BIOM9561

The Mechanical Properties of Biomaterials

Session 2, 2013
COURSE STAFF

Course coordinator: Penny Martens
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Consultation times: During office hours but please email for an appointment.

Lecturers
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Prof Melissa Knothe Take, m.knothetate@unsw.edu.au

COURSE INFORMATION

Background
BIOM9561 provides a theoretical and practical understanding of the mechanical properties of biomaterials. The course aims to bring an understanding of the fundamental relationships between the mechanical properties of a range of biomaterials and the biomedical applications of those materials. It looks at several applications of materials and the principles that have led to the choice of biomaterials for those applications. The use and properties of each type of material will be discussed in the light of current clinical applications (implants, surgical tools, catheters, biological implants). The major study topics include:

- **Principles of materials science and mechanical properties.** Refresher on basic concepts: the structure of solids, static mechanical properties eg stress, strain, failure, fracture toughness, multiaxial load analysis, simple bending, dynamic mechanical properties eg fatigue, viscoelasticity, creep, mathematical models of materials, tribology, wear, lubrication, testing methodology.

- **Polymers.** Mechanical properties of polymers and their relationship to polymer structure, molecular weight, crystallinity, fillers, plasticisers and cross-linking. Applications of polymers in medicine, eg soft tissue augmentation or repair, medical device coverings, catheters, sutures, tools, devices and problems with current generation polymers for their applications eg degradation.

- **Biological materials.** Mechanical properties and structures of tendons, ligaments, bone and cartilage, soft tissues. Applications of devices made from materials of biological origin (eg. coraline hydroxyapatite, collagen implants). Problems of use of treated biological tissues (resorption, inflammation, disease).

- **Ceramics.** Mechanical properties and production of bioceramics: inert (Al₂O₃, zirconias, silicon nitride) and bioactive (hydroxyapatite and other calcium phosphates, bioglass, calcium sulphates). Applications of ceramics in medicine (artificial joints, coatings, heart valves) and problems with use of ceramics (wear particles, poor union to bone).

- **Metals.** Properties of the major metals in use in medicine (316L stainless steel, cobalt chrome, titanium and titanium alloys). Applications in orthopaedics (eg. joints, plates screws, rods, bars), dentistry (dental implants, braces, fillings) neurological implants (eg. cochlear, pacemaker) and general surgery (tools) and problems with metals including corrosion, heavy metal ion release, wear and ductile failure.
• **Composites.** Mechanical behaviour of composite materials and their use to optimise mechanical properties and behaviour. Composite behaviour for simple classes of clinically useful composites. Applications of composites in dentistry and medicine including fillings, artificial skin, bone plates, bone substitutes and devices and problems with composite materials in medicine (e.g. matrix failure, delamination).

**Units of credit:** 6

BIOM9651 is a 6 UOC course and it is expected that you will devote 10 to 11 hours per week to this course. In addition to the 3 hours in class, you should spend 7 to 8 hours per week reading lecture and reference materials and working on tutorial problems and assignments.

**Presumed knowledge**

Some mathematics background and knowledge of basic mechanics is essential. The essential material will be reviewed during the course.

**Aims**

The aims of this course are to:

- develop an understanding of the relationships between material properties and the biomedical applications of materials
- review several applications of materials and the principles that have led to the choice of those materials
- relate the properties and use of each type of material in the light of current clinical applications (implants, surgical tools, catheters, biological implants) to develop a deeper understanding of the field of biomaterials

**Expected learning outcomes**

On completion of this course, the student should:

- have a broad understanding of fundamental mechanical principles as they relate to biomaterials
- be able to discuss, develop and apply these mechanical principles to a range of biomaterials and medical applications.
- critically review the literature in the area and apply knowledge gained from the course to analyse mechanical properties of biomaterials
- clearly summarise and communicate findings from literature research using oral and written methods

These learning outcomes relate most strongly to the following UNSW graduate capabilities:

- understanding of their discipline in its interdisciplinary context
- capable of independent and collaborative enquiry
- able to apply their knowledge and skills to solving problems
- collaborative and effective team workers

They are also moderately related to:

- information literate
- digitally literate
- enterprising, innovative and creative
Teaching strategies

Each week there will be a 3 hour period comprising a lecture and small group exercises, group discussions and other methods to facilitate student learning. The lectures will examine the mechanical properties of biomaterials and will provide students with the basic knowledge to solve the on line and in class tutorial problems as well as complete the assignments. Feedback on assessments and tutorial work will be regularly provided.

Suggested approach to learning

This course requires you to understand the lecture material and then apply the knowledge to biomaterial applications. It is important to understand the fundamental concepts as soon as possible and to ask for help if you do not understand. Attend all the lectures and if something is unclear, please ask questions. Make sure you review all the lecture notes and read all material that is suggested or handed out. Class participation through attendance at lectures and participation in class exercises and group work is expected and will allow for alternative methods of absorbing the relevant information.

