Biomedical Engineering

Biomedical Engineering - undergraduate course structure

Bachelor of Engineering (Biomedical Engineering)

The course structure below represents the core content for the first two years of the BE (Biomedical Engineering) degree. All students should check that they are enrolled in the subjects listed, as appropriate to the stream of Biomedical Engineering that they have selected. All students enrol in the same set of subjects in semester 1 of their first year and nominate their stream in semester 2 of their first year. Later year structures for this course will be published as they become available (for example, the fourth year of the course will be published in 2008 when the fourth year is first taught). For further information and up-to-date course advice, students should regularly check the Faculty of Engineering web page at <http://www.bme.unimelb.edu.au>

When setting the timetable every effort will be made to avoid clashes between the times of classes associated with these sets of subjects. Students should be aware however, that if it proves to be impossible to achieve a timetable without clashes in these sets of subjects, the Faculty reserves the right to modify these course structures in order to eliminate the conflicts. Students will be advised during the enrolment period of the semester if the recommended courses need to be varied.

First year (biocellular)		Points
Semester 1		
650-131	Biomed: Molecules, Cells & Organisms *(p.1)*	12.5
610-051	Chemistry (Biomedical Science A) *(p.1)*	12.5
620-121	Mathematics A (Advanced) *(p.4)*	12.5
or		
620-141	Mathematics A *(p.5)*	12.5
421-140	Introduction to Biomedical Engineering *(p.2)*	12.5
Semester 2		
650-132	Biomed: Genetics & Biodiversity *(p.1)*	12.5
610-052	Chemistry (Biomedical Science B) *(p.1)*	12.5
620-123	Applied Mathematics (Advanced) *(p.4)*	12.5
or		
620-143	Applied Mathematics *(p.5)*	12.5
411-102	Chemical Process Analysis *(p.5)*	12.5

Second year		Points
Semester 1		
521-225	Integrated Biomedical Science *(p.3)*	25
431-201	Engineering Analysis A *(p.11)*	12.5
421-285	Bioengineering Systems Modelling 1 *(p.2)*	12.5
Semester 2		
536-225	Integrated Biomedical Science II *(p.3)*	25
431-202	Engineering Analysis B *(p.12)*	12.5
421-286	Bioengineering Systems Modelling 2 *(p.2)*	12.5

Third year		Points
Semester 1		
411-254	Biomolecular Process Principles *(p.6)*	12.5
531-301	Cellular Basis of Disease *(p.1)*	12.5
534-301	Cellular and Molecular Pharmacology *(p.1)*	25
Semester 2		
411-336	Process Dynamics and Control *(p.7)*	12.5
411-391	Bionanoengineering *(p.8)*	12.5
411-394	Tissue Engineering *(p.2)*	12.5
436-387	Molecular Cellular & Tissue Biomechanics *(p.3)*	12.5

First year (bioinformatics)		Points
Semester 1		
650-131	Biomed: Molecules, Cells & Organisms *(p.1)*	12.5
610-051	Chemistry (Biomedical Science A) *(p.1)*	12.5
620-121	Mathematics A (Advanced) *(p.4)*	12.5
or		
620-141	Mathematics A *(p.5)*	12.5
421-140	Introduction to Biomedical Engineering *(p.2)*	12.5
Semester 2		
650-132	Biomed: Genetics & Biodiversity *(p.1)*	12.5
610-052	Chemistry (Biomedical Science B) *(p.1)*	12.5
620-123	Applied Mathematics (Advanced) *(p.4)*	12.5
or		
620-143	Applied Mathematics *(p.5)*	12.5
433-171	Introduction to Programming *(p.17)*	12.5

Second year		Points
Semester 1		
521-225	Integrated Biomedical Science *(p.3)*	25
421-285	Bioengineering Systems Modelling 1 *(p.2)*	12.5
431-201	Engineering Analysis A *(p.11)*	12.5
Semester 2		
536-225	Integrated Biomedical Science II *(p.3)*	25
421-286	Bioengineering Systems Modelling 2 *(p.2)*	12.5
433-172	Algorithmic Problem Solving *(p.17)*	12.5

