Syllabus for B.Sc. Engineering Honours Degree Programme

Biomedical Engineering Specialization

Department of Electronic and Telecommunication Engineering,

University of Moratuwa

(Effective from Intake 2020)

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*****Refer the ENTC syllabus for the other modules offered in the BME program.

Semester 2

BM1190: Engineering Design Project

Intake	2020 onwards	Specialization	Biomedical Engineering		
Semester	**Code**	**Module Title**		**C/E/O**	**GPA / NGPA**
2	BM1190	Engineering Design Project		C	GPA
Hours/Week		**Credits**	**Prerequisites / Corequisites**	**Evaluation %**	
Lecture	**Lab/Tutes**			**CA**	**WE**
2	4	4.0	-	100	-

Learning Outcomes

At the end of the module the student will be able to:

1. Describe major areas of biomedical engineering applications
2. Use of modularity and abstraction in solving engineering problems
3. Explain basic engineering design principles
4. Use of design tools for electronic product prototyping
5. Identify various manufacturing processes involved in electronic product manufacture
6. Design of a medical product prototype to comply with a given technical specifications
7. Analysis of performance, safety and manufacturability of developed prototype
8. Discuss the moral and ethical issues in medical research and development

Syllabus Outline

1. **Core aspects of biomedical engineering applications**
   - Introducing specific applications related to biomedical engineering through real world products and research, emphasising the underlying human anatomy and physiology, technology and associated ethics and safety.
2. **Handling complexity through modularity and abstraction**
   - Modularity and abstraction as the basis for handling complexity in engineering design.
3. **Engineering design principles**
   - Introduction to engineering design, life cycle of engineering products and processes, design processes and design tools, concurrent engineering, creativity and reasoning, analysis and synthesis, simulations, evaluation and decision making
4. **Basic software tools needed for electronic design and manufacture**
   - Electronic circuit design software, simulation software, solid modelling software and thermal analysis software.
5. **Product dissection**
   - Electronic product disassembly and identification of manufacturing processes.
6. **PCB manufacturing**
   - Schematic design, layout design, design rules, photo-tool creation, drilling, plating, etching, solder masking.
7. **Essential processes in PCB assembly**
   - Component mounting: through-hole component forming, component insertion, surface mounting, soldering methods: hand soldering, wave soldering, reflow soldering.

8. **Enclosures**
   - Injection moulding, metal forming, metal punching.
9. **Guided design project**
   - a) gathering of data and information from various sources as a preliminary to the design
   - b) preparing a work plan and delegating duties
   - c) working with others and to produce results by given deadlines and within given costs
   - d) learning the basic procedures required for conceptual, preliminary and detailed designs
   - e) learning the importance of the cost component in the manufacturing process
   - f) learning the importance of considering the limitations of manufacturing processes during design
   - g) preparing a report and making a presentation on the work done
   - h) demonstrating the working of the prototype
   - i) analysis of performance and manufacturability of the prototype

Semester 3

BM2012: Anatomy and Physiology for Engineers

Intake	2020 onwards	Specialization	Biomedical Engineering		
Semester	**Code**	**Module Title**		**C/E/O**	**GPA / NGPA**
3,4	BM2012	Anatomy and Physiology for Engineers		C	GPA
Hours/Week		**Credits**	**Prerequisites / Corequisites**	**Evaluation %**	
Lecture	**Lab/Tutes**			**CA**	**WE**
2	4	4.0	-	100	-

Learning Outcomes

At the end of the module the student will be able to:

1. Describe major areas of biomedical engineering applications
2. Use of modularity and abstraction in solving engineering problems
3. Explain basic engineering design principles
4. Use of design tools for electronic product prototyping
5. Identify various manufacturing processes involved in electronic product manufacture
6. Design of a medical product prototype to comply with a given technical specifications
7. Analysis of performance, safety and manufacturability of developed prototype
8. Discuss the moral and ethical issues in medical research and development

Syllabus Outline

1. **Core aspects of biomedical engineering applications**
   - Introducing specific applications related to biomedical engineering through real world products and research, emphasising the underlying human anatomy and physiology, technology and associated ethics and safety.
2. **Handling complexity through modularity and abstraction**
   - Modularity and abstraction as the basis for handling complexity in engineering design.
3. **Engineering design principles**
   - Introduction to engineering design, life cycle of engineering products and processes, design processes and design tools, concurrent engineering, creativity and reasoning, analysis and synthesis, simulations, evaluation and decision making
4. **Basic software tools needed for electronic design and manufacture**
   - Electronic circuit design software, simulation software, solid modelling software and thermal analysis software.
5. **Product dissection**
   - Electronic product disassembly and identification of manufacturing processes.
6. **PCB manufacturing**
   - Schematic design, layout design, design rules, photo-tool creation, drilling, plating, etching, solder masking.
7. **Essential processes in PCB assembly**
   - Component mounting: through-hole component forming, component insertion, surface mounting, soldering methods: hand soldering, wave soldering, reflow soldering.

