Indian Institute of Technology Guwahati
Jyoti & Bhupat Mehta School of Health Sciences and Technology

MTech Biomedical Engineering

Course Number & Title: HT501 Introduction to Cellular Processes
L-T-P-C: 3-0-0-6
Type of Letter Grading (Regular Letter Grades / PP or NP Letter Grades): Regular
Kind of Proposal (New Course / Revision of Existing Course): New Course
Offered as (Compulsory / Elective): Compulsory for M. Tech., Elective for Ph.D.
Offered to: M.Tech., Ph.D.
Offered in (Odd/ Even / Any): Odd
Offered by (Name of Department/ School/ Center): Health Science and Technology
Pre-Requisite: Nil
Preamble: The course has been designed for the postgraduate students from varying backgrounds to provide them fundamental knowledge about different processes that occur within cells. The modules are designed such that the students are provided the basic knowledge of a typical cellular system and cell membrane. The course will then give an overview of the molecular basis of cell physiology and their coordination in cell signaling for the understanding of the molecular and cellular basis of physiology and pathophysiology.
Course Content/Syllabus: Basics of cell types; structural organization and function of intracellular organelles: nucleus, mitochondria, Golgi bodies, lysosomes, endoplasmic reticulum, peroxisomes, plastids, vacuoles, chloroplasts, structure & function of cytoskeleton and its role in motility; Structure of model membrane, lipid bilayer and membrane protein diffusion, osmosis, ion channels, active transport, membrane pumps, mechanism of sorting and regulation of intracellular transport, electrical properties of membranes; Basics of thermodynamics in bio-systems, common biochemical reactions, phosphorylation and ATP, biological oxidation reduction; Chromosomes and their structure cell division: mitosis and meiosis, steps in cell cycle and its regulation; From gene to protein: DNA replication, transcription/RNA synthesis, and translation/protein synthesis; General principles of cell communication, cell adhesion and roles of different adhesion molecules, gap junctions, extracellular matrix, integrins, neurotransmission and its regulation; Introduction to metabolic pathways: catabolic pathways and anabolic pathways – glycolysis, TCA cycle, fatty acid and amino acid metabolism, metabolic regulation; Hormones and their receptors, cell surface receptor, signalling through G-protein coupled receptors, signal transduction pathways, light signalling in plants, bacterial chemotaxis and quorum sensing; Essential techniques applied in cell biology with case studies, basic of recombinant technology, reporter constructs, and oligonucleotide array.
References:

1	Nelson D.L., Cox, M.M., Hoskins, A. *Lehninger Principles of Biochemistry*, Eighth Edition, Macmillan Higher Education, New York, 2021.
2	Alberts B., Johnson A., Lewis J., Morgan D., Raff M., Roberts K., Walter P. Wilson J, Hunt T. *Molecular Biology of the Cell*, Sixth Edition, Garland Science, New York and Abingdon, 2017.
3	Copper G. *The Cell: A Molecular Approach*, Eighth Edition, Sinauer Associates, Inc, Sunderland, 2000.
4	Lodish H., Berl A., Kaiser C.A., Krieger M., Bretscher A., Ploegh H., Martin K.C., Yaffe M., Amon A. *Molecular Cell Biology*, Ninth Edition, Macmillan Learning, New York, 2021.

Lecture Plan:

Module	Content	No. of Lectures
Module 1: Cellular systems	Basics of cell types; structural organization and function of intracellular organelles: nucleus, mitochondria, Golgi bodies, lysosomes, endoplasmic reticulum, peroxisomes, plastids, vacuoles, chloroplasts, structure & function of cytoskeleton and its role in motility.	6
Module 2: Components of membrane	Structure of model membrane, lipid bilayer and membrane protein diffusion, osmosis, ion channels, active transport, membrane pumps, mechanism of sorting and regulation of intracellular transport, electrical properties of membranes.	4
Module 3: Bioenergetics and biochemical reactions	Basics of thermodynamics in bio-systems, common biochemical reactions, phosphorylation and ATP, biological oxidation reduction.	6
Module 4: Cell division, cycle, and biomolecule synthesis	Chromosomes and their structure cell division: mitosis and meiosis, steps in cell cycle and its regulation. DNA replication, transcription/RNA synthesis, and translation/protein synthesis.	4
Module 5: Cellular communication	General principles of cell communication, cell adhesion and roles of different adhesion molecules, gap junctions, extracellular matrix, integrins, neurotransmission and its regulation.	4
Module 6: Principles of metabolism	Introduction to metabolic pathways: catabolic pathways and anabolic pathways – glycolysis, TCA cycle, fatty acid and amino acid metabolism, metabolic regulation.	6
Module 7: Basic of biosignalling	Hormones and their receptors, cell surface receptor, signalling through G-protein coupled receptors, signal transduction pathways, light signalling in plants, bacterial chemotaxis and quorum sensing.	6
Module 8: Biochemical techniques	Essential techniques applied in cell biology with case studies, basic of recombinant technology, reporter constructs, and oligonucleotide array.	6
	Total Lectures	42

Indian Institute of Technology Guwahati

Course Number & Title: HT502 Basic Physiology for Clinical Immersion
L-T-P-C: 3-0-0-6
Type of Letter Grading (Regular Letter Grades / PP or NP Letter Grades): Regular
Kind of Proposal (New Course / Revision of Existing Course): New Course
Offered as (Compulsory / Elective): Compulsory for M Tech, Elective for PhD
Offered to: M Tech, PhD,
Offered in (Odd/ Even / Any): Odd
Offered by (Name of Department/ School/ Center): Health Science and Technology
Pre-Requisite: Nil
Preamble: The course has been designed for postgraduate students to provide basic understanding of human physiology required for the development of biomedical devices and biomaterials. The students would be provided an overview of the physical and chemical characteristics and mechanisms of human body. The students would be provided an overview of the functioning of different organ systems and their coordination for proper functioning of human body.
Course Content/Syllabus: An introduction to human body: Overview of anatomy and physiology, structural organizations of the human body, functions and requirements of human life, homeostasis, anatomical terminologies, medical imaging; Neural Physiology: Introduction to the nervous system, central nervous system (CNS), peripheral nervous system (PNS), general sensory system, sensory and motor neurons, cells of nervous system, reflexes, cerebrospinal fluid and blood brain barrier, communication between nerves, electrical and chemical synapse, mechanism of nerve impulse transmission, neurotransmitters, neural diseases/disorders - dementia, Alzheimer's disease; Muscle physiology: Overview of muscle function, skeletal muscle structure and function, skeletal muscle mechanics, force-length and velocity, cross bridge cycle, exercise, cardiac muscle, excitation-contraction coupling in cardiac & skeletal muscle, smooth muscle, development and regeneration of muscle tissue, muscle diseases/disorders - myasthenia gravis, multiple sclerosis; Cardiovascular physiology: Overview of the cardiovascular system, composition of blood, blood vessels, arteries, veins and capillaries, functional anatomy of the heart, the heart pump, cardiac muscle and electric activity, electrophysiology, cardiac function assessments, venous return and cardiac output, arterial and venous blood pressure, arterial pressure regulation, hypertension and hypotension, cardiovascular diseases; Pulmonary physiology: Overview of respiratory system organs and functions, pulmonary ventilation, mechanics of breathing, breathing and respiration, gas exchange – diffusion, transport of O_2 and CO_2, regulation of respiration, pulmonary diseases; Renal physiology: Overview of urinary system, organs and functions, kidney functional anatomy, nephrons, glomerular filtration, tubular absorption, secretion-mechanism of secretion, electrolytes and volume regulation, acid base balance, physiology of urine formation, urine composition, concentration and diluting mechanisms of urine, disorders of acid base balance and renal diseases, dialysis; Endocrinology: Organization of the hormonal systems, hormones, the hypothalamus-pituitary system, the adrenal and thyroid glands, development and aging of endocrine systems, calcium homeostasis and bone biology, diseases related to hormonal imbalance; Immune system: Overview of immune system, humoral and cell mediated immune system, immunoglobulin structure and classes, antigen-antibody reactions, and their applications in immunodiagnostics, complement system, autoimmune diseases, AIDS, hypersensitivity reactions and immunodeficiency diseases, graft rejection.

References:

1	Hall J. and Hall M. *Textbook of Medical Physiology*. 14th Ed, Saunders Company, London, 2020.
2	Barrett K., Barman S., Yuan J., Brooks H. *Review of Medical Physiology.* 26thEd, McGraw Hill INC. New York, 2019.
3	Tortora G.J. and Derrickson B.H. *Tortora's Principles of Anatomy & Physiology*, 15thEd, Tortora. Harper Collins College Publications, 2017.
4	Goldsby R.A., Kindt T.J., Osborne B.A., Kuby J. *Immunology*, W.H. Freeman, 2002.
5	Young K.A., Wise J.A., DeSaix P., Kruse D.H., Poe B., Johnson E. et al. *Anatomy and Physiology*, Benjamin-Cummings Publishing Company, 2013.