Third year		Points
Semester 1		
436-386	Biomaterials *(p.2)*	12.5
433-252	Software Engineering Principles & Tools *(p.17)*	12.5
433-253	Algorithms and Data Structures *(p.17)*	12.5
Approved elective		12.5
Semester 2		
436-387	Molecular Cellular & Tissue Biomechanics *(p.3)*	12.5
433-255	Logic and Computation *(p.18)*	12.5
433-254	Software Design *(p.17)*	12.5
Approved elective		12.5

First year (biomechanics)		Points
Semester 1		
650-131	Biomed: Molecules, Cells & Organisms *(p.1)*	12.5
620-121	Mathematics A (Advanced) *(p.4)*	12.5
or		
620-141	Mathematics A *(p.5)*	12.5
421-140	Introduction to Biomedical Engineering *(p.2)*	12.5
610-051	Chemistry (Biomedical Science A) *(p.1)*	12.5
Semester 2		
650-132	Biomed: Genetics & Biodiversity *(p.1)*	12.5
433-171	Introduction to Programming *(p.17)*	12.5
620-123	Applied Mathematics (Advanced) *(p.4)*	12.5
or		
620-143	Applied Mathematics *(p.5)*	12.5
436-121	Introduction to Mechanical Engineering *(p.6)*	12.5

Second year		Points
Semester 1		
521-225	Integrated Biomedical Science *(p.3)*	25
431-201	Engineering Analysis A *(p.11)*	12.5
421-285	Bioengineering Systems Modelling 1 *(p.2)*	12.5
Semester 2		
536-225	Integrated Biomedical Science II *(p.3)*	25
431-202	Engineering Analysis B *(p.12)*	12.5
421-286	Bioengineering Systems Modelling 2 *(p.2)*	12.5

Third year		Points
Semester 1		
436-285	Engineering Design and Materials 1 *(p.7)*	12.5
436-382	Control Systems 1 *(p.9)*	12.5
436-386	Biomaterials *(p.2)*	12.5
436-388	Introduction to Biomechanics *(p.3)*	12.5
Semester 2		
436-201	Thermofluids 1 *(p.6)*	12.5
436-286	Engineering Design & Materials 2 *(p.8)*	12.5
436-387	Molecular Cellular & Tissue Biomechanics *(p.3)*	12.5
620-370	Statistics for Mechanical Engineers *(p.12)*	12.5

First year (biosignals)		Points
Semester 1		
650-131	Biomed: Molecules, Cells & Organisms *(p.1)*	12.5
610-051	Chemistry (Biomedical Science A) *(p.1)*	12.5
620-121	Mathematics A (Advanced) *(p.4)*	12.5
or		
620-141	Mathematics A *(p.5)*	12.5
421-140	Introduction to Biomedical Engineering *(p.2)*	12.5
Semester 2		
650-132	Biomed: Genetics & Biodiversity *(p.1)*	12.5
640-142	Physics B *(p.3)*	12.5
620-123	Applied Mathematics (Advanced) *(p.4)*	12.5
or		
620-143	Applied Mathematics *(p.5)*	12.5
433-171	Introduction to Programming *(p.17)*	12.5

Second year		Points
Semester 1		
521-225	Integrated Biomedical Science *(p.3)*	25
421-285	Bioengineering Systems Modelling 1 *(p.2)*	12.5
431-201	Engineering Analysis A *(p.11)*	12.5
Semester 2		
536-225	Integrated Biomedical Science II *(p.3)*	25
421-286	Bioengineering Systems Modelling 2 *(p.2)*	12.5
or		
431-221	Fundamentals of Signals and Systems *(p.12)*	12.5
431-202	Engineering Analysis B *(p.12)*	12.5

Third year		Points
Semester 1		
436-386	Biomaterials *(p.2)*	12.5
or		
436-388	Introduction to Biomechanics *(p.3)*	12.5
431-330	Design Laboratory *(p.13)*	12.5
431-324	Control 1 (Classical Control) *(p.12)*	12.5
431-325	Stochastic Signals and Systems *(p.13)*	12.5
Semester 2		
436-387	Molecular Cellular & Tissue Biomechanics *(p.3)*	12.5
431-335	Signal Processing 1 (Fundamentals) *(p.13)*	12.5
431-336	Neurons:From Action Potential to Learn'g *(p.14)*	12.5
Approved non-technical elective		12.5

Subject descriptions

610-051 Chemistry (Biomedical Science A)

See full subject details on page 1.