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   - Injection moulding, metal forming, metal punching.
9. **Guided design project**
   - a) gathering of data and information from various sources as a preliminary to the design
   - b) preparing a work plan and delegating duties
   - c) working with others and to produce results by given deadlines and within given costs
   - d) learning the basic procedures required for conceptual, preliminary and detailed designs
   - e) learning the importance of the cost component in the manufacturing process
   - f) learning the importance of considering the limitations of manufacturing processes during design
   - g) preparing a report and making a presentation on the work done
   - h) demonstrating the working of the prototype
   - i) analysis of performance and manufacturability of the prototype

BM2210: Biomedical Device Design

Intake	2020 onwards	Specialization	Biomedical Engineering		
Semester	**Code**	**Module Title**		**C/E/O**	**GPA / NGPA**
3	BM2210	Biomedical Device Design		E	GPA
Hours/Week		**Credits**	**Prerequisites / Corequisites**	**Evaluation %**	
Lecture	**Lab/Tutes**			**CA**	**WE**
1	4	3.0	-	70	30

Learning Outcomes

At the end of the module the student will be able to:

1. Define the fundamental approach required for biomedical device design
2. Analyse the composition of a basic biomedical device design
3. Select suitable sensor modules and necessary components for realizing a biomedical device design
4. Design and build a simple prototype for a specified healthcare monitoring application
5. Test the device to achieve desirable level of performance

Syllabus Outline

1. **Introduction to biomedical device design**
   - Introducing specific devices related to biomedical engineering design through real world products and research, overview of device design projects done in the past.
2. **Real-world needs exploration in medicine and biology**
   - Exploring the real world needs in medicine and biology to outline problems, consulting with doctors to gather domain knowledge in specific areas.
3. **Conceptual solution generation, screening and testing methods**
   - Ideation, techniques to achieve conceptual designs based on the design process, concept generation and screening, testing process for devices.
4. **Biomedical device design process**
   - Outline task, identify the needs of the task, choose design inputs derived from the needs, implement a design to convert inputs to outputs, verify the outputs, finish the device for demonstration.
5. **Modularity of design task: sensor modules, power modules, communication interfaces and micro-controllers**
   - Introduction to the modularity of the healthcare monitoring device design, sensor modules and power modules, overview of the communication interfaces, overview of microcontrollers suitable for medical device design.
6. **Safety precautions, ethics and regulatory aspects**
   - Safety compliance and regulatory issues, emphasizing ethics and safety for BME.
7. **Building a wearable healthcare monitoring medical device**
   - a) design and develop a wearable healthcare monitoring device for a given task
   - b) wearable device conceptualization and planning
   - c) working with microcontroller-based programming boards

- d) sensor module integration for hardware design
- e) developing sensor interfacing firmware
- f) troubleshooting sensors, visualization output and firmware
- g) preparing a report and making a presentation on the work done
- h) demonstrating the working of the prototype

Semester 4

BM2012: Anatomy and Physiology for Engineers

Intake	2020 onwards	Specialization	Biomedical Engineering		
Semester	**Code**	**Module Title**		**C/E/O**	**GPA / NGPA**
3,4	BM2012	Anatomy and Physiology for Engineers		C	GPA
Hours/Week		**Credits**	**Prerequisites / Corequisites**	**Evaluation %**	
Lecture	**Lab/Tutes**			**CA**	**WE**
2	4	4.0	-	100	-

Learning Outcomes

At the end of the module the student will be able to:

1. Describe the human body, its organization and its constituents as relevant to biomedical engineering
2. Discuss the communication needs of human body and related systems
3. Describe the intake of raw materials and elimination of waste in the human body
4. Explain the protection and survival methods of the human life
5. Recognize disorders of the relevant physiological systems and existing engineering solutions

Syllabus Outline

1. **Introduction: Principles of anatomy**
   - Levels of structural organizations within the body, Basis for anatomical terminology.
2. **Cells and tissues**
   - Structure of the plasma membrane, functions of the principal organelles, Mitosis, active, passive and bulk transport systems.
3. **Blood**
   - Constituents of blood, function and formation of the different components; plasma, red blood cells while blood cells, disorders of blood.
4. **Cardiovascular system**
   - System components; Heart, Blood Vessels. Structure and function of Heart and blood vessels and their relationship to the overall transport and communication process within the body. Terms and definitions for Heart rate, Blood Pressure, Blood circulation, Disorders and pathology of the heart and blood vessels.
5. **Endocrine system**
   - The structure and composition of the endocrine system consisting of glands and hormones. The role of hormones in homeostasis. Disorders due to malfunction of the endocrine system and hormones.
6. **Lymphatic system**
   - Composition and main functions of lymph, location of main lymphatic vessels of the body, Lymph vessel and lymph node pathology.
7. **Respiratory system**

- Structure and function of the respiratory system consisting of the larynx, pharynx, trachea, lungs bronchi, bronchioles, and alveoli. Terms and definitions of respiration. Disorders of the respiratory system.

8. **Digestive system**
   - The structure and function of the organs of the digestive system and alimentary canal. The process of digestion, metabolism, and assimilation.
9. **Urinary system**
   - Structure and function of the Urinary system; Kidneys, ureters, bladder, urethra; process of urine formation, kidney dysfunctions.
10. **Reproductive system**
    - Structure and function of the male and female reproductive system and organs**.**
11. **Central nervous system**
    - Structure and function of neurons and neurotransmitters at synapses.
    - Structure and function of the brain and the spinal cord Identify the main sensory and motor areas of the brain and spinal cord, Events of a reflex arc. Disorders of the brain.
12. **Genetics**
    - Structural relationship between chromosomes, genes and DNA, autosomal and sex chromosomes. mutations, cell division, mitosis and meiosis, genetic basis of inheritance.
13. **Musculoskeletal system**
    - Structure and function of the bones and muscles. Main organization of the skeletal system. Different types of joints, muscles, and muscle groupings. Disorders of joints and bones.
14. **Special senses**
    - Structure and function of the ear, eye and nose and taste buds, Disorders of the ear and eye.