Lecture Plan:

Module	Content	No. of Lectures
Module 1: An introduction to human body	Overview of anatomy and physiology, structural organizations of the human body, functions and requirements of human life, homeostasis, anatomical terminologies, medical imaging.	4
Module 2: Neural Physiology	Introduction to the nervous system, central nervous system (CNS) (brain and spinal cord), peripheral nervous system (PNS) (somatic nervous system and the autonomic nervous system), general sensory system, sensory and motor neurons, cells of nervous system, reflexes, cerebrospinal fluid and blood brain barrier, Communication between nerves, electrical and chemical synapse, mechanism of nerve impulse transmission, neurotransmitters, neural diseases/disorders, e.g., dementia, Alzheimer's disease.	6
Module 3: Muscle physiology	Overview of muscle function, skeletal muscle structure and function, skeletal muscle mechanics, force-length and velocity, cross bridge cycle, exercise, cardiac muscle, excitation-contraction coupling in cardiac & skeletal muscle, smooth muscle, development and regeneration of muscle tissue, muscle diseases/disorders, e.g., Myasthenia gravis, Multiple sclerosis.	6
Module 4: Cardiovascular physiology	Overview of the cardiovascular system, composition of blood, blood vessels, arteries, veins and capillaries, functional anatomy of the heart, the heart pump, cardiac muscle and electric activity, electrophysiology, cardiac function assessments, venous return and cardiac output, arterial and venous blood pressure, arterial pressure regulation, hypertension and hypotension, cardiovascular diseases.	6
Module 5: Pulmonary physiology	Overview of respiratory system organs and functions, pulmonary ventilation, mechanics of breathing, breathing and respiration, gas exchange – diffusion, transport of O2 and CO2, regulation of respiration, pulmonary diseases, e.g., pulmonary allergy.	4
Module 6: Renal physiology	Overview of urinary system, organs and functions, kidney functional anatomy, nephrons, glomerular filtration, tubular absorption, secretion-mechanism of secretion, electrolytes and volume regulation, acid base balance, physiology of urine formation, urine composition, concentration and diluting mechanisms of urine, disorders of acid base balance and renal diseases, dialysis.	4
Module 7: Endocrinology	Organization of the hormonal systems, hormones, the hypothalamus-pituitary system, the adrenal and thyroid glands, development and aging of endocrine systems, calcium homeostasis and bone biology, diseases related to hormonal imbalance.	4
Module 8: Immune system	Overview of immune system, humoral and cell mediated immune system, immunoglobulin structure and classes, antigen-antibody reactions, and their applications in immunodiagnostics, complement system, autoimmune diseases, AIDS, hypersensitivity reactions and immunodeficiency diseases, graft rejection.	8
	Total Lectures	42

Indian Institute of Technology Guwahati

Course Number & Title: HT503 Introduction to Biomedical Electronics and Instrumentation
L-T-P-C: 2-1-0-6
Type of Letter Grading (Regular Letter Grades / PP or NP Letter Grades): Regular
Kind of Proposal (New Course / Revision of Existing Course): New Course
Offered as (Compulsory / Elective): Compulsory for M Tech, Elective for PhD
Offered to: M Tech, PhD
Offered in (Odd/ Even / Any): Odd
Offered by (Name of Department/ School/ Center): Health Science and Technology
Pre-Requisite: Nil
Preamble: This course has been designed for postgraduate students to provide basic understanding regarding biomedical instrumentation and its different building blocks. The course covers the entire spectrum from basic electronic devices and circuits associated with biomedical instrumentation to the examples of different biomedical applications including imaging. The course will help students in research activities and to understand, analyze, design, and develop biomedical instruments of interest.
Course Content/Syllabus: Basic Electronic Circuits: Active and passive components – IV characteristics of resistors, capacitors, inductors, diodes, and transistors; Basic circuit theory – Kirchhoff's laws, Thevenin's and Norton's theorems, mesh analysis, loop analysis; digital circuits – logic gates, half adder, full adder, multiplexer-demultiplexer, encoder-decoder; Basic Electronic Devices: PN junction – drift, diffusion, forward bias, reverse bias, depletion layer, space charge, diode circuits; Bipolar junction transistor – PNP/NPN transistor, BJT biasing, working principle, CB/CC/CE configurations, BJT amplifier; MOSFET – MOSFET structure and working, MOSFET biasing, CG/CD/CS configurations, MOSFET amplifier, differential amplifier and OPAMP; Sensors for Biomedical Applications: Introduction to sensors and transducers; mechanical, resistive, capacitive, thermal, optical, magnetic, piezoelectric, and quantum sensors; Device Fabrication and Characterization Methods: Electrode deposition techniques, thin film depositions, materials printing, circuit fabrication, materials characterization, electrical characterization; System Design and Instrumentation for Biomedical Instruments: Signal conditioning, bridge circuits, amplifiers, filters, timers, ADC/DAC, microcontroller, wireless systems; Biomedical Imaging: X-ray machine, MRI, ultrasonography, endoscopy, digital radiography, computerised tomography; Medical Instruments: Pulse oxymeter, spirometer, sphygmomanometer, ultrasound machine, defibrillators, ECG/EMG/EEG machines, ventilator, oxygen concentrator.
References:

1	Khandpur R.S., *Handbook of Biomedical Instrumentation*, 3rd ed, Tata McGraw Hill Publishing Company Limited, 2014.
2	Cromwell L., Weibell F.J., Pfeiffer E.A., *Bio-Medical Instrumentation and Measurements*, 2nd ed, Pearson Education, 2015.
3	Webster J.G., *Medical Instrumentation: Application and Design*, 3rd ed, John Wiley & Sons, 2007.
4	Sinclair I.R., *Sensors and Transducers*, 3rd ed, Newnes Oxford, 2011.
5	Doebelin E.O., Manik D.N., *Measurement Systems: Application & Design*, 6th ed, McGraw Hill, 2017.
6	Razavi B., *Design of Analog CMOS Integrated Circuits*, Indian ed, McGraw-Hill, 2002.

Lecture Plan:

Module	Content	No. of Lectures
Module 1: Basic Electronic Circuits	1. Active and Passive Components – IV Characteristics of Resistors, Capacitors, Inductors, Diodes, Transistors 2. Basic Circuit Theory – Kirchhoff's laws, Thevenin's and Norton's theorems, 3. Mesh analysis, Loop analysis 4. Digital Circuits – Logic gates, Half adder, Full adder, Multiplexer-Demultiplexer, Encoder-Decoder	4

Module 2: Basic Electronic Devices	1. PN Junction – Drift, Diffusion, Forward bias, Reverse bias, Depletion layer, Space charge, Diode circuits 2. Bipolar Junction Transistor – PNP/NPN transistor, BJT biasing, Working principle, CB/CC/CE configurations, BJT Amplifier 3. MOSFET – MOSFET structure and working, MOSFET biasing, CG/CD/CS configurations, MOSFET Amplifier, 4. Differential amplifier and OPAMP	4
Module 3: Sensors for Biomedical Applications	1. Introduction to Sensors and Transducer 2. Mechanical sensors, 3. Resistive, Capacitive sensors, 4. Thermal, Optical sensors, 5. Magnetic, Piezoelectric sensors, 6. Quantum sensors	6
Module 4: Device Fabrication and Characterization Methods	1. Electrode deposition techniques, Thin film depositions, 2. Materials printing, Circuit fabrication, 3. Materials characterization, 4. Electrical characterization.	4
Module 5: System Design and Instrumentation for Biomedical Instruments	1. Signal conditioning, 2. Bridge circuits, 3. Amplifiers, Filters, 4. Timers, ADC/DAC, 5. Microcontroller, 6. Wireless systems	6
	Tutorial: Examples of sensor systems, Arduino based sensing	4
Module 6: Biomedical Imaging	1. X-ray machine, MRI, 2. Ultrasonography, Endoscopy 3. Digital radiography 4. Computerised tomography	4
	Tutorial on Digital Image Processing: Attribute Extraction, Mapping and Equalization, Smoothening and Sharpening, Edge Detection using MATLAB	2
Module 7: Medical Instruments	1. Pulse oxymeter, Spirometer, Sphygmomanometer, 2. Ultrasound machine, Defibrillators, 3. ECG/EMG/EEG Machines, 4. Ventilator, Oxygen concentrator	4
	Tutorials	4
	Total Lectures	42

Indian Institute of Technology Guwahati

Course Number & Title: HT504 Basics of Mathematical Modelling and Simulation
L-T-P-C: 2-1-0-6
Type of Letter Grading (Regular Letter Grades / PP or NP Letter Grades): Regular
Kind of Proposal (New Course / Revision of Existing Course): New Course
Offered as (Compulsory / Elective): Compulsory for M Tech, Elective for PhD
Offered to: M Tech, PhD
Offered in (Odd/ Even / Any): Odd
Offered by (Name of Department/ School/ Center): Health Science and Technology
Pre-Requisite: Nil
Preamble: The course will enable the students to, (i) use engineering and mathematical modelling software packages to model, solve and visualize data using open-source and/or commercial software tools; (ii) utilize analytical, semi-analytical, and numerical mathematical techniques, short-programs and/or modules and subroutines, and assess data structure and statistics; (iii) identify and solve fundamental and classical mathematical problems relevant to modern biomedical engineering; (iv) explore modeling techniques, the logic and procedures behind problem solving and modeling.
Course Content/Syllabus: Numerical methods: Solution of equations & Eigenvalue Problems, numerical differentiation & integration, initial value problems and ordinary differential equations, boundary value problems: ordinary differential equations, partial differential equations, case studies in the biological domain; Data Processing and Computation: Data entry, sorting, validation, removing data duplicates, introduction to biostatistics, plotting data, interpolation, approximation and extrapolation, regression, artificial neural network (ANN), classification, case studies with biological data. Simulations: Energy minimization, optimization, force-fields, bio-molecular interaction, membrane simulation. data visualization, principal component methods, time-independent component, Markov modeling, introduction to classical mechanics. data driven simulation, regression and classification problems, supervised and unsupervised machine learning for biological dataset. Introduction to High Performance Computation (HPC), GPU, CPU and Compilers role in data processing. Linear and Nonlinear Models: Case studies on linear and nonlinear bio-systems; Computational Modeling: Key attributes of computational models, utility and limitations of software package(s), case studies from recent literature on biological systems; Molecular Modeling: Protein, DNA, drug, membrane structure, function, and bioinformatics, quantifying modeling outcome with high and low-resolution spectroscopy. algorithm, application and limitation of Maestro, CHARMM-GUI, and VMD programs. case studies from recent literature on a biological system.
References:

1	Hammin R.W., *Numerical Methods for Scientists and Engineers*, Dover Books on Mathematics, 1987.
2	Harvey M., *Intuitive biostatistics: a nonmathematical guide to statistical thinking,* Oxford University Press, USA, Fourth Edition, 2017.
3	James G., Witten D., Hastie T., Tibshirani R., *An Introduction to Statistical Learning with Applications in R*, Springer, 2013
4	William P., *Numerical Recipes in C++ and Fortran.* 2nd ed, Cambridge University Press 1992.
5	*User's Manuals, Maestro-Schrodinger Suite, Matlab, Mathematica.*
6	Smit B and Frenkel D, *Understanding Molecular Simulations: From Algorithms to Applications*, 2nd ed., Academic Press, 2001.
7	Leach A., *Molecular Modelling: Principles and Applications*, 2nd ed, Pearson Education, 2009

Lecture Plan:

Module	Content	No. of Lectures
Module 1: Numerical methods (using Matlab and Mathematica)	1. Solution of Equations & Eigenvalue Problems 2. Numerical Differentiation & Integration 3. Initial Value Problems and ODEs 4. Boundary Value Problems, ODEs, PDEs 5. Case study in the Biological Domain	5 Lectures + 3 tutorials
Module 2: Data Processing (using R/Mathematica, Matlab/Techplot/Excel)	1. Data entry, sorting, validation 2. Removing data duplicates 3. Introduction to Biostatistics with examples 4. Plotting data, Interpolation, Approximation, & Extrapolation 5. Regression, Artificial Neural Network (ANN), classification 6. case studies with biological data;	5 Lectures + 3 tutorials
Module 3: Simulations	1. Energy minimization algorithms, optimization 2. Biomolecular interaction 3. PCA, tICA, Markov modeling, classical simulations 4. Data science approaches in simulation – supervised and unsupervised learning 5. HPC, CPU, GPU, & compilers	5 Lectures + 3 tutorials
Module 4: Linear and Nonlinear Models	1. Case studies on linear and nonlinear bio-systems	2 Lectures + 1 tutorial
Module 5: Computational Modeling (with COMSOL and ANSYS)	1. Introduce key attributes of computational models 2. Appreciate the utility/limitations of software 3. Case study from recent literature on biological systems using ANSYS or COMSOL	5 Lectures + 3 tutorials
Module 6: Molecular Modeling (with Maestro, CHARMM-GUI, and VMD)	1. Molecules: structure and function 2. Software for classical mechanics - Algorithm, application and limitation 3. Case study from recent literature on a biological system using open-source software	4 Lectures + 3 tutorials
Module 7: Term Project	Simulate and analyze problems from latest literature – • Blood flow through an artery • Dialysis device • Tissue or organ under defined stress/strain • A stress/thermal analysis of a biomedical device • Drug released from an implanted polymer • Transport of a chemical species through a tissue • Biomolecular simulation and interaction	
	Total Lectures	42

Indian Institute of Technology Guwahati

Course Number & Title: HT505 Research Methodology, Ethics, IPR, Entrepreneurship and Biosafety
L-T-P-C: 2-1-0-6
Type of Letter Grading (Regular Letter Grades / PP or NP Letter Grades): Regular
Kind of Proposal (New Course / Revision of Existing Course): New Course
Offered as (Compulsory / Elective): Compulsory for M Tech, Elective for PhD
Offered to: M Tech, PhD
Offered in (Odd/ Even / Any): Odd
Offered by (Name of Department/ School/ Center): Health Science and Technology
Pre-Requisite: Nil
Preamble: The course will enable the students to perform literature survey, identify the knowledge gaps, analyse and interpret data and report the novel findings, writing up publishable documents, compiling documents for patent application and preparation of the research proposal. Further, the course will also introduce the various biosafety protocols required to be understood before starting the laboratory courses and research work.
Course Content/Syllabus: Defining and formulating the research problem, selecting the problem, necessity of defining the problem, importance of literature review in defining a problem, primary and secondary sources, papers, monographs, patents, research databases, web as a source, searching the web, critical literature review, identifying gap areas from literature and research database, development of working hypothesis; Aspects of method validation, observation and collection of data, methods of data collection, sampling methods, data processing and analysis strategies and tools. data analysis with package (Sigma STAT, SPSS for student t-test, ANOVA, etc.), hypothesis testing; Ethical issues, ethical committees (human & animal); intellectual property rights (IPR) and patent laws, commercialization, copyright, royalty, trade related aspects of intellectual property rights (TRIPS), IMRAD concept and design of research paper, citation and acknowledgement, plagiarism, reproducibility and accountability, Introduction to entrepreneurship and start-ups; Meaning of interpretation, techniques of interpretation, precautions in interpretation, significance of report writing, different steps in writing report, layout of the research report and types of reports, oral presentation, mechanics of writing a research report, precautions for writing research reports, conclusions. introduction to software of report writing – Latex, Bibtex, and Endnote; History of biosafety microbiology & molecular biology, risk assessment, biosafety levels, personal protective equipment, laboratory facilities and safety equipment, disinfection, decontamination, and sterilization, regulatory compliance, laboratory security and emergency response, administrative controls, current topics in biosafety; Master's Thesis Proposal: Title, abstract, literature, background, significance, knowledge gaps, objectives & specific aims, research design and outcomes, timeline, budget, references; Seminar, Group discussions on selected topics.
References:

1	Garg B.L., Karadia R., Agarwal F. and Agarwal U.K., *An introduction to Research Methodology*, RBSA Publishers, 2015.
2	Kothari C.R., Garg, G., *Research Methodology: Methods and Techniques*, 4th ed, New Age International, 2019.
3	Trochim W.M.K., *Research Methods: The Concise Knowledge Base*, Atomic Dog Publishing, 2004.
4	Wadehra, B.L. *Law relating to Patents, Trademarks, Copyright Designs and Geographical Indications*, Universal Law Publishing, 2004.
5	Graziano A.M. and Raulin M.L., *Research Methods: A Process of Inquiry*, English ed, Allyn and Bacon, 2012.
6	Carlos C.M., *Intellectual Property Rights, the WTO and Developing Countries: The TRIPS Agreement and Policy Options.* Zed Books, New York, 2000.
7	Coley S.M. and Scheinberg C.A., *Proposal Writing: Effective Grantsmanship for Funding*, 5th ed., Sage Publications, 2016.
8	Gastel B., and Day R.A., *How to Write and Publish a Scientific Paper*, 8th ed., Cambridge University Press, 2017.
9	Fink A., *Conducting Research Literature Reviews: From the Internet to Paper*, 3rd ed., Sage Publications, 2010.
10	Leedy P.D. and Ormrod J.E., *Practical Research: Planning and Design*, 11th ed., Prentice Hall, 2015.
11	Satarkar S.P., *Intellectual property rights and Copyrights.* Ess Publications, 2003.

Lecture Plan:

Module	Content	No. of Lectures
Module 1: Research Formulation & Design	1. Defining and formulating the research problem, selecting the problem, necessity of defining the problem. 2. Importance of literature review in defining a problem, primary and secondary sources, papers, monographs, patents, research databases, web as a source, searching the web. 3. Critical literature review, identifying gap areas from literature and research database. 4. Development of working hypothesis.	4 Lectures + 2 tutorials
Module 2: Data collection and analysis	1. Accepts of method validation, observation and collection of data, 2. Methods of data collection, sampling methods, data processing and analysis strategies and tools. 3. Data analysis with package (Sigma STAT, SPSS for student t-test, ANOVA, etc.), hypothesis testing.	4 Lectures + 2 tutorials
Module 3: Research Ethics, IPR, Entrepreneurship, Scholarly Publishing, Startups	1. Ethics- ethical issues, ethical committees (human & animal); 2. IPR- intellectual property rights and patent law, commercialization, copy right, royalty, trade related aspects of intellectual property rights (TRIPS); 3. Scholarly publishing - IMRAD concept and design of research paper, citation and acknowledgement, plagiarism, reproducibility and accountability. 4. Introduction to entrepreneurship and start-ups	4 Lectures + 2 tutorials
Module 4: Interpretation & Report Writing	1. Meaning of Interpretation, technique of Interpretation, precaution in Interpretation. 2. Significance of Report Writing, Different Steps in Writing Report, 3. Layout of the Research Report and types of Reports 4. Oral Presentation. 5. Mechanics of Writing a Research Report, 6. Precautions for Writing Research Reports, Conclusions. 7. Introduction to software of report writing – latex, bibtex, and endnote.	4 Lectures + 2 tutorials
Module 5: Biosafety	1. History of biosafety microbiology & molecular biology 2. Risk assessment 3. Biosafety levels 4. Personal protective equipment 5. Laboratory facilities and safety equipment 6. Disinfection, decontamination, and sterilization 7. Regulatory compliance 8. Laboratory security and emergency response 9. Administrative controls 10. Current topics in biosafety	8 Lectures + 4 tutorials
Module 6: Concept Master's Thesis Proposal	1. Title 2. Abstract 3. Literature 4. Background, Significance, Knowledge gap 5. Objectives & Specific Aims 6. Research Design and Outcome 7. Timeline 8. Budget 9. References	Term paper
Module 7: Seminar, Group discussions	On selected topics	6 lectures
	Total Lectures	42

