MODULE DESCRIPTION FORM

DEPARTMENT OF MECHANICAL AND AEROSPACE ENGINEERING

ME534 Advanced Topics in Mechanics and Dynamics

Module Registrar: Dr Wael Abdou **wael.abdou@strath.ac.uk**	**Taught To (Course): MEng Mechanical Engineering; MSc cohorts (AME - Advanced Mechanical Engineering, AME with Aerospace, AME with Energy Systems, AME with Materials)**		
Other Lecturers Involved: Mr D Johnston	**Credit Weighting: 10 (5 ECTS)**	**Semester: 2**	
Assumed Prerequisites: 16327, 16361, 16363, ME414, 16429 - Structural Mechanics; Dynamics & Control; Engineering Analysis 3; Advanced Mechanics & Dynamics; Computer Aided Engineering Design	**Compulsory module**	**Academic Level: 5**	**Suitable for Exchange: Y**

Module Format and Delivery (HOURS i.e. 1 credit = 10hrs of study):

Lecture	Tutorial	Laboratory	Groupwork	External	Online	Project	Assignments	Private Study	**Total**
20	10						20	50	100

Educational Aim

This module aims to advance students' understanding of solid mechanics and dynamics, enabling them to apply complex theoretical principles, analytical techniques, and simulation tools to tackle challenging engineering problems. Through rigorous study, students will enhance their skills in modelling and analysing materials under a range of loading conditions, while emphasising responsible and sustainable engineering practices. Students will gain the capability to model complex dynamic systems, ensuring structural integrity, safety, and compliance with professional standards. Additionally, the module promotes professional development by building key analytical and technical skills that support long-term growth and proficiency within the engineering field.

Learning Outcomes

On completion of the module the student is expected to be able to

LO1 Critically evaluate and predict failure modes in engineering materials, applying advanced stress and strain analyses, life prediction models, and stability criteria.

LO2 Analyse and describe the key characteristics and applications of ubiquitous nonlinear oscillator systems.

LO3 Solve nonlinear dynamic systems using approximate analytical techniques, including perturbation methods and series approximations.

LO4 Apply analytical approaches to understand systems' stability, including eigenvalue analysis and control-centred approaches.

Syllabus

The module will teach the following:

• Multi-Axial Stress and Strain Analysis: Analysis of stress and strain in complex geometries, focusing on non-linear materials and anisotropic behaviour in structural applications.

• Failure Prediction and Life Estimation: Fatigue under cyclic loads, creep in high-temperature environments, and brittle versus ductile fracture modes. Use of S-N curves, fracture mechanics, and fatigue life assessment techniques.

• Stability and Buckling Analysis in Complex Structures: Buckling in slender structures, advanced stability criteria for thin-walled sections, and evaluation of buckling loads in anisotropic materials.

• Experimental Validation Techniques in Solid Mechanics: Advanced laboratory methods, including strain gauging, acoustic emission monitoring, and digital image correlation for real-time validation of predictive models.

• Classical nonlinear oscillations: Characteristics and applications of ubiquitous nonlinear oscillator model, including the Van der Pol oscillator, the (hardening/softening) Duffing oscillator, and the Rayleigh oscillator.

• Approximate analytical methods: Perturbation techniques, series approximations, and linearisation strategies.

• Stability analysis: Approaches for assessing the stability of systems, including Eigenvalue analysis, Lyapunov stability analysis, and the Nyquist stability criterion.

Assessment of Learning Outcomes

Criteria

For each of the Module Learning Outcomes the following criteria will be used to make judgements on student learning:

LO1
C1: Demonstrate an understanding of stress and strain analyses in complex geometries, including the ability to apply non-linear and anisotropic material models (exam).
C2: Apply life prediction models and fatigue analysis methods, including the use of S-N curves and fracture mechanics, to assess failure risks in engineering materials (exam and case study project).
C3: Analyse stability and buckling criteria in structural applications, particularly for slender and thin-walled structures, and evaluate potential failure modes (exam and case study project).

LO2
C1: Identify different types of common nonlinear oscillator systems, including the Van der Pol, Duffing, and Rayleigh oscillator models, and distinguish between their behaviours.
C2: Articulate examples of where these nonlinear oscillator models can be used in practical (research and/or industrial) applications.
C3: Apply qualitative techniques such as phase portraits to assess the steady-state characteristics of these oscillators.

LO3
C1: Apply approximate analytical methods, including perturbation methods (such as Lighthill's technique, the Lindstedt-Poincaré technique and the method of multiple scales), the harmonic balance method, and Jacobian linearisation.
C2: Select from the range of taught approximate analytical methods to recommend an appropriate approach for a variety of dynamical system models.

LO4
C1: Apply eigenvalue analysis to linearised systems in order to assess their stability.
C2: Apply control-focused stability analysis techniques, such as Nyquist stability criterion and Lyapunov analysis, to assess the stability of various systems.