610-052 Chemistry (Biomedical Science B)

See full subject details on page 1.

620-121 Mathematics A (Advanced)

See full subject details on page 4.

620-123 Applied Mathematics (Advanced)

See full subject details on page 4.

620-141 Mathematics A

See full subject details on page 5.

620-143 Applied Mathematics

See full subject details on page 5.

640-142 Physics B

See full subject details on page 3.

650-131 Biomed: Molecules, Cells & Organisms

See full subject details on page 1.

650-132 Biomed: Genetics & Biodiversity

See full subject details on page 1.

411-394 Tissue Engineering

Credit points: 12.5

Coordinator: Dr A O'Connor

Prerequisites: 521-225 Integrated Biomedical Science, 536-225 Integrated Biomedical Science II

Contact: Thirty-six hours of lectures, 12 hours of tutorials *(Semester 2).*

Description: History, current status and potential of tissue engineering, major materials and fabrication methods for biomaterial scaffolds, scaffold strength and degradation. Cell-surface interactions, biocompatibility and surface engineering. The influence and delivery of growth factors in tissue engineering. Scale-up issues in vitro and in vivo, quantitative aspects of tissue engineering (including cell migration, molecular transport and mechanics in-vivo). Transplantation of engineered cells and tissues, in-vivo synthesis of tissues and organs, use of pluripotent stem cells. Clinical applications of tissue engineering such as bone regeneration vascular grafts, breast reconstruction, cardiac and corneal prostheses, artificial organs (eg. pancreas).

Assessment: An end-of-semester examination of three hours contributing 80% of the final assessment and an assignment not exceeding 4000 words contributing 20% of the assessment, due in the second half of the semester.

421-140 Introduction to Biomedical Engineering

Credit points: 12.5

Coordinator: Prof. D. W. Smith

Contact: Thirty-six hours of lectures, 12 hours of tutorials *(Semester 1).*

Description: Definition and scope of biomechanical engineering. Brief history of medicine, including human anatomy, physiology, and the rise of modern molecular biology. Description of the development of quantitative methods in biology, and the role of engineering in understanding complex biological systems. Brief description of relevant laws, professional ethics and regulatory environment.

Assessment: A 2-hour end-of-semester examination (50%): 30-minute mid-semester test (10%): three assignments each of 1000 word equivalent, due throughout the semester (30%): one concept design (10 page report including text and diagrams) at the end of semester (10%).

421-285 Bioengineering Systems Modelling 1

Credit points: 12.5

Coordinator: Prof. D. W. Smith

Contact: Thirty-six hours of lectures, twelve hours of tutorials *(Semester 1).*

Description: This subject will present material that complements and reinforces selected portions of material presented in the subject Biomedical Science I (521-213). The emphasis is on developing quantitative engineering models describing biological systems at the cellular and tissue scale.

Students will be introduced to the process of developing engineering models of biological systems, and to powerful simulation software for the solution of the mathematical equations describing the system behaviour. When possible, examples will be related to disease processes and the way in which engineering principles can be employed to improve understanding of the biological origin of disease, and subsequent differential diagnosis and patient management.

Assessment: A 2-hour end-of-semester examination (50%): 30-minute mid-semester test (10%): two assignments each of 1000 word equivalent, due throughout the semester (20%): one concept design (10 page report including text and diagrams) at the end of semester (10%): two laboratory work sessions and associated reports scheduled equally throughout the semester (10%).

421-286 Bioengineering Systems Modelling 2

Credit points: 12.5

Coordinator: Prof. D. W. Smith

Contact: Thirty-six hours of lectures, twelve hours of tutorials *(Semester 2).*

Description: This subject will present material that complements and reinforces selected portions of the material presented in the subject Biomedical Science II (536-250). The emphasis is on developing quantitative engineering models describing biological systems at the organ and whole body scale.

Students will be introduced to the process of developing engineering models of biological systems, and to powerful simulation software for the solution of the mathematical equations describing the system behaviour. When possible, examples will be related to disease processes and the way in which engineering principles can be employed to improve understanding of the biological origin of disease, and subsequent differential diagnosis and patient management.

Assessment: A 2-hour end-of-semester examination (50%): 30-minute mid-semester test (10%): four assignments each of 1000 word equivalent, due throughout the semester (30%): two laboratory work sessions and associated reports scheduled equally throughout the semester (10%).