Indian Institute of Technology Guwahati

Course Number & Title: HT510 Tissue Engineering and Regenerative Medicine	
L-T-P-C: 3-0-0-6	
Type of Letter Grading (Regular Letter Grades / PP or NP Letter Grades): Regular	
Kind of Proposal (New Course / Revision of Existing Course): New Course	
Offered as (Compulsory / Elective): Compulsory for M. Tech., Elective for Ph.D.	
Offered to: M. Tech., Ph.D.	
Offered in (Odd/ Even / Any): Even	
Offered by (Name of Department/ School/ Center): Jyoti and Bhupat Mehta School of Health Sciences and Technology	
Pre-Requisite: Nil	
Preamble: The course has been designed for undergraduate and postgraduate students to introduce technologies to regenerate tissues and organs utilizing stem cells and engineered biomaterials. Widely utilized and most advanced regenerative engineering technologies will be presented and discussed. Translational and clinical applications of engineered tissues will be discussed as well.	
Course Content/Syllabus: Introduction to tissue engineering and regenerative medicine: Principles, key concepts, and current available technologies; Structure and organization of tissues: Cell and tissue types, structure-function relationship; Biomaterials: Matrix interactions and organ printing: Material class and properties, characterization of materials, host reactions to biomaterials, biocompatibility, cell-cell and cell matrix interactions, extracellular matrices, biological and non-biological biomaterials; 3D printing: Considerations for the design of artificial organs, Computational Modeling, biodegradable polymers and polymer scaffold processing; bioreactors for tissue engineering, implantable devices, 3D tissue and organ printing; Cellular processes, growth factors and signaling: Coordination of cellular fate processes: Growth factors and chemokines, signalling responses, cell junctions, mechanical stimuli; vascularization; Drug delivery: Pharmacokinetics, pharmacodynamics, sustained and controlled delivery, Novel drug delivery system; Tissue engineering case studies: artificial skin, artificial blood vessels, artificial liver, regeneration of bone and cartilage, muscle, nerve engineering, in vitro disease models.	
References: (Format: Authors, *Book Title in Italics font*, Volume/Series, Edition Number, Publisher, Year.)	
1	Lanza R., Langer R., and Vacanti J., *The Principles of Tissue Engineering*, 4th ed., Academic Press (AP), 2013.
2	Lanza R. and Atala A., *Essentials of Stem Cell Biology*, 3rd ed., Academic Press, 2013.
3	Ratner B.D., Hoffman A., Schoen F., and Lemons J., *Biomaterials Science: An Introduction to Materials and Medicine*, 3rd ed., Academic Press, 2012.
4	Freshney R.I., *Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications*, 6th ed., Wiley-Blackwell, 2010.
5	Park J.B. and Bronzino J.D., *Biomaterials: Principles and Applications*, CRC Press, 2002.
6	Dee K.C., Puleo D.A. and Bizios R., *An Introduction to Tissue-Biomaterial Interactions*, Wiley, 2002.
7	Li L., Heureux and Elisseeff, *Stem cell and Tissue Engineering*, Editors World Scientific, ISBN: 9789814317054, 2011.
8	Artmann G.M., Minger S., and Hescheler J., *Stem Cell Engineering : Principles and Application* Editors, Springer, ISBN 978-3-642-11865-4, 2011.
9	Wang, Q., *Smart Materials for Tissue Engineering: Fundamental Principles*, Smart Materials Series, Volume 24. RSC Publication. 1st Edition. 2016.

Lecture Plan:

Module	Content	No. of Lectures
Module 1: Introduction to tissue engineering and regenerative medicine	Principles, key concepts, and current available technologies relevant to tissue engineering and regenerative medicine.	5
Module 2: Structure and organization of tissues	Cell and tissue types, structure-function relationship.	5
Module 3: Biomaterials	Matrix interactions and organ printing: Material class and properties, characterization of materials, host reactions to biomaterials, biocompatibility, cell-cell and cell matrix interactions, extracellular matrices, biological and non-biological biomaterials.	7
Module 4: 3D printing	Considerations for the design of artificial organs, Computational Modeling, biodegradable polymers and polymer scaffold processing; bioreactors for tissue engineering, implantable devices, 3D tissue and organ printing	7
Module 5: Cellular processes, growth factors and signaling	Coordination of cellular fate processes: Growth factors and chemokines, signalling responses, cell junctions, mechanical stimuli; vascularization	6
Module 6: Drug delivery	Pharmacokinetics, pharmacodynamics, sustained and controlled delivery, Novel drug delivery system	6
Module 7: Tissue engineering case studies	artificial skin, artificial blood vessels, artificial liver, regeneration of bone and cartilage, muscle, nerve engineering, in vitro disease models.	6
	Total Lectures	42

Indian Institute of Technology Guwahati

Course Number & Title: HT511 Stem Cells and Therapeutics	
L-T-P-C: 3-0-0-6	
Type of Letter Grading (Regular Letter Grades / PP or NP Letter Grades): Regular	
Kind of Proposal (New Course / Revision of Existing Course): New Course	
Offered as (Compulsory / Elective): Compulsory for M. Tech., Elective for Ph.D.	
Offered to: M. Tech., Ph.D.	
Offered in (Odd/ Even / Any): Even	
Offered by (Name of Department/ School/ Center): Jyoti and Bhupat Mehta School of Health Sciences and Technology	
Pre-Requisite: Nil	
Preamble: The course has been designed for undergraduate and postgraduate students to introduce stem cell, exploring its potential role in regenerative medicine, disease intervention and therapeutic applications. The learning involves critical aspects of stem cell biology, ethical consideration, and rigorous scientific principles. The translational application and outlook concerning innovative technologies will be discussed.	
Course Content/Syllabus: Fundamentals of stem cells: Origin and different types of stem cells: embryonic, adult, and induced pluripotent stem cells; Genetic reprogramming and application: Gene expression, stem cell signalling and transcription factors, differentiation, application in personalized medicine; Genome Editing: History of genetic engineering, Gene Editing - gene targeting, CRISPR technology, multiplex automated genomic engineering, Engineered nuclease: meganuclease and zinc finger nuclease; Synthetic Biology: Understanding and creating metabolic and regulatory pathways; DNA synthesis technology, microfluidics; computational protein design; chimeric protein; modified/unnatural nucleotides; Biomedical application of stem cells: Drug screening, toxicology, disease modelling, cell therapy. iPS application for treatment of disease conditions: diabetes, leukaemia, and neurological disorders; Modeling and analytics for stem cell biology: Clustering, PCA, and enrichment analysis. Machine learning for classification. Data visualization methods. Artificial intelligence algorithms to assist iPSC identification. Modeling of single-cell data; Current trends in stem cells: Stem cell application in tissue engineering & biomaterials; Precision medicine, treatment of genetic disorders and autoimmune; legal guidelines governing embryonic stem cells research.	
References: (Format: Authors, *Book Title in Italics font*, Volume/Series, Edition Number, Publisher, Year.)(TEXTBOOK)	
1	A. Atala, R. Lanza, J. A. Thomson., **Principles of Regenerative medicine**, Academic Press, 3rd Edition (2019)
2	M.A. Hayat, Stem Cells and Cancer Stem Cells, **Volume 4: Therapeutic Applications in Disease and Injury Springer Science**, 1st Edition (2016)
3	Jonathan Slack, **Stem Cells: A Very Short Introduction**, Oxford University Press, 2nd Edition (2021)
4	J. B. Reece, L.A. Urry, M.L. Cain, S.A. Wasserman, P.V. Minorsky, R.B. Jackson, **Campbell Biology**. 9th Edition. MasteringBiology® with Pearson eText (2010).
6	Alice Park ., The Stem Cell Hope: How Stem Cell Medicine Can Change Our Lives, Penguin, 09-Jun- (2011)
7	H. Green, Therapy With Cultured cells, 1st Edition, Jenny Stanford Publishing (2010)
8	P. Cahan, Computational Stem Cell Biology. Methods and Protocols – Methods in Molecular Biology Book Series. Springer Press (2019)

Lecture Plan:

Module	Content	No. of Lectures	Instructors	Tentative Time
Module 1: Fundamentals of stem cells	Origin and different types of stem cells: embryonic, adult, and induced pluripotent stem cells.	6	Bithiah Grace Jaganathan	
Module 2: Genetic reprogramming and application	Gene expression, stem cell signalling and transcription factors, differentiation, application in personalized medicine.	4	Bithiah Grace Jaganathan	
Module 3: Genome Editing	History of genetic engineering, Gene Editing - gene targeting, CRISPR technology, multiplex automated genomic engineering, Engineered nuclease: meganuclease and zinc finger nuclease.	6	Rajiv K. Kar (**Course coordinator**)	
Module 4: Synthetic Biology	Understanding and creating metabolic and regulatory pathways; DNA synthesis technology, microfluidics; computational protein design; chimeric protein; modified/unnatural nucleotides.	8	Subrata Pramanik	
Module 5: Biomedical application of stem cells	Drug screening, toxicology, disease modelling, cell therapy. iPS application for treatment of disease conditions: diabetes, leukaemia, and neurological disorders.	6	Bithiah Grace Jaganathan	
Module 6: Modeling and analytics for stem cell biology	Clustering, PCA, and enrichment analysis. Machine learning for classification. Data visualization methods. Artificial intelligence algorithms to assist iPSC identification. Modeling of single-cell data.	6	Rajiv K. Kar (**Course coordinator**)	
Module 7: Current trends in stem cells	Stem cell application in tissue engineering & biomaterials, Precision medicine, treatment of genetic disorders and autoimmune; legal guidelines governing embryonic stem cells research.	6	Bithiah Grace Jaganathan	
	Total Lectures	42		

Indian Institute of Technology Guwahati

Elective Courses

Course Number & Title: HT 601 Medical Diagnostic Devices, BioMEMS, and Biosensors	
L-T-P-C: 2-1-0-6	
Type of Letter Grading (Regular Letter Grades / PP or NP Letter Grades): Regular	
Kind of Proposal (New Course / Revision of Existing Course): New Course	
Offered as (Compulsory / Elective): Elective	
Offered to: M.Tech., Ph.D.	
Offered in (Odd/ Even / Any): Even	
Offered by (Name of Department/ School/ Center): Jyoti and Bhupat Mehta School of Health Sciences and Technology	
Pre-Requisite: None	
Preamble: The increasing need for integration, sensitivity, and reliability in biological measurements is leading the researchers to delve into biosensing microsystems and BioMEMS. Integration in biosystems aims at implementing valuable monitoring techniques as a replacement of conventional time-consuming and often sophisticated approaches, which can be performed only by highly specialized technicians in a laboratory environment. The course provides insight into the design flow methodology for biosystems, fabrication techniques, bio-transducing principles, metrology theory and signal acquisition systems. Furthermore, the course introduces emerging fields in BioMEMS, sensors, microfluidic technology, DNA detection, organic photodetectors and wearable microsystem technologies.	
Course Content/Syllabus: BioMEMS, BioSensors, Microfluidics: Introduction to nanotechnology and biosensors, sensors, transduction and performance factors, bioMEMS and microfluidics; Materials for Fabrication: Important materials for fabrication, Introduction to silicon device fabrication, fabrication methods for soft materials, emerging carbon, 2D, and metamaterials; Design, Principles and Applications: Cell potential, SHEs cell reaction, Nernst equation, design, construction, measurement and calibration of ion selective electrodes (ISE), gas sensing electrodes, electrokinetic principles and electro-kinetic flows in silicon channels, applications for biosensors in diagnostics; Integration of Biology to Microfluidics and Biosensing: Introduction to cell biology and protein structure, DNA, DNA hybridization, DNA polymerization, PCR, thermal cycle, RTPCR, gel and capillary electrophoresis, DNA microarrays, sequencing and DNA nano-pores, DNA detection using micro-nano cantilevers; Biomicrofluidics: Protein charging at different pH range, amino acids, protein polymerization, transcription, translation antibody, microencapsulation, cyclic voltammetry, microfluidics - streamlines, pathlines, sreaklines for a steady flow stress tensor, Newtonian, non-Newtonian fluids and their flow in different geometries, kinematics of fluids. Microfluidics and Microfabrication: Microscale mixers, valves and pumps, microelectronic fabrication, lithography and photo-resists. Micro/Nano Fabrication: Etching techniques, evaporation and sputtering, vacuum science and plasmas, polymeric micromachining technology, replication technologies, laser machining, micro-stereo lithography, micro-molding, assembly and packaging; Device Architectures: Amperometric, potentiometric and impedimetric biosensors, electrochemical sensors and FET-based biosensors, acoustic and piezoelectric biosensors, optical biosensors, wearable microsystem technologies; Applications: Polymer PDMS-based microtechnology, additive and subtractive techniques, 3D printing, Lab-on-a-chip technology, integrated gene analysis, integrated analysis of pathogenic bacteria, electrochemical and optical (labelled and unlabelled) techniques.	
References: (Format: Authors, *Book Title in Italics font,* Volume/Series, Edition Number, Publisher, Year.)	
1	Marks R.S., Lowe C.R., Cullen D.C., Weetall H.H. and Karube, I., *Handbook of biosensors and biochips*, Wiley Online Library, ISBN: 978-0-470-06156-5, 2007.

2	Karunakaran C., Bhargava K., Benjamin R., *Biosensors and Bioelectronics*, 1st ed., Elsevier, ISBN: 9780128031018, 2015.
3	Plonsey R., and Barr R.C., *Bioelectricity: A Quantitative Approach*, Springer, ISBN: 978-1-4899-8408-1, 2007.
4	Carrara S., *Bio/CMOS Interfaces and Co-Design*, Springer, ISBN: 978-1-4614-4689-7, 2013.
5	Banica F.-G., *Chemical Sensors and Biosensors; Fundamental and Applications*, John Wiley & Sons, Inc., 2012.
6	Shinar R. and Shinar J., *Organics Electronics in Sensors and Biotechnology*, McGraw-Hill Education-Europe, ISBN: 978-0-071-59675-6, 2009.

Lecture Plan:

Module	Content	No. of Lectures
Module 1: BioMEMS, BioSensors, Microfluidics	1. Introduction to Nanotechnology and Biosensors 2. Sensors, Transduction and Performance factors 3. BioMEMS and microfluidics	3 Lectures
Module 2: Materials for Fabrication	1. Important materials for fabrication 2. Introduction to silicon device fabrication 3. Fabrication methods for soft materials 4. Emerging Carbon, 2D, and metamaterials	3 Lectures
Module 3: Design, Principles and Applications	1. Cell potential, SHEs Cell reaction, Nernst equation 2. Design, construction, measurement and calibration of Ion selective electrodes (ISE) 3. Gas sensing electrodes 4. Electrokinetic principles and electro-kinetic flows in silicon channels. 5. Applications for biosensors in diagnostics	4 Lectures + 2 Tutorials
Module 4: Integration of Biology to Microfluidics and Biosensing	1. Introduction to cell biology and protein structure 2. DNA, DNA hybridization, DNA polymerization, PCR, Thermal cycle, RTPCR 3. Gel and Capillary electrophoresis 4. DNA microarrays, sequencing and DNA nano-pores 5. DNA detection using micro-nano cantilevers.	4 Lectures + 2 Tutorials
Module 5: Biomicrofluidics	1. Protein charging at different pH range, amino acids, protein polymerization, Transcription, Translation Antibody, Microencapsulation 2. Cyclic voltammetry 3. Microfluidics - Streamlines, Pathlines, Sreaklines for a steady flow Stress tensor, Newtonian, non-Newtonian fluids and their flow in different geometries, Kinematics of fluids.	4 Lectures + 2 Tutorials
Module 6: Microfluidics and Microfabrication	1. Microscale mixers, valves and pumps 2. Microelectronic fabrication, lithography and photo-resists.	4 Lectures + 2 Tutorials
Module 7: Micro/Nano Fabrication	1. Etching techniques, evaporation and sputtering 2. Vacuum science and plasmas 3. Polymeric micromachining technology. 4. Replication technologies, laser machining, micro-stereo lithography, micro-molding, Assembly and packaging.	4 Lectures + 2 Tutorials

Module 8: Device Architectures	1. Amperometric, potentiometric and impedimetric biosensors. 2. Electrochemical sensors and FET-based biosensors. 3. Acoustic and piezoelectric biosensors. 4. Optical biosensors. 5. Wearable microsystem technologies	3 Lectures
Module 9: Applications	1. Polymer PDMS based microtechnology 2. Additive and Subtractive techniques, 3D printing 3. Lab-on-a-chip technology 4. Integrated gene analysis 5. Integrated analysis of pathogenic bacteria 6. Electrochemical and optical (labelled and unlabelled) techniques.	3 Lectures
Module 10: Term Paper	On a latest relevant topic	-
	Total Lectures	42

Indian Institute of Technology Guwahati

Course Number & Title: HT 602 Regulatory Affairs of Biomedical Devices
L-T-P-C: 3-0-0-6
Type of Letter Grading (Regular Letter Grades / PP or NP Letter Grades): Regular
Kind of Proposal (New Course / Revision of Existing Course): New Course
Offered as (Compulsory / Elective): Elective
Offered to: M.Tech., Ph.D.
Offered in (Odd/ Even / Any): Even
Offered by (Name of Department/ School/ Center): Jyoti and Bhupat Mehta School of Health Sciences and Technology
Pre-Requisite: None
Preamble: This course has been developed for those who are involved with ensuring regulatory compliance for medical devices. The course is primarily geared towards those who are new to industry or require a basic understanding of medical device regulatory compliance issues. It is also useful to industry veterans who need extra training on these topics and to clear basic concepts. Demonstration of safety and efficacy of medical device and in vitro diagnostic (IVD) kit for use in humans is essential before the product can be approved for import or manufacturing and marketing in the country. Medical devices are currently regulated under the definition of DRUG.
Course Content/Syllabus: Medical Devices: Introduction, Classification of medical devices USA/EU/INDIA, Product Development Indian and International Rules: Rules 109-A - Labeling of medical devices, Rule 125-A - Standards for medical devices, Schedule M III - QMS requirements, Schedule R - Standard for mechanical contraceptives, Schedule R1-Standards for medical devices, Schedule DII -Annexure B – IVD, TRL/MRL/BRL Standards and Regulations: Standards of medical device and testing, How to obtain a license to manufacture a medical device, Technical personnel required for manufacturing, USFDA/EU/CDSCO Regulations. Certification: Import and export USA/EU/INDIA, Local manufacturer: How to apply? Schedule M-III and other standards like ISO 13485 Trials and Validations: Management of risks associated with Medical devices, Biocompatibility Studies and Medical Devices, Clinical Trials: Medical Devices. Licensing: Product Design, Research & Development, Quality Assurance and Quality Control, Inspection and fees, Inspection before licensing, Licensing, Labelling and marketing, Registration

References: (Format: Authors, *Book Title in Italics font*, Volume/Series, Edition Number, Publisher, Year.)	
1	Ramakrishna S., Tian L., Wang C., Liao S., Teo W.E., *Medical Devices: Regulations, Standards and Practices*, Woodhead Publishing, 2015.
2	Theisz V., *Medical Device Regulatory Practices: An International Perspective*, 1st ed., Jenny Stanford Publishing, 2015.
3	Ogrodnik P.J., *Medical Device Design: Innovation from Concept to Market*, 2nd ed., Academic Press Inc, 2012.

