Department of Applied Sciences

Courses detailing for:

- **Dual Degree Programs -**

1) **B. Tech. (IT) - M. Tech. BI 5+ Year Dual Degree Program AND B. Tech. (ECE) - M.Tech. BI 5+ Year Dual Degree Program: (Total 12 Semesters Each):** Till VIth Sem, the Dual Degree Students, shall have course syllabus same as that of B.Tech.(IT)/ B.Tech (ECE), as the case may be. From VIIth Semester and onwards, the Dual Degree Students shall study with M. Tech.(BI) Direct entry students, as detailed herein below.

2) **B. Tech.(IT) - M. Tech. BME 5+ Year Dual Degree Program AND B. Tech.(ECE) - M. Tech. BME 5+ Year Dual Degree Program : (Total 12 Semesters Each):**Till VIth Sem, the Dual Degree Students, shall have course syllabus same as that of B.Tech.(IT)/ B. Tech (ECE), as the case may be. From VIIth Semester and onwards, the Dual Degree Students shall study with M. Tech. (BME) Direct entry students, as detailed herein below.

- **Direct Entry PG Programs -**

1) **M. Tech. BI, 2 Year (4 Semesters)**
2) **M. Tech. BME, 2 Year (4 Semesters)**

Credits Distribution for:

<table>
<tr><th colspan="12">M. Tech. (BI) portion of Dual Degree (BMBI-7 to BMBI-12)
as well as M. Tech. BI (MBI-1 To MBI-4) Direct Entry Programs</th></tr>
<tr><th rowspan="2">Semester</th><th colspan="7">Normal Successive Semester</th><th colspan="4">Spill Over Semesters</th></tr>
<tr><th>BMBI - 7 & MBI-1</th><th>BMBI - 8 & MBI - 2</th><th>BMBI - 9 (Summer)</th><th>BMBI - 10 & MBI - 3</th><th>BMBI - 11 & MBI - 4</th><th>BMBI - 12 (Summer)</th><th rowspan="2">Total Credits</th><th>5th</th><th>6th</th><th>7th</th><th>8th</th></tr>
<tr><td>Duration</td><td>July-Dec</td><td>Jan-May</td><td>May - July</td><td>July - Dec</td><td>Jan-May</td><td>May - July</td><td colspan="5">Odd Sems - July-Dec
Even Sems - Jan-May
Summer Sems - May-July</td></tr>
<tr><td>Regular Credits
For Dual Degree Students</td><td>20</td><td>20</td><td>12</td><td>12</td><td>12</td><td>12</td><td>88</td><td colspan="5">As per DROPs</td></tr>
<tr><td>For Direct Entry Students</td><td>20</td><td>20</td><td>-</td><td>12</td><td>12</td><td>-</td><td>64</td><td colspan="5">As per DROPs</td></tr>
<tr><td>Maximum Credit that can be Enrolled into</td><td>24</td><td>24</td><td>12</td><td>24</td><td>24</td><td>12</td><td></td><td>24</td><td>24</td><td>24</td><td>24</td></tr>
</table>

Indian Institute of Information Technology, Allahabad
Department of Applied Science
M. Tech. (Bio-informatics) Course Curriculum

Total Credit: 64

Semester : MBI-1 & BMBI – 7				
Sl. No.	**Course Name**	**Core/Elect**	**Credit**	**L-T-P**
1	Omics	Core(H)	4	2-1-1
2	Biological Data Analytics	Core(H)	4	3-1-0
3	Biological Information System and Management	Core(H)	4	2-1-1
4	Scripting and Computer Environments	Core(H)	4	3-0-1
5	Data Structure and Algorithms	Core(H)	4	2-0-2
		Total	20	

Semester : MBI – 2 BMBI – 8				
Sl. No.	**Course Name**	**Core/Elect**	**Credit**	**L-T-P**
1	Next Generation Sequencing Tools and Algorithms	Core(H)	4	1-2-1
2	Cheminformatics	Core(H)	4	2-1-1
3	Numerical Methods	Core(H)	4	2-1-1
4	Elective-1	Core(S)	4	
5	Elective-2	Core(S)	4	
		Total	20	

Semester : BMBI-9 (Summer Semester)				
Sl. No.	**Course Name**	**Core/Elect**	**Credit**	**L-T-P**
1	Summer Project		12	0-2-10
		Total	12	

Semester : MBI – 3 & BMBI – 10				
Sl. No.	**Course Name**	**Core/Elect**	**Credit**	**L-T-P**
1	Mini Project	Core(S)	4	0-1-3
2	Elective-3	Core(S)	4	
3	Elective-4	Core(S)	4	
		Total	12	

Semester : MBI – 4 & BMBI –11				
Sl. No.	**Course Name**	**Core/Elect**	**Credit**	**L-T-P**
1	M. Tech. Thesis	Core(H)	12	0-2-10
		Total	12	

Semester : BMBI-12 (Summer Semester)				
Sl. No.	**Course Name**	**Core/Elect**	**Credit**	**L-T-P**
1	Summer Project		12	0-2-10
		Total	12	

Note:

- A candidate can earn a maximum of 24 credits in any semester through regular registration including a dropped course.
- For dropped-out courses-, Provision of Summer semester is introduced.
- For the purpose of branch change, plz refer to Ordinance.

List of SUGGESTIVE Electives:

(Electives -1, 2, 3, 4 May be chosen from this list)

Course Name	Credit Structure L-T-P	Total Grade Value
Machine Learning for Biological Systems	1-1-2	4
Molecular Medicine	2-1-1	4
Cognition and Cognitive Processes Modeling	2-1-1	4
Advance Data Analytics	2-1-1	4
Systems Biology	3-0-1	4
Molecular Structure Prediction and Visualization	1-1-2	4
Parallel Computing	2-1-1	4
Pattern Recognition	2-1-1	4
Deep Learning	2-1-1	4

Course Syllabus for Core and Elective courses

Indian Institute of Information Technology, Allahabad
Department of Applied Science

Semester - MBI-1 & BMBI-7

1. Name of the Course: Omics

2. **LTP structure** of the course: 2-1-1

3. **Objective of the course:** The aim is to provide the fundamental knowledge of Molecular biology, Biochemistry, Genomics and Proteomics to the 1st semester M. Tech. BI and 7th semester B. Tech (IT)-M. Tech. Dual Degree BI students.

4. **Outcome of the course**: Since a mixed population of students from Biology, Computer Science and Information Technology is taking this course, it is very necessary to provide them the basic understanding about the Advanced Biology, especially in the areas of Molecular biology and Biochemistry. The students will be endowed with the knowledge about the different biological processes and the biomolecules involved. In addition, the students will learn the principles of different laboratory techniques from Proteomics and Genomics which will be implemented in the practical classes. They will also learn how to handle different wet laboratory instruments. The overall goal is to inculcate the passion for biological research among the engineering students to improve the interdisciplinary research.

5. **Course Plan:**

Component	Unit	Topics for Coverage
C1	Unit1	DNA as a genetic material, Nucleic acid (DNA & RNA) structure, Central dogma of molecular biology, Gene structure (Regulator, Operator, Promoter, Structural genes, Exons, Intron, ORF) and its expression, Genetic codon, Operon, Restriction enzymes and mapping, Site directed Mutagenesis.
	Unit 2	DNA Replication, Transcription and Translation in prokaryotes, Regulation of gene expression.
C2	Unit 3	Cloning and expression plasmid, Recombinant DNA technology, Construction and screening of Genomic DNA library.
	Unit 4	Principles of Gel electrophoresis, 2D-PAGE, Blotting Techniques (Southern, Northern, Western), Immunoprecipitation, Chip-seq, EMSA, PCR, RT-PCR, ELISA, Mass spectrometry, DNA Microarray, Protein microarray.

6. **Text Books and References:**

i. Molecular Biology of the Gene by James D. Watson, Tania A. Baker, Stephen P. Bell, Alexander Gann, Michael Levine, and Richard Losick.
ii. Biochemistry by Jeremy M. Berg, John L. Tymoczko, and Lubert Stryer.
iii. Kuby Immunology by Thomas J. Kindt, Richard A. Goldsby, Barbara A. Osborne, Janis Kuby.
iv. Lehninger Principles of Biochemistry by Albert L. Lehninger, David L. Nelson and Michael M. Cox

Biological Data Analytics

1. Name of the Course: Biological Data Analytics

2. LTP structure of the course: 3-1-0

3. Objective of the course: To expose the M. Tech. BI students with the advanced techniques of Probability and statistics applied to biological data.

4. Outcome of the course: The students will learn modern statistical techniques (sampling, hypothesis tests, correlation and regression analysis etc.) to analyse different kinds of data associated to Health Sciences. As the examples would be taken directly from the health sciences literature instead of contrived examples, we believe that this course should appear more interesting for the students, and would provide very good platform for them to build their skill to become practicing health professionals.

5. Course Plan:

Component	Unit	Topics for Coverage
C 1	Unit 1	Review of the basic concepts of Probability (up to Bayes Theorem) and Statistics (Central tendencies and standard deviations)
	Unit 2	Probability Distribution functions: Binomial, Poisson and Normal distributions, Central Limit Theorem and it's applications.
C2	Unit 3	Sampling distribution, Estimation, Interval estimation, Confidence interval, Test of hypotheses, Z-test, t-test, the chi-square test, F-test and ANOVA test.
	Unit 4	Correlation and Regression analyses, Correlation Coefficients, Least square method and curve fittings, Single and multi variable regression.

6. **Text Book:**'Biostatistics -A Foundation for Analysis in the Health Sciences' by Wayne E. Daniel and Chad L. Gross.

7. **References:** 'Fundamental of Biostatistics' by Bernard Rosner.

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Biological Information System and Management

1. Name of the Course: Biological Information System and Management

2. LTP structure of the course: 2-1-1

3. Objective of the course: To expose the M. Tech. BI students with the techniques of Database Management System along with different available flat files and database handling techniques

4. Outcome of the course: The students will learn DBMS role, usage, creation, designing and implementation database to create in-house database. Further they will learn the usage of different flat file formats along with their parsing and information retrieval. This will be sufficed with few case studies using available data mining techniques and data clustering and classification.

5. Course Plan:

Component	Unit	Topics for Coverage
C1	Unit 1	Introduction to the database, Database models, Flat model, Hierarchical model, & Network model, Profile & Block, Secondary and Tertiary sequence databases, Relational model, Codd's rule with explanation, 1st, 2nd and 3rd level normalisation, Relational operations, Dimensional Model and Object database models.
	Unit 2	Applications of Databases, Introduction to MySQL, Introduction to Database interfacing language, PHP, Introduction to PHP manipulating APACHE server.

C 2	Unit 3	Database internals, Indexing and triggers, Binary tree and Hash-key based indexing, Transactions, concurrency, and Replication. Data Mining & Warehousing, Association, Clustering & Classification.
	Unit 4	Applications: Introduction to Protein and Nucleic Acid Databases (PDB, NCBI etc.), PDB and NCBI database formalism, Further manipulation of PDB and NCBI data with the help of already acquired RDBMS knowledge based on PHP-MySQL manipulation, Pearl based data mining and linkage with databases (DBI).

6. **Text Book:**
7. **References:**

1. Biological Databases by Attwood.
2. Programming the Perl DBI by O'Reilly
3. Essential of MATLAB for Scientist and Engineer by Hahn Brian D
4. Beginning PHP and MySQL 5: from novice to professional by W.Jason Gilmore

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Scripting and Computer Environments

1. **Name of the Course:** Scripting and Computer Environments
2. **LTP structure** of the course: 3-0-1
3. **Objective of the course**: To expose students to scripting languages of relevance to Bioinformatics.
4. **Outcome of the course:** Bioinformatics is a discipline that requires expertise in using various scripting languages and tools. At the end of course, the students will be able to use scripting languages Perl, Python and R to accomplish tasks required for general purposes in Bioinformatics.
5. **Course Plan:**

Component	Unit	Topics for Coverage
C1	Unit 1	Introduction to programming, statements, numeric, string literals, variables, arrays and hashes, control statements, subroutines, file handling, regular expression
	Unit 2	References, Advanced Programming in Perl Packages, Object Oriented Programming**,** BioPerl
C2	Unit 3	Introductory Python and R, Local & Global Alignment Algorithms, Dynamic Programming: Smith & Waterman, Needleman & Wunsch Algorithm.
	Unit 4	Multiple Sequence Alignment, Concepts & Implementations, Amino Acid Substitution Matrices PAM & BLOSUM Derivation of Dayhoff Matrices, Profiles & Motifs General Tools, Techniques & Resources Clustal W, BLAST and FASTA.

