts of the theory of random vibrations as applied to structural and mechanical systems. The approach to accomplishing this is largely mathematical; however, applications of random vibration theory in practical engineering problems (e.g. vibrations of jet aircraft in flight and during taxiing; lift-off accelerations and acoustic pressures applied to rocket-powered missiles and spacecraft) will be examined in this course.

TENTATIVE COURSE OUTLINE

Mtg	Date	Topic	Readings
1	24 Aug	Introduction; Aspects of Probability Theory	Newland 1-11
2	31 Aug	Probability Theory (continued)	Newland 12-20
	7 Sep	Labor Day – no class	
3	14 Sep	Correlation; Random Processes	Newland 21-32
4	21 Sep	Operations on Random Processes	Newland 33-40
5	28 Sep	Spectral Density; Wide Band and Narrow Band Processes	Newland 41-52
6	5 Oct	Review of Deterministic Theory of Vibrations	Newland 53-66
7	12 Oct	Transmission of Random Vibration **MID-TERM EXAM electronic distribution**	Newland 67-81
	19 Oct	Fall Semester Break – no class	
	26 Oct	Statistics of Narrow Band Processes	Newland 82-94
		Mid-Term Exam solutions are due at 6:00 pm	
8	2 Nov	Failure Due to Random Vibration	Crandall & Mark 103-125; Clough & Penzien 532-534; notes & handouts
9	9 Nov	Random Vibration Response of Linear Multi-Degree of Freedom Systems	Clough & Penzien 539-547
10	16 Nov	Random Vibration Response of Linear Continuous Systems	Clough & Penzien 547-551
11	23 Nov	Nonstationary Stochastic Processes	Clough & Penzien 483, 510, 528-531
12	30 Nov	Introduction to Random Vibration of Nonlinear Systems **Final Exam Distribution**	Notes and handouts
13	7 Dec	***Student presentations of course projects (both 001 and DL1 sections)***	
14	14 Dec	**FINAL EXAM solutions are due in class at 6:00 pm**	

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COURSE DESCRIPTION

Random vibration theory is used in the design and analysis of structures and structural components when the parameters of the dynamic loads applied to the structural system are not known exactly and can only be described in a statistical manner. Examples of random vibration loading include vibrations of jet aircraft in flight and during taxiing; lift-off accelerations and acoustic pressures applied to rocket-powered missiles and spacecraft; vibration of ships in rough seas, high-speed trains on rails, and automobiles on highways; and strong earthquake motion effects on buildings and dams.

COURSE CONDUCT

Course Materials

Before and after each class, electronic versions of course materials will be available to the students by accessing the website http://vucoe.drbriansullivan.com/me-8217/.

Homework Assignments

Homework assignments are due exactly one week after they have been assigned in class. Without instructor approval provided on the Friday prior to the Monday due date, and granted only due to special circumstances (e.g., illness), no late homework assignments will be accepted. Printed copies of homework solutions are the required form of submittal for students in Section 001 (the in-class section). Electronic submission for students in Section 001 is permitted only in the event that the student is unable to attend the class in person. Such a request must be made in advance. Electronic submission is permitted for all students enrolled in Section DL1.

Examinations

All exams are take-home, open book and open notes examinations.

The Mid-Term and Final examination will be provided to the students electronically no later than one week before the student solutions are due. **Student solutions must be hard copy format only for students in Section 001 and electronic format for students in Section DL1.**

Course Text

There is no single text book which treats each of the above topics in exactly the same way as they will be covered in this course, or which places the exact same emphasis on the topics as will be placed on them in this course. Consequently, class notes developed by the students from the lectures and including handouts provided by the instructor, supplemented by regularly assigned homework problems, will form the primary source of information. The text book which will be used in the class, and from which most of the homework problems will be assigned, is

D.E. Newland, An Introduction to Random Vibrations, Spectral & Wavelet Analysis, 3rd Edition, Addison Wesley Longman Ltd., Essex, Great Britain, 1993.

It is suggested that the students refer to any of the following books for supplementary material:

S.H. Crandall and W.D. Mark, Random Vibration in Mechanical Systems, Academic Press, New York, 1963.