BM2102: Modelling and Analysis of Physiological Systems

Intake	2020 onwards	Specialization	Biomedical Engineering		
Semester	**Code**	**Module Title**		**C/E/O**	**GPA / NGPA**
4	BM2102	Modelling and Analysis of Physiological Systems		C	GPA
Hours/Week		**Credits**	**Prerequisites / Corequisites**	**Evaluation %**	
Lecture	**Lab/Tutes**			**CA**	**WE**
2	2	3.0	-	60	40

Learning Outcomes

At the end of the module the student will be able to:

1. Interpret biological systems in engineering perspective
2. Construct computational models to analyse physiological systems
3. Analyse the limitations of physiological models

Syllabus Outline

1. **Basic principles and concepts in physiological modelling**
   - Introduction to mathematical modelling providing a review of linear and non-linear systems along with their solutions.
2. **Musculoskeletal modelling**
   - Biomechanics of bone and cartilage and remodelling, Biomechanics of muscles and joints.
3. **Modelling and analysis of the respiratory system**
   - Model the respiratory system and analyse its physiology and pathophysiology. Aspects of the regulation of respiration and brief introduction to mechanical ventilation.
4. **Model of the circulatory system-and related medical equipment**
   - Circulatory system, Circulator system models, Cardiovascular mechanics.
5. **Modelling and analysis of biological conductors**
   - Fundamental phenomena of electrophysiology will be explained in association of neuronal activity of the brain and the heart. This will be then mathematically modelled and analysed using the core-conductor model, cable equation and the Hodgkin and Huxley model.
6. **Compartmental modelling**
   - The idea of compartmentalization of biological activity and its relevance to human physiology is explained through iodine, glucose and pharmacokinetic models.

BM2801: Biomedical Engineering and Applications - Faculty Elective. Not offered for Biomedical Engineering students.

Intake	2020 onwards	Specialization	Biomedical Engineering		
Semester	**Code**	**Module Title**		**C/E/O**	**GPA / NGPA**
4	BM2801	Biomedical Engineering and Applications		E	GPA
Hours/Week		**Credits**	**Prerequisites / Corequisites**	**Evaluation %**	
Lecture	**Lab/Tutes**			**CA**	**WE**
2	2	3.0	-	40	60

Learning Outcomes

At the end of the module the student will be able to:

1. Identify different biological systems and their functions
2. Analyse physiological systems and construct engineering models to represent their functionality
3. Compare and contrast characteristics of different medical imaging modalities
4. Describe applications of biomedical engineering relevant to engineering disciplines
5. Analysis of performance, safety and manufacturability of medical devices
6. Discuss the moral and ethical issues in medical research and development

Syllabus Outline

1. **Overview of biomedical engineering**
   - Activities of biomedical engineers, divisions of biomedical engineering.
2. **Overview of the human body**
   - Introduction, cells and tissues of the body, major physiological systems, homeostasis.
3. **Respiratory mechanics and mechanical ventilation**
   - Introduction to modelling and analysis, respiratory mechanics, abnormalities of respiratory system, mechanical ventilators.
4. **Medical imaging and physiological signals**
   - Different imaging modalities and fundamentals of physiological signals.
5. **Safety, ethics and regulatory aspects**
   - Safety compliance and regulatory issues, ethical issues in BME.
6. **Biomedical engineering applications**
   - Discuss specific applications related to biomedical engineering through real world products and research, emphasizing the underlying human anatomy and physiology, technology and associated ethics and safety.

Semester 5

BM3122: Medical Imaging

Intake	2020 onwards	Specialization	Biomedical Engineering		
Semester	**Code**	**Module Title**		**C/E/O**	**GPA / NGPA**
5	BM3122	Medical Imaging		C	GPA
Hours/Week		**Credits**	**Prerequisites / Corequisites**	**Evaluation %**	
Lecture	**Lab/Tutes**			**CA**	**WE**
2	2	3.0	-	50	50

Learning Outcomes

At the end of the module the student will be able to:

1. Explain fundamentals of image formation using signals obtained from the body
2. Compare and contrast characteristics of different medical imaging modalities
3. Identify effects of different imaging modalities on the human body
4. Interpret parameters of medical images for measurements and analysis

Syllabus Outline

1. **Introduction to medical imaging**
   - Overview and examples, imaging signals and systems, image quality.
2. **Radiographic imaging**
   - Physics of radiography, projection radiography (X-ray), computed tomography (CT).
3. **Magnetic resonance imaging**
   - Nuclear magnetic resonance (NMR), magnetic resonance imaging (MRI), functional MRI.
4. **Ultrasound imaging**
   - Ultrasound imaging principles, ultrasound imaging systems, doppler ultrasound.
5. **Nuclear medicine imaging**
   - Radiopharmaceuticals, gamma camera, planar scintigraphy, single photon emission computed tomography (SPECT), positron-emission tomography (PET).
6. **Optical and thermal imaging**
   - Medical thermography, and optical coherent tomography (OCT).
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BM3110: Electronic Instrumentation