6. Text Book: Mandatory for UG core courses
7. References:

- Learning Perl
  Randal Schwartz, Tom Phoenix, drian d foy (O'Reilly)
- Molecular Modeling: Principles and Applications (2nd Edition)
  Andrew R. Leach (Prentice Hall)
- Proteins: Structures and Molecular Properties
  Thomas E. Creighton (Freeman)
- Fast Lane to Python
  http://heather.cs.ucdavis.edu/~matloff//Python/PLN/FastLanePython.pdf

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Data Structure and Algorithms

1. **Name of the Course:** Data Structure and Algorithms
2. **LTP structure** of the course: 2-0-2
3. **Objective of the course:** To impart the knowledge of basic programming and elementary data structure to non-IT/CS students
4. **Outcome of the course:**
5. **Course Plan:**

Component	Unit	Topics for Coverage
C1	Unit 1	Computer basics Flowcharts, Algorithms, Data representation Characters, Integers, Fractions, Hexadecimal & Binary Conversions
	Unit 2	C programming, Arrays and Strings, Conditions, Loops, File Handling, Data Types and Pointers
C2	Unit 3	Linked lists, Sorting Algorithms
	Unit 4	Graphs, Binary Search Trees, Shortest Path Algorithms

6. **References:**
    - Think Python (2e), Allen Downey, O'Reilly
    - Introduction to Algorithms, Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest, Clifford Stein
    - Data Structures Using C and C++, Yedidyah Langsam, Moshe J. Augenstein, and Aaron M. Tenenbaum

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Semester - BMBI-8 & MBI-2

Next Generation Sequencing Tools and Algorithms

1. Name of the Course: Next Generation Sequencing Tools and Algorithms

2. **LTP structure of the course**: 1- 2-1

3. **Objective of the course**: To get acquainted with the high throughput sequencing data and its processing. Since these data often pose a problem of big data domain, the existing algorithm to tackle such problems will be discussed with the limits and lacunas of each such existing technique. This will enable the students to ponder more about the string processing techniques and to come with novel approach of genomic strings processing.

4. Outcome of the course: Trained individuals with basic knowhow of the string processing techniques and a good understanding about the tools for such data analytic.

5. Course Plan:

Component	Unit	Topics for Coverage
C1	Unit 1	DNA sequencing, strings, and matching: DNA sequencers and working principle, DNA as a string. Parsing and manipulating real genome sequences and real DNA sequencing data. Naive exact matching, homology detection; optimal pair-wise sequence alignment, alignment score statistics, efficient database searches (BLAST), Data science of metabolomics, pathway models.

	Unit 2	Preprocessing, indexing and approximate matching: Improving on naive exact matching with Boyer-Moore. Preprocessing and indexing. Indexing through grouping and ordering, k-mers and k-mer indexes. Approximate matching and the pigeonhole principle. Edit distance, assembly, overlaps: Hamming and edit distance. Algorithms for computing edit distance. Dynamic programming. Global and local alignment. De novo assembly. Overlaps and overlap graphs.
C2	Unit 3	Algorithms for assembly: Shortest common superstring and the greedy version. How repetitive DNA makes assembly difficult. De Bruijn graphs and Eulerian walks. How real assemblers work. The future of assembly.
	Unit 4	Data variability and replication, Data transforms, Clustering, Dimension reduction, Pre-processing and normalization, Linear models with categorical covariates, Logistic regression, Null and alternative hypotheses analysis, false discovery rate, permutation and bootstrapping, Gene expression repository (GEO).

7. **References:**

Analytical Techniques In DNA Sequencing by Veena Kumari
DNA Sequencing From Experimental Methods To Bioinformatics by Alphey, Luke
Next-Generation Sequencing Data Analysis by Xinkun Wang

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Cheminformatics

1. Name of the Course: Cheminformatics and Molecular modeling
2. LTP structure of the course: 2-1-1
3. Objective of the course: Students should be able to build up QSAR models
4. Outcome of the course: Efficiency in drug design
5. Course Plan:

Component	Unit	Topics for Coverage
C1	Unit 1	Detail Introduction to Cheminformatics in Drug Discovery. 2D Databases and Database searching: Substructure search, Virtual Screening, property searching, similarity searching, Representation and manipulation of 2D Molecular Structures, 3D Databases: experimental data sources, database searching, Representation and manipulation of 3D Molecular Structures, Selecting Diverse Sets of Compounds.
	Unit 2	QSAR: Quantitative Structure and Activity Relationship, Historical Development of QSAR, Hammett Equation, Hansch Equation, Kubinyi bilinear model, Tools and Techniques of QSAR: Biological Parameters, Statistical Methods: Linear Regression Analysis. Parameters used in QSAR: Electronic Parameters, Hydrophobicity Parameters, Steric Parameters, Molecular Structure Descriptors, Quantitative Models: Linear Models, Nonlinear Models, Free- Wilson Approach, Applications of QSAR: Isolated Receptor Interactions, Interactions at the Cellular Level Interactions in-Vivo, Comparative QSAR: Database Development, Software: GRID, CoMFA.
C2	Unit 3	QSPR : Quantitative Structure and Property Relationship, Octonal Water Partition Coefficient, Quantum Chemical Descriptor, HUMO/LUMO, Predictive Quantitative Structure –Activity Relationships Modeling: Data Preparation and General Modeling Workflow, Reaction network Generation, Open Source Chemoinformatics Software and Database Technologies, Machine Learning based Bioinformatics Algorithms-Applications to Chemicals.

	Unit 4	Combinatorial Library Designing: Diverse and Focussed Libraries, Monomer Selection, Product. based Library Design, Structure Based Library design. High Throughput / Virtual screening Screening, Introduction, Basic Steps, Important Drug Databases, Database Designing Lipinski's Rule of Five, ADMET screening

6. Text Book: Mandatory for UG core courses
7. References:

1. Chemoinformatics, Concepts, Methods & Tools for Drug Discovery; Ed. Jurgen Bajorath (Humana Press)
2. Chemoinformatics Ed by Johann Gasteigen, Thomas Engel, Wiley-VCH
3. Molecular Modeling, Principles & Applications, Andrew R. Leach
4. Bioinformatics from Genomes to Drugs ; Vol I & 2
5. An Introduction to Chemoinformatics, Andrew R. Leach, Valerie J. Gillet. R Eisberg and R. Resnick.

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Numerical Methods

1. Name of the Course: Numerical Methods

2. LTP structure of the course: 2-1-1

3. Objective of the course: To expose students to numerical methods of relevance to computational Biology and Bioinformatics

4. Outcome of the course: Students will be able to convert a qualitative problem into computer based solutions

5. Course Plan:

Component	Unit	Topics for Coverage
C1	Unit 1	Introduction, Curve fitting, Taylor series, Roots of equations, Linear algebraic equations
	Unit 2	Optimization and minimization, Numerical differentiation and integration
C2	Unit 3	Ordinary differential equations, Eigen Values and Eigen Vectors
	Unit 4	Molecular dynamics, Monte Carlo algorithm

7. Text book: Numerical Methods for Engineers by Chapra and Canale

Elective Course Syllabus: (Electives-1, 2, 3, 4)

Machine Learning for Biological Systems

1. Name of the Course: Machine Learning in Biological System

2. LTP structure of the course: 1-1-2

3. Objective of the course: To provide M. Tech. IT (spln. In Bioinformatics) students knowledge and exposure in hands-on experience on solution of “exon-intron sequence identification”, “gene identification”, “secondary structure prediction” and various solution of biological problems through existing and state of the art machine learning methods.

4. Outcome of the course: Intelligent solutions of non-linear and complex biomolecular sub-systems are needed to get holistic information of pathobiological system (health condition) from the angle of Systems Biology. Students will have exposure of such intelligent solutions through this course.

5. Course Plan:

Component	Unit	Topics for Coverage

C 1	Unit 1	Foundation of Machine learning: Turing Machine, Concepts of John von Neumann, computation of amount of learning of a machine, Concept of supervised and unsupervised learning, concept of clusters and classes, concept of training and testing. Statistical Machine Learning: Design of rule based expert system, knowledge engineering, forward chaining and backward chaining inference techniques, Application to discriminate intron from exon within eukaryotic DNA, Application of rule based system to discover knowledge from data, concept of clustering, condition to find best clusters. Various clustering techniques.
	Unit 2	Important components of a classifier, Probabilistic classifier, Bayesian classifier, Hidden Markov Models and applications, Applications to discriminate Exon from Intron, to predict secondary structures of proteins, discover group of genes having similar up-regulation or down-regulation pattern from micro-array data.
C 2	Unit 3	Nearest Neighbor Classifier, Discriminant Function Analysis (Linear and non-linear) as precursor to Artificial Neural Network. Application for protein secondary structure prediction
	Unit 4	Soft computing method based machine learning: Artificial Neural Network for clustering and classification, local optimization of ANN weights, Back propagation network, Hopfield network, Genetic algorithm for optimizing parameters of classifiers, Support Vector Machine foundation, constrained local optimization using Lagrange, Multiplier, application and Cross validation.

Text:

1. Pattern recognition and image analysis by Earl Gose.
2. Pattern Classification by Duda, Richard and David Stork
3. Machine Learning by Mitchell and Tom

Reference Books: 1. Artificial Intelligence and Molecular Biology: Lawrence Hunter (MIT Press) (freely available ebook)

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Molecular Medicine

1. Name of the Course: Molecular Medicine
2. LTP structure of the course: 2-1-1
3. Objective of the course: Objective was to make students aware aboutphysical, chemical, biological, bioinformatics and medical techniques used to describe molecular structures and mechanisms to identify fundamental molecular and genetic errors of disease, and to develop molecular interventions to correct them.
4. Outcome of the course: Students were able to emphasize cellular and molecular phenomena and interventions rather than the previous conceptual and observational focus on patients and their organs.
5. Course Plan:

Component	Unit	Topics for Coverage
C1	Unit 1	Concept and perspective of molecular medicine,History of Drug Development, Basic pharmacodynamics and pharmacokinetics, Principles of Chemotherapy, Human genome : implication and applications..

	Unit 2	Bioinformatics, Genomics, Proteomics and Metabolomics in Biomedical research, Molecular basis of diseases(Mixed system) , Molecular basis of inherited diseases, Pathological basis of neurological diseases, Molecular diagnostics of Infectious diseases..
C2	Unit 3	Drug targets at the molecular level, bonding forces, classification of drugs, Receptors-Role, activation, Active site, Strategies of drug design.
	Unit 4	Stem cells and regenerative therapy, Gene therapy for human diseases, personalized medicine, Structure Based Drug Designing (SBDD), Ligand Based Drug Designing (LBDD), Pharmacophore Generation,Docking and scoring methods for proteins-ligands, protein-protein, protein-DNA, DNA-ligand,Identifying Cavities and Surface Matching, Shape Complementarity, Solvent-Accessible Surface.Targeted drug delivery, Nanotechnology in medicine, Biomaterials in tissue engineering, Enzymes in clinical diagnosis.

6. **Text book/Reference:**

1. Drug Design: Structure and ligand-based approaches: Kenneth M.Merz, Dagmar Ringe, Charles H.Reynolds.
2. Bioinformatics-from genomes to drugs (Vol.2- Applications Lengauer, Thomas (ed.).
3. Burger`s medicinal chemistry & drug discovery; Vol.-2(Drug discovery and drug development) Abraham, Donald J. (ed.)
4. Drug design : structure and ligand-based approaches: edited by Kenneth M. Merz, Dagmar Ringe, Charles H. Reynolds
5. Chemoinformatics; (Vol.-275 - Methods in molecular biology) : concepts, methods and tools for drug discovery : Bajorath, Jurgen (ed.)

