MSc Syllabus Review 2018
Department of Biomedical Engineering
Military Institute of Science and Technoloogy

CHAPTER 1

Master's in Biomedical Engineering (BME)
DEPARTMENT OF BIOMEDICAL ENGINEERING
MIST, Mirpur Cantonment, Dhaka – 1216

1. Introduction

Biomedical Engineering is a broad, interdisciplinary field that deals with the problems in biology, medicine, and biotechnology. These problems include the design and analysis of physiologic measuring and diagnostic systems as well as quantitative analysis and experimentation directed toward obtaining a clearer understanding of the human body's normal and abnormal functions. The true integration of the life sciences and engineering is essential in educating a substantial percentage of the next generation of biomedical engineers in order to benefit from the biological revolution and its applications to medicine.

The Master's programme in Biomedical engineering offers students deep knowledge and functional skills in most fields of relevance for Biomedical engineering. The mission of the Biomedical Engineering Department is to pursue excellence in biomedical engineering education, research, and innovation; creating and imparting knowledge for improving society, human health, and health care. After graduation, students will be the proud member of this noble society.

1.1 Program Outline

The 2.0 year Master's programme includes three terms of course activities and two terms of degree project work, adding up to a total of 36 credits. Courses will include lectures, classroom exercises, laboratory exercises, study visits and project work. The 36 credit curriculum ensures that students looking for a career in the healthcare sector gain fundamental technology, technology development and commercialization skills important to biomedical engineers. Students in the M.Engg degree program develop deep technical skills through advanced biomedical engineering courses and are exposed to issues related to product development, intellectual property and commercialization. Through the thesis workstudents can get engaged with the clinical community to identify and develop novel engineering solutions to medical problems.

1.2 Career Prospects

Biomedical engineers apply engineering principles and materials technology to healthcare.This can include researching, designing and developing medical products, such as joint replacements or robotic surgical instruments, designing or modifying equipment for clients with special needs in a rehabilitation setting, or managing the use of clinical equipment in hospitals and the community. The scope for biomedical engineers is growing rapidly. These job opportunities are most commonly found in fields such as cellular, tissue, genetic, clinical, and rehabilitation engineering. Additionally, there are opportunities within the fields of bioinstrumentation,

biomaterials, biomechanics, drug design and delivery, medical imaging, orthopedic surgery, pharmaceuticals, and systems physiology.

.CHAPTER 2

2 DETAIL OUTLINE OF POSTGRADUATE COURSES OFFERED BY DEPARTMENT OF BME, MIST

2.1 The courses offered by the Department for Masters Program are generally divided in the following divisions.

a. Thesis / Project,
b. Core (Compulsory) Courses, and
c. Elective Courses.

2.2 The following courses are offered by the Department for Master's Program. Each term only some of the courses (typically 4-6) are offered from the Elective Courses.

Serial	Course Name	Course Code	Credit	Responsible faculty to write PO and CO
	Thesis (M. Sc. Engg.)	BME 7500	18.0	
	Project (M. Engg.)	BME 7500	6.0	
Core (Compulsory Courses) (Any 3 Courses)				
1.	Biomedical Engineering Practices and Innovations	BME 7501	3.0	Maj Ashraf and Maruf
2.	Management of Healthcare Technology	BME 7503	3.0	Prof Enam
3.	Biomaterials Properties and Application	BME 7505	3.0	Maj Ashraf
4.	Human Anatomy and Physiology	BME 7507	3.0	MajMaruf
5.	Design and Development of Bioinstrumentation	BME 7509	3.0	MajMaruf
Elective Courses (Any 3 Courses for M.Sc. and 7 Courses for M.Engg.)				
1.	Biomedical Signals and Systems Analysis	BME 7511	3.0	MajMaruf
2.	Biomedical Image Processing	BME 7513	3.0	MajMaruf
3.	Advanced Neuroengineering	BME 7515	3.0	MajMaruf
4.	Applied Bioinformatics	BME 7517	3.0	Maj Ashraf
5.	Applied Biomechanics	BME 7519	3.0	Prof Enam
6.	Advanced Biofluid Mechanics	BME 7521	3.0	Prof Enam
7.	Biomedical Implants and Prosthetics	BME 7523	3.0	Prof Enam
8.	Applied Rehabilitation Engineering	BME 7525	3.0	Prof Enam
9.	Bioreactors and Bioprocess Engineering	BME 7527	3.0	Dr. Mahfuza
10.	Tissue Engineering and Regenerative Medicine	BME 7529	3.0	MajMaruf Dr. Mahfuza
11.	Nuclear Medicine Application	BME 7531	3.0	Maj Ashraf
12.	Development of Drug Delivery Systems	BME 7533	3.0	Maj Ashraf
13.	Biomolecular and Cellular Engineering	BME 7535	3.0	MajMaruf

