

ES386-15 Dynamics of Vibrating Systems

22/23

Department

School of Engineering

Level

Undergraduate Level 3

Module leader

Peter Brommer

Credit value

15

Module duration

10 weeks

Assessment

30% coursework, 70% exam

Study location

University of Warwick main campus, Coventry

Description

Introductory description

ES386-15 Dynamics of Vibrating Systems

[Module web page](#)

Module aims

Vibrations exert a significant influence on the performance of the majority of engineering systems. All engineers should understand the basic concepts and all mechanical engineers should be familiar with the analytical techniques for the modelling and quantitative prediction of behaviour. Thus, this module provides students with fundamental skills necessary for the analysis of the dynamics of mechanical systems, as well as providing opportunities to apply these skills to the modelling and analysis of vibration.

This third-year module is mandatory for students pursuing a degree in Mechanical Engineering, building upon competences acquired earlier in the course. This module introduces students to the use of Lagrange's equations (applied to 1D and 2D systems only for this module) and to techniques for modelling both lumped and continuous vibrating systems. It includes some coverage of approximate methods both as an aid to physical understanding of the principles and

because of their continuing usefulness. The module assumes basic understanding of mechanics and linear algebra consistent with the level of Year 2 modules.

At the end of the module students should have a sound understanding of the wide application of vibration theory and of the underlying physical principles. In particular, they should be able to use either Newtonian or Lagrangian mechanics to analyse 2D systems, and to determine the response of simple damped and undamped multi-degrees of freedom (DOF) systems to both periodic and aperiodic excitation. They should also be familiar with engineering solutions for measuring and influencing vibrational behaviour.

Outline syllabus

This is an indicative module outline only to give an indication of the sort of topics that may be covered. Actual sessions held may differ.

- Generalised co-ordinates, Lagrange's equation (including preliminary study of other classical methods)
- General application of the Lagrange equation to vibrating systems
- Multi-degree of freedom systems: lumped system models, continuous system models; geared and branched systems; reduction of an n-DOF system to a set of n single-DOF systems; principal co-ordinates
- Matrix methods of analysis: conservative and non-conservative (damped) systems; determination of principal co-ordinates
- Modelling of damping: hysteretic, Coulomb, viscous; measurement of damping factor
- Forced vibration: harmonic excitation of multi-DOF systems; shaft whirling; transmissibility; vibration isolation; non-harmonic and arbitrary excitation (convolution integral)
- Approximate methods e.g. Rayleigh's method, Dunkerley's method

Learning outcomes

By the end of the module, students should be able to:

1. Model planar mechanical systems using Newton's and Lagrange's equations: Determine appropriate co-ordinate systems, analyse vibrations.
2. Abstract more complex engineering mechanisms: analyse using lumped system models or simple distributed mass and stiffness models. Use and justify standard methods and approximations for extended and continuous vibrating systems.
3. Evaluate the natural frequencies and modes of vibration of a multi-degree of freedom linear system.
4. Determine and analyse the free and forced response of single-degree of freedom systems to periodic and aperiodic excitation, as well as the effects of linear and non-linear damping on the system behaviour.
5. Evaluate complex (multi-degree of freedom) undamped or damped systems numerically, using a systematic approach to analyse the natural frequencies and modes, and the response of the system to periodic and aperiodic excitations.
6. Demonstrate a sound understanding of the application of vibration analysis to key engineering systems.

Indicative reading list

1. Theory of Vibration with Applications, by W. T. Thomson and M. D. Dahleh. Publisher: Pearson. Fifth edition, 1998. ISBN-10: 013651068X, ISBN-13: 9780136510680.
2. Principles of Vibration, by B. H. Tongue. Publisher: Oxford University Press. Second edition, 2002. ISBN-10: 0195142462.
3. Engineering Vibrations, by D. J. Inman. Publisher: Pearson. Fourth international edition, 2013. ISBN-10: 0273768441, ISBN-13: 9780273768449.
4. Mechanical vibrations, by S. S. Rao, Fook Fah Yap. Publisher: Prentice Hall. Fifth edition in SI units, 2011. ISBN-10: 9810687125, ISBN-13: 9789810687120
5. Vibrations, by B. Balachandran, E. B. Magrab. Publisher: Cengage. Second international SI edition, 2009. ISBN10: 0495411256, ISBN-13: 9780495411253.

