

ES442-15 Precision Engineering and Microsystems

23/24

Department

School of Engineering

Level

Undergraduate Level 4

Module leader

Derek Chetwynd

Credit value

15

Module duration

10 weeks

Assessment

60% coursework, 40% exam

Study location

University of Warwick main campus, Coventry

Description

Introductory description

ES442-15 - Precision Engineering and Microsystems

[Module web page](#)

Module aims

To provide a rigorous understanding of first-principles mechanical design applied at the limits of practical performance. To introduce ideas and methodologies suited to precise dimensional and positional control and to miniaturization that are essential to modern technology, e.g. in the large UK instrumentation sector, as sub-systems for use in aerospace, automotive, etc. Additionally, to provide insights into the science and practice of metrology.

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.

1. Introduction: the need for miniaturization; scaling effects; the interactions of precision

- engineering, micro-mechanics and nanotechnology.
2. Uncertainty, tolerance and the influence of surface topography.
 3. Principles of precision mechanism design: loop analysis, alignment principles, kinematics of constraint, mechanism mobility, semi-kinematic design, symmetry, nulling and compensation strategies.
 4. Design of sub-systems for precision instruments and machine tools: semi-kinematic slideways and bearings, flexure mechanisms, sensors, actuators and drives, generalized levers, materials selection, vibration isolation.
 5. Sub-micrometre metrology, drawing examples from, e.g., optical interferometry, grating technologies, surface metrology instruments, length comparators and their sensors, scanning probe microscopes.
 6. Micromechanical manufacture: limits of capability of conventional mechanical manufacturing; concepts and general performance of non-conventional methods such as diamond turning, ductile mode grinding, photo-lithography, LIGA, ion-beam processes, laser ablation.
 7. Micro-Systems Technology: examples of design and fabrication approaches for micro-mechatronic systems (or MEMS).

Learning outcomes

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

- Produce and defend conceptual design solutions for applications that make unusually high demands for mechanical stability, precise motion control, etc. or that benefit from high degrees of miniaturization. [M2, M3, M5, M6, M17]
- Evaluate the physical limits on achievable precision in advanced mechanical systems, the nature of uncertainties, etc., and thereby critically review the plausibility of proposed machine specifications. [M1, M2, M6]
- Interpret and apply guidelines for good practice in precision metrology in order to select sound principles for the efficient operation of high-precision mechanical systems. [M3, M6]
- Evaluate and criticize constructively designs for (electro-) mechanical systems, using model archetypes to aid interpretation of their appropriateness and effectiveness. [M1, M3, M6]
- Critique the typical constraints imposed on designs by materials and manufacturing capabilities and so make sound judgments on design approaches that mitigate their effects cost-efficiently. [M2, M13]
- Understand the general principles and limitations of a range of special manufacturing methods needed for high-precision systems and micro-devices in order to make informed choices of candidate processes for specific tasks. [M13]

Indicative reading list

1. Set Book: ST Smith, S.T., Chetwynd, D.G., 1994, Foundations of Ultraprecision Mechanism Design, Taylor Francis (ISBN 2-88449-001-9)
2. Alternative Set Book: Leach, R.K., Smith, S.T., 2018 Basics of Precision Engineering, Taylor Francis (ISBN 978-1-4987-6085-0)
3. Nakazawa, H., 1994, Principles of Precision Engineering, OUP
4. Norton, R.L., 2012, Design of Machinery: an Introduction to the Synthesis and Analysis of

Mechanisms and Machines, McGraw Hill

5. Gardner, J.W. et al., 2001, Microsensors, MEMS and Smart Devices, Wiley

6. Beckwith, T.G., Marangon, R.D., Lienhard, J.H., 2009, Mechanical Measurement (6th Ed.), Addison Wesley

Subject specific skills

Ability to conceive and realise a component, product, system or process that operates close to the limits of current technical capabilities.

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

Ability to assess risk, cost and values in potential design solutions integrating sub-systems, codes of practice, International Standards and wider professional engineering issues.

Transferable skills

Apply design and other problem solving skills, when confronted with incomplete specifications; including information retrieval and the effective use or rejection of 'standardised' solutions.

Ability to justify (design) assumptions by an appropriate mix of verbal reasoning, mathematical models and empirical observations.

Ability to formulate and operate within appropriate published guidelines, Standards or other formal codes, technically, commercially and professionally.

Overcome difficulties by employing skills, knowledge and understanding in a flexible manner, with proper awareness of appropriate business, economic and social constraints.

Study

Study time

Type	Required
Lectures	(0%)
Seminars	20 sessions of 1 hour (13%)
Tutorials	(0%)
Online learning (independent)	30 sessions of 1 hour (20%)
Private study	100 hours (67%)
Total	150 hours

Private study description

For the whole module, 100 hours guided independent learning, including and interlaced with that for coursework assignments

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 D9

	Weighting	Study time
Written Assignment	60%	
Design study with written report 10 pages/2700		
Online Examination	40%	
QMP		
~Platforms - QMP		

- Online examination: No Answerbook required
- Students may use a calculator
- Engineering Data Book 8th Edition
- Graph paper

Feedback on assessment

- Appended summary of typical strengths/weaknesses (individually annotated);
- Annotations onto submitted script;
- Nominal mark via Tabula and feedback (or link to feedback on returned script);
- Student support through advertised Office Hours.

[Past exam papers for ES442](#)

Availability

Courses

This module is Core for:

- Year 1 of TESA-H341 Postgraduate Taught Advanced Mechanical Engineering

This module is Optional for:

- Year 4 of UESA-H116 MEng Engineering with Exchange Year
- Year 5 of UESA-H115 MEng Engineering with Intercalated Year

This module is Option list A for:

- Year 4 of UESA-H114 MEng Engineering
- UESA-H311 MEng Mechanical Engineering
 - Year 4 of H311 Mechanical Engineering
 - Year 4 of H30J Mechanical Engineering with Appropriate Technology
 - Year 4 of H30L Mechanical Engineering with Automotive Engineering
 - Year 4 of H30G Mechanical Engineering with Business Management
 - Year 4 of H30P Mechanical Engineering with Fluid Dynamics
 - Year 4 of H30K Mechanical Engineering with Instrumentation
 - Year 4 of H30M Mechanical Engineering with Robotics
 - Year 4 of H30H Mechanical Engineering with Sustainability
 - Year 4 of H30N Mechanical Engineering with Systems Engineering
- Year 4 of UESA-H316 MEng Mechanical Engineering
- Year 4 of UESA-H318 MEng Mechanical Engineering with Exchange Year
- Year 5 of UESA-H317 MEng Mechanical Engineering with Intercalated Year

This module is Option list B for:

- Year 4 of UCSA-G408 Undergraduate Computer Systems Engineering
- Year 5 of UCSA-G409 Undergraduate Computer Systems Engineering (with Intercalated Year)