14.	Nanotechnology in Biomedical Engineering	BME 7537	3.0	Dr. Mahfuza
15.	Additive Biomanufacturing	BME 7539	3.0	Prof Enam
16.	Seminar	BME 7502	0.0	

Syllabuses of the Courses

The details of the courses are as follows:

BME 7500 Thesis/Project

The students will complete the 2 years Master's Programme with 18 credits thesis or 6 credits degree project to be conducted in two parts during the last two semesters. A student must complete at least 12 credits of general theory courses before starting the thesis or degree project. The thesis or degree project may be performed at the different nuclear institutes of this country. With the growing need for competent employees in the nuclear industry, there are many opportunities to perform this project at a company in the industry.

Research may be undertaken in Biomedical Engineering or in a related field. A thesis supervisor must be a member of the faculty of the Biomedical Engineering Department of MIST. A thesis can be primarily theoretical or experimental, or can combine both approaches. A Master's thesis is normally completed within 12 months. Students should use this as a guide in planning their research schedule. No student will be allowed to register for more than two semesters of Master's thesis work without petitioning for and receiving the express consent of the Departmental Committee on Graduate Students. Careful initial planning is essential for successful completion of a research project. Each thesis student is required, therefore, to turn in one copy of a brief thesis prospectus to the Department Academic Office by the end of the eighth week of the first term of Master's thesis registration. The prospectus should be a clear and well-organized preliminary report. It should contain (1) an introduction to the subject, giving a brief general statement of the field of interest and a concrete statement of the limited area of work which it is intended to undertake; (2) a review of relevant background information; (3) the proposed method of solution; (4) a tentative time schedule for completion of the work; (5) the name of the faculty member who will act as thesis advisor, and co-supervisor to be selected by the student with the concurrence of the advisor; (6) signatures of thesis advisor and co-supervisor to indicate approval of the proposed research project. It is the responsibility of the student to maintain a rate of progress that will insure completion of the thesis within the two semesters allowed. The thesis supervisor may require periodic, written reports on the progress of the thesis. Students should be prepared to submit these if requested.

Each graduate student preparing a thesis is responsible for compliance with Institute and Department instructions regarding thesis preparation. Three copies of the thesis in final printed form and one electronic copy, in PDF form, on CD are to be submitted to the Department Academic Office. Original signatures of the thesis supervisor and co-supervisor (if any) must appear on the thesis cover page.

The students will perform their research work in the laboratories of Biomedical Engineering Department of MIST or related facilities in other academic and research institutes in home & abroad with the guidance of thesis / project supervisor.

BME 7501Biomedical Engineering Practices and Innovations (Johns Hopkins Univ. USA)
Credit 3.0 Contact Hours 3

This course covers hands-on experimental and design work primarily in the areas of physiology, cell and tissue engineering, and biomedical instrumentation. In addition to teaching and allowing students to perform state-of-the art experimental techniques, this course will emphasize the business end of biomedical engineering innovation including identification of engineered needs and FDA regulation. This course covers Skeletal Muscle Function & EMGs; Cardiac Mechanics & ECGs; Biointerfacing; Microfabrication; Tissue Engineering; Ultrasound Imaging; Cardiac Catheterization; and Biophotonics.

Text & Reference Books:

1. Medical Device Design: Innovation from concept to market, *1st Edition*, Peter J Ogrodnik
2. Advanced Manufacturing Technology for Medical Applications: Reverse Engineering, Software Conversion and Rapid Prototyping, *1st Edition*, Ian Gibson
3. New Technologies in Health Care: Challenge, Change and Innovation (Health Technology and Society), *1st Edition*, Andrew Webster
4. From X-rays to DNA: How Engineering Drives Biology, W. David Lee, Jeffrey Drazen, Phillip A. Sharp, Robert S. Langer
5. Microfabrication in Tissue Engineering and Bioartificial Organs (Microsystems), *1st Edition*, Sangeeta N. Bhatia

BME7503 Management of Healthcare Technology (Duke University, USA)
Credit 3.0 Contact Hours 3

This course provides the students with an overview of how health care institutions are organized and governed, the role of the management staff, physicians, nurses and other clinical and support staff in these organizations, and the management systems designed for their efficient and effective operation. The course focuses on the principles and management of technology, device development, marketing, financing and regulatory requirements for the diagnosis, treatment, and prevention of chronic and acute diseases in the modern health care environment.

