Module Code	BM1011	**Module Title**	Engineering in Medicine and Biology			
Credits	2.0	**Hours/Week**	**Lectures**	1	**Pre/Co – requisites**	-
GPA/NGPA	NGPA		**Lab/Assignments**	3/1		

Learning Outcomes

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

1. Recognize the historical perspective of biomedical engineering
2. Describe major areas of biomedical engineering
3. Discuss the moral and ethical issues in medical research and development

Outline Syllabus

1. **Biomedical Engineering: A historical perspective (2 hrs):** Evolution of the Modern Health Care System, Roles of Biomedical, Professional Status of Biomedical Engineering, Professional Societies, clinical engineering

2. **Biomechanics and related areas (3 hrs):**Mechanics of physiological systems, rehabilitation engineering and prosthetics.

3. **Chemical and material engineering applications in biology and medicine (3 hrs):** Transport phenomena, biomaterials, biotechnology and tissue engineering.

4. **Biomedical instrumentation (2 hrs):** Biosensors, instrumentations, biosignal processing, standards, and safety.

5. **ICT in medicine (2 hrs):** Physiological modeling and simulation, medical informatics, computational cell biology.

6. **Moral and ethical issues in medical research and development (2 hrs)**: Morality and ethics, human experiments, and ethical issues biomedical activities.

Module Code	BM2011	**Module Title**	Human Anatomy and Physiology I			
Credits	3.0	**Hours/Week**	**Lectures**	3	**Pre/Co – requisites**	-
GPA/NGPA	GPA		**Lab/Assignments**	-		

Learning Outcomes

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

1. Describe the human body and its constituents
2. Explains the organization of the body
3. Discuss the communication needs of human body and related systems and their disorders

Outline Syllabus

1. **Introduction to the human body and the chemistry of life (3 hrs):**

2. **The cells, tissues and organization of the body (6 hrs):**

2. **Communication needs of the body (27 hrs):** Blood, cardiovascular system, lymphatic system, nervous system, special senses, and endocrine system.

Module Code	BM2020	**Module Title**	Human Anatomy and Physiology II			
Credits	2.5	**Hours/Week**	**Lectures**	2	**Pre/Co – requisites**	BM2011
GPA/NGPA	GPA		**Lab/Assignments**	3/2		

Learning Outcomes

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

1. Describe the intake of raw materials and elimination of waste in the human body and the disorders of the relevant physiological systems
2. Explain the protection and survival methods of the human life and the disorders of the relevant physiological systems

Outline Syllabus

1. **Intake of raw materials and elimination of waste (14 hrs):** Respiratory system, introduction to nutrition, digestive system, urinary system.
2. **Protection and survival of the human body (12 hrs):** Skin, resistance and immunity, musculoskeletal system, introduction to genetics, reproductive system.

Module Code	BM2101	**Module Title**	Analysis of Physiological Systems			
Credits	3.0	**Hours/Week**	**Lectures**	2	**Pre/Co – requisites**	BM2011 BM2020
GPA/NGPA	GPA		**Lab/Assignments**	3/1		

Learning Outcomes

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

1. Compare engineering and biological systems using concepts from systems analysis
2. Construct analytic and computational models to analyze the regulation of the respiratory, cardiovascular and saccadic eye movement systems

Outline Syllabus

1. **Modeling strategies in physiology (4 hrs):** Hybrid approaches and model reduction, compartmental models, methods and tools for identification of physiologic systems.

2. **Respiratory models and control (6 hrs):** Models for respiratory mechanics, method of identifying abnormalities respiration, and ventilators.

3. **Cardiovascular models and control (8 hrs):** Chemoreflex regulation of respiration, cardiovascular mechanics, heart-rate variability, cardiac electrophysiology, pacemakers, and defibrillators.

4. **The fast eye movement control system (6 hrs):** Saccade characteristics, saccadic eye movement models, and saccade control mechanism.