COURSE RESOURCES

Lecture notes for the course will be available via Blackboard at http://lms-blackboard.telt.unsw.edu.au/webapps/portal/frameset.jsp. Some useful reference books that are held in the UNSW Library are listed below:

**Basic Principles**

Biomaterials, J.B. Park and R.S. Lakes MB617.95/39B
Biomaterials Science. BD Ratner, AS Hoffman, FJ Schoen and JE Lemons, Elsevier San Diego, 2004 MBQ 610.28/190

**Biological Tissues**

The Mechanical Properties of Biological Materials, SEB, Cambridge University Press, 1980 MB574.1912/6

**Polymers**

Polymers: Strength and physics of modern materials, JMG Cowie, Intertext, London, 1933 P547.84/170C
Strength and Stiffness of Polymers P620.192/35
Estimation of Properties, DW van Krevelen P620.192/16A
Wear and Friction of Elastomers, R.Denton & MK Keshavan, ASTM, Philadelphia, 1992 P620.19492/1
ASSESSMENT

The assessment for the course has been designed to measure your achievement of the learning outcomes. You are expected to attend all lectures, tutorials and practical sessions and assessment will be via a series of on line tutorials (total 10%), one assignment worth 10%, a lab worth 10%, a group project and presentation worth 20%, a mid-term exam worth 15% and the final exam worth 35%. The following criteria will be applied in assessing your work:

- evidence of critical understanding of the concepts developed in the course
- ability to apply these concepts to a range of biomaterial problems
- clarity of description, explanation and attention to the focus of the assessment task
- capacity to structure an assessment task logically and limit it to the length required
- degree to which the material submitted for assessment addresses the specified requirements

In order to pass this course, you must submit all assessment components, achieve a composite mark of at least 50% and achieve a mark of at least 50% on the final exam. Assessment of this course has been designed to maximise your learning opportunities. The assessment items apply all the main knowledge and skills areas in the course. In particular, they provide you with an opportunity to:

- synthesise and integrate the core concepts and issues raised in the lectures, practicals and tutorials,
- develop skills in evaluating and conveying arguments and issues,
- share ideas, knowledge and different perspectives during seminar preparation, tutorials and practical sessions and
- receive ongoing feedback on your learning.

On line tutorials (10%)

Students will complete a series of on line tutorials which can be accessed via Blackboard 9. Each tutorial has a quiz at the end of the revision material and these should be submitted via Blackboard 9.
Assignment (10%)  
To complete the assignment, students will use fundamental material from the lectures and apply it to a variety of models. It is expected that the assignment report will clearly detail the model used and the method of solution including all assumptions. This assessment is a direct measure of the degree to which the learning outcomes described above have been achieved.

Assignments and reports should be submitted on time. A daily penalty of up to 10% of the marks available for that assignment will apply for work received after the due date. The only exemption will be when prior permission for late submission has been granted by the Course coordinator. Extensions will be granted only on medical or compassionate grounds under extreme circumstances. Requests for extension must be made in writing to the Course Coordinator prior to the due date with supporting medical certificates or other evidence attached to the request.

Lab (10%)  
Students will work in groups to complete a lab. This lab will involve mechanical testing of various materials related to biomedical applications. This assessment task should allow students to put into practice many of the concepts discussed in class. A lab report will be marked. More information will be provided in class, closer to the date of the lab.

Group project and presentation (20%)  
The objectives of the group project and presentation are to consolidate information learned in class and to develop literature research skills and skills relating to working in a group. Specific literature research skills developed and reinforced are critical review of the medical, scientific and engineering literature, communication of findings and application of knowledge from literature and course materials for analysing biomechanical applications. This assessment is a direct measure of the degree to which the learning outcomes described above have been achieved.

Mid Term exam (15%)  
You will sit a 1 hour examination in week 7 of the session. The mid term exam may be made up of any of the following: true/false, multiple choice, matching, short answer and essay questions. The aims of this assessment are to encourage you to review the first half of course and to allow you to apply all the knowledge gained to solve a range of problems. This assessment is a direct test of the degree to which the knowledge based learning outcomes listed above have been achieved.

Final exam (35%)  
You will sit a 3 hour examination at the end of the session during the formal examination period. The final exam may be made up of any of the following: true/false, multiple choice, matching, short answer and essay questions. The aims of this assessment are to encourage you to review the entire course, with a greater emphasis on the second half, and to allow you to apply all the knowledge gained to solve a range of problems. This assessment is a direct test of the degree to which the knowledge based learning outcomes listed above have been achieved.

You must achieve a minimum of 50% in the final exam to pass the course.
HOW THIS COURSE RELATES TO OTHER COURSES

BIOM9561 is part of the suite of biomechanics courses offered by the Graduate School of Biomedical Engineering and School of Safety Science which include: BIOM9510 Introductory Biomechanics, BIOM9541 Mechanics of the Human Body, and SESC9451 Experimental Biomechanics. Related courses are BIOM9551 The Biomechanics of Physical Rehabilitation and BIOM9701 Dynamics of the Cardiovascular System.

CONTINUAL COURSE IMPROVEMENT

Student feedback on the course and the lecturers in the course is gathered periodically using the university's Course and Teaching Evaluation and Improvement (CATEI) Process. Your feedback is much appreciated and taken very seriously. Continual improvements are made to the course based in part on such feedback and this helps us to improve the course for future students. In the 2012 course, students were mainly concerned about feedback and lecture notes.