Text & Reference Materials**:**

1. Introduction to Health Care Management; Jones & Bartlett Publishers
2. Healthcare Technology Management - A Systematic Approach; Frances Fyfield, John Amoore, Justin McCarthy, Paul Blackett, and Richard Scott
3. Healthcare Technology Management Systems: Towards a New Organizational Model for Health; Luis Vilcahuamán

4. Management of Medical Technology: Theory, Practice and Cases; EliezerGeisler and Ori Heller

BME 7505 Biomaterials properties and Applications(Johns Hopkins Univ. USA)
Credit 3.0 Contact Hours 3

This course covers the fundamentals of the synthesis, properties, and biocompatibility of metallic, ceramic, polymeric, and biological materials that come in contact with tissue and biological fluids. Emphasis is placed on using biomaterials for both hard and soft tissue replacement, organ replacement, coatings and adhesives, dental implants, and drug delivery systems. New trends in biomaterials, such as electrically conductive polymers, piezoelectric biomaterials, and sol-gel processing are discussed, and the recent merging of cell biology and biochemistry with materials is examined. Case studies and in-class scenarios are frequently used to highlight the current opportunities and challenges of using biomaterials in medicine. This course focuses on the Metallic Implant Materials**;** Ceramic Implant Materials**;** Hard and Soft Tissue Replacement**;** Introduction to Polymer Science**;** Polymer Implant Materials**;** Polymers for Biomaterials**;** Composites for Biomaterials**;** Biological Materials**;** Tissue Response to Implants;andTissue Engineering.

Text & Reference Books:

1. Biomedical Engineering & Design Handbook, Volumes I and II, *2nd Edition*, Myer Kutz
2. Biomimetics - Materials, Structures and Processes: Examples, Ideas and Case Studies (Biological and Medical Physics, Biomedical Engineering), *2011th Edition*, Petra gruber, Dietmar Bruckner, Christian Hellmich, Heinz-BodoSchmiedmayer, Herbert Stachelberger, Ille C. Gebeshuber
3. Carbon Nanotubes for Biomedical Applications (Carbon Nanostructures), *2011th Edition*, RüdigerKlingeler, Robert B. Sim
4. Modified Fibers with Medical and Specialty Applications, *2006th Edition*, Vincent Edwards (Editor), Gisela Buschle-Diller (Editor), Steve Goheen
5. Nanostructured Materials and Coatings for Biomedical and Sensor Applications (Nato Science Series II:), Yury G. Gogotsi (Editor), Irina V. Uvarova

BME7507 Human Anatomy and Physiology (Duke University, USA)
Credit 3.0 Contact Hours 3

This course provides the students with an overview of Body Structure (Anatomy):Cell biology: Cell death, cell migration, cell culture, cell proliferation and differentiation, Polarization and depolarization of cell. Human Physiology:Composition of Blood, Blood cells and their functions. Immune system: Immune response, models of immune response, Autoimmune diseases. Nervous System: Different parts, their functions, Structure and functions of Neurons and Glia, Synapse, Reflex action and Receptors, Nervous control of Heart. Musculo Skeletal System: Muscle Tissue, Structure of Skeletal Muscle, Types of Muscle, Types of Joints, Reproductive System:

(Male and Female) Different organs and their functions. Main actions of Androgens, Oestrogens and Progesterone. Cardiovascular system: Heart, Conductive tissues of heart, Cardiac cycle, Heart Valves, System and Pulmonary Circulation, Transmission of Cardiac Impulse, Blood Pressure, ECG (Einthoven's Triangle, Various leads and Waveforms). Respiratory system: Physiological aspects of respiration, Exchange of gases. Digestion and absorption: Movement of GI tract, Structure and function of kidneys and Nephron, Temperature regulation. Eyes and Ears: Eyes-Structure, Refractive Medias of the eye, formation of image on the Retina, Ophthalmoscope; Ear: Structure of Cochlea, Hearing mechanism, type of Deafness. Endocrine System: All glands, their secretions and functions.