<table>
<tr><td>Module Code</td><td>BM2900</td><td>Module Title</td><td colspan="4">Field Visits</td></tr>
<tr><td>Credits</td><td>1.0</td><td rowspan="2">Hours/Week</td><td>Lectures</td><td>-</td><td rowspan="2">Pre/Co – requisites</td><td rowspan="2">-</td></tr>
<tr><td>GPA/NGPA</td><td>NGPA</td><td>Lab/Assignments</td><td>-</td></tr>
<tr><td colspan="7">Learning Outcomes</td></tr>
<tr><td colspan="7">At the end of the module the student will be able to:
1. Perceive the application of engineering in medicine.</td></tr>
<tr><td colspan="7">Outline Syllabus</td></tr>
<tr><td colspan="7">1. The course will be in the form of one or more field visits to places of interest to Biomedical Engineering graduates. These will include, but not limited to healthcare facilities, medical device design and manufacturing companies, and medical technology service providers.</td></tr>
</table>

Module Code	BM3121	Module Title	Medical Imaging			
Credits	4.0	Hours/Week	Lectures	3	Pre/Co – requisites	-
GPA/NGPA	GPA		Lab/Assignments	3/1		

Learning Outcomes

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

1. Discuss physics of how signals, from which images are formed, are obtained
2. Discriminate characteristics of different medical imaging modalities
3. Compare the effect of different imaging modalities on the human body
4. Interpret various parameters of medical images for measurements and analysis

Outline Syllabus

1. **X-ray imaging (4 hrs):** Projection x-ray principles and equipment, dose and exposure, attenuation coefficient, clinical x-ray procedures, digital radiography, x-ray computed tomography (CT)

2. **Magnetic resonance imaging (8 hrs):** Nuclear magnetic resonance (NMR), magnets and coils, spatial encoding, k-space, image quality, contrast manipulation, pulse sequences, functional MRI

3. **Ultrasound imaging (4 hrs):** Ultrasound principle, transducer, ultrasound-tissue interactions, acoustic impedance, a-mode imaging, time gain compensation (TGC), beamsteering, b-mode imaging, resolution and penetration, Doppler ultrasound.

4. **Nuclear medicine (4 hrs):** Radiopharmaceuticals, gamma camera, single photon emission computed tomography (SPECT), positron-emission tomography (PET)

5. **Optical and Thermal imaging (4 hrs):** Medical thermography, thermographic equipment, and optical coherent tomography (OCT).

6. **Image perception and quality (2 hrs):**

Module Code	BM3990	Module Title	Industrial Training			
Credits	6.0	Hours/Week	Lectures	-	Pre/Co – requisites	-
GPA/NGPA	NGPA		Lab/Assignments	-		

Learning Outcomes

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

1. Identify the differences between academic and industrial environments
2. Evaluate the training institutions relevance to engineering and engineering management
3. Adhere to engineering ethics, industrial safety standards and processes
4. Present the findings in a training report.

Outline Syllabus

1. **Induction**: This is an initial period to help the student in the transition from academic to industrial life. The students should meet a mentor to discuss the contents and the objectives of training. Students should also receive information about the training organization, its products or services and the terms and conditions of employment.
2. **Practical Skills**: During this period the student should receive instructions in the practical skills essential for 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**: In a large organization this should include an introduction to the work done in a number of departments. Under these circumstances, the student may eventually be working as a member of a team in the organization. The student should be made aware of the management and administration sectors of the organization.
4. **Directed Objective Training**: The major part of the training should have directed application to the activity which the student intends to follow after the training program (activities should be relevant to the major in which the student will be graduating in). At this stage the student should be encouraged to work on a real project and be given increasing responsibility for independent work to establish interest and confidence in his/her work.

* *This is an individual project, but supervisors can divide a complex project into sub areas to allow a group of students to collaborate. Students are evaluated individually.*

<table>
<tr><td>Module Code</td><td>BM3180</td><td>Module Title</td><td colspan="4">Scientific Communications for BME</td></tr>
<tr><td>Credits</td><td>2.0</td><td rowspan="2">Hours/Week</td><td>Lectures</td><td>1</td><td rowspan="2">Pre/Co – requisites</td><td rowspan="2">-</td></tr>
<tr><td>GPA/NGPA</td><td>GPA</td><td>Lab/Assignments</td><td>3/1</td></tr>
<tr><td colspan="7">Learning Outcomes</td></tr>
<tr><td colspan="7">At the end of the module the student will be able to:
1. Adopt widely accepted procedure in scientific research and publications
2. Communicate effectively in both oral and written formats</td></tr>
<tr><td colspan="7">Outline Syllabus</td></tr>
<tr><td colspan="7">1. Scientific conduct and method (2 hrs):
2. Scientific writing (2 hrs): Abstracts, project outlines, journal papers, grant proposals
3. Oral and poster presentations (4 hrs): Structure, function, content
4. Communication with lay audiences (2 hrs):
5. Intellectual property and disclosures (2 hrs):</td></tr>
</table>