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Cognition and Cognitive Processes Modeling

1. **Name of the Course:** Cognition and Cognitive Processes Modeling
2. **LTP structure of the course:** 2-1-1
3. **Objective of the course:**
    a. To provide an overview of cognition in human brain.
    b. To introduce students about several AI debates and pro and against arguments of realization of true AI.
    c. To provide comprehensive details about the cutting-edge approaches and recent developments of cognitive systems.
    d. Introducing students about several cognitive architectures and hand-on working in these architectures.
4. **Outcome of the course:**
    a. Students will get the understanding of how human cognition works as per the explanations till date.
    b. Students will get new side of AI development (Using cognitive architectures).
    c. Students will get to know the challenges which have been accomplished and which are yet to be addressed to make true AI systems.
5. **Course Plan:**

Component	**Unit**	**Topics for Coverage**

C 1	Unit 1:	Introduction: Human Brain: Introduction, cognitive faculties: memory, attention, vision and language, What is cognition, introduction about approaches to cognition, theories of mind: mind - body dualism, materialist theory of mind, identity theory of mind, computational theory of mind.
	Unit 2:	Consciousness: First person approach , third person approach, Chalmers view of consciousness, problem of third person approach, Pattern-Information duality, Free Will: Sloman view, free will as continuous dimension, design distinctions for agent modeling.
C2	Unit 3:	First AI Debate: Is AI possible? Pro: Roger Penrose, moravec, Herbert Simon. Artificial mind via symbolic AI, Turing test of AI. Against: Dreyfus five stages of learning, Searle's chinese room thought experiment, Degrees of understanding, godel's incompleteness theorem Second AI Debate: Connectionist Model, Objectives of Connectionist model, Feldman's hundred step rules, Brain vs computer model of mind, Lloyd's cautions, Fodor's attack, Chamlmers' defense, Rule based AI.
	Unit 4:	Cognitive Architectures: ACT-R, CLARION, SOAR, Reinforcement Learning, Distributed Cognition, Learning and Memory Architectures.
	Projects	1. Hands-on on cognitive architectures. 2. Analysis of cognition of brain using complex networks.

Books:

1. Artificial Mind by Stan Franklin
2. Siegelbaum, Steven A., and A. J. Hudspeth. Principles of neural science. Eds. Eric R. Kandel, James H. Schwartz, and Thomas M. Jessell. Vol. 4. New York: McGraw-hill, 2000.
3. Research papers for brain modeling.

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Advance Data Analytics

1. **Name of the Course:** Advanced data analytics
2. **LTP structure of the course:** 2-1-1
3. **Objective of the course:** Talks about domain specific mining issues and methods. Large data mining
4. **Outcome of the course:** Students will get exposure of various methods of performing data mining.
5. **Course Plan:**

Component	Unit	Topics for Coverage
C1	Unit 1	Association mining, Classification and Clustering: Revision.Data Streams mining, Social Network Analysis, Graph mining.
	Unit 2	Mining algorithms for large data, Mining Big Data, Hadoop, Map-Reduce, HDFS, Spark + seminars.
	Unit 3	Mining Sequence pattern in TD, Mining, Time-series data Mining WWW + seminars

C2	Unit 4	Advanced Machine Learning: Deep Learning, probabilistic learning + seminars Detail + seminars

6. Text Book: Mandatory for UG core courses
7. References Books:

Ian H. Witten and Eibe Frank, Data Mining: Practical Machine Learning Tools and Techniques (Second Edition), Morgan Kaufmann, 2005, ISBN: 0-12-088407-0.
Hadzic F., Tan H. & Dillon T. S. "Mining data with Complex Structures" Springer, 2011
Yates R. B. and Neto B. R. "Modern Information Retrieval " Pearson Education, 2005

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Systems Biology

1. **Name of the Course:** Systems Biology
2. **LTP structure of the course**: 3-0-1
3. **Objective of the course**: Expose students to interdisciplinary branch, Systems Biology
4. **Outcome of the course:** Upon completion of the course, the student will be able to appreciate and gain insights into multi-disciplinary approaches made necessary by advancing technology in the field of Systems Biology. Familiarity into various aspects of integrated approaches to understand organisms/organs/tissues/cells at various levels will be obtained.
5. **Course Plan:**

Component	Unit	Topics for Coverage
C1	Unit 1	Biological Systems, Introduction to Mathematical Modeling, Introduction to Graph Theory
	Unit 2	Static Network Models, The Mathematics of Biological Systems, Parameter Estimation
C2	Unit 3	Gene Systems, Protein Systems, Metabolic Systems
	Unit 4	Signaling Systems, Design of Biological Systems

6. Text Book: A first Course in System Biology, *Eberhard Voit*, Mar 2012.
7. References:
   i. Systems Biology: A Text Book, *Edda Klipp et al.* Aug 2009.

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Molecular Structure Prediction and Visualization

1. Name of the Course: Molecular Structure Prediction and Visualization

2. LTP structure of the course: 1-1-2

3. Objective of the course: To provide M.Tech. IT (spln. In Bioinformatics) students knowledge and exposure in hands-on experience on Molecular Structure Prediction for use in control of disease (patho-physiological condition of health) through application

4. Outcome of the course: student will learn state of the art and specialized algorithm to tackle the non-linear and complex problem of prediction of molecular structure that will be useful as part of target specific drug design and to explore structure-influenced patho-physiological conditions.

5. **Course Plan:**

Component	**Unit**	**Topics for Coverage**

C1	Unit 1	Basic structural principles: Building blocks of life, Chemical properties of polypeptides & PDB Database, Intermolecular forces: Types of intermolecular forces, Entropy and temperature, Protein folding & Levinthal Paradox.Levels of protein structure: Primary structure, Secondary structure, Tertiary structure & Quaternary structure, Motifs of protein structure: Hydrophobic and hydrophilic regions, Ramachandran plot Alpha-helix, Beta sheets, Loops, Topology diagrams &various structural motifs.
	Unit 2	**Structure determination primer:** X-Ray crystallography and NMR: Structure determination methods & Structure evaluation methods. Structure prediction primers: Protein structure prediction: Impediments, Secondary/fold recognition, Threading/teritiary structures, Sequence considerations, Structural considerations, Energy consideration, Energy landscape &Validation.
C2	Unit 3	Structure prediction of small proteins using ab initio stochastic models: Lattice simulation, Randomwalk model, Self-avoiding model & HP-models, Structure prediction of small proteins using ab initio deterministic models Ergodic hypothesis, Use of Newtonian equations of motion , Optimization techniques: Steepest descent, GA, simulated annealing & Force fields (Amber, CHARMM)
	Unit 4	Nucleic acid structures: DNA structures, RNA structures & Secondary structure prediction in RNA, Useful Tools: Visualization using VMD, PROCHECK, WHATIF & Simulation using Amber.

Text/Reference Books:

1. Introduction to Protein Structure: Carl Branden, John Tooze (Garland)
2. Proteins: Structures and Molecular Properties: Thomas E. Creighton (Freeman)

Guide lines for practical's: A two credit lab is to be conducted by covering the most relevant and useful topics from afore mentioned syllabus.

References:

1. Molecular Modelling: Principles and Applications (2nd Edition): Andrew R. Leach (Prentice Hall)
2. Principles of Nucleic Acid Structure Stephen Neidle (Academic Press)

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Parallel Computing

1. Name of the Course: Parallel Computing

2. LTP structure of the course: 2-1-1

3. Objective of the course: To introduce concepts of Parallel Computing.

4. Outcome of the course: Upon successful completion, the students will be able to approach designing of parallel computation based better. They shall have not only the theoretical concepts but also practical skill to implement the solutions.

5. Course Plan:

Component	Unit	Topics for Coverage
C1	Unit 1	Introduction, Motivation, Scope of parallel computing, Basics of Parallelization, Mutual exclusion

	Unit 2	Concurrent objects, Principles of parallel algorithm design Scheduling and Work Distribution, Foundations of Shared Memory, Primitive Synchronization Operations
C2	Unit 3	Tools and Platforms: C++11 threads, Intel Threading Building Blocks, Open CL and CUDA, Introduction to LAM/MIPCH, Issues of Multicore Programming, Basic Communication Operations, Analytical Modelling of Parallel Programs
	Unit 4	Universality of Consensus, Spin Locks and Contention Monitors and Blocking Synchronization, Parallel Algorithms & Data Structures, Decomposition Techniques, Characteristics of Tasks and Interactions, Mapping Techniques for Load Balancing, Methods for Containing Interaction Overheads Parallel Algorithm Models

6. Text Book: The Art of Multiprocessor Programming by Maurice Herlihy and Nir Shavit, Morgan Kaufmann Publishers

7. References:

i. The Art of Concurrency by Clay Breshears, O Reilly
ii. Introduction to Parallel Computing (2 Ed) by Ananth Grama, Anshul Gupta, George Karypis, Vipin Kumar, Addison Wesley
iii. Professional C++ by M Gregoire, NA Solter, SJ Kleper (2Ed)

Pattern Recognition

1. Name of the Course: Pattern Recognition

2. LTP structure of the course: 2-1-1

3. Objective of the course: This course deals with pattern recognition which has several important applications. For example, multimedia document recognition (MDR) and automatic medical diagnosis are two such.

4. Outcome of the course: Students will learn Pattern Recognition techniques and its applications.

5. Course Plan:

Component	Unit	Topics for Coverage
C1	Unit 1	Preliminary concepts and pre-processing phases, coding, normalization, filtering, linear prediction, Feature extraction and representation thresholding, contours, regions, textures, template matching
	Unit 2	Data structure for pattern recognition, statistical pattern recognition, clustering Technique and application. Study of pattern classifiers: Supervised and unsupervised.
C2	Unit 3	Pattern Classifiers: Naïve Bayes, Linear Discriminant Analysis, k- nearest neighbour (K-NN), Artificial Neural Network etc. and Case studies
	Unit 4	Application: Finance, Multimedia.

6. References:

1. R.O.Duda, P.E.Hart and D.G.Stork, Pattern Classification, John Wiley, 2001.
2. K. Fukunaga, Statistical pattern Recognition; Academic Press, 2000.
3. Devi V.S.; Murty, M.N., Pattern Recognition: An Introduction, Universities Press, Hyderabad, 2011

Deep Learning

1. **Name of the Course:** Deep Learning
2. **LTP structure of the course**: 2-1-1
3. **Objective of the course**: To get the students and researchers exposed to the state of the art deep learning techniques, approaches and how to optimize their results to increase its efficiency and get some hands-on on the same to digest the important concepts.
4. **Outcome of the course**: As deep learning has demonstrated its tremendous ability to solve the learning and recognition problems related to the real world problems, the software industries have accepted it as an effective tool. As a result there is a paradigm shift of learning and recognition process. The students and researchers should acquire knowledge about this important area and must learn how to approach to a problem, whether to deal with deep learning solution or not. After undergoing this course they should be able to categorize which algorithm to use for solving which kind of problem. Students will be able to find out the ways to regularize the solution better and optimize it as per the problem requirement. Students will be exposed to the background mathematics involved in deep learning solutions. They will be able to deal with real time problems and problems being worked upon in industries. Taking this course will substantially improve their acceptability to the machine learning community – both as an intelligent software developer as well as a matured researcher.
5. **Course Plan:**

Component	Unit	Topics for Coverage
C1	Unit 1	Basic concepts of perceptron, learning and recognition- supervise and unsupervised learning. Fundamentals of delta learning rules and back propagation algorithm, SVM, KNN. Machine Learning, machine learning techniques, challenges motivating deep learning. over fitting and under fitting, bias and variance, Gradient based optimization, Maximum Likelihood Estimation. Deep Feed-forward network, backpropagation. Some Regularization and Optimization Techniques.
	Unit 2	Convolutional Neural Network, RNN, methodology and Applications of deep learning.
C2	Unit 3	Linear Factor Models and Autoencoders
	Unit 4	Monte Carlo Methods, Stochastic Maximum, Likelihood and Contrastive Divergence Deep Generative Models: Boltzmann Machine, RBM, Deep Belief Nets, Deep Boltzmann Machine, Convolutional Boltzmann Machine

6. Text Book:

Deep Learning by- Ian Goodfellow, Yoshua Bengio and Aaron Courville

In addition other machine learning books , research papers etc. will be used.