Text and reference books:

1. Essentials of Anatomy and Physiology, Valerie C Scanlon, Tina Sanders
2. Seeley's Essentials of Anatomy and Physiology, Cinnamon L Vanputte, Jennifer L Rigan

BME 7509 Design and Development of Bioinstrumentation (Prof K Rabbani, DU)
Credit 3.0 Contact Hours 3

This course provides the students with an overview of Bio-electric Amplifier, Bioelectric Data Sampling and Acquisition requirements. ECG System: ECG amplifier, CMRR and filter requirements, patient safety issues and isolation circuitry, Right Leg Drive, Techniques to obtain 12 lead ECG, Data acquisition and display techniques using PC. Neuro-Muscular System, Peripheral: EMG amplifiers, CMRR and filter requirements, patient safety issues and isolation circuitry for both (i) Needle EMG and (ii) Surface EMG, Data acquisition and display techniques using PC for voluntary and evoked EMG measurements, Nerve conduction measurement techniques using evoked EMG and evoked nerve action potentials, EOG signal recording. Central nervous system: EEG electrode placement modalities. EEG amplifiers, CMRR and filter requirements, patient safety issues and isolation circuitry, Evoked Visual (Slow Vertex Response and Brain Stem evoked Response) signal measurement techniques and systems. Electrical Impedance Measurement System: Tetrapolar Impedance Measurement (TPIM), Electrical Impedance Toography, Focused Impedance Method (FIM), Basic TPIM measurement system design and circuits, Measurement of impedance and phase. Optical measurements of physical parameters: Photo-plethysmography, Pulse Oximetry, blood oxygen saturation and perfusion index, Reagent based hematology measurements, Spectral measurement system. Hearing defect measurements and remedy: Basics of subjective hearing defect measurement techniques: pure tone audiometry, bone conduction measurements, Objective hearing defect measurement techniques: Auditory Evoked potentials (i) Slow Vertex Response, (ii) Brain Stem Electrical Response and (iii) Otoacoustic Emissions (OAE); Hearing aids – different types, Cochlear implants

Text & Reference Books:

1. The Biomedical Engineering Handbook, *Fourth Edition*, Joseph D. Bronzino

2. Medical Instruments and Devices: Principles and Practices, *1st Edition*, Steven Schreiner, Joseph D. Bronzino, Donald R. Peterson
3. Medical Instrument Design and Development: From Requirements to Market Placements, *1st Edition*, Claudio Becchetti, Alessandro Neri
4. Noninvasive Instrumentation and Measurement in Medical Diagnosis (Biomedical Engineering), *1st Edition*, Robert B. Northrop
5. Measurement and Data Analysis for Engineering and Science, *2nd Edition*, Patrick F. Dunn.

BME 7511Biomedical Signals and Systems Analysis (Boston University, USA)
Credit 3.0 Contact Hours 3

This course covers the topics of ECG signal Analysis: Signal characteristics: amplitude, frequency spectrum, variation between subjects, Filtering requirements, post processing, Removal of wandering baseline, Heart Rate measurement, PQ, ST segment detection and QRS complex detection, Other automated analysis. EMG signal Analysis: Voluntary EMG and Evoked EMG patterns, Signal characteristics: (amplitude, frequency spectrum, time variable patterns) for (i) Needle Electrode EMG and (ii) Surface electrode EMG. Filtering requirements, post processing, Processing to identify pathology, integration in time, Multiple EMG from adjacent muscle groups for classification in prosthetic control, Classification of EOG for communication and control. EEG and ECoG signal analysis System: Signal characteristics: amplitude, frequency spectrum, variation under different environmental inputs, Filtering requirements, post processing, Auto detection of seizures, analysis of Evoked Visual and Auditory responses for automated detection of pathology. Application of Data Classification and Machine learning methods: Pathological condition detection by various measured signals and parameters, Equation fitting for nonlinear response of physiological parameters, Medical image processing and detection of anomalies. Communication and Control Systems: Eyeball Tracking, Brain Computer Interface (BCI).

Text & Reference Books:

1. MATLAB: An Introduction with Applications, *5th Edition*, Amos Gilat
2. Advanced Fuzzy Logic Technologies in Industrial Applications (Advances in Industrial Control), *2006th Edition*, Ying Bai, HanqiZhuang, Dali Wang
3. Advanced Methods of Biomedical Signal Processing, *1st Edition*, Sergio Cerutti, Carlo Marchesi
4. Advanced Signal Processing on Brain Event-Related Potentials: Filtering ERPs in Time, Frequency and Space Domains Sequentially and Simultaneously, *1st Edition*, Fengyu Cong, TapaniRistaniemi, HeikkiLyytinen
5. Lung Sounds: An Advanced Signal Processing Perspective (Synthesis Lectures on Biomedical Engineering), *1st Edition*, LeontiosHadjileontiadis