Module Code	BM3190	**Module Title**	Biostatistics and Ethics for BME			
Credits	1.0	**Hours/Week**	**Lectures**	-	**Pre/Co – requisites**	-
GPA/NGPA	NGPA		**Lab/Assignments**	3/1		

Learning Outcomes

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

1. Identify issues in biomedical research ethics
2. Discuss the basics of setting up and running pre-clinical and clinical trials
3. Interpret experiment results using basic biostatistics

Outline Syllabus

1. **Ethics in health research**: International guidelines, good clinical practice, research ethics boards, research involving animals

2. **Basic biostatistics**: Fundamental concepts, common statistics

3. **Research integrity**: Collegiality and authorship, collaborative research, copyrights, licenses and patents

4. **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.

Module Code	BM4200	Module Title	Research Project			
Credits	10.0	Hours/Week	Lectures	-	Pre/Co – requisites	-
GPA/NGPA	GPA		Lab/Assignments	-		

Learning Outcomes

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

1. Identify a problem of sufficient complexity in medicine that can be solved using the technologies learnt during the undergraduate career within a given time frame
2. Explain specific issues related to the chosen research topic based on how concepts have been built up through cross referencing of related research material
3. Analyze different approaches to solve the identified problem
4. Develop the solution using the selected approach
5. Evaluate the effectiveness of the solution
6. Justify the methods adopted in the solution
7. Prepare the undergraduate research thesis and a research paper for publication

Outline Syllabus

1. **Investigation Stage**: The student should be capable of independently referring to books, papers, academic literature and electronic resources to justify their choice of project. Conduct a literature survey in order to academically support any claims, technologies and methods used in the research project. This phase should also be used to determine if there are other methods that have been used to address the same or similar problems.
2. **Implementation Stage**: Once the preliminary investigation is carried out and a project of appropriate complexity is chosen, the next stage is to design and implement the research. Identifying the proper approach of implementation for completing the research successfully. At the implementation stage, the student is allowed to alter or modify the methodologies proposed in the previous phase depending on any new information available at this stage. Students are expected to design proper experiments for evaluating their research outcome against the ground truth and/or existing methods of similar work.
3. **Presentation Phase**: Placing the work in context and presenting it effectively is also an important part of the project. Effective presentation of the project material and a well structured thesis is expected for the satisfactory completion of the research project. The documentation and knowledge preservation includes a presentation, thesis DVD with structured information, a viva, and a draft paper for publication.

Module Code	BM4111	**Module Title**	Medical Electronics & Instrumentation			
Credits	3.0	**Hours/Week**	**Lectures**	2	**Pre/Co – requisites**	-
GPA/NGPA	GPA		**Lab/Assignments**	3/1		

Learning Outcomes

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

1. Describe the operational principle of transducers and electrodes used in medical instrumentation
2. Explain the principles of operation of medical devices
3. Describe the use of therapeutic equipment in medicine
4. Analyze the effects of medical instruments on the human body

Outline Syllabus

1. **Measuring, Recording, and Monitoring Instruments (14 hrs)**: Fundamentals of medical instrumentation, physiological transducers, monitoring systems, biomedical telemetry, physiological measurements, and patient safety.

2. **Therapeutic Equipment (10 hrs)**: Cardiac pacemakers and defibrillators, dialysis systems, surgical instruments, life supporting devices and radiotherapy equipment.

Module Code	BM4151	Module Title	Biosignal Processing			
Credits	3.0	Hours/Week	Lectures	2	Pre/Co – requisites	EN1060 EN2510
GPA/NGPA	GPA		Lab/Assignments	3/1		

Learning Outcomes

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

1. Describe the generating process of key biosignals.
2. Analyse different type of biosignals to get a deeper contextual understanding.
3. Demonstrate the understanding of biosignal representation techniques and their applicability to the analysis of biosignals.
4. Describe the effects of noise on biosignals and removal methods of such noise.
5. Demonstrate the ability to implement key algorithms on software and evaluate their performance.