R.W. Clough and J. Penzien, Dynamics of Structures, 2nd Edition, McGraw-Hill Inc., New York, NY, 1993.

P.H. Wirsching, T.L. Paez and K. Ortiz, Random Vibrations: Theory and Practice, Dover Publications, 2006.

C.Y. Yang, Random Vibration of Structures, John Wiley & Sons, New York, 1986.

Other appropriate texts from the engineering literature will be referenced as required. On occasion, selected papers from the literature of Random Vibrations will be referenced and distributed.

The final course grade will be determined on the following basis:

Homeworks	10%
Course Project	30%
Mid-Term Examination	30%
Final Examination	30%

INSTRUCTOR AVAILABILITY

The best way to contact me is via email. My e-mail address is brian.sullivan@villanova.edu. I will respond as promptly as possible.

Please note that work does take me out of town, usually in the middle of the week, on average, for part of approximately two weeks each month. Except in the case of unplanned trips, students will be advised when I will be out of town so that they are not waiting too long for responses to e-mail messages.

COURSE PROJECT

The course project consists of a research paper on a selected topic in the mechanics of composite materials, not covered within the course material. The research paper should include a limited literature search on the selected topic, citing each publication and summarizing the most important aspects of the publications. The algorithm(s) associated with the selected topic on random vibrations, which will be provided and described within the publications found in the literature search, should be clearly explained and then used to investigate the topic of interest to the student. The code used to exercise the algorithm should be written by the student in their preferred software, e.g. Mathcad, Matlab, Excel, etc. A copy of the code, results generated by the code, and an explanation of the results, including some basis of verification, should all be included within the student's research paper. Research papers may be written on any of the following topics:

- Stresses in composite beams on elastic foundations subjected to random base excitation
- Stresses in orthotropic plates subjected to random pressures

- Program for algorithm for calculation of von Mises stress in structures subjected to random loads and containing three-dimensional stress states
- Development of algorithm for calculating stress invariants (e.g., J1 or J2) or strain invariants in structures subjected to random loads and containing three-dimensional stress states
- Failure due to excessive displacements in structures subjected to random loading
- Monte Carlo methods for simulation of random loads on nonlinear structures

Students are free to select a course project from this list or to decide on an alternative topic.

The table below provides the timeline of due dates for the preparation of the research papers:

Research paper item	Description	Due Date	% of Course Project Grade	File Format	Nature of Submission
Research paper topic	Selection of topic for student's Course Project	26 Oct	5%	MS Word	Electronic (Sections 001 and DL1)
Research paper outline	Detailed outline to be used by student in writing the research paper	9 Nov	20%	MS Word	Electronic (Sections 001 and DL1)
Research paper initial draft	Draft version of student's research paper, containing preliminary results	23 Nov	20%	MS Word	Electronic (Sections 001 and DL1)
Final form of research paper	Final version of student's research paper containing final results	7 Dec	40%	MS Word	Hard copy (Section 001) Electronic (Section DL1)
Research paper presentation	Presentation file summarizing research topic & findings	7 Dec	15%	MS Powerpoint	Electronic only

In the preparation of the research papers, the format to be used by the students is the following:

- A cover page providing the title of the report and the name of the student.
- A brief introductory section providing some background on the nature of the topic.
- A short section describing the objective of the course project.

- A section describing the technical approach used by the student, including key equations. This section should also describe where the equations were obtained and how they were used in the study.
- A section describing results obtained by the students. The use of graphs and tables, sequentially numbered and containing appropriately descriptive captions, should be freely used in this section.
- A section summarizing the principal conclusions of the research project.
- References used in the performance of the course project can be placed at the end of the report, or can be cited as footnotes and appear at the bottom of selected, specific pages.

As shown in the table above, a Microsoft PowerPoint version of the research paper must also be prepared and used by the students in the presentation of their work to the class. All student presentations, both Section 001 and Section DL1, will occur in class on December 7, 2015, the same date as the due date for the written research papers. Section DL1 students not able to come to class due to geographical issues will be accommodated via webex and telephone conferencing. All DL1 students who wish to participate in this fashion must notify the instructor no later than November 16, 2015 of their desire to do so, so that proper arrangements can be made.