Intake	2020 onwards	Specialization	Biomedical Engineering		
Semester	**Code**	**Module Title**		**C/E/O**	**GPA / NGPA**
5	BM3110	Electronic Instrumentation		C	GPA
Hours/Week		**Credits**	**Prerequisites / Corequisites**	**Evaluation %**	
Lecture	**Lab/Tutes**			**CA**	**WE**
2	2	3.0	-	50	50

Learning Outcomes

At the end of the module the student will be able to:

1. Explain the concepts and properties of measurements and electronic measuring instruments
2. Choose transducers for a given application and select the relevant method of interfacing and digitizing
3. Apply signal conditioning methods to improve the quality of measurements
4. Explain noise and interference on measurements and minimization techniques

Syllabus Outline

1. **Characteristics of measurement systems**
   - Static and dynamic characteristics, types of errors and estimation of errors, measures for improving electronic systems.
2. **Measurement concepts of instruments**
   - Voltmeters and ammeters, signal sources and function generators, oscilloscopes, electronic counters power supplies, spectrum and network analysers, logic analysers.
3. **Transducers**
   - Characteristics and operating principles of transducers based optical, mechanical, thermal, magnetic, and chemical energy.
4. **Review of noise and interference in instrumentation system**
   - Noise in instrumentation systems, interference sources, effects of ground loops, observing noise and interference effects from measuring instruments.
5. **Signal conditioning**
   - Guarding and shielding, null deflection methods, amplification/attenuation, offset correction, filtering, linearizing and isolation. Selection considerations of op amps, use of low noise and low drift series op amps for sensitive measurements
   - Key considerations: integration, connectivity, expandability, isolation, bandwidth, configuration, and calibration.
6. **Schematic and PCB design practices for instrumentation systems**
   - Schematic design practices, PCB stack, mounting holes, design rules and design rule checking, ground planes and PCB design practices.
7. **Display of measurements and metrology**
   - Human perception of information, testing, calibration and standards.

BM3880: Engineer and Society

Intake	2020 onwards	Specialization	Biomedical Engineering		
Semester	**Code**	**Module Title**		**C/E/O**	**GPA / NGPA**
5,6	BM3880	Engineer and Society		C	GPA
Hours/Week		**Credits**	**Prerequisites / Corequisites**	**Evaluation %**	
Lecture	**Lab/Tutes**			**CA**	**WE**
1	4	3.0	-	100	-

Learning Outcomes

At the end of the module the student will be able to:

1. Demonstrate an understanding of the responsibilities of the engineering profession and its social context
2. Demonstrate an understanding of the health, safety and environmental requirements of the society
3. Practise with integrity in the social context of the engineering profession with an understanding of ethical issues
4. Identify and apply appropriate tools/ techniques for the evaluation of health, safety and environmental hazards/consequences and risk assessment
5. Interpret the engineers' role in ethically assuring healthy, safe and excellent environmental conditions targeting the overall sustainable development of the society
6. Ability to critique technology
7. Apply the knowledge and skills gained of towards building character as a socially responsible professional engineer.
8. Be exposed to frameworks for ethical decision making in the biomedical engineering profession
9. Identify ethical issues in biomedical research
10. Discuss the basics of setting up and running pre-clinical and clinical trials
11. Interpret experimental results using basic biostatistics

Syllabus Outline

1. **Introduction to engineering ethics**
   - Historical context, moral responsibility, IESL code of ethics, community standards and personal responsibility.
2. **Ethics in society**
   - Respect for social & cultural values, respect for other professions, ethical decisions as individuals, workplace ethics, identifying ethical issues, conflicting scenarios and problems in the field of engineering, leading organizations towards ethical behaviour.
3. **Ethics in biomedicine**
   - Ethical and moral frameworks for personal and professional decision making, "ethical" character building – societal, cultural practices and pressures in ethical decision making, with practical case studies.
4. **Ethics and diversity**

- Autonomy, patient rights, consent, institutional rights, equity, equality, gender inclusion, disability.

5. **Legal requirements related to engineering practice – acts and ordinances**
   - Health & safety – definitions, areas and hazard identification, risk assessment, evaluation and management.
6. **Health and safety management**
   - Management practices, local regulations, global standard and best practices, designing of health and safety management systems, special topics.
7. **Environment**
   - Waste generation in industry, overview of controlling and treatment technologies, local standards and EPL procedure, environmental impact assessment.
8. **Case studies (industry specific)**
   - Medical Device malfunction- senate inquiry.
9. **Ethics in health research**
   - International guidelines, good clinical practice, research ethics boards, research involving animals.
10. **Research integrity**
    - Collegiality and authorship, collaborative research, copyrights, licenses and patents.
11. **Conducting clinical trials**
    - Types of clinical trials, the clinical protocol and trial design, institutional overhead, confidentiality and informed consent, data handling and record keeping, adverse events, audit and the audit trail, close out.
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BM3500: Biomechanics

Intake	2020 onwards	Specialization	Biomedical Engineering		
Semester	**Code**	**Module Title**		**C/E/O**	**GPA / NGPA**
5	BM3500	Biomechanics		E	GPA
Hours/Week		**Credits**	**Prerequisites / Corequisites**	**Evaluation %**	
Lecture	**Lab/Tutes**			**CA**	**WE**
2	2	3.0	-	50	50

Learning Outcomes

At the end of the module the student will be able to:

1. Describe human biomechanics and its role to improve human health and wellbeing
2. Describe the fundamental areas of human biomechanics and applications
3. Apply principles of mechanics to the biological systems of the human body and solve simple numerical problems
4. Measure and analyse biomechanical parameters using qualitative and quantitative techniques
5. Evaluate the effectiveness of biomechanical solutions within industrial applications for selected case studies