Outline Syllabus

1. **Physiology and characteristics of bioignals (2hrs):** Introduction

2. **Electrocardiogram (6 hrs):** Cardiac electrophysiology, relation of electrocardiogram (ECG) components to cardiac events, clinical applications, ECG filtering and frequency analysis, QRS detection, P & T wave detection

3. **Effect of Noise on Medical Signal Processing (4 hrs):** Noise characteristics, noise reduction techniques, adaptive signal processing, LMS, RLS

4. **Electroencephalogram (6 hrs):** Source of EEG signals, measurement of EEG signals, frequency domain analysis of EEG, modeling of EEG signals (AR, ARMA), EEG artifacts, use of software tools to analyze EEG

5. **Signal Representation by Basis Functions (4 hrs):** Principal component analysis (PCA), independent component analysis (ICA)

6. **Time-frequency analysis of biosignals (4 hrs):** Sort-time Fourier transform (STFT), Wavelet denoising, Wavelet compression

7. **Oscillometric wave and speech signals (2 hrs):** Blood pressure measurements using the oscillomertic wave and spectrographic analysis of speech signals.

Module Code	BM4301	**Module Title**	Medical Image Processing			
Credits	3.0	**Hours/Week**	**Lectures**	2	**Pre/Co – requisites**	-
GPA/NGPA	GPA		**Lab/Assignments**	3/1		

Learning Outcomes

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

1. Discuss principles of image reconstruction and visualization
2. Discuss the advantages and limitations of imaging techniques and identify which technique is suitable to a given application.
3. Describe morphological image processing
4. Differentiate medical image segmentation algorithms
5. Discuss medical image registration techniques
6. Design an image processing application for medical images

Outline Syllabus

1. **Image reconstruction and visualization (4 hrs):** Fundamentals, image enhancement, popular software libraries, texture and motion analysis

2. **Morphological image processing (6 hrs):** Binary images, gray-scale images

3. **Medical image segmentation (4 hrs)**
   Region growing, watershed, level-set segmentation, deformable models

4. **Medical image registration and fusion (6 hrs):** Geometric features, similarity measures, modelling tissue deformation, finite element analysis, tissue deformation models

Module Code	BM4321	Module Title	Genomic Signal Processing			
Credits	3.0	Hours/Week	Lectures	2	Pre/Co – requisites	-
GPA/NGPA	GPA		Lab/Assignments	3/1		

Learning Outcomes

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

1. Describe the underlying processes of the genetic code of living organisms
2. Apply machine learning algorithms for processing genomic data
3. Develop new algorithms for novel problems in genomics

Outline Syllabus

1. **Introduction (2 hours)**
   Motivation and challenges for genomic signal processing, hereditary diseases, contagious disease control, influence of genes on cancer, heart disease, diabetes, drug efficacy etc. genetic engineering and phylogenetic analysis.

2. **The Genetic Code (4 hours)**
   DNA, RNA and proteins. DNA organization in prokaryotes, simple eukaryotes and higher eukaryotes. Viruses. DNA sequencing methods.

3. **DNA Sequence Alignment (4 hours)**
   Computational challenges, local, global and overlap alignment, alignment algorithms

4. **Use of Markov Chains, Hidden Markov Models and the Vitterby Algorithm in GSP (6 hours)**

5. **Clustering Algorithms and Advanced Topics (4 hours)**
   Oligonucleotide clustering, haplotypes, information theoretic approaches, parallel processing and hardware implementation of GSP algorithms, other emerging topics.

Module Code	BM4500	**Module Title**	Biomechanics			
Credits	2.5	**Hours/Week**	**Lectures**	2	**Pre/Co – requisites**	
GPA/NGPA	GPA		**Lab/Assignments**	3/2		

Learning Outcomes

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

1. Describe the fundamental areas of human biomechanics
2. Use mathematical models to describe human tissue, orthopaedic implants, limb replacements, and human motion
3. Apply principles of mechanics to biological systems of the human body

Outline Syllabus

1. **Human tissue and modelling of tissue (6 hrs):**Growth, structure and composition, mechanical properties, mathematical modelling of human tissue

2. **Joints and movement of the human body (4 hrs):** Classification of joints, mathematical representation and calculation of joint movement. Why and how human movement is studied. Gait analysis and force measurements.

3. **Materials in biomechanics (6 hrs):** Types of implants and orthopaedic interventions, principles behind materials selection, procedure followed when introducing new materials.

4. **Limb replacement, orthopaedic implants and materials used (6 hrs)** Types of limb replacements and orthotic devices. Existing technology in developing and developed.

