ES97E-15 Biomechanics

23/24

Department
School of Engineering
Level
Taught Postgraduate Level
Module leader
Neil Evans
Credit value
15
Module duration
10 weeks
Assessment
30% coursework, 70% exam
Study location
University of Warwick main campus, Coventry

Description

Introductory description

ES97E-15 Biomechanics

Module web page

Module aims

To impart a firm understanding and knowledge of the principles of mechanics as applied to biomedical and biological systems, across the spectrum from single cell and tissue mechanics, through to analysis of human gait. The module will introduce fundamental principles involved in both experimental and analytical methods, and enable students to use such methods.

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.

- Experimental methods for single cells. Introduction of various techniques for measuring the mechanical properties of single biological cells
- Cell mechanics. Mechanical models for cell deformation and their biomedical applications
- Cell adhesion and cell-material interaction. Mechanistic and adhesion mechanisms in cell-to-

cell and cell-biomaterial interactions
- Tissue mechanics. Measurement and modelling of the deformation behaviours of biological tissues
- Multi-scale biomechanics. Mechanical characterisations bridging the gap between discrete cell level and continuous tissue level
- Kinematics, anatomical models and marker sets. Will include: the standard anatomical position, associated terms of location, axes and planes; the use of markers with motion capture to obtain kinematic variables, including a simple and Vicon's Plug-in-Gait marker sets; conventions for kinematics, such as global and segment reference frames, and descriptions of segments in space; techniques for direct measurement of certain kinematic variables; calculation of other kinematic variables (such as limb-segment angles). Associated with these topics are training sessions (4 hours duration) in the use of the School of Engineering's Gait Laboratory.
- Kinetics: Forces and moments. Will include: link-segment biomechanical models; ground reaction force and force plates; combining force plate data and kinematic data for a basic foot model, and then using the Gait Laboratory for inverse dynamics [this will form basis for related assignment]; centers of mass and pressure, and their differences; the inverted pendulum model.
- Mechanical Work, Energy and Power. Will include: the relationship between moments, angular velocity and joint power during normal gait; internal versus external work, and their calculation; sign convention for muscle work; mechanical energy transfer between segments, power balances at joints and within segments; forms of energy storage and the total energy of a multi-segment system.
- Forward dynamics. Lagrangian mechanics based formulation of so-called forward models to include: Generalised coordinates, degrees of freedom and reference systems; displacement and velocity vectors; system energy; external forces and torques.
- Muscle mechanics. Will include: Basic introduction to muscles; Hill-type mathematical models of muscles; force-length and force-velocity characteristics of muscles; processing of the electromyogram.

Learning outcomes

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

- Understand the core principles of biomechanics and be able to apply these principles to complex mechanical systems in biology and medicine [M1, M2]
- Have an advanced understanding of kinematics, and be able to determine key kinematic variables in human motion in a systematic fashion [M1, M2]
- Use state-of-the-art data capture, via a Gait Laboratory, to determine and analyse key kinematic and kinetic variables in human motion [M3, M12]
- Have an advanced understanding of kinetics in human motion; be able to derive basic link-segment equations; and perform a kinetic analysis of reaction forces and moments in 2D [M1, M2]
- Understand the concepts of work, energy and power in human movement and how they relate to muscle function [M1, M2]
- Have a deep understanding of mechanical models in biological cells/tissues; be able to derive force-balance equations; and perform a systematic analysis of cell/tissue mechanics

[M1, M2]
- Understand and critically evaluate modern experimental techniques for the measurements of cell and tissue/mechanics; and be able to explain the working principles, merits and drawbacks of the techniques [M1]

Indicative reading list

1. Winter, D.A. Biomechanics and Motor Control of Human Movement, Wiley, 2009. (ISBN: 9780470398180)
2. Robertson, G., Caldwell, G., Hamill, J., Kamen, G. and Whittlesey, S. Research Methods in Biomechanics, Human Kinetics, 2013. (ISBN: 9780736093408)
3. Latash, M.L., Zatsiorsky, V. Biomechanics and Motor Control: Defining Central Concepts, Academic Press, 2015. (ISBN: 9780128003848)
4. Boal, D. Mechanics of the cell, Cambridge University Press, 2012. (ISBN: 9780521540629)
5. Fung, Y.C. Biomechanics: Mechanical Properties of Living Tissues, Springer-Verlag, 2010. (ISBN: 9781441931047)
6. Budynas, R.G. and Nisbett, J.K. Shigley’s Mechanical Engineering Design, McGraw-Hill, 2008. (ISBN: 9780071257633)
7. Cook, R.D., Malkus, D.S., Plesha, M.E. and Witt, R.J. Concepts and applications of finite element analysis, Wiley, 2007. (ISBN: 9788126513369)

Subject specific skills

TBC

Transferable skills

TBC

Study

Study time

Type	Required
Lectures	28 sessions of 1 hour (19%)
Seminars	2 sessions of 1 hour (1%)
Other activity	6 hours (4%)
Private study	114 hours (76%)
Total	150 hours

Private study description

Reinforcement of concepts introduced in lectures and seminars. Further directed reading of relevant sections of principal module text and papers from the literature. Self-directed learning and training associated with mastery of skills in the gait laboratory in order to perform a gait analysis on a healthy volunteer.

Other activity description

2×1 hr revision classes
4×1 hr training in Gait Laboratory

Costs

No further costs have been identified for this module.

Assessment

You must pass all assessment components to pass the module.

Assessment group D8

	Weighting	Study time
Gait laboratory Essay	30%	
Assignment: Gait laboratory (max 8 sides A4 excluding title page, references and appendices)		
Written Exam	70%	
2 HR written exam		

- Answerbook Pink (12 page)
- Students may use a calculator
- Engineering Data Book 8th Edition
- Graph paper

Feedback on assessment

Seminars and Revision Classes to align student expectation with requirements for assessment, and preparation for coursework. Coursework marked with detailed individual comments (aligned with assessment criteria) together with cohort feedback. Cohort level feedback on examinations.

[Past exam papers for ES97E](#)

Availability

Courses

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
- Year 1 of TESA-H341 Postgraduate Taught Advanced Mechanical Engineering
- Year 1 of TESA-H800 Postgraduate Taught Biomedical Engineering

This module is Option list A for:

- Year 4 of UESA-H114 MEng Engineering

This module is Option list B for:

- Year 4 of UESA-H311 MEng Mechanical 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
- Year 4 of UESA-HH31 MEng Systems Engineering
- Year 4 of UESA-HH33 MEng Systems Engineering with Exchange Year
- Year 5 of UESA-HH32 MEng Systems Engineering with Intercalated Year
- Year 4 of UCSA-G408 Undergraduate Computer Systems Engineering
- Year 5 of UCSA-G409 Undergraduate Computer Systems Engineering (with Intercalated Year)

This module is Option list C for:

- UESA-H311 MEng Mechanical Engineering
    - Year 4 of H30G Mechanical Engineering with Business Management
    - Year 4 of H30P Mechanical Engineering with Fluid Dynamics
    - Year 4 of H30H Mechanical Engineering with Sustainability