Mini Project of IIIrd Sem: Guidelines as MAY BE decided by Dept. of AS time to time

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IV SEMESTER

M. Tech. Thesis: Guidelines as MAY BE decided by the Dept. of AS time to time

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Credits Distribution for:

M. Tech. (BME) portion of Dual Degree Programs (BMBE-7 to BMBE-12) as well as M. Tech. BME (MBE - 1 to MBE - 4) Direct Entry Program											
Semester	**Normal Successive Semester**							**Spill Over Semesters**			
	BMBE - 7 & MBE-1	**BMBE - 8 & MBE - 2**	**BMBE - 9 (Summer)**	**BMBE – 10 & MBE - 3**	**BMBE -11 & MBE - 4**	**BMBE - 12 (Summer)**	**Total Credits**	**5th**	**6th**	**7th**	**8th**
Duration	**July- Dec**	**Jan-May**	**May - July**	**July - Dec**	**Jan-May**	**May - July**		**Odd Sems -** July-Dec **Even Sems -** Jan-May **Summer Sems -** May-July			
Regular Credits For Dual Degree Students ***	**20**	**20**	**12**	**12**	**12**	**12**	**88**	**As per DROPs**			
For Direct Entry Students	**20**	**20**	**-**	**12**	**12**	**-**	**64**	**As per DROPs**			
Maximum Credit that can be Enrolled into	**24**	**24**	**12**	**24**	**24**	**12**		**24**	**24**	**24**	**24**

Total Credit: 64

Semester : MBE - 1 & BMBE- 7				
Sl. No.	**Course Name**	**Core/Elect**	**Credit**	**L-T-P**
1	Anatomy & Physiology	Core(H)	4	2-1-1
2	Biosignal Processing	Core(H)	4	3-1-0
3	Biomedical Instrumentation	Core(H)	4	2-1-1
4	Biomaterials and Tissue Engineering	Core(H)	4	2-1-1
5	Seminar Course	Core(S)	1	0-1-0
6	Mini Research Project		3	0-1-2
		Total Credit	20	

Semester : MBE- 2 & BMBE - 8				
Sl. No.	**Course Name**	**Core/Elect**	**Credit**	**L-T-P**
1	Medical Imaging	Core(H)	4	2-1-1
2	Biomechanics	Core(H)	4	2-1-1
3	Chemical Processes in Biosystems	Core(H)	4	2-1-1
4	Seminar Course	Core(S)	2	0-2-0
5	Mini Research Project	Core(S)	6	0-1-5
		Total Credit	20	

Semester : BMBE - 9 (Summer Semester)				
Sl. No.	**Course Name**	**Core/Elect**	**Credit**	**L-T-P**
1	Summer Project		12	0-2-10
		Total	12	

Semester : MBE- 3 & BMBE - 10				
Sl. No.	**Course Name**	**Core/Elect**	**Credit**	**L-T-P**
1	Elective 1	Core(S)	4	2-1-1
2	Seminar Course	Core(S)	2	0-2-0
3	Mini Research Project	Core(S)	6	0-1-5
		Total Credit	12	

Semester : MBE- 4 & BMBE - 11				
Sl. No.	**Course Name**	**Core/Elect**	**Credit**	**L-T-P**
1	M. Tech. Thesis	Core(H)	12	0-2-10
		Total Credit	12	

Semester : BMBE-12 (Summer Semester)				
Sl. No.	**Course Name**	**Core/Elect**	**Credit**	**L-T-P**
1	Summer Project		12	0-2-10
		Total	12	

Note:

- A candidate can earn a maximum of 24 credits in any semester through regular registration including a dropped course.
- For dropped-out courses- Provision of Summer semester is introduced.
- For the purpose of branch change, plz refer to Ordinance.

Any One should be chosen out of the elective basket given below

Sl. No.	Course Title	Credit Structure L-T-P	Total Course Credit
1	Bioelectrics	3-1-0	4
2	Medical Image Processing	2-1-1	4
3	Nanobiotechnology	2-1-1	4
4	Bio-MEMs and Microfluidics	2-1-1	4
5	Artificial Organs and Implants	3-1-0	4
6	Engineering Processes in Biological Systems	2-1-1	4
7	Soft Computing Tools for Biomedical Engineering	2-1-1	4

Till VI sem course syllabus of Dual Degree Programs are same as that of B.Tech.(EC)./B.Tech (IT). In VIIth semester they will study with M. Tech. (BME) direct entry students.

Course Syllabus for M. Tech. (BME)
Compulsory and Elective courses

Indian Institute of Information Technology, Allahabad
Department of Applied Science

Semester - MBE-1 & BMBE-7

Anatomy & Physiology

1. Name of the Course: Anatomy & Physiology
2. LTP structure of the course: 2-1-1
3. Objective of the course: The aim of this course is to teach about human anatomy which is the study of the structures associated with the human body and physiology which is the study of the function of each of these structures.
4. Outcome of the course: Knowledge of human anatomy and physiology is very essential for biomedical students. Students will learn about anatomy, basic human physiology and the normal functioning of all the organ systems of the body and their interactions. They will accumulate ideas of physiological aspects of normal growth and development. Students also learn about how organ systems are interconnected in biological systems.
5. Course Plan:

Component	Unit	Topics for Coverage
C 1	Unit 1	Basic cell physiology; Biochemical cycles. Systemic physiology: Nervous System, Neuromuscular system;
	Unit 2	Blood and lymph; Circulatory system; Respiratory and Cardiovascular system.
C 2	Unit 3	Gastro-intestinal system; Kidney and excretory system.
	Unit 4	Sensory systems- visual, auditory, vestibular; Endocrine- pituitary, adrenal, pancreas, Clinical and technological implications.

6. **Text Books:**

I. Arthur C. Guyton : Textbook of Medical Physiology, 8th ed, Prism Books (Pvt) Ltd & W.B. Saunders Company, 1991.
II. W.F.Ganong, Review of Medical Physiology, 13th ed., Prentice-Hall, 17th edition, 1995.

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Biosignal Processing

1. Name of the Course: Biosignal Processing
2. LTP structure of the course: 3-1-0
3. Objective of the course: To impart understanding of Signals and their transformation.
4. Outcome of the course: The students are expected to be concurrent with understanding Biological Signals acquisition, sampling rate and its impact, discrete domain analysis and application of signal processing tools to extract information relevant to the medical domain.
5. Course Plan:

Component	Unit	Topics for Coverage
C 1	Unit 1	Essentials of continuous time signals and systems: convolution,
	Unit 2	Discrete time signals and systems: sampling and quantization, the sampling theorem and signal reconstruction; Z-transform, Filters
C 2	Unit 3	Fourier transforms, system transfer functions, Frequency analysis of discrete signals and systems: the discrete Fourier transform, power spectrum estimation and system identification;
	Unit 4	Systems with Feedback Control: stability analysis.

6. **Text Books:**

I. A.V. Oppenheim, A.S. Willsky& H.S. Nawab: Signals & Systems, Prentice Hall, India, 1997

II. Discrete Time Signal Processing, Oppenheim, Schaefer, Pearson

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Biomedical Instrumentation

1. Name of the Course: Biomedical Instrumentation

2. LTP structure of the course: 2-1-1

3. Objective of the course: To instruct about medical instruments currently in use in medical domain with a special focus on the building blocks of such instruments.

4. Outcome of the course: Familiarity with key Medical Devices such as ECG, EMG, EEG, Cardiac Output Computer, Blood Pressure Measurement, Plethysmograph, Ultrasound Machine, etc., their operation principle, static and dynamic characteristics.

5. Course Plan:

Component	Unit	Topics for Coverage
C 1	Unit 1	Transducers for Biomedical Application: Resistive transducers – Muscle force and Stress (Strain gauge), Spirometers (Potentiometric), humidity, Respiration (Thermistor); Inductive Transducers – Flow measurements, muscle movement (LVDT); Capacitive Transducers – Heart sound measurement, Pulse pick up;
	Unit 2	Photoelectric Transducers - Pulse transducers, Blood pressure, oxygen Analyses; Piezoelectric Transducers – Pulse pickup, ultrasonic blood flowmeter; Chemical Transducer:
C 2	Unit 3	ECG (Amplifiers and Circuits), EEG, Plethysmography, Cardiac Output Measurement,
	Unit 4	Ultrasonic Transducers and Ultrasonic Imaging, Beam Steering, Flowmeters, Full Body Plethysmograph, EMG

6. **Text Books:**

I. D. Patranabis, Sensors and Transducers, Prentice Hall of India, 2nd Edition,1984

II. H. S. Kalsi , Electronics instrumentation, Tata Mc Grow Hill education Pvt. Ltd., 3rd edition 2010.

III. Jon. B. Olansen and Eric Rosow, Virtual Bio-Instrumentation Biomedical, Clinical and Healthcare Applications using LabVIEW, Prentice Hall, first edition, 2002.

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Biomaterials and Tissue Engineering

1. Name of the Course: Biomaterials and Tissue Engineering

2. LTP structure of the course: 2-1-1

3. Objective of the course: The aim of the course is to teach the development of biomaterials and its response with the host body which is an emerging aspect of medical device development.

4. Outcome of the course: Understand the fundamental principles in biomedical engineering, material science and chemistry, and how they contribute to development biomaterial and its performance. Students will gain knowledge about how to do biomaterial selection and design. It will be useful in the understanding of properties of synthetic and natural biomaterials, new and different classes of materials used in biomedical applications, and the various factors (materials properties, biologic response, etc.) that define the utility and applications of these materials.

5. Course Plan:

Component	Unit	Topics for Coverage
C 1	Unit 1	Introduction to Materials in Medicine, Classification of materials. Fundamentals of biomaterials science. Evolution of biomaterials. Physico-chemical properties of biomaterials: mechanical (elasticity, yield stress, ductility, toughness, strength, fatigue, hardness, wear resistance).
	Unit 2	Natural polymers in synthesis of biomaterials, Degradable polymers, Surface treatments and analysis. Case study of few advanced biomaterials.
C 2	Unit 3	Phenomena at the biointerfaces. Interactions between biomaterials and tissues. Surface interactions. Cell-Biomaterial Interactions and Host Integration. Concept of biocompatibility.
	Unit 4	Cells, Tissue organization. Structure, morphology and properties. Cell-matrix interactions. Stem cell engineering. Use of biomaterials in Stem cell engineering.

6. **Text Book:**

I. Lanza RP, Langer R, Vacanti JP, Principles of Tissue Engineering, Academic Press, 3rd Edition (2007).
II. Palsson B and Bhatia SN, Tissue Engineering, Pearson Prentice Hall (2003).
III. Biomaterials Science: An Introduction to Materials in Medicine - *Buddy D. Ratner, Allan S. Hoffman, Frederick J. Schoen, Jack E. Lemons, second sedition.*

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Semester – MBE - 2 & BMBE- 8

Medical Imaging

1. Name of the Course: Medical Imaging

2. LTP structure of the course: 2-1-1

3. Objective of the course: The aim of the course is to teach physics of various medical imaging techniques. We will study how sound wave propagates in tissue medium and interacts with the same; how sound beams for imaging can be generated. How can blood velocity be measured using Doppler's shift of ultrasound waves? How the simple principle of interference of light waves can be used to develop an imaging modality will be shown in this course. The generation and detection of X-rays for medical imaging are done in practice will be described. Its interaction with tissue will be

outlined. Besides, the concept of tomography imaging and reconstruction using the backprojection method will be introduced. The derivation involving solution of linear equations to obtain image matrix will be carried out. The physics of nuclear structure, its magnetic properties will be illustrated in detail. The interaction of nucleus with external magnetic field will also be highlighted. The effects of application and withdrawal of external magnetic field on an ensemble of nuclei leading to magnetic resonance signals will be presented. Finally, methods to localize magnetic signals coming from a macroscopic system (e.g. human body) for generating images will be described.

4. Outcome of the course: This course will help to understand as well as to develop a strong foundation on underlying physics of medical imaging. This will provide enough background and confidence to conceive methods of modern medical imaging and accordingly to pursue research projects.