Lecture Plan:

Module	Content	No. of Lectures
Module 1: Medical Devices	1. Introduction 2. Classification of medical devices USA/EU/INDIA 3. Product Development	6 Lectures
Module 2: Indian and International Rules	1. Rules 109-A - Labeling of medical devices 2. Rule 125-A - Standards for medical devices 3. Schedule M III - QMS requirements 4. Schedule R - Standard for mechanical contraceptives, 5. Schedule R1-Standards for medical devices	9 Lectures

	6. Schedule DII -Annexure B - IVD. 7. TRL/MRL/BRL	
Module 3: Standards and Regulations	1. Standards of medical device and testing 2. How to obtain a license to manufacture a medical device. 3. Technical personnel required for manufacturing. 4. USFDA/EU/CDSCO Regulations	6 Lectures
Module 4: Certification	1. Import and export USA/EU/INDIA 2. Local manufacturer: How to apply? 3. Schedule M-III and other standards like ISO 13485	6 Lectures
Module 5: Trials and Validations	1. Management of risks associated with Medical devices 2. Biocompatibility Studies and Medical Devices 3. Clinical Trials: Medical Devices	6 Lectures
Module 6: Licensing	1. Product Design, Research & Development 2. Quality Assurance and Quality Control 3. Inspection and fees 4. Inspection before licensing 5. Licensing 6. Labelling and marketing 7. Registration	9 Lectures
	Total Lectures	42

Indian Institute of Technology Guwahati

Course Number & Title: HT 603 Advanced Immunology	
L-T-P-C: 3-0-0-6	
Type of Letter Grading (Regular Letter Grades / PP or NP Letter Grades): Regular	
Kind of Proposal (New Course / Revision of Existing Course): New Course	
Offered as (Compulsory / Elective): Elective	
Offered to: M. Tech., Ph.D.	
Offered in (Odd/ Even / Any): Even	
Offered by (Name of Department/ School/ Center): Jyoti and Bhupat Mehta School of Health Sciences and Technology	
Pre-Requisite: None	
Preamble: The course has been designed for postgraduate students to provide them an understanding of development, functions, and defects of the immune system. It provides the strategy for the development of vaccines against deadly diseases. The modules are of immense importance in understanding human health to combat several diseases.	
Course Content/Syllabus: Immune Systems: Immune cell types, Hematopoiesis, B and T lymphocytes, NK cells, Lymphoid organs (primary and secondary), Introduction to inflammation, Innate Immune system; Antigens: Antigenicity and immunogenicity, generation of antibody diversity and TCR rearrangement, Epitopes, MHC molecules, antigen processing and presentation, APC's, Humoral immunity/Cell-mediated immunity, Pro-inflammatory and anti-inflammatory cytokines, cell polarization/complement activation, Toll-like receptors; Antibodies: Basic Structure of Antibodies, Antibody Classes and Biological Activities, Antibody-Mediated Effector Functions, Antigenic Determinants on Immunoglobulins, The B-Cell Receptor, The Immunoglobulin Superfamily, Monoclonal Antibodies; Hypersensitivity and its types: Effector and Memory T cells, thymus and aging, congenital and acquired immune deficiencies; Immunologic Tolerance: Autoimmunity, Immune deficiency diseases, host vs graft reaction, Transplantation strategies; Microbiome on Immunity: B cells in health and disease, gut microbiota and health, host-pathogen interactions, immune response during bacterial (tuberculosis) and viral (HIV) infections, Immune Response to SARS-CoV-2; Immunotherapeutics: Tumor immunology, Active immunization Vaccines, Vaccine production, passive immunization, polyclonal and monoclonal antibodies, and antibody engineering; Tools and Techniques: Case studies and examples for Immuno-diffusion assay, ELISA, Immuno-blotting, and flowcytometry.	
References: (Format: Authors, *Book Title in Italics font,* Volume/Series, Edition Number, Publisher, Year.)	
1	Delves P.J., Matrin S.J., Burton D.R., Roitt I.M., *Roitt's Essential Immunology*, 13th ed., Willey Blackwell, 2016.
2	Murphy K. and Weaver C., *Janeway's Immunobiology*, 9th ed., Garland Science, 2018.
3	Goldsby R.A., Kindt T.J., Osborne B.A., and Kuby J., *Immunology*, 5th ed., W. H. Freeman, 2002.
4	Abbas A., Lichtman A., and Pillai S., *Cellular and Molecular Immunology*, 9th ed., W.B. Saunders, Philadelphia, PA, 2018.
5	Paul W.E., *Fundamental Immunology*. 7th ed, Lippincott Williams & Wilkins, 2013.

Lecture Plan:

Module	Content	No. of Lectures
Module 1: Immune Systems	Immune cell types, Hematopoiesis, B and T lymphocytes, NK cells, Lymphoid organs (primary and secondary), Introduction to inflammation, Innate Immune system: Pattern Recognition and Anti-microbial Mechanisms, cellular mechanisms, Myeloid Cells in Immune Responses and Adaptive Immune system.	6
Module 2: Antigens	Antigenicity and immunogenicity, generation of antibody diversity and TCR rearrangement, MHC molecules, Epitopes, Antigen Processing and Presentation, APC's, Humoral immunity/Cell-mediated immunity, Pro-inflammatory and anti-inflammatory cytokines, cell polarization/complement activation, Toll-like receptors	5
Module 3: Antibodies	Basic Structure of Antibodies, Antibody Classes and Biological Activities, Antibody-Mediated Effector Functions, Antigenic Determinants on Immunoglobulins, The B-Cell Receptor, The Immunoglobulin Superfamily, Monoclonal Antibodies	5
Module 4: Hypersensitivity and its types	Effector and Memory T cells, thymus and aging, Congenital and acquired immune deficiencies	4
Module 5: Immunologic Tolerance	Autoimmunity, Immune deficiency diseases, host vs graft reaction, Transplantation strategies.	4
Module 6: Microbiome on Immunity	B cells in health and disease, gut microbiota and health, host-pathogen interactions, immune response during bacterial (tuberculosis) and viral (HIV) infections, Immune Response to SARS-CoV-2	6
Module 7: Immunotherapeutics	Tumor immunology, Active immunization Vaccines, Vaccine production, passive immunization, polyclonal and monoclonal antibodies, and antibody engineering.	6
Module 8: Tools and Techniques	Case studies and examples for Immuno-diffusion assay, ELISA, Immuno-blotting, flowcytometry	6
	Total Lectures	42

Indian Institute of Technology Guwahati

Laboratory Courses

Course Number & Title: HT506 Biotechniques and Bioinstrumentation Laboratory	
L-T-P-C: 0-0-3-3	
Type of Letter Grading (Regular Letter Grades / PP or NP Letter Grades): Regular	
Kind of Proposal (New Course / Revision of Existing Course): New Course	
Offered as (Compulsory / Elective): Compulsory for M Tech	
Offered to: M Tech, PhD	
Offered in (Odd/ Even / Any): Even	
Offered by (Name of Department/ School/ Center): Jyoti and Bhupat Mehta School of Health Sciences and Technology	
Pre-Requisite: None	
Preamble: This course has been designed for postgraduate students to provide basic understanding regarding biomedical instrumentation and its different building blocks. The course covers diverse aspects within the scope of biotechniques and bioinstrumentation. The laboratory design will prepare students to become expert in fundamental and applied bio-modules to resolve frontier issues in biomedical sciences and engineering. Overall, it will enable students to understand, analyze, design, and develop biomedical instruments of interest.	
Course Content/Syllabus: Hands on Training on mammalian cell culture; Cell counting Neubauer Haemocytometry; MTT assay for Cell Viability Estimation; Live and Dead Cell Staining Assay; RNA extraction and concentration measurement; Bioinformatics Data Retrieval and primer design; cDNA synthesis and real-time qPCR; SDS-PAGE preparation for Western Blot; Western blotting; Cell Surface Marker Staining using Flow Cytometry; DNA Content Analysis by Flow Cytometry; Demonstration of advanced Bioinstruments; Computer-aided protein analysis. *Every semester 9 laboratory experiments will be offered from this syllabus.	
References:	
1	*Berg, Jeremy M.; Tymoczko, John L.; Stryer, Biochemistry (6th Edition)* W. H.Freeman & Co Ltd. 2006
2	Lehninger *Principles of Biochemistry (4th Edition)* Nelson and Cox. W. H. Freeman & Co. 2004
3	Bhaskar A., *Biochemical Methods: A Practical Approach*, Alpha Science International Ltd 2014
4	Ye. S.Q. *Big Data Analysis for Bioinformatics and Biomedical Discoveries*, First Edition, Chapman and Hall, CRC Press, 2021
5	*T. A. Brown*, Essential Molecular Biology: A Practical Approach, Oxford University Press 2000