BME 7513Biomedical Image Processing (Georgia Instituteof Technology, USA)
Credit 3.0 Contact Hours 3

This course covers the topic of Medical Imaging: What is it, history, rationale, importance, uses, present trends, challenges; Medical Image Formation: Imaging Modalities (X-Ray, MRI, PET, SPECT, Ultrasound); omparison of Data Resulting from Different Modalities; 2D and 3D Medical Image Data; Dynamic (4D) Medical Image Information. Image Enhancement: Thresholding; Signal-to-Noise Characteristics; Filtering, Histogram Modeling; Pseudocolor. Image Analysis: Edge detection; feature extraction; grouping and contour following; dimensional analysis; transforms; segmentation.Image Display and Visualization: Color Usage; 3D Reconstruction; 3D Modeling and Display; Volume Visualization; Multimodality Integration; Animation of Dynamic Processes. Image Interpretation: Model-Based Vision; Labeling: Recognition; Knowledge-Based Processing; Interactive decision support. Case Studies: Seminars and guest lectures by medical and/or clinical researchers in medical imaging discussing the application of concepts learned in class in the medical environment.Software Usage: Hands-on seminar and demonstration of software tools used in medical image enhancement, analysis, display and/or interpretation.

Text & Reference Books:

1. MATLAB: An Introduction with Applications, *5th Edition*, Amos Gilat
2. The Essential Physics of Medical Imaging, Third Edition 3rd Edition, Jerrold T. Bushberg, J. Anthony Seibert , Edwin M. Leidholdt Jr., John M. Boone.
3. Fundamentals of Medical Imaging, Paul Suetens
4. Medical Imaging Signals & Systems, 5th Edition, Jerry L. Prince, Jonathan Links

BME 7515Advanced Neuroengineering (Boston University, USA)
Credit 3.0 Contact Hours 3

This course covers existing and future neurotechnologies for analyzing brain signals and for treating neurological and psychiatric diseases. It focuses on the biophysical, biochemical, anatomical principles governing the design of current neurotechnologies, with a goal of encouraging innovations of a new generation of therapies. Topics include basic microscopic and macroscopic architecture of the brain, the fundamental properties of individual neurons and ensemble neural networks, electrophysiology, DBS, TMS, various imaging methods, optical neural control technologies, optogenetics, neuropharmacology, gene therapy, and stem-cell therapy. Discussions of related literatures and design projects will be involved.

Text & Reference Books:

1. Neuroscience, Dale Purves, Georgage J Augustine, et al.,
2. Neuroengineering, 1st Edition, Daniel J. DiLorenzo (Editor), Joseph D. Bronzino
3. From Neurology to Methodology and Back: An Introduction to Clinical Neuroengineering, 2012th Edition, Natasha Maurits
4. Brain Extracellular Matrix in Health and Disease, Volume 214 (Progress in Brain Research), 1st Edition, Alexander Dityatev (Editor), Bernhard Wehrle-Haller (Editor), AslaPitkänen
5. Electrochemical Methods for Neuroscience (Frontiers in Neuroengineering Series), *2006th Edition*, Adrian C. Michael and Laura Borland

BME 7517 Applied Bioinformatics (Johns Hopkins University, USA)
Credit 3.0 Contact Hours 3

Course overview and objectives includewhat is computational biology and bioinformatics and why is it important? Intake survey. Topics include Introduction to probabilistic models for computational molecular biology in the 21st century: Getting the biology right; Null models and statistical significance; Introduction to probabilistic models in computational biology: parametric probability distributions and their alternatives; Introduction to maximum likelihood in computational biology; Pairwise sequence alignment algorithms; Hidden Markov models in computational biology; Introduction to machine learning in computational biology; Bayesian methods in computational biology; and Phylogenetic methods in computational biology.

Text & Reference Books:

1. Modeling of Physiological Flows (MS&A), 2012th Edition, DavideAmbrosi, AlfioQuarteroni, GianluigiRozza.
2. Modeling in Computational Biology and Biomedicine: A Multidisciplinary Endeavor, 2013th Edition, FrédéricCazals (Editor), Pierre Kornprobst (Editor), Oliver Faugeras (Foreword), JoëlJanin.
3. Biomedical Informatics, David J. Lubliner
4. Medical Informatics, Kenneth R. Ong
5. Biomedical Signals, Imaging, and Informatics, Joseph D. Bronzino, Donald R. Peterson

BME7519 Applied Biomechanics (Boston University, USA)
Credit 3.0 Contact Hours 3

This course introduces the students to the mechanics of materials and their applications to study the mechanical behavior of skeletal tissues, whole bones, bone-implant systems, and diarthroidal joints. Contents focus on mechanical behavior of tissues (anisotropy, viscoelasticity, fracture and fatigue) with emphasis on the role of the microstructure of these tissues, structural properties of whole bones and implants, and mechanical function of joints (contact mechanics, lubrication, and wear). Emphasis is placed on integrating the basic analytical, experimental, and computational methods towards deeper understanding of the underlying mechanobiology.