5. Course Plan:

Component	Unit	Topics for Coverage
C1	Unit 1	**US imaging**- Ultrasound wave propagation in homogenous medium, scattering, absorption and attenuation of ultrasound waves in tissue, pulse-echo imaging, pulse parameters, ultrasound transducers, field calculation for a single element transducer, delay-sum beamforming for array transducers, Doppler ultrasound **Optical coherence tomography**-Michelson Morley experiment
	Unit 2	**X-ray imaging**- Instrumentation, mechanism of attenuation of X-ray in tissue, scintillation detection, digital radiography, X-ray CT, backprojection algorithm
C 2	Unit 3	**MRI imaging**-angular momentum, nuclear magnetic moment, Zeeman effect, Larmour precision, T_1, T_2, T_2* relaxations, chemical shift, free induction decay, 90^0, 180^0 pulse sequence, magnetic coils, localization of MRI signals.
	Unit 4	**Nuclear imaging**-introduction to SPECT, and PET, pair production, coincidence detection

6. **Text Books:**

I. The Essential Physics of Medical Imaging, Bushberg, Lippincott, Williams and Wilkins, Third Edition.

II. The Physics of Medical Imaging, Webb, CRC Press, 1988.

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Biomechanics

1. Name of the Course: Biomechanics

2. LTP structure of the course: 2-1-1

3. Objective of the course: This course will focus primarily on the various aspects of application of the principles of mechanics to the study of biological systems - covering the interaction of the human body with the physical world by combining principles from biology and physics - statics, dynamics, muscle activation, mechanical properties of muscle and movement analysis.

4. Outcome of the course: The students will learn the concepts of mechanics concerning to human movement, particularly those pertaining to exercise, sport, and physical activity. The student should gain an understanding of the mechanical and anatomical principles that govern human motion and develop the ability to link the structure of the human body with its function from a mechanical perspective. They will understand the domain of Biofluid mechanics and Cardiovascular mechanics, which will help them in understanding the governing laws of physics related to the mechanical behavior, as well as movement of fluid present in our body. Furthermore, in this course it is desired that each student be able to: 1) describe motion with precise, well-defined mechanical and anatomical

terminology; 2) understand and quantify linear and angular characteristics of motion; 3) understand the quantitative relationships between angular and linear motion characteristics of a rotating body; and 4) understand and quantify the cause and effect relationship between force and linear and angular motion.

5. Course Plan:

Component	Unit	Topics for Coverage
C1	Unit 1:	Introduction to biomechanics, Joint mechanics, Human joint forces, Mechanics of elbow joints, Mechanics of shoulder joints, Mechanics of hip joints, Mechanics of knee joints, Mechanics of ankle joints.
	Unit 2:	Tissue mechanics, Introduction, Mechanical properties, Biological materials, Bone as composite material, Adaptation of bone stress and strain, Properties of cortical bone., Properties of cancellous bone, Teeth and its properties, Viscoelasicity, Dynamic behavior, Viscoelastic model, Soft tissue mechanics, Soft tissue properties: contribution of collagen, Elastin and mucopolysaccarides, Mechanical testing of soft tissue.
C 2	Unit 3:	Human locomotion, Gait analysis, Events of gait, Variable measured during gait, Motion analysis, Energy considerations, Muscles function, Force data, Prediction of segment moment of inertia, Measurement devices, Kinematics, Foot pressure pedobarograph.
	Unit 4:	Introduction to Biofluid mechanics, Viscosity and viscometry, Cardiovascular mechanics, Layers of heart wall, Chambers of heart, Heart valves, Blood supply to myocardium, Conduction system, Heart sound, Heart rate cardiac cycle, Electrical activity of heart, Cardiac output, Disease of cardiovascular system, Artificial heart valve, Design of valve, Structural deterioration of biological valves.

6. Suggested Text & References:

I. Fung, Y. C.: Biomechanics: Mechanical Properties of Living Tissues. 2nd Ed., Springer

II. C. Ross Ethier and Craig A. Simmons: Introductory Biomechanics: From Cells to Organisms. Cambridge University Press.

III. J.D. Humphrey and S.L. Delange. An Introduction to Biomechanics: Solids and Fluids, Analysis and Design. Springer. 425

IV. B. Alberts, D. Bray, J. Levis, M. Raff, K. Roberts & J. D. Watson: Molecular Biology of the Cell; 5th Ed, Garland Science.

V. R. Kamm and M. K. Mofrad. Cytoskeletal Mechanics: Models and Measurements. Cambridge University Press.

VI. Supplementary Class notes.

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Chemical Processes in Biological System

1. Name of the Course: Chemical Processes in Biological System

2. LTP structure of the course: 2-1-1

3. Objective of the course: This course will focus primarily on the study of how fundamental biological processes work at the chemical level and how they are regulated. To help students develop an appropriate mastery of the field, the structure and function of biomolecules, molecular biology, and metabolism are presented. The emphasis is on clinical relevance, and the underlying assumption is that knowledge of biochemistry is essential for understanding the causes of manifestations of human illness, as well as the rationale of therapeutic strategies.

4. Outcome of the course: By the completion of the course, it is expected that students will learn the concepts of the metabolism of glucose and glycogen, fatty acids and ketonebodies, amino acids. They

will learn the process of Food assimilation and Chemistry, functions and mechanism of action of hormones.

5. Course Plan:

Component	Unit	Topics for Coverage
C 1	Unit 1	Carbohydrate metabolism**,** Pathways of glucose metabolism: glycolysis, HMP shunt, Gluconeogenesis, Glycogenolysis, glycogenesis, Glycogen storage disease, Regulation of glucose metabolism.
	Unit 2	Inborn errors of glucose metabolism,Blood glucose regulation, and its impairment in diabetes mellitus. Metabolic adaptation in the fed state, fasting and prolonged starvation.
C 2	Unit 3	Absorption of glucose, amino acids and lipids. Gastric, pancreatic and intestinal function tests, liver function tests.Malnutrition, Iron metabolism and heme synthesis.
	Unit 4	Physiological buffer systems & Environmental biochemistry, Regulation of blood pH, acidosis, alkalosis,Renal functions tests.

6. **Suggested Text & References:**

I. Biochemistry Ed. LubertStryer. W.H. Freeman and Company, New York.
II. Principles of Biochemistry. Ed. Lehinger, Nelson and Cox. CBS Publishers and distributors.
III. Harper"s Biochemistry, Ed. R.K. Murray, D.K. Granner, P.A. Mayes and V.W. Rodwell. Appleton
IV. and Lange, Stamford, Connecticut.
V. Textbook of Biochemistry with Clinical Correlations. Ed. Thomas M. Devlin, Wiley-Liss Publishers.
VI. Tietz Textbook of Clinical Chemistry. Ed. Burtis and Ashwood. W.B. Saunders Company.
VII. Biochemistry. Ed. Donald Voet and Judith G. Voet. John Wiley & Sons, Inc.

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Elective Course Syllabus

Bioelectrics

1. Name of the Course: Bioelectrics

2. LTP structure of the course: 3-1-0

3. Objective of the course: To introduce students to the effect of electrical energy and its interaction with biological tissue.

4. Outcome of the course: Familiarity with concepts such as electroporation, cell and membrane dynamics under electrical stress, impact of electroporation on ion movement, electrical shock and electrical exposure to tissue and its effect. Students should also become familiar with excitation models and the notion of strength-duration characteristics, tissue impedance in micro and macro scales.

5. Course Plan:

Component	Unit	Topics for Coverage
C 1	Unit 1	Introduction (General Idea/Electrical Exposure/Short-term exposure/ reactions (Sensory, Muscle, Cardiac, Thermal), Threshold and Variability, Bio-impedance and Current, Dielectric Properties (Cellular membrane/ Skin Impedance - LF and HF), High Voltage and Transient Properties, Full body impedance,

	Unit 2	3.Cardiac Action Potential (Dynamics and Recovery)
C 2	Unit 3	Electroporation (Introduction/ Electroporation density
	Unit 4	E-field /Electroporation and Membrane conductivity)

6. **Text Books:**

I. Applied Bioelectricity: J. Patrick Reilly, Springer Publications, ISBN 0-387-98407-0

II. Bio electricity: A Quantitative Approach [Hardcover] - Robert Plonsey, Roger C. Barr, Springer, 3rd edition (June 21, 2007)

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Medical Image Processing

1. Name of the Course: Medical Image Processing

2. LTP structure of the course: 2-1-1

3. Objective of the course: The goal of the course will be to introduce methods of image processing and the application of mathematical approaches for quantifying image parameters.

4. Outcome of the course: The students will become familiar with the mathematical concepts of image processing tools. They will learn how various image parameters can be quantified using signal processing schemes. The physics and instrumentation aspects of advance biological image recording techniques will be demonstrated. They will also become conversant with the computational tools for extracting image parameters.

5. Course Plan:

Component	Unit	Topics for Coverage
C 1	Unit 1	Basics of the Fourier series, transform, DFT, FFT, filter designing in frequency domain, image smoothing using frequency domain filters, image sharpening using frequency domain filters
	Unit 2	Introduction to wavelet analysis, multiresolution expansion, WT in 1D, WT in 2D, Types of wavelets-Haar wavelet, Daubechies wavelet, Biorthogonal wavelet. Coislet wavelet, Morlet wavelet, Mexican Hat wavelet, Symlet wavelet. Medical applications.
C2	Unit 3	Optical microscopy, scanning electron microscopy, transmission electron microscopy, atomic force microscopy
	Unit 4	Application of image processing tools on microscopic imaging

Text books:

I. Digital Image Processing, Gonzalez and Woods, Pearson, Third edition.

II. Fundamentals of light microscopy and electronic imaging, Murphy and Davidson, Wiley, Second edition.

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Nanobiotechnology

1. Name of the Course: Nanobiotechnology

2. LTP structure of the course: 2-1-1

3. Objective of the course: The aim of this course is to provide basic knowledge in the interface between chemistry, physics and biology on the nanostructural level with a focus on biotechnological usage.

4. Outcome of the course: This course will educate in the interdisciplinary areas of nanobiotechnology and bioengineering, including engineering principles and inherent technological

applications. It will help in earning the principles governing the effect of size on material properties at the nanoscale, and perform quantitative analysis. Students will learn about synthesis methods, properties and applications of engineered nanomaterials. Diagnostic and therapeutic use of nanoscale materials which are useful for biomedical applications.

5. Course Plan:

Component	Unit	Topics for Coverage
C1	Unit 1	Nanomaterial in biotechnology, Classification of nanoscale materials, 0D, 1D, 2D and 3D nanoscale materials. Unique properties of nanoscale materials, Physical and chemical fundamentals of nanomaterials. Top down and bottom up approaches.
	Unit 2:	Characterization of nanoscale materials. Nanoscale visualization techniques (TEM, SEM), Diffraction techniques (XRD)
C 2	Unit 3:	Miniaturized devices in Nanobiotechnology - types and applications, nanobiosensors, lab-on a chip concept. Diagnostic applications
	Unit 4:	How nanoscale materials interact with cell and biomolecules. DNA nanotechnology, Theranostics applications of nanoscale materials, Nanotoxicology.

Text Book:

I. *Nanobiotechnology II: More Concepts and Applications,* Chad A. Mirkin and Christof M. Niemeyer, 2007, Wiley
II. *Nanotechnology: Principles and Practices,* Kulkarni, Sulabha K. Springer, 2015
III.

Bio-MEMS and Microfluidics

1. Name of the Course: Bio-MEMS and Microfluidics

2. LTP structure of the course: 2-1-1

3. Objective of the course: During the last several decades, micro-system research mainly addressed electromechanical systems and in recent years, the focus has shifted to Bio-Microelectromechanical Systems (BioMEMS). This shift is driven primarily by the potential applications of the micro-systems to chemistry, biology and medicine. In fact, a combination of BioMEMS and microsystems has made possible the realization of physical systems at scales and dimensions similar to biological entities such as bacterial and mammalian cells, viruses, spores, etc., and this has resulted in the development of a variety of diagnostic and therapeutic applications, intelligent biochips and sensors.

BioMEMS today finds many applications within the chemical, health-care, biotechnological and manufacturing industries and this has necessitated a considerable shift in the focus of engineering education. This course illustrates a post graduate level introductory course in BioMEMS and micro-systems.