Laboratory Plan:

Module	Content	No. of Labs
Experiment 1: Hands-on Training on mammalian cell culture	1. Introduction to cell culture equipment and biosafety, e.g., BSL-2 cabinet, CO_2 incubator, inverted microscope, centrifuge, cell counter, cryostorage container, sterilizer, water bath, pipettes, and other accessories. 2. Phosphate buffered saline (PBS) preparation, pH adjustment, and familiarization with stains and dissociation reagents. Media and serum preparation methods. 3. Handling procedure of cells, subculturing of cells. * 1A includes 1 and 2; 1B includes 3.	2
Experiment 2: Computer-aided protein analysis	1. Retrieval of structural models from database 2. Sequence alignment 3. Hydropathicity, secondary structure prediction, isoelectric point, and instability index analysis.	2

	4. Homology modelling and docking calculation.	
Experiment 3: Bioinformatics Data Retrieval and primer design	1. FASTA sequence retrieval from the database 2. BLAST 3. Coding sequence analysis 4. Analysis of GC content	1
Experiment 4: Cell counting Neubauer Haemocytometry	1. Preparing hemocytometer, preparing cell suspension, counting, viability.	1
Experiment 5: Live and Dead Cell Staining Assay	1. Centrifuge an aliquot of cell suspension 2. Resuspension of cell pellet (trypan blue) 3. Count the unstained and stained cells in hemacytometer	1
Experiment 6: Demonstration of advanced Bioinstruments	1. Transmission electron microscopes (TEM) 2. Scanning electron microscope (SEM) 3. X-ray powder diffraction (XRD) 4. Confocal microscope * 6A includes 1 and 2; 6B includes 3 and 4.	2
Experiment 7: Human physiology demonstration	1. Demonstration of the human physiological system such as the Liver, Kidney, and Heart (any one of them).	1
Experiment 8: RNA extraction and concentration measurement	1. Buffer Preparation 2. Sample Preparation from cultured cells/saliva 3. RNA Purification 4. Concentration measurement using Spectrophotometers.	1
Experiment 9: cDNA synthesis and real-time qPCR	1. Thaw of frozen components 2. Use of PCR for the reverse transcriptase PCR reaction 3. Vortex generator, centrifugation, thermal cycling 4. Real-Time qPCR	1
Experiment 10: SDS-PAGE preparation for Western Blot	1. Preparation of the separation gel 2. Prepare the stacking gel	1
Experiment 11: Western blotting	1. Protein sample preparation 2. Loading and running the gel 3. Transferring the protein from the gel to the membrane 4. Antibody staining	1
Experiment 12: Cell Surface Marker Staining using Flow Cytometry	1. Preparation of PBS and Cell staining buffer 2. Staining and samples analysis by flow cytometry 3. Flow cytometry-based cell sorter	1
Experiment 13: Cell Cycle Analysis by Flow Cytometry	1. Harvesting cells 2. Cell Fixation (pellet with vortex). 3. Cell treatment with ribonuclease 4. Staining 5. Flow cytometry measurement using fluorescence	1
Experiment 14: DNA Content Analysis by Flow Cytometry	1. Cell pellet - DAPI staining solution. 2. Flow cytometry measurement using fluorescence	1
Experiment 15: MTT assay for Cell Viability Estimation	1. Preparation of MTT Reagent and Solubilization Solution 2. Measurement of absorbance using a microplate (ELISA) reader.	1
	Total Lectures	18*

*Any 9 experiments based on the instrument availability will be performed.

Indian Institute of Technology Guwahati

Course Number & Title: HT507 Diagnostics & Devices Laboratory
L-T-P-C: 0-0-3-3
Type of Letter Grading (Regular Letter Grades / PP or NP Letter Grades): Regular
Kind of Proposal (New Course / Revision of Existing Course): New Course
Offered as (Compulsory / Elective): Compulsory for M Tech
Offered to: M Tech, PhD
Offered in (Odd/ Even / Any): Even
Offered by (Name of Department/ School/ Center): Jyoti and Bhupat Mehta School of Health Sciences and Technology
Pre-Requisite: None
Preamble: The course has been designed for postgraduate students to provide a basic understanding of diagnostics to develop biomedical devices and their applications. The students learn the reverse engineering of the diagnostic devices, sample preparation, characterization techniques, and electronics concepts. This multidisciplinary course will enable students to gain hands-on training for spectroscopy and electronic instrumentation to integrate them into biomedical devices.
Course Content/Syllabus: Introduction to sample analysis techniques/ instruments; Nano/biomaterial preparation and synthesis; Reverse engineering and making of existing biomedical devices and instrumentation; Introduction to colorimetric, electromedical, microfluidic and semiconductor diagnostic devices (e.g. CV/CMOS/SAW/OFET and others; sensors, biosensors, nanobiosensors; Image analysis and advances imaging; Simulating nanoparticle-based systems; Electronic structure of biomaterials; Inverting, Non-inverting, Instrumentation amplifier characterization; Active filter design; Microcontroller based control and integration. *Every semester 9 laboratory experiments will be offered from this syllabus.
References:

1	Fischbach, F., *A Manual of Laboratory & Diagnostic Tests*, Wolters Kluwer India Pvt. Ltd.; Ninth edition, 2014
2	*Myhra Sverre et al.,* Characterization of Nanostructures, CRC Press, 2013
3	Dumitriu S, Popa V, Polymeric Biomaterials: Structure and Function, CRC Press, 2013
4	Leach A., *Molecular Modelling: Principles and Applications,* 2nd ed, Pearson Education, 2009
5	Bhaskar K B, Arumugam, V., *Microcontroller Based System Design*, LAP Lambert Academic Publishing, 2020

Laboratory Plan:

Module	Content	No. of Labs
Experiment 1: Introduction to sample analysis techniques/ instruments	1. Familiarization with different analytical instruments and facilities.	1
Experiment 2: Nano/biomaterial preparation and synthesis	1. Synthesis of Au nanoparticles 2. Preparation of buffer solutions of different pH 3. Determining the specificity of enzymatic reaction: BSA and urease in pH7 buffer for UV-Vis analysis. 4. Polymer (PANI) and Nanoparticle (Au) composite preparation with vortex mixing. 5. Centrifuge and sample preparation for TEM (AuNP), and FESEM (polymer composite), UV-Vis analysis	2

Experiment 3: Simulating nanoparticle-based system	1. Computational modelling and solvation of polymer 2. Coarse-grain modelling. 3. Run a short molecular dynamics simulation	1
Experiment 4. Reverse engineering of lateral flow assay (LFA) for pregnancy test using a colorimetric test.	1. Reverse engineering of colorimetric lateral flow assay diagnostic kits. 2. Microfluidic sensors.	1
Experiment 5: Electronic structure of Biomaterials	1. Geometry optimization using ab initio method. 2. Analyze the HOMO and LUMO involved in electronic transitions. 3. Calculate and compare the absorbance in vacuum (gas phase) and solvent (water and ethanol).	2
Experiment 6: Cyclic voltammetry	1. Fabrication and characterization of an electrochemical sensor. 2. Measurements of zeta potential, capacitance, linear sweep voltammetry, chrono-amperometry, impedance analyzer.	2
Experiment 7: Semi-conductor devices	1. Introduction to the sensor of semiconductor devices. 2. OFET, OLED, SAW, MOS Capacitor 3. Demonstration of any one of these	1
Experiment 8: Image analysis in diagnostics	1. Case study on cystic fibrosis or tuberculosis 2. Introduction to ImageJ, Mathematica, and MATLAB	1
Experiment 9: Inverting, Non-inverting, Instrumentation Amplifier Characterization	1. Inverting and non-inverting amplifier of gain 10 using OP-AMP and characterize with a sine wave of frequency 10 kHz and amplitude of 1 V. 2. Two-stage instrumentation amplifier using OP-AMP of gain 10 and characterize with a sine wave of frequency 10 kHz and amplitude of 1 V. 3. Increase the gain of the amplifier to 20 and characterize	2
Experiment 10: Microcontroller based Control and Integration	1. Generate PWM signal of 20%, 50%, and 75% duty cycle using a microcontroller-based circuit (Arduino). 2. Develop a microcontroller-based circuit in Arduino Board to control the ON-OFF frequency of three LEDs using an external push-button.	2
Experiment 11. Demonstration and reverse engineering of point-of-care devices	1. Hemocue (image analysis based), Sanket (electrochemical based), Glucometer (colorimetry and electrometric), Pulse oximetry, Pressure monitoring device, weighing balance, Magic box (MobiLab).	1
Experiment 12: Active Filter Design	1. Make an active high-pass filter and characterize the same. 2. Make an active low-pass filter and characterize the same. 3. Make RC high-pass and low-pass filters and compare with active filters.	2
Experiment 12. Medical and Biomedical Field visit	1. Hospital and field visit (PHC, CHC, Patholabs, clinics)	1
	Total Lectures	19*

*Any 9 experiments based on the instrument availability will be performed.