The standards set for each criterion per Module Learning Outcome to achieve a pass grade are indicated on the assessment sheet for all assessment.

Principles of Assessment and Feedback
(within Assessment and Feedback Policy at: https://www.strath.ac.uk/professionalservices/staff/policies/academic/)

ME534 Advanced Topics in Mechanics and Dynamics is a 10-credit level 5 module taught in the second semester. Assessment consists of a final exam (60%) and a case study coursework (40%). The case study coursework is introduced in week 4, with students working on it throughout the latter part of the module.

Feedback is integrated throughout lectures and tutorial sessions, providing ongoing guidance on theoretical concepts, problem-solving approaches, and practical applications. Interactive discussions in response to student questions support deeper understanding and application of module content.

During tutorial sessions, informal feedback is given as verbal guidance to individuals or groups on exercises completed in advance. Active attendance and participation in tutorials are encouraged, although attendance is not compulsory, as this feedback helps students refine their analytical and computational techniques.

Written feedback on the case study coursework assignment will be provided through Myplace, with specific comments on analytical techniques, application of theory, and presentation skills.

Assessment Method(s) Including Percentage Breakdown and Duration of Exams *(individual weightings)*

Examination				**Coursework**		**Practical**		**Project**	
Number	Month(s)	Duration	***Weighting***	Number	***Weighting***	Number	***Weighting***	Number	***Weighting***
1	Apr/May	2hr	60%	1	40%				
LO1-LO4				LO1-LO4		*		*	

* ***L/Os:*** *Indicate which Learning Outcomes (L01, L02, etc) are to be assessed by exam/coursework/practical/project as required.*

Coursework / Submissions deadlines (*academic weeks*):
Case study coursework assignment to be issued in week 4 – online submission windows will be given via Myplace. Submitted by 4pm on Thursday week11

Resit Assessment Procedures:
2hr examination in July/August diet.

PLEASE NOTE:
Students must gain a summative mark of at least 50% to pass the module. Students who fail the module at the first attempt will be re-assessed during the July/August exam diet. This re-assessment will consist entirely of an exam / project. No marks from any previous attempts will be transferred to a new resit attempt.

Recommended Reading

*****Purchase recommended **Highly recommended reading *For reference**

* Dowling, Norman E, Katakam Siva Prasad, and R Narayanasamy. Mechanical Behavior of Materials: Engineering Methods for Deformation, Fracture, and Fatigue. 4th ed., International ed. Boston, Mass. ; London: Pearson, 2013.
* Anderson, Ted L. Fracture Mechanics: Fundamentals and Applications. Fourth edition. Boca Raton: Chapman and Hall/CRC, 2017.
* Socie, Darrell, and G Marquis. Multiaxial Fatigue. Warrendale, Pa. (400 Commonwealth Dr., Wallendale PA USA): Society of Automotive Engineers, 2000.
* Christ, Hans-Jürgen. Fatigue of Materials at Very High Numbers of Loading Cycles : Experimental Techniques, Mechanisms, Modeling and Fatigue Life Assessment. 1st ed. 2018. Wiesbaden: Springer Spektrum, 2018.
* Kovacic, I. *Nonlinear Oscillations: Exact Solutions and Their Approximations*. 1st Edition 2020. Cham: Springer, 2020.
* Nayfeh, A.H. and Mook, D.T. *Nonlinear Oscillations*. New York: Wiley, 1979.
* Nayfeh, A.H. *Introduction to Perturbation Techniques*. New York: Wiley, 1981.

Additional Student Feedback

Date	Time	Room No
Weekly classes and tutorials		Check timetable webpages for details

Session: 2025/2026

Approved:

Course Director Signature: Dr Andrew McLaren
Date of Last Modifications: 30 September 2025

(MAE template updated June 2025)

MODULE TIMETABLE

Module Code:	**ME534**	**Module Title:**	**Advanced Topics in Mechanics and Dynamics**

Brief Description of Assessment:
Case Study coursework assignment – A comprehensive, structured report involving detailed computational analysis, including typed calculations, annotated simulations, and technical sketches to address a complex engineering problem (40% weighting)

Exam – 2hour open-book format covering theoretical and practical aspects of advanced solid mechanics and dynamics, with emphasis on analytical and applied problem-solving (60% weighting)

Assessment Timing

Indicated on the table below are the start/submission dates for each assignment/project and the timing of each exam/assessment.

Please note: Timings could change during unforeseen periods of disruption; this should only be used as a guide.

Semester Two	C&D Wk	WK1	WK2	WK3	WK4	WK5	WK6	WK7	WK8	WK9	WK10	WK11	Exam Period
	Choose an item. Choose an item.	Choose an item. Choose an item.	Choose an item. Choose an item.	Choose an item. Choose an item.	Course work Set	Choose an item. Choose an item.	Choose an item. Choose an item.	Choose an item. Choose an item.	Choose an item. Choose an item.	Choose an item. Choose an item.	Choose an item. Choose an item.	Course work Submit	Exam