Module Code	BM4521	**Module Title**	Rehabilitation Engineering			
Credits	2.5	**Hours/Week**	**Lectures**	2	**Pre/Co – requisites**	
GPA/NGPA	GPA		**Lab/Assignments**	3/2		

Learning Outcomes

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

1. Discuss methods used to substitute disabled functions of human body
2. Explain measurement tools and process used in rehabilitation engineering
3. Describe operation of prosthetic and artificial organs

Outline Syllabus

1. **Rehabilitation engineering technologies (12 hrs):** Principles of application, orthopaedic prosthetics and orthotics, wheeled mobility, externally powered and controlled orthotics and prosthetics, Sensory augmentation and substitution, Augmentative and alternative communication, Measurement tools and processes in rehabilitation engineering.

2. **Prosthetic devices and assist devices (6 hrs):** Cardiac prostheses, vascular grafts, artificial lungs and blood-gas exchange devices, orthopaedic devices, bone and cartilage grafts

3. **Common medical devices and support systems (10 hrs):** Artificial kidney, peritoneal dialysis equipment, liver support systems, artificial pancreas, tracheal and oesophageal replacement devices, artificial skin and dermal equivalents

Module Code	BM4600	**Module Title**	Biomaterials			
Credits	2.5	**Hours/Week**	**Lectures**	2	**Pre/Co – requisites**	
GPA/NGPA	GPA		**Lab/Assignments**	3/2		

Learning Outcomes

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

1. Apply the fundamental principals in material science and chemistry, and how they contribute to biomaterial development and performance.
2. Discuss different types of materials used in biomedical applications
3. Differentiate between artificial and bio-compatible materials
4. Develop methods for biocompatibility improvement and practical aspects of biomedical devices: sterilization, manufacturing, clinical trials, price of implants.
5. Describe preservation techniques used with biomaterials

Outline Syllabus

1. **Materials in biomedical applications (4 hrs):** Characteristics of material used in the human body (Metallic, ceramic, polymeric, composite, etc.)

2. **Bio-compatible materials (4 hrs):** Biodegradable polymeric biomaterials, tissue-derived biomaterials

3. **Tissue replacements (6 hrs):** Soft tissue, hard tissue

4. **Materials considered for implants (6 hrs):** physical characteristics and compatibility with the bio environment.

5. **Preservation techniques for biomaterials (4 hrs):**

Module Code	BM4620	**Module Title**	Biotechnology			
Credits	2.5	**Hours/Week**	**Lectures**	2	**Pre/Co – requisites**	
GPA/NGPA	GPA		**Lab/Assignments**	3/2		

Learning Outcomes

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

1. Describe cell structures and their functions
2. Illustrate use of technology principles in vaccine production and gene therapy
3. Outline principles of tissue engineering

Outline Syllabus

1. **Cellular bioprocesses (8 hours):** Cell structure and their functions, cell membranes, energy and thermodynamics of cells, the genetic code, genetic engineering, enzymes, metabolomics, cell engineering

2. **Monoclonal antibodies and their engineered fragments (2 hours)**

3. **Gene therapy (2 hours)**

4. **Antisense technology (2 hours)**

5. **Vaccine production (2 hours)**

6. **Tissue engineering (2 hours):** Basic principles and considerations

7. **Drug delivery (2 hours):** Engineering targeted drug delivery methods and sustained release. Application of nanotechnology.

Module Code	BM2800	Module Title	Introduction to Biomedical Engineering			
Credits	2.0	Hours/Week	Lectures	2	Pre/Co – requisites	-
GPA/NGPA	GPA		Lab/Assignments	-		

Learning Outcomes

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

1. Identify different biological systems and their functions
2. Construct simple engineering models for physiological systems
3. Analyze engineering solutions to physiological phenomena.

Outline Syllabus

1. **Overview of Biomedical Engineering (2 hrs)**: Divisions of biomedical engineering, activities of biomedical engineers, ethical issues in biomedical engineering.

2. **Overview of the Human Body (8 hrs)**: Brief description of anatomical and physiological divisions of the human body.

3. **Basic Principles and Concepts in Biomedical Engineering (4 hrs)**: Review of linear systems, time and frequency domain techniques.

4. **Respiratory Mechanics and Mechanical Ventilation (6 hrs)**: Models for respiratory mechanics, method of identifying abnormalities respiration, ventilators.

5. **Models of Cardiovascular System and Related Medical Equipment (8 hrs)**: Chemoreflex regulation of respiration, cardiovascular mechanics, heart-rate variability, cardiac electrophysiology, pacemakers, and defibrillators.