Indian Institute of Technology Guwahati

Course Number & Title: HT508 Product Design and Prototyping Laboratory	
L-T-P-C: 0-0-3-3	
Type of Letter Grading (Regular Letter Grades / PP or NP Letter Grades): Regular	
Kind of Proposal (New Course / Revision of Existing Course): New Course	
Offered as (Compulsory / Elective): Compulsory	
Offered to: M Tech, PhD	
Offered in (Odd/ Even / Any): Even	
Offered by (Name of Department/ School/ Center): Jyoti and Bhupat Mehta School of Health Sciences and Technology	
Pre-Requisite: None	
Preamble: This course has been designed for postgraduate students to provide basic understanding regarding the computer aided design aspects of the biomedical devices and instrumentation and their different building blocks. The course is developed to instill the design and ergonomic perspectives of the biomedical devices and electronic circuits with the real-life examples of different biomedical applications. The course will help students in research activities and to understand, analyze, design, and develop biomedical instruments of interest.	
Course Content/Syllabus: Model or structure designing using CAD tool; 3D Printing of various structures; Circuit simulation and analysis in Spice tool; PCB Layout design and analysis; PCB fabrication and testing of the same; Designing a digital thermometer. *Every semester 9 laboratory experiments will be offered from this syllabus.	
References:	
1	Chang K-H., *Product Design Modeling using CAD/CAE: The Computer Aided Engineering Design Series*, Academic Press, 2014
2	Tuinenga P. W., *SPICE: A Guide to Circuit Simulation and Analysis Using PSpice*, Pearson Education, 1995
3	Hu R., *PCB Design and Layout Fundamentals for EMC*, Independently Published, 2019
4	R S Khandpur, Printed Circuit Boards: Design – Fabrication, McGraw Hill Education, 2017

Laboratory Plan:

Module	Content	No. of Labs
Experiment 1: Model or structure designing using CAD tool	1. Design of simple geometry using a CAD tool 2. Design of complex geometries in the CAD tool having different dimensions and thread-pitch	2
Experiment 2: 3D Printing of various structures	1. 3D-print the designs mentioned designs using available 3D-printers and materials 2. Finishing work (cutting filing). 3. Making hollow cube container with one-side shutter having (a) push locking (b) slide locking (similar to a battery container in a typical TV or AC remote control)	2
Experiment 3: Circuit simulation and analysis in Spice tool	1. Simulate instrumentation amplifier circuit in a spice tool. 2. Simulate active band pass filter with an instrumentation filter. 3. Simulate a microcontroller based (PIC) circuit for temperature measurement with LCD to display the temperature value.	2
Experiment 4: PCB Layout design and analysis	1. Design PCB layout of the simulated circuit in any software (say eagle) 2. Design the layout in a circular board. 3. Design the layout in a L-shaped board.	2

	4. Design the layout with minimum possible dimension.	
Experiment 5: Product Design and Development	1. Market Study 2. Brainstorming 3. Ideation/concept development 4. Benchmarking the final concept 5. Product detailing of the final concept 6. CAD model 7. Prototyping	1
Experiment 6: PCB fabrication and testing of the same	1. Test the above circuits in bread board. 2. Fabricate the PCBs and test the same.	1
Experiment 7: Designing a digital thermometer	1. Design the circuit of the digital thermometer 2. Egonomics design of outer cabinet of the thermometer 3. Fabricate the 3D printed cabinet. 4. Make the PCB layout according to the design. 5. Fabricate the PCB and test. 6. Integrate the components in the cabinet and test the same.	3
	Total Lectures	12*

* Any 9 experiments based on the instrument availability will be performed.

Indian Institute of Technology Guwahati

Course Number & Title: HT509 Regenerative Medicine and Stem Cells Laboratory
L-T-P-C: 0-0-3-3
Type of Letter Grading (Regular Letter Grades / PP or NP Letter Grades): Regular
Kind of Proposal (New Course / Revision of Existing Course): New Course
Offered as (Compulsory / Elective): Compulsory for M Tech
Offered to: M Tech, PhD
Offered in (Odd/ Even / Any): Even
Offered by (Name of Department/ School/ Center): Jyoti and Bhupat Mehta School of Health Sciences and Technology
Pre-Requisite: None
Preamble: This course has been designed for postgraduate students to provide a basic understanding of stem cell biology and its implication/application in disease modeling and regenerative medicine. The course covers diverse aspects within the scope of stem cell biology, including stem cell isolation, culturing, engineering, induced pluripotent stem cells (iPSCs) technology, stem cell therapy, and regenerative medicine. The laboratory design provides hands-on training to the students to become experts in the field of stem cell biology and regenerative medicine, which will eventually meet the social need in biomedical sciences and engineering. Overall, it will enable students to understand, analyze, design, and develop stem cell therapeutics and regenerative medicine.
Course Content/Syllabus: Hands-on training on mammalian stem cell culture; hands-on training on stem cell culture; maintenance of iPSC Cultures, passaging iPSC cultures, counting of iPSCs, alkaline phosphatase live stain, cryopreservation of iPSCs, characterization of iPSCs, pluripotent factors characterization; computational stem cell biology *Every semester 9 laboratory experiments will be offered from this syllabus.
References:

1	*Nagwa El-Badri, Regenerative Medicine and Stem Cell Biology (Edition Number 1)* Springer Nature Switzerland AG 2020
2	*Indumathi Somasundaram, Dhanasekaran Marappagounder, Pankaj Kaingade, Stem Cell Biology: A Practical Laboratory Manual, Evincepub Publishing (1 January 2019); Evincepub Publishing*
3	*Eran Meshorer, Kathrin Plath, The Cell Biology of Stem Cells (Edition Number1) , Springer New York, NY*

Laboratory Plan:

Module	Content	No. of Labs
Experiment 1: Hands-on training on stem cell culture	4. Introduction to stem cell culture 5. Preparation the lists the minimal equipment required for basic culture and characterization of stem cell and biosafety, e.g., BSL-2 cabinet, CO_2 incubator, vacuum source, inverted microscope, centrifuge, cell counter, cryostorage container, sterilizer, water bath, pipettes, and other accessories. 6. Preparation of Stem Cell Culture Medium and Reagents 7. Aliquoting Cell Basement Membrane for long-term storage. 8. Prepare Membrane/Metrigel Coated Culture Dishes 9. Thawing of Cryopreserved cells and plating	1
Experiment 2: Maintenance of Cell Cultures	5. Changing media (culture need to be done for 2-5 days depending upon confluency) 6. Microscopic observation to determine percent cellular confluence and morphology of undifferentiated cells	1

	7. Understanding characteristics of differentiated and undifferentiated cells. 8. Identification and Removal of Differentiated Cells	
Experiment 3: Passaging Cell Cultures, Counting, Cryopreservation	5. Preparation of supporting layer of feeder cells / basement membrane gel / matrigel 6. Prepare Cell Basement Membrane Coated Culture Dishes 7. Inspection of the cells by microscope and imaging and plating 8. Preparing hemocytometer, trypan blue, and cell suspension 9. Count viable and dead cells using trypan blue exclusion assay on a hemacytometer 10. Calculate the number of viable cells/mL 11. Stem cell dissociation reagent 12. Reagent preparation for cryopreservation 13. Transfer the cell aggregates to conical tube 14. Centrifugation and discard of supernatant 15. Transfer of cell suspension into cryovials 16. Freeze the cells gradually at a rate of -1°C/min until the temperature reaches -70°C to -80°C 17. Transferred to the vapor phase of liquid nitrogen for long-term storage	1
Experiment 4: Alkaline phosphatase live stain	4. Prepare a 1X working solution from staining solution A and B 5. Cells Staining 6. Count the red stained cell colonies vs. colorless colonies using a light microscope.	1
Experiment 5: RNA extraction from Cells	1. Preparation of buffers, e.g., RNA PreWash, RNA Wash Buffer, Reconstitute lyophilized DNase I with DNase/RNase-Free Water 2. Sample Preparation 3. Column preparation 4. Extraction, elution and concentration measurement	1
Experiment 6: DNA extraction from Cells	2. Preparation of buffers, e.g., Beta mercaptoethanol lysis buffer, genomic lysis buffer, DNA Pre-Wash Buffer, g-DNA wash buffer, and DNA elution buffer 3. Sample Preparation 4. Column preparation 5. Extraction and concentration measurement	1
Experiment 7: Gene expression Study of Cells	5. Reverse transcriptase stock preparation 6. cDNA synthesis 7. performs qPCR with that cDNA	1
Experiment 8: Sequence characterization of pluripotency factors	3. Identification of pluripotency factors from Literature and NCBI-Blast 4. Detection of exon, intron, 5', 3', and CDSs of pluripotency factors	1
Experiment 9: Sequence comparison of pluripotency factors between human and rat	5. Collection of CDSs pluripotency factors 6. Multiple sequence alignment 7. Detection of point mutation among the sequences.	1
Experiment 10: 3D bioprinted- Cells	4. Selection of materials for bioactuator fabrication 5. Hydrogels characterization	1
Experiment 11:	6. Pre-bioprinting 7. Preparation of bio-ink	1

Bioactuation for Cell culture	8. Bioinks culture in printer cartridge	
Total		11*

*Any 9 labs based on the instrument availability will be performed.