An emphasis on improving Feedback will be undertaken. Details of how feedback will be given will be clearly defined in week 1. In particular, answers to quizzes will be discussed in class after the quiz is returned. All assessment tasks will be marked and handed back before the final examination. In addition, individual feedback on any aspect of the class can be gained through an appointment with the course coordinator. In addition, students with low marks will be notified confidentially via email, and be asked to set up appointments to discuss success strategies.

Every effort will be made to improve the lecture notes. Where possible, notes will be provided on Blackboard at least 1 day before the lecture.
### BIOM9561: Mechanics of Biomaterials

#### COURSE SCHEDULE, S2 2013

**Time:** Wednesdays, 1-4pm  
**Location:** Tyree LG03

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<tr>
<th>Date</th>
<th>Week</th>
<th>Topic</th>
<th>Lecturer</th>
<th>Assessments Due</th>
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<tr>
<td>31 July</td>
<td>1</td>
<td>Course outline and general overview. Intro to materials and mechanics</td>
<td>PM OS</td>
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<tr>
<td>7 August</td>
<td>2</td>
<td>Metals 1</td>
<td>OS</td>
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<tr>
<td>14 August</td>
<td>3</td>
<td>Metals 2</td>
<td>OS</td>
<td>Tutorials: Bonding, Stress-Strain</td>
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<td>21 August</td>
<td>4</td>
<td>Ceramics 1</td>
<td>OS</td>
<td>Tutorials: Tensile, Dislocation,</td>
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<td>28 August</td>
<td>5</td>
<td>Ceramics 2</td>
<td>OS</td>
<td>Tutorial: Light Alloys</td>
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<td>4 September</td>
<td>6</td>
<td>Composites</td>
<td>OS</td>
<td>Mid Term Exam</td>
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<td>11 September</td>
<td>7</td>
<td>Biological tissues 1</td>
<td>MKT</td>
<td>Tutorial: Fracture, Ceramics</td>
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<tr>
<td>18 September</td>
<td>8</td>
<td>Biological tissues 2</td>
<td>MKT</td>
<td>Tutorial: Composites</td>
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<td>25 September</td>
<td>9</td>
<td>LAB</td>
<td></td>
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<td>2 October</td>
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<td>Mid-semester break</td>
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<td>9 October</td>
<td>10</td>
<td>Polymers 1</td>
<td>PM</td>
<td>Lab Report</td>
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<td>16 October</td>
<td>11</td>
<td>Polymers 2</td>
<td>PM</td>
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<td>23 October</td>
<td>12</td>
<td>Group project presentations</td>
<td>PM</td>
<td>Polymer Assignment Group report Group Presentation</td>
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Course Coordinator: Penny Martens (PM), x53902, p.martens@unsw.edu.au

Other Lecturers: Owen Standard (OS), x54437, o.standard@unsw.edu.au  
Dr Melissa Knothe Tate (MKT), m.knothetate@unsw.edu.au

**Assessment:**  
- Tutorials: 10%  
- Group Report and Presentation: 20%  
- Assignments: 10%  
- Lab: 10%  
- Mid Term Examination: 15%  
- Final Theory Examination: 35%
ADMINISTRATIVE MATTERS

Please consult the policies of the Graduate School of Biomedical Engineering on academic matters which can be found at http://www.gsbme.unsw.edu.au/info-about/our-school/academic-matters_10041. You should pay particular attention to the School’s policy on plagiarism. If you are at all uncertain about what constitutes plagiarism and how to avoid it, The Learning Centre has excellent advice on recognizing and avoiding plagiarism at http://www.lc.unsw.edu.au/plagiarism/pintro.html. All assignments in this course must be accompanied by a signed GSBmE cover sheet available from the school’s website at http://www.gsbme.unsw.edu.au/info-about/our-school/academic-matters_10041.

UNSW has a wide range of student support services. The resources listed below should be used by students needing assistance related to aspects of their overall University experience. Specific help regarding this course can be sought from the course coordinator.

http://www.student.unsw.edu.au/
https://my.unsw.edu.au/student/howdoi/HowDoI_MainPage.html
http://www.counselling.unsw.edu.au/

Those students who have a disability that requires some adjustment in their teaching or learning environment are encouraged to discuss their study needs with the course coordinator prior to, or at the commencement of, their course, or with the Student Equity Unit (http://www.studentequity.unsw.edu.au/). Issues to be discussed may include access to materials, signers or note-takers, the provision of services and additional exam and assessment arrangements. Early notification is essential to enable any necessary adjustments to be made.

If you believe that your performance in an assessable component of the course has been affected by illness or another unexpected circumstance, you should make an application for special consideration as soon as possible after the event by visiting UNSW Student Central. Please talk to the course coordinator as well and note that considerations are not granted automatically.

UNSW has strict policies and expectations relating to Occupational Health and Safety (OHS) and these can be accessed at http://www.ohs.unsw.edu.au/.