4. Outcome of the course: The students will learn the concepts of (1) micro-systems engineering emphasizing Biomedical micro-devices. This would also include some basic biological/ biochemical concepts and techniques which are necessary for understanding of diagnostics and therapeutics (2) fundamental of micro-fabrication/ microelectronic processing technologies (3) micro-system design issues and various characterization schemes / biomedical/ chemical testing practices and procedures.

5. Course Plan:

Component	Unit	Topics for Coverage
C 1	Unit 1:	Introduction; Miniaturisation and Scalling, Benefit of BioMEMs, Introduction with Some examples of Lab on a Chip (micro TAS) Technology: Concept of Capillary electrophoresis and PCR on chip, Miniatuare biosensors, biosensors arrays.
	Unit 2:	Introduction: photolithography; mask design; wet and dry etching; thin film deposition and growth, electroplating, molding, LIGA, bonding and sacrificial processes,
C 2	Unit 3:	Implantable devices, neural interfaces, microsurgical tools, microneedles, and drug delivery, miniature biroeactors, and Microsystems for tissue engineering, tissue scaffolds.
	Unit 4:	Microfluidic (single phase): Microfluidic laminar flow and gradient generators, Micromixers, Microvalves, Micropumps, Particle and cell sorting, Nanofluidics, Centrifugal microfluidics, Paper microfluidics, Introduction to Multiphase Microfluidics, On-chip Proteomics and sequencing.

6. **Suggested Text & References:**

I. Nguyen, N. T., Werley. S. T, Fundamentals and applications of microfluidics. Arctech house Inc.. 2002.
II. Madou M.J., Fundamentals of Microfabrication, CRC press 2002.
III. Tab-ling. P. Introduction to microfluidics. Oxford Unmmty Press Inc.. 2005.
IV. Microsystem Technology in Chemistry and Life, Sciences Spronger-Verlag, New York, 1999. ISBN: 3-540-65555-7.
V. Albert Folch, Introduction to BioMEMs.
VI. Supplementary Texts: Any standard microfabrication text book will prove valuable to the student

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Artificial Organs and Implants

1. Name of the Course: Artificial Organs and Implants
2. LTP structure of the course: 3-1-0
3. Objective of the course: This course will focus primarily on to acquainting the studentwith modern artificial organs devices and methods used to partially support or completely replace pathological organ
4. Outcome of the course: The students will learn about the principles, construction and control algorithms of artificial organs. Student will know state of the art in Artificial Organ domain and the main features of biomaterials and the biocompatibility phenomena. They will gather the basic knowledge of function and relationship between the structure and functionality of chosen artificial organ, as well as the transplantology connected with the immunological problems caused artificial organs application.
5. Course Plan:

Component	Unit	Topics for Coverage
C 1	Unit 1:	Introduction (definitions, requirements, strategies, type of replacements, historical review), Review of major physiological systems, Basic concepts in mechanics of materials, Structure of biological tissues, Human joints (shoulder, elbow, wrist, hip, knee, ankle), Total replacement of the knee and hip joints, Osseointegrated implants and bone replacements,

	Unit 2:	Upper and lower limb prostheses, Respiratory assist devices, Neural implants, Eye prosthetic devices, Urologic prosthetic devices, Cosmetic implants.
C 2	Unit 3:	Heart assist devices: principles, functionality, types of ventricular assist devices (VAD) and total artificial hearts (TAH), main wolrd known products and manufactures, Artificial Pancreas, Liver artificial support, Hybrid organs
	Unit 4:	Artificial Skin, Bio-membranes – artificial kidneys, Biocompatibility and biomaterials, Chosen aspects of tissue engineering, Regenerative medicine – is it a future of artificial organ? Ethical, economical, environmental and legal aspects in artificial organs domain.

6. **Text Book and References:**

I. Joseph D. Bronsino Tissue Engineering and Artificial Organs. The Biomedical Engineering Handbook, 2006
II. Gerald Miller Artificial Organs, 2006
III. Lary Hench, John Jones Biomaterials, Artificial Organs and Tissue Engineering, 2005
IV. Pety, W. Total Joint Replacement. Saunders, 1991.

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Engineering Processes in Biological Systems

1. Name of the Course: Engineering Processes in Biological Systems

2. LTP structure of the course: 2-1-1

3. Objective of the course: To familiarize student with biological processes from an engineering (mathematical) perspective.

4. Outcome of the course: Beginning with introduction with basic concepts such as lipid bi-layer and moving onto the nervous system, this course should hopefully provide insight about various sub-systems such as the nerve conduction process and its model, the muscle and muscle fiber activation and recruitment, locomotion and gait analysis, etc.

5. Course Plan:

Component	Unit	Topics for Coverage
C 1	Unit 1	Electrical Processes: Ionic pumps and their activation/deactivation; Cellular membrane & Lipid bi-layer; Ionic regulation; Central Nervous system – Cable model for Nerves (HH Model), Nerve conduction (mechanism and velocity);
	Unit 2	Cardiac sub-system – Cardiac contraction/expansion cycle, Cardiac potential vectors, ECG, Einthoven's Triangle, Natural Pacemaker. Mechanical Processes: Cellular biomechanics – Viscoelastic model of the cell, Actin filaments (mathematical model), Mechanoreceptors and Cellular response to mechanical stress
C 2	Unit 3	Muscles and Movement – Whole muscle mechanics (Parallel/Pinnate), Muscle & Bone Interaction, Gait Analysis; Ocular and Respiratory biomechanics.

	Unit 4	Transport Processes: Heat Transfer and thermal regulation – Conduction, Biological heat production, Non-biological heat; Mass transfer – Membrane diffusion, Convection, Enzymatic Reactions, Storage; Vascular sub-system – Blood flow, Vascular pressure, Bifurcation.

6. **Text Books:**

I. Introductory Biomechanics: From Cells to Organisms (Cambridge Texts in Biomedical Engineering) - C. Ross Ethier, Craig A. Simmons, Cambridge University Press; 1 edition (March 12, 2007).

II. Biological Process Engineering: An Analogical Approach to Fluid Flow, Heat Transfer, and Mass Transfer Applied to Biological Systems - Arthur T. Johnson, Wiley-Interscience; 1st edition(December 14, 1998).

III. Applied Bio-electricity: From Electrical Stimulation to Electropathology - J. Patrick Reilly, H. Antoni (Contributor), M.A. Chilbert (Contributor), J.D. Sweeney (Contributor), Springer; 1998 edition (August 21, 1998).

IV. Bio electricity: A Quantitative Approach [Hardcover] - Robert Plonsey, Roger C. Barr, Springer, 3rd edition (June 21, 2007)

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Soft Computing Tools for Biomedical Engineering

1. Name of the Course: Soft Computing Tools for Biomedical Engineering

2. LTP structure of the course: 2-1-1

3. Objective of the course: To familiarize students with learning machines and their application in Health Diagnostics and Instrumentation

4. Outcome of the course: The students are expected to become familiar with the idea of "features" from a biophysical signal context, and understanding how to select the most appropriate classification/clustering tool to employ when dealing with highly unstable and multi-variate data such as that from physiological measurements.

5. Course Plan:

Component	Unit	Topics for Coverage
C1	Unit 1	Classification vs Recognition, Features, Noise in biological signals, Classes of classifiers, Bayesian Theory, Linear vs Non-linear classifiers,
	Unit 2	Introduction to perceptron, Probabilistic processes in actual physiological space, Distributions and their application in modeling events, Parameter Estimation
C2	Unit 3	Multi-class problems, ANNs, Training, Memorization and other pitfalls
	Unit 4	SVM, Feature space and its reduction, Hidden Markov Models

Text Books:

I. Pattern Classification: Duda, Hart, Stork, Wiley

II. Biomedical Signal Analysis: Rangayyan - Wiley

Scheme for ADD ONs / Certifications

ADD-ON Specialization	
Basket 1 – Bioinformatics (Each 2 Credits)	**L-T-P**
1. Functional genomics	1-1-0
2. Genetic Engineering	1-1-0
3. Methods in Biotechnology	1-1-0
4. Stringology (String Processing)	1-1-0
5. Biological Data Mining	1-1-0
6. Bioinspired Computation	1-1-0
7. Machine Learning application in biomedical science	1-0-1
8. Molecular Dynamics Simulation	1-1-0
9. Cell culture Techniques	1-1-0
10. Molecular Immunotechology	1-1-0
Basket 2 - Biomedical Engineering (Each 2 Credits)	**L-T-P**
1. Electrical Equivalent Circuit Model of Biological Cell	1-1-0
2. Monte Carlo simulation methods for construction of tissue realizations	1-1-0
3. Computational methods in tomography	1-1-0
4. Numerical Techniques	1-1-0
5. Medical Instrumentation	1-1-0
6. Medical Image Processing	1-1-0
7. Biosensors	1-1-0
8. Nanomedicines	1-1-0
Basket 3 - Physical Sciences (Each 2 Credits)	**L-T-P**
1. Introduction to Major Topics in Digital Signal Processing	1-1-0
2. Introduction to Tensor analysis	1-1-0
3. Introduction to Non-linear Dynamics	1-1-0
4. Path Integral methods and Applications	1-1-0
5. Crystal Physics	1-1-0
6. Physics of Magnetism and Magnetic Materials	1-1-0
7. Spintronics and Magnetic Materials	1-1-0
8. Physics of Solar Cells	1-1-0
9. Modeling, Simulation and Information Technology for Space	1-1-0
10. Biomedical Engineering for Space	1-1-0
11. Workshop on Physics Principles -1	1-1-0
12. Workshop on Physics Principles -2	1-1-0
Basket 4 – Mathematical Studies (Each 2 Credits)	**L-T-P**
1. Basics of Group Theory	2-0-0
2. Field Theory	2-0-0
3. Ordinary Differential Equations	2-0-0
4. Complex Analysis	2-0-0
5. Introduction to Topology	2-0-0
6. Topological Graph Theory	2-0-0
7. Basics of Convex Analysis	2-0-0
8. Calculus of Several Variable	2-0-0
9. Introduction to Laplace Transforms	2-0-0

Minor courses for B. Tech. (IT) /B. Tech. (ECE)

Syllabus for Add on/Minors

Basket – 1: Bio-informatics

Functional Genomics

1. Name of the Course: Functional Genomics

2. **LTP structure of the course:** 1-1-0

3. **Objective of the course:** The goal is to provide the students with the fundamental knowledge of genome function and its regulation.

4. Outcome of the course: With the development of high throughput DNA sequencing technologies, the whole genome sequences of many organisms are deciphered. Despite the progress, it remains a challenge to understand the cellular functions of most of the identified genes. The emerging fields like 'Functional Genomics' aims to provide the comprehensive approaches to develop and promote high throughput approaches to investigate the functions of the genomes and their interactions. Hence, this course will provide an overview of the concept of Functional Genomics and modern approaches used to understand the genome function.

5. **Course Plan:**

Component	Unit	Topics or Coverage
C1	Unit 1	Central Dogma of Molecular Biology
	Unit 2	Transcription
C2	Unit 3	Post -transcriptional and Post-translational modifications
	Unit 4	Regulation of gene expression

6.Text Books: (i) Biochemistry by Jeremy M. Berg, John L. Tymoczko, and Lubert Stryer.

(ii)Molecular Biology of the Gene by James D. Watson, Tania A. Baker, Stephen P. Bell, (iii)Alexander Gann, Michael Levine, and Richard Losick.

Lehninger Principles of Biochemistry by Albert L. Lehninger, David L. Nelson and Michael M. Cox.

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Genetic Engineering

1. Name of the Course: Genetic engineering

2. LTP structure of the course: 1-1-0

3. Objective of the course: The aim is to provide the students with the essential knowledge about the structure & function of genome and different methods used for its manipulation for wide spread applications.

4 Outcome of the course: Genetic engineering is one of the sophisticated and complicated branches of science in 21st century. Different techniques have been developed to modify the genome of an organism which has wide applications in Medical industry, Agriculture sector, Pharmaceuticals and Biotechnology industry. This course will provide an overview of the structures and functions of the genetic materials and discuss the different methods used for their manipulation. The study will be extended further to understand the applications of Genetic engineering.