Syllabus Outline

1. **Introduction and Basic Definitions**
   - Introduction to biomechanical related problems, biomechanical planes, definitions of kinematic and kinetic loads and motions, examples of different areas of biomechanics.
2. **Statics and Dynamics of Muscle and Joint Loads**
   - Use of basic laws of physics to understand and apply into determining joint and muscle loads, appreciation of inverse and forward dynamics.
3. **Biomechanics of Muscle and Muscle Modelling**
   - Muscle classification, macroscopic structure (shape) of muscles, microscopic structure of muscle, how muscle works, modelling of muscle, force-length relationships, force-velocity relationships.
4. **Biomechanics of the foot**
   - The anatomy and biomechanical structures of the foot, different methods used to study foot and lower limb biomechanics, foot pathologies related to foot biomechanics, appreciate biomechanics in footcare- product development.
5. **Biomechanics of Spine and Cartilage**
   - Spine anatomy, classification of regions of the spine, ligaments and muscles in relation to spinal column, anatomy of a motion segment, biomechanics of load carriage and process of disc herniation and other injuries to the spine.
6. **Biomechanics of joints in the human body**
   - Classification of joints, movable Ranges, Joint Torques, modelling of Joints, joint related problems.
7. **Exoskeletons and robotics in medical engineering**

- Prosthetic devices and their categories, orthotic devices and their categories, control methods and applications for orthotic and prosthetic devices.

8. **Control of bionics using bio-signals**
   - Bionics, bio-signals, signal processing, EMG based control methods.
9. **Human Movement and Motion Capturing - Part 1**
   - Human movement basics- Gait and phases of normal gait, quantitative and qualitative measuring methods in human movement, motion capturing using vision and IMU based systems- comparison.
10. **Human Movement and Motion Capturing - Part 2**
    - Analysis of 2D inverse dynamics problems, motion capturing example in sports, discussion on Industry applications.
11. **Miscellaneous Topics in Biomechanics - Case Studies**
    - Sport performance improvement – case study with cricket fast bowlers.
12. **Miscellaneous Topics in Biomechanics - Case Studies**
    - Industrial case study in ergonomics related to work, work posture and injuries.
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Semester 6

BM3991: Industrial Training

Intake	2020 onwards	Specialization	Biomedical Engineering		
Semester	**Code**	**Module Title**		**C/E/O**	**GPA / NGPA**
6	BM3991	Industrial Training		C	NPGA
Hours/Week		**Credits**	**Prerequisites / Corequisites**	**Evaluation %**	
Lecture	**Lab/Tutes**			**CA**	**WE**
		6	-	100	-

Learning Outcomes

At the end of the module the student will be able to:

1. Describe the organisation structure, its business practices, emerging trends in its industry, financial, human and other resource management and further, appreciate the differences between academic and industrial environments and work ethics
2. Apply the knowledge of mathematics, science and engineering fundamentals learnt in the university to an industrial setting, and apply the industrial experience to enhance academic work
3. Practice health and safety procedures, risk management, professional ethics, industrial standards and processes as required by an employee
4. Demonstrate technical, teamwork and managerial skills developed through the training
5. Evaluate the economic, environmental, social, and cultural impact of the tasks performed during training period.

Syllabus Outline

1. **Induction**
   - Initial period to help students in the transition from academic to industrial life. Discussions with supervisor to understand the nature of work carried out in the organization. Students should make their supervisors aware of the expected learning outcomes of this module. Introduction to organizational structure, its business practices, and financial management. Awareness of terms and conditions of employment.
2. **Practical Skills**
   - During this period, the student should receive instructions for practical skills essential for their future employment. It should also include an appreciation of the work of others in converting an engineering design into a final product (if appropriate).
3. **General Engineering Training**
   - Acquire knowledge of industrial standards and processes as required by an employee in the organization. Introduction to work performed at various departments. Gain an understanding of management and administration tasks. Practice health and safety procedures, and risk management. Thorough understanding of the operations of the training place in Biomedical engineering context.
4. **Directed Objective Training**

- Conducting specialized engineering and technical activities. Working on real world problems and substantial responsibility should be vested upon to encourage independent work to establish interest and confidence within the student. Ability to identify, formulate and model problems and find engineering solution based on a systematic approach. Design and development, documentation and data preparation and commissioning. Become updated with state-of-the-art technologies in the domain of the organization.

5. Soft Skills

- Develop effective communication skills, leadership skills and entrepreneurship skills. Teamwork and collaboration with team members. Develop positive attitudes and strong work ethic: punctuality, time management, meeting deadlines, dependability and dedication. Awareness of the social, cultural, global and environmental responsibility as an engineer.