Text & Reference Materials:

1. Introductory Biomechanics - From Cells to Organisms; Ethier, C. Ross
2. Fundamentals of Biomechanics; Knudson, Duane
3. Biomechanical basis of Human movement; Joseph Hamill, Kathleen M Knutzen
4. Biomechanics and motor control of human movement; Winter, D.A

BME7521 Advanced Biofluid Mechanics (Duke University, USA)

Credit 3.0 Contact Hours 3

The overall purpose of this course is to learn about the relationship between the mechanics and physiology (i.e. biology) of tissues and cells using practical examples and clinical case studies. It focuses on the kinematics and dynamics of biofluids related to biological systems, medical science, cardiovascular devices, and computational fluid dynamics. The topics will cover advanced aspects of fluid mechanics and physical principles of circulation, blood rheology, properties of flowing blood, blood flow in vessels, veins, coronary arteries, microcirculation, models of biofluids, computational biofluid mechanics and fluid in the lung.

Text & Reference Materials:

1. Complex Fluids in Biological Systems: Experiment: Theory, and Computation (Biological and Medical Physics, Biomedical Engineering); SaverioSpagnolie
2. Fluid-Structure Interaction and Biomedical Applications (Advances in Mathematical Fluid Mechanics); Tomas Bodnar, Giovanni P. Galdi, SarkaNecasova
3. The Application of Biofluid Mechanics: Boundary Effects on Phoretic Motions of Colloidal Spheres (SpringerBriefs in Physics); Po-Yuan Chen
4. Relevant Journal

BME7523 Biomedical Implants & Prosthetics (Duke University, USA)
Credit 3.0 Contact Hours 3

This course aims to train the students how underlying technology can be applied to the design, development and application of biomedical implants and prosthetics for the treatment of a range of human diseases and disabilities. In particular, the students will learn about the different aspects (i.e. requirements and functions) of various implants and prosthetics (e.g. cardiovascular implants, prosthetic limbs etc.). The relevant background to anatomy, disease, injury and the mechanical properties of biological materials will be covered such that engineering solutions can be presented with respect to the associated clinical needs. In addition, this course will also discuss the research developments in the areas of biomedical implants and prosthetics.

Text and Reference Materials:

1. Fundamentals of Orthopaedic Biomechanics; Albert H. Burstein, Timothy M. Wright
2. Implant Restorations: A Step-by-Step Guide; Luis Vilcahuamán
3. Dental Implant Prosthetics; Carl E. Misch
4. Indwelling Neural Implants: Strategies for Contending with the In Vivo Environment; William M. Reichert

BME7525 Applied Rehabilitation Engineering (Marquette University, USA)
Credit 3.0 Contact Hours 3

The overall purpose of this course is to learn about principles and applications of rehabilitative assessment and therapy, with special focus on the use of technology to enhance access and consideration of the continuum of rehab care as an optimization problem. Overview of

sensorimotor systems, as related to human performance and usability analysis.Models for access engineering and telerehabilitation, with focus on accessible design strategies, telemonitoring and teletherapy, and wireless and augmentative communication technologies. Rehabilitation biomechanics of interfaces for seated mobility and for manipulation tasks will also be covered.

Text & Reference Materials:

1. An Introduction to Rehabilitation Engineering; Rory A. Cooper
2. Rehabilitation Engineering; Raymond Virgil Smith
3. Rehabilitation Engineering Applied to Mobility and Manipulation; Rory A. Cooper
4. Relevant Journal

BME7525 Bioreactors and Bioprocess Engineering(Georgia Institute of Technology)
Credit 3.0 Contact Hours 3