5. Course Plan:

Component	Unit	Topics or Coverage
C1	Unit 1	Structure & function of genetic materials, Cloning Vectors, Enzymes
	Unit 2	Restriction enzymes, Types of Restriction Enzymes, Cutting sites
C2	Unit 3	Techniques used in genetic engineering, Mutagenesis, Knock-in, Knock-out, conditional knock-outs, Regulation of gene expression,
	Unit 4	Recombinant DNA technology and its application

6.Text Books:

i. Biochemistry by Jeremy M. Berg, John L. Tymoczko, and Lubert Stryer.
ii. Lehninger Principles of Biochemistry by Albert L. Lehninger, David L. Nelson and Michael M. Cox.
iii. Molecular Biology of the Gene by James D. Watson, Tania A. Baker, Stephen P. Bell, Alexander Gann, Michael Levine, and Richard Losick.

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Methods in Biotechnology

1. Name of the Course: Methods in Biotechnology

2. **LTP structure of the course**: 1-1-0

3. **Objective of the course:** The goal of this particular course is to make acquainted the engineering students with the various techniques used in different areas of Biotechnology.

4 Outcome of the course: Biotechnology brings together different areas of science including biochemistry, microbiology, molecular biology, genetics and agriculture, in a combined effort to increase the production of commercially important pharmaceutical and agricultural products and/or to solve environmental problems. The course will provide an outline of different methods employed in various biotechnological processes.

5. **Course Plan:**

Component	Unit	Topics or Coverage
C1	Unit 1	Introduction to different areas of Biotechnology
	Unit 2	Various techniques used in Biochemistry, ,
C2	Unit 3	Microbiology
	Unit 4	Molecular biology and Immunology

6.Text Books:

i. Prescott, Harley, and Klein's Microbiology by Joanne M. Willey, Linda Sherwood, and Christopher J. Woolverton.
ii. Immunology by Thomas J. Kindt,,Goldsby .Richard A Barbara A. Osborne,.Kuby Janis
iii. Molecular Biology of the Gene by James D. Watson, Tania A. Baker, Stephen P. Bell, Alexander Gann, Michael Levine, and Richard Losick.
iv. Biochemistry by Jeremy M. Berg, John L. Tymoczko, and Lubert Stryer.
v. Kuby Immunology by Thomas J. Kindt,,Goldsby .Richard A Barbara A. Osborne, .Janis Kuby

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Stringology (String Processing)

1. **Name of the Course:** Stringology (String Processing)
2. **LTP structure of the course:**1-1-0
3. **Objective of the course:** World and internet is full of textual information. We search for information using textual queries, we read websites, books, e-mails. All those are strings from the point of view of computer science. To make sense of all that information and make search efficient, search engines use many string algorithms. Moreover, the emerging field of personalized medicine uses many search algorithms to find disease-causing mutations in the human genome.
4. **Outcome of the course:** Programmers with basic experience looking to understand the practical and conceptual underpinnings of algorithms, with the goal of the course is to get more profound understanding of algorithms and hands-on experience implementing them and applying for real-world problems.
5. **Course Plan:**

Component	Unit	Topics or Coverage
C1	Unit 1	Suffix Trees, Burrows-Wheeler Transform and Suffix Arrays
	Unit 2	Knuth–Morris–Pratt Algorithm
C2	Unit 3	Boyers Moore Algorithm
	Unit 4	Constructing Suffix Arrays and Suffix Trees

6.Text Books:

1. DNA Sequencing From Experimental Methods To Bioinformatics by Alphey, Luke
2. Next-Generation Sequencing Data Analysis by Xinkun Wang

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Biological Data Mining

1. Name of the Course: Biological Data Mining

2. LTP structure of the course: 1-1-0

3. Objective of the course: To make sense of all that information generated through high-throughput experiments and make the mining of pattern possible, one need to go through the available algorithms and tools for biological data mining.

4. Outcome of the course: The goal of the course is to get more profound understanding of algorithms and tools in data mining with hands-on experience in implementing them and applying for real-world biological data.

5. Course Plan:

Component	Unit	Topics or Coverage
C1	Unit 1	Introduction to various biological data & Data mining, Concepts and their Techniques, Data mining pre-processing and handling of high-throughput data.
	Unit 2	Different challenges and opportunities in biological data mining (Biological Sequences & Structures, Functional and molecular interaction networks and High-through Omics (HTO), Gene expression),

C2	Unit 3	Different tools used in biological data mining.
	Unit 4	Case study related to Chip Seq, RNA Seq, Methyl Seq. and SRA Data mining.

6.Text Books:

1. Xiaoli, L., See-kiong, N., & TL, W. J. (Eds.). (2013). *Biological data mining and its applications in healthcare* (Vol. 8). World Scientific.
2. Chen, J. Y., & Lonardi, S. (Eds.). (2009). *Biological data mining*. CRC Press.

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Bioinspired Computation

1. Name of the Course: Bioinspired Computation

2. LTP structure of the course: 1-1-0

3. Objective of the course: Biological organisms cope with the demands of their environments using solutions quite unlike the traditional human-engineered approaches to problem solving. Biological systems tend to be adaptive, reactive, and distributed. Bio-inspired computing is a field devoted to tackling complex problems using computational methods modeled after design principles encountered in nature. This course is strongly grounded on the foundations of complex systems and theoretical biology. It aims to provide an understanding of the distributed architectures of natural complex systems, and how those can be used to produce informatics tools with enhanced robustness, scalability, flexibility and which can interface more effectively with humans. It is a multi-disciplinary field strongly based on biology, complexity, computer science, informatics, cognitive science, robotics, and cybernetics.

4 Outcome of the course: Students will be introduced to fundamental topics in bio-inspired computing, and build up their proficiency in the application of various algorithms in real-world problems.

5. **Course Plan:**

Component	Unit	Topics or Coverage
C1	Unit 1	Life and its limitation, Life as (Self-) Organization, Artificial life, Bio-inspired design and problem solving.
	Unit 2	Bio-inspired algorithms, Complex systems and Complex Networks, Cellular Automatam, Boolean networks.
C2	Unit 3	Self organization and emergent complex behavior, Development and morphogenesis, Evolution and adaptation and Optimization, Genetics and evolutionary algorithms.
	Unit 4	Genetics Programming, Swarm Optimization, Neuro-computing and learning, Immuno-computing

6.Text Books:

1. Yang, X. S., & Karamanoglu, M. (2013). Swarm intelligence and bio-inspired computation: an overview. In *Swarm Intelligence and Bio-Inspired Computation* (pp. 3-23).
2. Neumann, F., & Witt, C. (2013, July). Bioinspired computation in combinatorial optimization: Algorithms and their computational complexity. In *Proceedings of the 15th annual conference companion on Genetic and evolutionary computation* (pp. 567-590). ACM.

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Machine Learning application in biomedical science

1. Name of the Course: Machine learning application in biomedical science

2. LTP structure of the course: 1-0-1

3. Objective of the course: To give exposure in need of application of customized form of machine learning approach to solve various types of biomedical problems. For example, automated diagnostics through medical signal and image processing, semantic study of biological strings (DNA, RNA and Protein chains) to help faster drug design, problems of classification of protein structure, etc.

4. Outcome of the course: Knowledge gained through this course will generate human resource with skill in dealing with classification and decision problems for complex real life area in general and biomedical are in particular.

5. Course Plan:

Component	Unit	Topics or Coverage
C1	Unit 1	Introduction to machine learning and its various popular applications in biomedical industry. Concept of classification and clustering as components of supervised and unsupervised learning. Concept of data and feature space, training, testing. Wide applied classifiers stemmed from Statistical Machine Learning.
	Unit 2	Extraction of features from various types of biomedical data, medical image and signals. Important components of a classifier, Probabilistic classifier, Bayesian classifier, Nearest Neighbor Classifier, Discriminant Function Analysis (Linear and non-linear) as precursor to Artificial Neural Network.Hidden Markov Models.
C2	Unit 3	Soft computing method based machine learning: Artificial Neural Network for clustering and classification, local optimization of ANN weights, Back propagation network, Hopfield network, Genetic algorithm for optimizing parameters of classifiers, Support Vector Machine foundation, constrained local optimization using Lagrange Multiplier, VC dimension, application and Cross validation.
	Unit 4	Applications to automated diagnostics using medical image and signals, discriminate Exon from Intron, to predict secondary structures of proteins, discover group of genes having similar up-regulation or down-regulation pattern from micro-array data.

6.Text Books: 1. Pattern recognition and image analysis by Earl Gose.

2. Pattern Classification by Duda, Richard and David Stork

3. Machine Learning by Mitchell and Tom

7. Reference book: Artificial Intelligence and Molecular Biology, Lawrence E. Hunter, MIT Press

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Molecular Dynamics Simulation

1. Name of the Course: Molecular Dynamics Simulation

2. LTP structure of the course: 1-1-0

3. Objective of the course: To make computational simulation of complex bimolecular structure to get an insight into the functional behavior of the system. It is also helpful to decipher the minute intricacy/behaviour of the said structural complex in certain constrained environment in time scaled simulation.

4. Outcome of the course: The goal of the course is to get more profound understanding of algorithms and tools in molecular dynamics with hands-on experience in implementing them and applying for real-world biological data.

5. Course Plan:

Component	Unit	Topics or Coverage
C1	Unit 1	Introduction to Molecular dynamics Simulation (MDS), Importance of MDS in bimolecular simulation, Force field, Types of force field.
	Unit 2	Classical mechanics, Classical mechanics in MDS, Energy minimization, Methods of energy minimization, Ensembles and fluctuations
	Unit 3	Different integration algorithms and their uses, Importance sampling and Equilibrium, Monte Carlo simulation, Ensembles and their types, Thermostats and their types,
C2	Unit 4	Use and limitation of MDS, Different of MDS and their uses, Advanced molecular dynamics methods, including constraints and non-equilibrium molecular dynamics

6.Text Books:

1. Haile, J. M. (1992). *Molecular dynamics simulation: elementary methods*. John Wiley & Sons, Inc..
2. Ciccotti, G., Ferrario, M., & Schuette, C. (2014). Molecular dynamics simulation. *Entropy*, *16*, 233.

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Cell Culture Techniques

1. Name of the Course: Cell Culture Techniques

2. LTP structure of the course: 1-1-0

3. Objective of the course: This course introduces students to basic principles and techniques of cell culture and explains factors of significance in the cultivation of cells in vitro. The course will be a short primer to understand how 'animal cell culture technologies' have strengthened the bio-medical research from basic research to the modern drug discovery.

4 Outcome of the course: On completion of this course students should be able to successfully complete tasks required for the routine culture of animal cells including freezing and thawing cells, seeding cells, counting cells, passaging anchorage dependent and suspension cells. and working aseptically in the Biological Safety Cabinet.

5. **Course Plan:**

Component	Unit	Topics or Coverage
C1	Unit 1	Introduction- History, development and importance, biology of cultured cell and cellular interactions, safety protocols.
	Unit 2	Culture vessels, Media development and sterilization, Primary and Secondary cultures, Cell Lines and Cell Strain,
C2	Unit 3	Morphology of cells in culture, Cultural conditions, Cell separation, differentiation and characterization
	Unit 4	Growth parameters, kinetics of cells in culture, *In Vitro* Transformation of Cells, Contamination, Cryopreservation, Cytotoxicity.

6.Text Books:

1. Culture of Animal Cells: A Manual of Basic Technique. *R.* Ian Freshney. 6th Edition. Wiley. (2010).
2. Animal Cell Culture and Technology (The Basics) (Garland Science)) by Michael Butler

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Molecular Immunotechnology

1. Name of the Course: Molecular Immunotechnology

2. LTP structure of the course: 1-1-0

3. Objective of the course: The objective of this course is to introduce students about the basic concept of immunology and various Immunotechniques.

4 Outcome of the course: On completion of this course student gets an understanding of theoretical concepts of Immunology and research methods employing immunological techniques for application in biomedical and clinical research

5. **Course Plan:**

Component	Unit	Topics or Coverage
C1	Unit 1	Introduction- Antigens, Immunogens, Haptens, Epitopes, antibodies, Antigen-Antibody interactions, Immunotechniques: agglutination, precipitation, complement fixation, immunofluorescence, immunoelectrophoresis,
	Unit 2	ELISA, immunoblot analysis, Immunohistochemistry, Immunoprecipitation, Immuno diffusion.
C2	Unit 3	Methods used in immunology, Raising antibodies: by immunization, hybridoma techniques, Characterizing antibodies, Purifying antibodies, Preparing antibody fragments, Conjugating antibodies
	Unit 4	Production of cellular cytokines, Development & useof vaccines, Antibody engineering, Catalytic antibodies.