BM3181: Seminar and Scientific Communication

Intake	2020 onwards	Specialization	Biomedical Engineering		
Semester	**Code**	**Module Title**		**C/E/O**	**GPA / NGPA**
6	BM3181	Seminar and Scientific Communication		C	GPA
Hours/Week		**Credits**	**Prerequisites / Corequisites**	**Evaluation %**	
Lecture	**Lab/Tutes**			**CA**	**WE**
1	2	2.0	-	100	-

Learning Outcomes

At the end of the module the student will be able to:

1. Explain emerging research and development areas in biomedical engineering
2. Demonstrate the knowledge of the practices and techniques (written, oral, media) that promote scientific communication, both in academic and non-academic environments
3. Demonstrate the basic knowledge of various forms and purposes of written and oral communication of technical knowledge in English
4. Present a seminar on technological topic for an audience having a technical background
5. Display skills on defending an argument, constructive criticism, and accepting feedback as part of the process of peer review
6. Demonstrate technical and scientific information using modern technological platforms to both academic and non-academic audiences

Syllabus Outline

1. **Seminars on emerging R&D areas**
   - Invited seminars presented by faculty members and practicing engineers.
2. **Handling complexity through modularity and abstraction**
   - Interest and knowledge, organization, visual aids, presentation skills, responding to questions slides.
3. **Engineering design principles**
   - Format, language, summary, citation, effective presentation of data, ethics.
4. **Scientific journal review**
   - Discussion on different viewpoints, ability to offer an objective view with reasons.
5. **Poster presentations**
   - Format, content, referencing.
6. **Personal profile**
   - Ability to personally communicate via different media available, Linked-In, CV.
7. **Social media**
   - Using social media in an effective way to communicate, infographics and use of media in communication, elevator pitch.

BM3880: Engineer and Society

Intake	2020 onwards	Specialization	Biomedical Engineering		
Semester	**Code**	**Module Title**		**C/E/O**	**GPA / NGPA**
5,6	BM3880	Engineer and Society		C	GPA
Hours/Week		**Credits**	**Prerequisites / Corequisites**	**Evaluation %**	
Lecture	**Lab/Tutes**			**CA**	**WE**
1	4	3.0	-	100	-

Learning Outcomes

At the end of the module the student will be able to:

1. Demonstrate an understanding of the responsibilities of the engineering profession and its social context
2. Demonstrate an understanding of the health, safety and environmental requirements of the society
3. Practise with integrity in the social context of the engineering profession with an understanding of ethical issues
4. Identify and apply appropriate tools/ techniques for the evaluation of health, safety and environmental hazards/consequences and risk assessment
5. Interpret the engineers' role in ethically assuring healthy, safe and excellent environmental conditions targeting the overall sustainable development of the society
6. Ability to critique technology
7. Apply the knowledge and skills gained of towards building character as a socially responsible professional engineer.
8. Be exposed to frameworks for ethical decision making in the biomedical engineering profession
9. Identify ethical issues in biomedical research
10. Discuss the basics of setting up and running pre-clinical and clinical trials
11. Interpret experimental results using basic biostatistics

Syllabus Outline

1. **Introduction to engineering ethics**
   - Historical context, moral responsibility, IESL code of ethics, community standards and personal responsibility.
2. **Ethics in society**
   - Respect for social & cultural values, respect for other professions, ethical decisions as individuals, workplace ethics, identifying ethical issues, conflicting scenarios and problems in the field of engineering, leading organizations towards ethical behaviour.
3. **Ethics in biomedicine**
   - Ethical and moral frameworks for personal and professional decision making, "ethical" character building – societal, cultural practices and pressures in ethical decision making, with practical case studies.
4. **Ethics and diversity**

- Autonomy, patient rights, consent, institutional rights, equity, equality, gender inclusion, disability.

5. **Legal requirements related to engineering practice – acts and ordinances**
   - Health & safety – definitions, areas and hazard identification, risk assessment, evaluation and management.
6. **Health and safety management**
   - Management practices, local regulations, global standard and best practices, designing of health and safety management systems, special topics.
7. **Environment**
   - Waste generation in industry, overview of controlling and treatment technologies, local standards and EPL procedure, environmental impact assessment.
8. **Case studies (industry specific)**
   - Medical Device malfunction- senate inquiry.
9. **Ethics in health research**
   - International guidelines, good clinical practice, research ethics boards, research involving animals.
10. **Research integrity**
    - Collegiality and authorship, collaborative research, copyrights, licenses and patents.
11. **Conducting clinical trials**
    - Types of clinical trials, the clinical protocol and trial design, institutional overhead, confidentiality and informed consent, data handling and record keeping, adverse events, audit and the audit trail, close out.

BM3210: Self-Initiated Innovation

Intake	2020 onwards	Specialization	Biomedical Engineering		
Semester	**Code**	**Module Title**		**C/E/O**	**GPA / NGPA**
6	BM3210	Self-Initiated Innovation		E	GPA
Hours/Week		**Credits**	**Prerequisites / Corequisites**	**Evaluation %**	
Lecture	**Lab/Tutes**			**CA**	**WE**
-	6	3.0	-	100	-

Learning Outcomes

At the end of the module the student will be able to:

1. Generate self-motivation and enthusiasm in identifying, analysing and solving a problem related to biomedical engineering of a complexity appropriate for a senior undergraduate
2. Discover creative ways of solving the identified problem
3. Apply a multidisciplinary approach as appropriate towards solving the identified problem
4. Demonstrate correct scientific and engineering approach in solving the identified problem
5. Present the solution orally and in writing

Syllabus Outline

1. **Problem identification**
   - Identify an existing problem in the industry or in society in biomedical engineering of a complexity appropriate for a senior undergraduate.
2. **Domain knowledge**
   - Gather domain knowledge related to the identified problem and collaborate with resource persons having domain knowledge.
3. **Problem solution**
   - Adopt the correct scientific and engineering problem solving approach towards solving an identified problem.
4. **Case study**
   - Study and critically evaluate existing solutions to identified problems and propose improvements.
5. **Technical presentation**
   - Present the solution to the identified problem in a professional manner, prepare a technical report describing the solution.