This course introduces the students to the media components and media composition, development of media, Growth kinetics and growth models (Monod model and logistic growth), Balancing of bioprocesses, Derivation of bioprocess models (batch, fed -batch, continuous process with and without cell retention), Cleaning and sterilization processes, Transport processes in biosuspensions, Process monitoring and online and offline analysis (substrate and metabolic products), Gas - chromatography analysis of products including derivatisation, Evaluation with regards to the specific process parameters in the bioreactor, Determination of the yields of the complete process, Introduction to design of experiments (DOE) (full-factorial and fractional factorial experiment designs, data evaluation, introduction to the "MODDE" software. Bioreactors: Introduction, Some Fundamental Concepts, Mechanically Stirred Tanks, Gas Dispersion in Stirred Tanks, Bubble Columns, Airlift Reactors, Packed-Bed Reactors, Microreactors, Bioreactors as 3D In vitro Model Systems, Open Challenge, Computational Modeling in Bioreactor Systems, Streamlining Graft Manufacturing Processes, Centralized Versus De-Centralized Production Facilities. Bioreactors: types, applications,Study of enzymes and microbial and mammalian cells for production of biochemicals and protein therapeutics in bioreactors; downstream separation and purification; integrated view of bioprocesses.

Text & Reference Books:

1. Bioprocess Engineering: Basic Concepts, Michael L Shuler, FikretKargi.
2. Bioreactors: Animal Cell Culture Control for Bioprocess Engineering, GoutamSaha, AlokBarua, SatyabrotoSinha
3. Bioreactor Systems for Tissue Engineering, Kasper, Cornelia; van Griensven, Martijn; Pörtner, Ralf (Eds.)

BME7529 Tissue Engineering and Regenerative Medicine (Duke University)
Credit 3.0 Contact Hours 3

This course will serve as an overview of selected topics and problems in the emerging field of tissue engineering. General topics include cell sourcing: Introduction: Historical perspective of tissue engineering, sources of cells for tissue engineering applications, Influences of cell function: extracellular matrix, mechanical environment; structure/function relationships, Cell procurement of auto-, allo-, and xenogeneic cells; genetic engineering of cells for tissue engineering applications; cell amplification in culture; stem cells and maintenance of differentiated state, culture scaffolds, Biomaterials and functional requirements of biomaterials in tissue engineering applications, cell-biomaterials interactions modifications for eliciting specific cellular/tissue responses, culturing mode, bioreactor design, Immunoacceptance of transplanted cells, immunocompatibility, Preservation of tissue engineered constructs, Integration of constructs into living systems; Specific tissue types to be reviewed include cartilage tissue engineering, skin equivalents, blood vessels, myocardium and heart valves, and bioartificial livers.

Text & Reference Books:

1. Cell and Tissue Engineering, *2012th Edition*, BojanaObradovic
2. Introduction to Tissue Engineering: Applications and Challenges (IEEE Press Series on Biomedical Engineering), *1st Edition*, Ravi Birla
3. Tissue Engineering in Regenerative Medicine (Stem Cell Biology and Regenerative Medicine), *2011th Edition*, Harold S. Bernstein
4. Cardiac Tissue Engineering: Principles, Materials, and Applications (Synthesis Lectures on Tissue Engineering), *1st Edition*, Emil Ruvinov, Yulia Sapir, Smadar Cohen
5. Tissue Engineering: Engineering Principles for the Design of Replacement Organs and Tissues, *1st Edition*, W. Mark Saltzman

BME 7531Nuclear Medicine Application
Credit 3.0 Contact Hours 3

The overall purpose of this course is to learn about introduction of Nuclear medicine: The production of technetium generator; The distribution of technetium-based radiotracers within the body; The gamma camera; Nuclear Image characteristics; Clinical applications of gamma camera; Single photon emission computed tomography (SPECT), Data processing in SPECT, SPECT/CT, Clinical applications of SPECT and SPECT/CT, Positron emission tomography (PET), Radiotracers used for PET/CT, Instrumentation for PET/CT, Two-dimensional and three-dimensional PET imaging, PET/CT, Data processing in PET/CT, Image characteristics, Time-of-flight PET, Clinical applications of PET/CT, uptake study, RIA study with Iodine 125; and production of PET isotopes.

Text and Reference Books:

1. The Essential Physics of Medical Imaging by J.T. Bushberg, J.A. Seibert

BME 7533 Development of Drug Delivery Systems (Johns Hopkins University, USA)

Credit 3.0 Contact Hours 3

This course introduces the students to the fundamental concepts in drug delivery from an engineering perspective. Biological organisms are viewed as highly interconnected networks where the surfaces/interfaces can be activated or altered "chemically" and "physically/mechanically." The importance of intermolecular and interfacial interactions on drug delivery carriers is the focal point of this course. Topics include drug delivery mechanisms (passive, targeted); therapeutic modalities and mechanisms of action; engineering principles of controlled release and quantitative understanding of drug transport (diffusion, convection); effects of electrostatics, macromolecular conformation, and molecular dynamics on interfacial interactions; thermodynamic principles of self-assembly; chemical and physical characteristics of delivery molecules and assemblies (polymer based, lipid based); significance of biodistributions and pharmacokinetic models; toxicity issues; and immune responses.