[View reading list on Talis Aspire](#)

Subject specific skills

SSS4: Ability to apply relevant practical and laboratory skills.

SSS8: Ability to be pragmatic, taking a systematic approach and the logical and practical steps necessary for, often complex, concepts to become reality.

Transferable skills

TS1: Numeracy: apply mathematical and computational methods to communicate parameters, model and optimize solutions.

TS2: Apply problem solving skills, information retrieval, and the effective use of general IT facilities.

TS3: Communicate (written and oral; to technical and non-technical audiences) and work with others.

TS7: Overcome difficulties by employing skills, knowledge and understanding in a flexible manner.

Study

Study time

| Type | Required |
|-------------------|-----------------------------|
| Lectures | 30 sessions of 1 hour (25%) |
| Seminars | 2 sessions of 1 hour (2%) |
| Practical classes | 1 session of 2 hours (2%) |
| Total | 120 hours |

| Type | Required |
|---------------|----------------|
| Private study | 86 hours (72%) |
| Total | 120 hours |

Private study description

Guided independent learning, assignment preparation, etc 86 hours.

Costs

No further costs have been identified for this module.

Assessment

You must pass all assessment components to pass the module.

Students can register for this module without taking any assessment.

Assessment group D4

| Assessment component | Weighting | Study time | Eligible for self-certification |
|---|-----------|------------|---------------------------------|
| Vibration computational and analysis assignment | 30% | | Yes (extension) |
| Matlab code submitted on Matlab Grader (10% of module credit) and a brief computational report (1000 words, 20% of module credit) | | | |

Reassessment component is the same

| Assessment component | Weighting | Study time | Eligible for self-certification |
|----------------------|-----------|------------|---------------------------------|
| Online Examination | 70% | | No |
| QMP test (2x 1h) | | | |
| ~Platforms - AEP,QMP | | | |

- Online examination: No Answerbook required

Weighting

Study time

**Eligible for self-
certification**

Reassessment component is the same

Feedback on assessment

- Feedback during laboratory sessions
- Feedback on assignments.
- Model solutions to exam type questions.
- Support through advice and feedback hours.
- Cohort level feedback on examinations

[Past exam papers for ES386](#)

Availability

Pre-requisites

To take this module, you must have passed:

- All of
 - [ES2C5-15 Dynamics and Fluid Mechanics](#)
 - [ES2C7-15 Engineering Mathematics and Data Analytics](#)

Courses

This module is Core for:

- Year 3 of UESA-H310 BEng Mechanical Engineering
- Year 3 of UESA-H315 BEng Mechanical Engineering
- Year 4 of UESA-H314 BEng Mechanical Engineering with Intercalated Year
- Year 3 of UESA-HH35 BEng Systems Engineering
- Year 3 of UESA-HH36 BEng Systems Engineering
- Year 4 of UESA-HH34 BEng Systems Engineering with Intercalated Year
- Year 3 of UESA-H311 MEng Mechanical Engineering
- UESA-H316 MEng Mechanical Engineering
 - Year 3 of H315 Mechanical Engineering BEng
 - Year 3 of H316 Mechanical Engineering MEng
- Year 4 of UESA-H317 MEng Mechanical Engineering with Intercalated Year
- UESA-HH31 MEng Systems Engineering
 - Year 3 of HH31 Systems Engineering
 - Year 3 of HH35 Systems Engineering

- Year 4 of UESA-HH32 MEng Systems Engineering with Intercalated Year

This module is Core optional for:

- Year 3 of UESA-H115 MEng Engineering with Intercalated Year
- UESA-H317 MEng Mechanical Engineering with Intercalated Year
 - Year 3 of H317 Mechanical Engineering with Intercalated Year
 - Year 4 of H317 Mechanical Engineering with Intercalated Year

This module is Optional for:

- Year 3 of UESA-H113 BEng Engineering
- Year 3 of UESA-H114 MEng Engineering
- Year 4 of UESA-H115 MEng Engineering with Intercalated Year
- UESA-H11L Undergraduate Engineering (with Intercalated Year)
 - Year 3 of H11L Engineering (with Intercalated Year)
 - Year 4 of H11L Engineering (with Intercalated Year)

This module is Option list A for:

- Year 4 of UESA-H111 BEng Engineering with Intercalated Year
- Year 3 of UESA-H112 BSc Engineering