436-386 Biomaterials

Credit points: 12.5

Contact: Thirty-two hours of lectures, 12 hours of tutorials and 4 hours of laboratory work *(Semester 1).*

Description: Biomaterials are produced naturally by living systems, and may be manufactured to fulfil a purpose within the body. This subject provides the basis for material acceptance before any implant or device can be integrated into the biological system. Materials in the form of solids, micro and nanoparticles, layers and coatings, and porous materials will be addressed. An emphasis will be placed on the production, structure, properties and function of materials. This will provide the background to design implanted materials with the knowledge of materials (ceramics, metals, plastics, elastomers and composites), their processing and cellular reaction. Biomaterials as inert, active and resorbable bodies will be discussed. This will be followed by a discussion on biocompatibility, and cellular events during the repair of damaged tissue. Natural biomaterials produced by living systems, in dense, porous and particulate form will cover a range of natural materials covering biomineralized tissues and deposits and protein based biomaterials (keratins, silks, collagens, protein elastomers). With a knowledge of material design and natural systems, the final topic on smart materials will provide a platform into intelligent systems. This will set the scene for cutting edge devices that interact with the tissue and organs, or are modified in response to the biological environment.

Assessment: Final exam 3-hours (50%), project report 10 pages due during semester (30%), lab report based on practical work performed during semester (15%) and mid semester quiz 1-hour (5%).

436-387 Molecular Cellular & Tissue Biomechanics

Credit points: 12.5

Contact: Thirty-two hours of lectures, 12 hours of tutorials and 4 hours of laboratory work *(Semester 2).*

Description: Mechanical properties of macromolecules, cells and tissues. Methods for measuring the mechanical properties of these materials. Molecular basis for cell motility. Response of cells to biochemical, mechanical and electromagnetic fields. Continuum models describing soft and hard tissue mechanics. Modelling injury arising from impact. Modelling cell motility, neoplastic growth and metastasis. Modelling tumour treatment using various modalities, including drug and radiotherapy. Biomechanics of cartilage and bone. Importance of the mechanical and chemical environment in cellular differentiation and apoptosis. Structural organisation of bone and cartilage and the relation of structure to maintaining healthy tissue. Repeat mechanisms, tissue turnover and genomic responses to the mechanical and chemical environment. Overview of orthopaedic devices used for the replacement and repair of diseased tissue in the musculoskeletal system (including design, manufacture and use of various prostheses). Continuum modelling of orthopaedic devices in-vivo. When possible, mechanical properties, engineering analysis and biological processes are related to clinically important conditions like osteoporosis and osteoarthritis and the performance of prostheses in-vivo.

Assessment: One 2-hour examination (60%) and two assignments of 2000 words each or equivalent (40%).

436-388 Introduction to Biomechanics

Credit points: 12.5

Prerequisites: Students will be expected to be familiar with material covered in 436-121 Introduction to Mechanical Engineering (prior to 2005 436-101 Engineering Mechanics and Materials) and 431-202 Engineering Analysis B or equivalent

Contact: Thirty-two hours of lectures, 12 hours of tutorials *(Semester 1).*

Description: This subject provides an introduction to modelling of the human body at the macroscopic level. On completion of this subject students should understand principles of the two-dimensional mechanics of a rigid body; be able to carry out dynamic analysis of planar mechanical systems and apply these concepts to carry out analysis on the Biomechanics of Jumping/Hopping, Biomechanics of walking/running and animal locomotion. Students should then be able to mathematically model, joint mechanics, kinematics and dynamics of human gait analysis. Where possible, modelling will be related to understanding the origin of gait defects and planning corrective prosthetic or surgical interventions. Topics covered include dynamics of a particle in terms of inertial frames (work, kinetic energy, power, equations of motion), plane dynamics of a rigid body (kinetic energy, moments of inertia, equations of motion), dynamics of plane mechanisms (constraints, mobility, degrees of freedom, equations of motion), mechanical vibrations of one-degree-of-freedom linear systems (modelling, free vibrations, forced vibrations), Interchange of Kinetic and Potential Energy During Movement, VO2 consumption during walking and running, Efficiency of Movement, Positive/ Negative Work: Concentric/Eccentric Contractions, Joint Reaction Forces, Joint Power.