Text & Reference Books:

1. Malsch, N.H. Biomedical Nanotechnology, CRC Press, (2005).
2. Mirkin, C.A. and Niemeyer, C.M., "Nanobiotechnology II: More Concepts and Applications", Wiley-VCH, (2007).
3. Jain, K.K. The Handbook of Nanomedicine, Humana Press, (2008).
4. Drug Delivery: Engineering Principles for Drug Therapy. W. Mark Saltzman. Oxford University Press, New York, 2001.
5. Drug Delivery Systems, Third Edition, Vasant V. Ranade, John B. Cannon

BME 7535Biomolecular and Cellular Engineering (University of Pensylvania, USA)
Credit 3.0 Contact Hours 3

In this course we will introduce the fundamentals of molecular cellular biology underpinning applications in bioengineering. The course will emphasize core concepts, quantitative analyses, high -throughput advanced 'omics techniques, and multi-scale system s approaches. Textbook readings will be used to develop a foundation of basic facts and concepts. Lectures will build on this foundation to dive into key concepts, explore the experimental logic and techniques used to study molecular biology, and develop quantitative models.Topics include: Protein and DNA structure, Recombinant DNA, cloning and genomics, Prokaryotic and eukaryotic gene regulation and single cell gene expression, The structure and dynamics of gene regulatory networks, Metabolism and cellular energetics, Cell Structure, cytoskeleton and cellular motors, Synthetic gene circuits and metabolic engineering

Text & Reference Books:

1. Molecular Biology of the Cell, 6th Edition, by Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, and Peter Walter.
2. Molecular Cell Biology, by Harvey Lodish and Arnold Berk
3. Stem cell engineering.Loredana De Bartolo, Augustinus Bader.
4. Biomaterials for Stem Cell Therapy: Stateof Art and Vision for the Future

BME 7537Nanotechnology in Biomedical Engineering (University of California, San Diego, USA)
Credit 3.0 Contact Hours 3

The overall purpose of this course is to learn about the fundamentals of the synthesis, properties, and biocompatibility of metallic, ceramic, polymeric, and biological materials that come in contact with tissue and biological fluids. Emphasis is placed on using biomaterials for both hard and soft tissue replacement, organ replacement, coatings and adhesives, dental implants, and drug delivery systems. Nanosensors, nanodevices for clinical diagnostics, biowarfare agent detection; nanostructures for drug delivery; nanoarrays, nanodevices, nanoanalytical devices and systems, methods for modification or functionalization of nanoparticles, nanostructures with biological molecules; nanostructural aspects of fuel cells; biofuel cells; potential use of DNA, other biomolecules.

Text & Reference Books:

1. Malsch, N.H. Biomedical Nanotechnology, CRC Press, (2005).
2. Mirkin, C.A. and Niemeyer, C.M., "Nanobiotechnology II: More Concepts and Applications", Wiley-VCH, (2007).
3. Jain, K.K. The Handbook of Nanomedicine, Humana Press, (2008).
4. Drug Delivery: Engineering Principles for Drug Therapy. W. Mark Saltzman. Oxford University Press, New York, 2001.
5. Drug Delivery Systems, Third Edition, Vasant V. Ranade, John B. Cannon

BME 7539Additive Biomanufacturing (University of Wollongong, Australia)
Credit 3.0 Contact Hours 3

The course will introduce students to the emerging area of additive biofabrication starting from the concepts that distinguish this additive approach from traditional manufacturing. Major contents include fundamental topics and methodologies of additive fabrication, printable materials and their properties (e.g. biopolymers and bio-inks), techniques/instrumentation such as commercial additive fabrication systems, rapid prototypers, reactive printers, extrusion printers, metal printers, coating techniques, bioplotters and live cell printing. Recent developments in additive biofabrication for biomedical applications will be discussed.

Text & Reference Materials:

1. Biofabrication; Gabor Forgacs, Wei Sun
2. 3D Printing and Biofabrication; Ovsianikov, Aleksandr, Yoo, James, Mironov, Vladimir
3. Essentials of 3D Biofabrication and Translation; Anthony Atala, James J Yoo
4. Biofabrication and 3D Tissue ModelingEditor; Dong-Woo Cho