Engineering Tripos Part IIB, 4C7: Random & Non-Linear Vibrations, 2018-19

Module Leader

Prof R Langley [1]

Lecturers

Prof R Langley and Dr A Seshia

Lab Leader

Dr A Seshia

Timing and Structure

Michaelmas term. 12 lectures + 2 examples classes + coursework. Assessment: 75% exam/25% coursework

Prerequisites

3C6 useful.

Aims

The aims of the course are to:

- analyse the effects of random vibrations on machines and structures and the effects that occur as a result of non-linearities.
- describe the characteristics of random and non linear vibrations, deriving the effects of a system's dynamic response on the input and giving methods of determining resulting deflections or stresses.
- describe some of the characteristics of self excited vibrations.

Objectives

As specific objectives, by the end of the course students should be able to:

- identify and describe random processes.
- predict the output from a system subjected to random forcing.
- predict how frequently output levels will be exceeded.
- apply the correct windows and filters for analysis.
- assess the reliability of frequency analyses.
- understand the effects of non-linearities on system response.
- calculate and use describing functions and harmonic balance.
- predict phase-plane behaviour of second-order systems.
- understand some of the common self excited vibrations and their characteristics.

Content

Non-linear and self-excited vibration. (6L, Dr A A Seshia)

- Types of non-linearities in engineering systems and their major qualitative effects. Method of harmonic balance, describing functions;
- Representation of second-order nonlinear systems in the phase plane. Stationary points and their classification. Periodic orbits;
- Introduction to self-excited vibration. Examples of systems which are excited by instability and dry friction. Self excited oscillations in micro electromechanical systems.

Random vibration. (6L, Professor R S Langely)

- Characteristics of random vibrations and the use of probability distributions and spectral densities to describe such vibration:
- Auto and cross spectra. Transmission of random vibration through linear systems and derivation of output statistics and spectral densities;
- Narrow-band processes and determination of level-crossing frequency, distribution of peaks and frequency of maxima;
- Spectral analysis. Fourier transforms. Problems with sampling and relevance of aliasing. Calculation of spectra for sampled points;
- Basic lag and use of windows and smoothing. Coherence. Accuracy of measurements.

Coursework

Experiment on non-linear vibrations. This involves about 4 hours in the laboratory and 4 hours writing-up.

Coursework	Format	Due date & marks
Nonlinear vibration of a clamped beam Learning objective: (i) To explore nonlinear effects due to high forcing amplitudes about resonance in mechanical structures. (ii) To construct a model to explain the nonlinear behaviour of the mechanism provided and use this model to simulate the behaviour of the system under specified conditions. (iii) Demonstrate use of the sonogram (time-varying spectrum) as an analytical tool to distinguish both frequency and temporal characteristics of a transient record.	Individual Report Anonymously marked	Weds Week 28 Nov [15/60]

Booklists

Please see the Booklist for Group C Courses [2] for references for this module.

Examination Guidelines

Please refer to Form & conduct of the examinations [3].

UK-SPEC

This syllabus contributes to the following areas of the UK-SPEC [4] standard:

Toggle display of UK-SPEC areas.

GT1

Develop transferable skills that will be of value in a wide range of situations. These are exemplified by the Qualifications and Curriculum Authority Higher Level Key Skills and include problem solving, communication, and working with others, as well as the effective use of general IT facilities and information retrieval skills. They also include planning self-learning and improving performance, as the foundation for lifelong learning/CPD.

IA1

Apply appropriate quantitative science and engineering tools to the analysis of problems.

IA2

Demonstrate creative and innovative ability in the synthesis of solutions and in formulating designs.

KU1

Demonstrate knowledge and understanding of essential facts, concepts, theories and principles of their engineering discipline, and its underpinning science and mathematics.

KU2

Have an appreciation of the wider multidisciplinary engineering context and its underlying principles.

E1

Ability to use fundamental knowledge to investigate new and emerging technologies.

E2

Ability to extract data pertinent to an unfamiliar problem, and apply its solution using computer based engineering tools when appropriate.

E3

Ability to apply mathematical and computer based models for solving problems in engineering, and the ability to assess the limitations of particular cases.

E4

Understanding of and ability to apply a systems approach to engineering problems.

P1

A thorough understanding of current practice and its limitations and some appreciation of likely new developments.

P3

Understanding of contexts in which engineering knowledge can be applied (e.g. operations and management, technology, development, etc).

P8

Ability to apply engineering techniques taking account of a range of commercial and industrial constraints.

US1

A comprehensive understanding of the scientific principles of own specialisation and related disciplines.

US2

A comprehensive knowledge and understanding of mathematical and computer models relevant to the engineering discipline, and an appreciation of their limitations.

Last modified: 27/11/2018 15:24

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