Semester 7

BM4201: Project

Intake	2020 onwards	Specialization	Biomedical Engineering		
Semester	**Code**	**Module Title**		**C/E/O**	**GPA / NGPA**
7,8	BM4201	Project		C	GPA
Hours/Week		**Credits**	**Prerequisites / Corequisites**	**Evaluation %**	
Lecture	**Lab/Tutes**			**CA**	**WE**
-	20	10.0	-	100	-

Learning Outcomes

At the end of the module the student will be able to:

1. Identify a problem of sufficient complexity applicable to biomedical engineering that can be solved using the technologies learnt during the undergraduate tenure
2. Demonstrate both teamwork and individual contribution towards solving the identified problem
3. Explain specific issues related to the identified problem based on how concepts have been developed through cross referencing current literature
4. Analyse different approaches to solve the identified problem
5. Evaluate different approaches to find the most suitable option based on the technical feasibility, time and resource constraints
6. Develop and defend a project proposal with an appropriate business case
7. Design and develop the solution using the selected approach
8. Evaluate the effectiveness of the solution and justify the methods adopted
9. Compile a dissertation and a research manuscript

Syllabus Outline

1. **Investigation feasibility phase**
   - The student should independently refer to literature such as books, scientific publications, patents and electronic resources to analyse a problem related to biomedical engineering and justify their choice of the project. The student should evaluate multiple approaches towards solving the problem. Base on this evaluation, the student should justify the choice and identify the scope of the project and required resources for the successful completion within the time period and budget constraints.
2. **Implementation phase**
   - The implementation phase includes implementing and testing of the prototype solution to the identified problem. The approach/s towards the solution has to be implemented using both learned and new knowledge with the aid of tools to support design strategies. The student has to evaluate and justify the implemented solution against both the expected solution and with related implementations elsewhere. At this stage, the student is allowed to alter or modify the methodologies proposed within reason.
3. **Presentation phase**
   - Placing the work in context and presenting it effectively is an important part of the project. Effective presentation of the project material and a well-structured report is expected for

	the satisfactory completion of this module. The documentation and knowledge preservation includes a presentation, dissertation, research manuscript and a viva voce examination.

BM4112: Medical Electronics and Instrumentation

Intake	2020 onwards	Specialization	Biomedical Engineering		
Semester	**Code**	**Module Title**		**C/E/O**	**GPA / NGPA**
7	BM4112	Medical Electronics and Instrumentation		C	GPA
Hours/Week		**Credits**	**Prerequisites / Corequisites**	**Evaluation %**	
Lecture	**Lab/Tutes**			**CA**	**WE**
2	2	3.0	BM3110	50	50

Learning Outcomes

At the end of the module the student will be able to:

1. Explain the operation and characteristics of transducers used in biomedical applications
2. Apply signal conditions techniques to enhance biomedical measurements
3. Analyse measurements acquired from instruments
4. Apply medical safety standards onto medical instrumentation design
5. Explain the functionality of commonly used diagnostic and therapeutic medical devices

Syllabus Outline

1. **Transducers for biomedical applications**
   - Biopotential electrodes, ultrasound transducers, magnetic sensors, radiation detectors (pulse shaping circuits).
2. **Medical imaging related instrumentation**
   - Intraoperative equipment safety and standards, imaging specific interfacing circuitry.
3. **Signal conditioning**
   - Biopotential amplifiers (chopper amplifiers), isolation methods specific to biomedical instrumentation (signal isolation, digital isolation, power isolation), high voltage transient protection, earthing.
4. **Signal estimation**
   - Properties of estimators, maximum likelihood estimator, least square estimation, Kalman filtering.
5. **Standards and regulatory bodies**
   - IEC and ISO electrical safety standards, FDA and NMRA regulations.
6. **Diagnostic and therapeutic devices**
   - Operating principles and functionality of commonly used diagnostic and therapeutic medical devices.

BM4180: Technical and Scientific Writing

Intake	2020 onwards	Specialization	Biomedical Engineering		
Semester	**Code**	**Module Title**		**C/E/O**	**GPA / NGPA**
7	BM4180	Technical and Scientific Writing		C	GPA
Hours/Week		**Credits**	**Prerequisites / Corequisites**	**Evaluation %**	
Lecture	**Lab/Tutes**			**CA**	**WE**
1	2	2.0	-	100	-

Learning Outcomes

At the end of the module the student will be able to:

1. Explain different types of technical reports
2. Apply the elements of the general structure of technical reports
3. Explain the criteria of a basic literature survey
4. Select appropriate citations, cross references, bibliography styles and indexes appropriately
5. Apply knowledge in writing coherent and precise paragraphs to suit technical context

Syllabus Outline

1. **Criteria for technical writing**
   - Language criteria: how easy it is for people to understand the words, design criteria: the visual impact of the document and the way its design influences usability, relationship criteria: how far the document establishes a relationship with its users, content criteria: how the content and the way it is organized deliver the document's purpose.
2. **Difference between fiction vs technical writing**
   - Learn & apply the basics of an abstract, write a comprehensive introduction, understand the importance of the first pages (List of figures, tables, abbreviations, table of contents), scientific paper writing – discussion of the different techniques.
3. **Elements of a literature review**
   - Critically analyse the background of a topic, select and source the information that is necessary to develop a context for a research, write important facts to show how an investigation relates to previous research.
4. **Plagiarism**
   - Cite sources correctly, use quotation marks, able to be paraphrasing.
5. **Writing paragraphs coherently**
   - Unify paragraphs by making every sentence contribute to a controlling idea, which is usually stated in a topic sentence (paragraph unity), write a coherent paragraph organizing facts, creating a logical argument that makes sense from idea to idea (paragraph coherence), paragraph development.