Assessment: One 3-hour end of semester written examination (80%), together with one assignment not exceeding 2000 words (20%).

521-225 Integrated Biomedical Science

Note: This subject is only available to Bachelor of Biomedical Engineering students

Credit points: 25

Coordinator: A/Prof T Lithgow; Dr T Mulhern

Prerequisites: 650-131 and 650-132; or 600-131 and 600-132 prior to 2004

Contact: Six hours of lectures and three hours of practical or self-directed computer-based learning exercises per week *(Semester 1).*

Description: This multidisciplinary subject blends biochemistry, molecular and cell biology, tissue biology and physiology, to develop knowledge of the relationship between the structure and function of the major classes of biomolecules, higher ordered structures and cells, as well as the contribution these molecules make to cellular, tissue and whole systems biology. The biochemistry component (36 lectures) covers structure and function of proteins, biological membranes and nucleic acids; and an introduction to recombinant DNA technology, including genome analysis, proteomics and bioinformatics. The cell biology stream (24 lectures) includes the histology and ultrastructure of cells and basic tissue types, epithelium, muscle, nerve, haemopoietic and connective tissues; and the organisation of the major organs and the structure and function of cellular organelles, cytoskeletal structures and the extracellular matrix. The introductory physiology stream (12 lectures) will concentrate on mammalian (especially human) physiology: homeostasis, the relationship between organs and organ systems, cell physiology, excitable cells and electrolyte transport. Practical work will develop basic experimental, data analysis and interpretation skills in biochemistry, physiology and cell and tissue biology techniques. In addition to the specific skills gained, students will think critically and organise knowledge from diverse resources, expand from theoretical principles to practical explanations and acquire abilities in collaborative work.

Assessment: Two 2-hour end-of-semester examinations on the theory and practical work (70%); laboratory practical work (15%); short (1500-word) written assignment (10%); multiple-choice tests (5%).

536-225 Integrated Biomedical Science II

Note: This subject is only available to Bachelor of Biomedical Engineering students

Credit points: 25

Coordinator: Associate Prof. Robert Kemm

Prerequisites: 521-225 Integrated Biomedical Science

Contact: Sixty-six hours of lectures and 54 hours of practicals and computer-aided learning classes *(Semester 2).*

Description: The overall aim will be to build on the knowledge developed in 521-225 Integrated Biomedical Science and to extend coverage to include the intermediary metabolism, organ and whole systems physiology and tissue biology, genes and gene expression and the major regulatory systems. The biochemistry stream (22 lectures) will cover metabolism, bioenergetics, waste elimination, regulation of metabolism including the molecular basis of cell signalling, molecular mechanisms and regulation of gene replication, expression and protein synthesis. Biochemistry will also combine with physiology to cover integrated whole body responses to metabolic and physiological stress and nutrition. The physiology stream (44 lectures) will concentrate on the transduction of neurotransmitter, hormone and other messages; control systems common to many organs, the autonomic nervous system and the endocrine system. Coverage of specific organ systems will include renal, respiratory and cardiovascular systems, digestive and excretory, reproductive, locomotor, neurophysiology (taught with relevant histology and structure in conjunction with anatomy and cell biology). The practical work will be designed to develop and extend experimental, data analysis and interpretation skills in biochemistry and physiology techniques. Following completion of this subject, students should be able to develop communication skills (written and oral), critical thinking and analytical skills and participate effectively as a team member.

Assessment: Weekly assessment of written practical class reports of less than 1500 words (15%); and computer-aided learning classes (5%); online e-learning (5%) and 1 scientific report in a journal format of less than 2000 words (10% total); one 1-hour written examination held mid-semester (15%); two 2-hour written examinations in the examination period on theory and practical work (25% each).

Prescribed texts: Dee U. Silverthorn, *Human Physiology*, 4th edn. Pearson Education. **or** Rhoades and Pflanzer, *Human Physiology,* 4th edn. Thomas Learning. **or** Sherwood, *Human Physiology: From Cells to Systems,* 5th edn. Thomas learning and. • Stryer, *Biochemistry,* 4th edn. WH Freeman and Co. **or** Nelson and Cox, *Lehninger Principles of Biochemistry,* 3rd edn. Worth Publishers.