ES442-15 Precision Engineering and Microsystems

22/23

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.
- Evaluate the physical limits on achievable precision in advanced mechanical systems, the nature of uncertainties, etc., and thereby assess satisfactorily the plausibility of proposed machine specifications.
- Interpret the guidelines for good practice in precision metrology in order to select sound principles for the operation of high-precision mechanical systems.
- Evaluate and criticize constructively designs for (electro-) mechanical systems, interpreting their effectiveness.
- Critique the typical constraints imposed on designs by manufacturing capabilities and make sound judgments on designs that minimize their effect.
- Appreciate the range and principles of special manufacturing methods needed for high-precision systems and micro-devices and make informed choices of candidate processes for specific tasks.

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	30 sessions of 1 hour (20%)
Tutorials	1 session of 1 hour (1%)
Private study	119 hours (79%)
Total	150 hours

Private study description

For the whole module, 119 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 D7

	Weighting	Study time	Eligible for self-certification
Assessment component			
Written Assignment Design study with written report 10 pages/2700	60%		Yes (extension)
Reassessment component is the same			
Assessment component			
Online Examination QMP ~Platforms - QMP	40%		No

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

Reassessment component is the same

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)