BM4152: Biosignal Processing - Faculty Elective

Intake	2020 onwards	Specialization	Biomedical Engineering		
Semester	**Code**	**Module Title**		**C/E/O**	**GPA / NGPA**
7	BM4152	Biosignal processing		E	GPA
Hours/Week		**Credits**	**Prerequisites / Corequisites**	**Evaluation %**	
Lecture	**Lab/Tutes**			**CA**	**WE**
2	2	3.0	-	70	30

Learning Outcomes

At the end of the module the student will be able to:

1. Explain the origin of physiological signals
2. Apply signal processing methods to improve the signal quality and extract features
3. Review recent literature in biosignal processing
4. Implement recent algorithms in biosignal processing

Syllabus Outline

1. **Physiology and characteristics of biosignals**
   - Signals related to the cardiovascular system, the brain and muscles.
2. **Pre-processing pipelines**
   - Filtering, adaptive filtering, artifact removal.
3. **Feature extraction**
   - Time-frequency analysis (STFT), decomposition methods (CWT, DWT, WPT, EMD, VMD), graph signal processing.
4. **Classification techniques**
   - LSTM, RNN, conventional classification methods on biosignals.
5. **Special topics in biosignal Processing**
   - Review of recent literature.

BM4302: Medical Image Processing - Faculty Elective

Intake	2020 onwards	Specialization	Biomedical Engineering		
Semester	**Code**	**Module Title**		**C/E/O**	**GPA / NGPA**
7	BM4302	Medical Image Processing		E	GPA
Hours/Week		**Credits**	**Prerequisites / Corequisites**	**Evaluation %**	
Lecture	**Lab/Tutes**			**CA**	**WE**
2	2	3.0	-	70	30

Learning Outcomes

At the end of the module the student will be able to:

1. Describe available techniques in medical image processing
2. Identify open medical image processing problems
3. Review current literature in medical image processing
4. Implement a recent algorithm in medical image processing
5. Propose novel solutions to open medical image processing problems

Syllabus Outline

1. **Review of image representation, processing and visualization techniques**
   - Fundamentals, popular software libraries, image enhancement, texture and motion analysis, morphological operations.
2. **Review of medical image segmentation algorithms**
   - Region growing, watershed, level-set segmentation, deformable models.
3. **Medical image registration and fusion**
   - Geometric features, similarity measures, modelling tissue deformation, finite element analysis
4. **Deep learning methods in medical image processing**
   - Autoencoders, convolutional neural networks in medical image processing. Applications in classification and segmentation (e.g., reconstruction, cell classification, tumour segmentation, retinopathy). Spatio-temporal deep learning (e.g., analysis of brain images).
5. **Special topics in medical image processing**
   - Review of recent literature.
   -

BM4322: Genomic Signal Processing - Faculty Elective

Intake	2020 onwards	Specialization	Biomedical Engineering		
Semester	**Code**	**Module Title**		**C/E/O**	**GPA / NGPA**
7	BM4322	Genomic Signal Processing		E	GPA
Hours/Week		**Credits**	**Prerequisites / Corequisites**	**Evaluation %**	
Lecture	**Lab/Tutes**			**CA**	**WE**
2	2	3.0	-	50	50

Learning Outcomes

At the end of the module the student will be able to:

1. Gaining the intuition on the functionality of biological systems
2. The ability to utilize fundamentals from mathematics and statistics to formulate algorithms to process genomic data

Syllabus Outline

1. **Basic concepts**
   - The cell, cellular biochemistry (carbohydrates, lipids and proteins), DNA, RNA, amino acids, DNA replication, gene transcription, regulation of transcription, prokaryotes and eukaryotes.
2. **Sequence alignment**
   - Global, local and semiglobal alignment, multi sequence alignment.
3. **Statistical methods**
   - Statistical sequence alignment, gene prediction, hypothesis testing, genome assembly.
4. **Phylogenetic trees**
   - Evolutionary relationships, the molecular clock, computational phylogenetics (WPGMA, UPGMA, Neighbor Joining, Fitch–Margoliash method, maximum parsimony-based methods), limitations (horizontal gene transfer, hybridization etc.).
5. **Proteomics**
   - Codon degeneracy, protein motif discovery, protein alignment.

Semester 8

BM4201: Project

Intake	2020 onwards	Specialization	Biomedical Engineering		
Semester	**Code**	**Module Title**		**C/E/O**	**GPA / NGPA**
7,8	BM4201	Project		C	GPA
Hours/Week		**Credits**	**Prerequisites / Corequisites**	**Evaluation %**	
Lecture	**Lab/Tutes**			**CA**	**WE**
-	20	10.0	-	100	-

Learning Outcomes

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1. Identify a problem of sufficient complexity applicable to biomedical engineering that can be solved using the technologies learnt during the undergraduate tenure
2. Demonstrate both teamwork and individual contribution towards solving the identified problem
3. Explain specific issues related to the identified problem based on how concepts have been developed through cross referencing current literature
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