6.Text Books:

1. J. Owen, J. Punt, S. Stranford, (2012) Kuby Immunology (8th Edition), WH Freeman and Company, USA
2. A. Moran and J .P. Gosling, Immunotechnology: Principles, Concepts and Applications, John Wiley & Sons, 2008.

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Basket – 2: Biomedical Engineering

Electrical Equivalent Circuit Model of Biological Cell

1. Name of the Course: Electrical Equivalent Circuit Model of Biological Cell

2. LTP structure of the course: 1-1-0

3. Objective of the course: The aim of the course is to study the electrical activity of biological cells.

4. Outcome of the course: The students will learn about the structure of biological cell membrane and its electrical activity. The complex membrane structures that help in the generation and propagation of electrical signal to the regions of interest. Also, students will learn about the biological cell is a 'living circuits' that might act as model systems for studying various biological behaviors including nerve impulses.

5. Course Plan:

Component	Unit	Topics or Coverage
C1	Unit 1	Membrane structure, Ion channels, Different type of ion channels.
	Unit2	Nernst equation, Resting potential, Depolarization.
C2	Unit 3	Action potential, End point potential.
	Unit 4	Refractory period, Hodgkin–Huxley model.

8. Text Books: Will be provided at the starting of the course

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Monte Carlo Simulation Methods for Construction of Tissue Realizations

1. Name of the Course: Monte Carlo simulation methods for construction of tissue realizations
2. LTP structure of the course: 1-1-0
3. Objective of the course: The aim of the course is to introduce the Monte Carlo simulation methods in general and its application in tissue simulation.
4. Outcome of the course: The students will know about the Monte Carlo methods and various algorithms associated with it.
5. Course Plan:

Component	Unit	Topics or Coverage
C1	Unit 1	Normal, Gaussian, exponential random numbers.
	Unit 2	Packing fraction, sequential adsorption technique, cooperative sequential adsorption technique.
C2	Unit 3	Metropolis algorithm.
	Unit 4	ensemble average.

8. Text Books: Will be provided at the starting of the course.

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Computational Methods in Tomography

1. Name of the Course: Computational methods in tomography
2. LTP structure of the course: 1-1-0
3. **Objective of the course:** The objective of the course is to introduce the concept of tomography in Medical Imaging.
4. Outcome of the course: The students will know the physics of tomography, different algorithms for solving ill-posed problems.
5. Course Plan:

Component	Unit	Topics or Coverage
C1	Unit 1	Concept of surface measurement, volume reconstruction.
	Unit 2	Gauss theorem, back projection algorithm, X-ray CT, Photoacoustic.
C2	Unit 3	Tikhonov regularization.

	Unit 4	L-curve method.

6. **Text Books:** Will be provided at the starting of the course.

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Numerical Techniques

1. Name of the Course: Numerical Techniques
2. LTP structure of the course: 1-1-0
3. Prerequisite: Knowledge of 10+2 Math, Physics, programming (Matlab).
4. Objective of the course: The goal of the course is to explain numerical methods for computing various mathematical operations.
4. Outcome of the course: The students will get a flavor how computer performs scientific computing.
5. Course Plan:

Component	Unit	Topics or Coverage
C1	Unit 1	Differentiation, integration
	Unit 2	ODE and PDE solutions
C2	Unit 3	Least-square, Eigen value problem
	Unit 4	Gauss-Jordan elimination method

5. **Text Books:** Will be provided at the starting of the course.

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Biomedical Instrumentation

1. Name of the Course: Biomedical Instrumentation
2. LTP structure of the course: 1-1-0
3. Objective of the course: To instruct about medical instruments currently in use in medical domain with a special focus on the building blocks of such instruments.
4. Outcome of the course: Familiarity with key Medical Devices such as ECG, EMG, EEG, Cardiac Output Computer, Blood Pressure Measurement, Plethysmograph, Ultrasound Machine, etc., their operation principle, static and dynamic characteristics.
5. Course Plan:

Component	Unit	Topics for Coverage
C1	Unit 1	Transducers for Biomedical Application: Resistive transducers – Muscle force and Stress (Strain gauge), Spirometers (Potentiometric), humidity, Respiration (Thermistor); Inductive Transducers – Flow measurements, muscle movement (LVDT)
	Unit 2	Capacitive Transducers – Heart sound measurement, Pulse pick up; Photoelectric Transducers - Pulse transducers, Blood pressure, oxygen Analyses; Piezoelectric Transducers – Pulse pickup, ultrasonic blood flowmeter; Chemical Transducer:
C2	Unit 3	ECG (Amplifiers and Circuits), EEG, Plethysmography, Cardiac Output
	Unit 4	Measurement, Ultrasonic Transducers and Ultrasonic Imaging, Beam

		Steering, Flowmeters, Full Body Plethysmograph, EMG

6. **Text Books:**

IV. D. Patranabis, Sensors and Transducers, Prentice Hall of India, 2nd Edition,1984

V. H. S. Kalsi , Electronics instrumentation, Tata Mc Grow Hill education Pvt. Ltd., 3rd edition 2010.

VI. Jon. B. Olansen and Eric Rosow, Virtual Bio-Instrumentation Biomedical, Clinical and Healthcare Applications using LabVIEW, Prentice Hall, first edition, 2002.

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Medical Image Processing

1. Name of the Course: Medical Image Processing

2. LTP structure of the course: 1-1-0

3. Objective of the course: The goal of the course will be to introduce methods of image processing and the application of mathematical approaches for quantifying image parameters.

4. Outcome of the course: The students will become familiar with the mathematical concepts of image processing tools. They will learn how various image parameters can be quantified using signal processing schemes. The physics and instrumentation aspects of advance biological image recording techniques will be demonstrated. They will also become conversant with the computational tools for extracting image parameters.

5. Course Plan:

Component	Unit	Topics for Coverage
C1	Unit 1	Basics of the Fourier series, transform, DFT, FFT, filter designing in frequency domain, image smoothing using frequency domain filters, image sharpening using frequency domain filters
	Unit 2	Introduction to wavelet analysis, multiresolution expansion, WT in 1D, WT in 2D, Types of wavelets-Haar wavelet, Daubechies wavelet, Biorthogonal wavelet. Coislet wavelet, Morlet wavelet, Mexican Hat wavelet, Symlet wavelet. Medical applications.
C2	Unit 3	Optical microscopy, scanning electron microscopy, transmission electron microscopy, atomic force microscopy
	Unit 4	Application of image processing tools on microscopic imaging

Text books:

III. Digital Image Processing, Gonzalez and Woods, Pearson, Third edition.

IV. Fundamentals of light microscopy and electronic imaging, Murphy and Davidson, Wiley, Second edition.

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Biosensors

1. Name of the Course: Biosensors

2. LTP structure of the course: 1-1-0

3. Objective of the course: To familiarize students with importance of biosensor technology, characteristics of biosensors and their application areas.

4 Outcome of the course: This course provides a broad perspective about description of biosensor and its general principles, immobilization of biological materials, their types and properties, the properties and characteristic of biosensors, performance factors in biosensors and different transduction mechanism.

5. Course Plan:

Component	Unit	Topics or Coverage
C1	Unit 1	Description of Biosensors, Classification, 1st, 2nd, 3rd generation of biosensors, Optical.
	Unit 2	Electrochemical, Potentiometric biosensor, Redox-enzymes in amperometric methods.
C2	Unit 3	DNA biosensors, Immunobiosensors.
	Unit 4	Sensitivity, selectivity and stability of biosensors.

6. Text Books:

- Doeblin. E. O, Measurment Systems, McGraw Hill Book Co. 1998
- Renganathan S, Transducer Engineering, Allied Publishers, Chennai,2000

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Nanomedicines

1. Name of the Course: Nanomedicine
2. LTP structure of the course: 1-1-0
3. Objective of the course: The aims of the course are to in an interdisciplinary way demonstrate synergies between medicine and nanotechnology in order to develop new healthcare techniques.
4 Outcome of the course: This course will help students to increase their understanding of different interdisciplinary areas including material science and biology. Students will learn about the use of nanotechnology in order to do the synthesis of advanced material, new bioimaging and therapeutic agents.
5. Course Plan:

Component	Unit	Topics or Coverage
C1	Unit 1	Introduction to Nanomedicine, Synthesis, characterization of nanoscale materials.
	Unit 2	Smart nanomaterials for drug delivery and imaging Applications,
C2	Unit 3	Biofunctionalization (e.g. passive and active targeting) of nanomaterials.
	Unit 4	lab-on-a-chip nanobiosensors.

6.Text Books: Nano Medicines Edited by Dr.Parag Diwan and Ashish Bharadwaj, Pentagon press(2006) ISBN 81-8274-139-4

Geoffery A. Ozin, Andre C. Arsenault, Nanochemistry: A chemical approach to nanomaterials, RSC publishing (2005).

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Basket – 3: Physical Sciences

Introduction to Major Topics in Digital Signal Processing

1. Name of the Course: Introduction to Major topics in digital signal processing
2. LTP structure of the course: 1-1-0

3. Objective of the course: The goal of the course is to introduce major topics in digital signal processing and motivate them to study this course later in detail.

4. Outcome of the course: The students will become familiar with the mathematics and begin to think physical meaning of notations, expressions associated with these topics.

5. Course Plan:

Component	Unit	Topics or Coverage
C1	Unit 1	Fourier transform, Laplace transform.
	Unit 2	Z transform
C2	Unit 3	IIR
	Unit 4	FIR filters

6.Text Books: List will be provided at the starting of the course.

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Introduction to Tensor Analysis

1. Name of the Course: Introduction to Tensor Analysis

2. LTP structure of the course: 1-1-0

3. Objective of the course: To expose the B. Tech. /M. Tech/ PhD students to tensor manipulations.

4. Outcome of the course: Students can apply to attack many problems in mathematical and computational physics. This course will also be helpful to learn many things related to applied mathematics and computer science from a different perspective.

5. Course Plan:

Component	Unit	Topics for Coverage	Prerequisite
C1	Unit 1	Cartesian tensors, the metric, vectors, the tangent space, dual vectors, tensors, tensor products, the Levi-Civita tensor, differential forms, Maps, continuity, the chain rule, open sets, charts and atlases, manifolds examples of charts	Exposure to calculus and linear algebra
	Unit 2	Differentiation, vectors as derivatives, coordinate bases, the tensor transformation law, canonical form of the metric, Riemann normal coordinates,	
C2	Unit 3	Tensor densities, volume forms and integration Covariant derivatives and connections, connection coefficients, transformation properties.	
	Unit 4	The Christoffel connection, structures on manifolds, parallel transport,the parallel propagator, geodesics.	

6. **Text Book:** N. J. Hicks, Notes on Differential Geometry.

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Introduction to Non-Linear Dynamics

1. Name of the Course: Introduction to Non-linear Dynamics

2. LTP structure of the course: 1-1-0

3. Objective of the course: To expose the B. Tech./M. Tech/ PhD students to the techniques of non-linear dynamics.

4. Outcome of the course: Students will be able to work on many dynamical problems that are applicable to physical, chemical, technological systems which involve non-linearity.

5. Course Plan:

Component	Unit	Topics for Coverage	Prerequisite
C1	Unit 1	Vector fields and flows, One-Dimensional Flows, Flows on a line, Bifurcations.	Exposure to classical mechanics.
	Unit 2	Flows on the circle, two dimensional flows,	
C2	Unit 3	Linear systems, phase plane.	
	Unit 4	limit cycles.	

6. Text Book: Nonlinear Dynamics and Chaos: With Applications to Physics, Biology, Chemistry and Engineering by S. Strogatz.

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Path Integral Methods and Applications

1. Name of the Course: Path Integral Methods and Applications

2. LTP structure of the course: 1-1-0

3. Objective of the course: To expose the B. Tech./M. Tech/ PhD students to the techniques of path integrals. To show numerous applications of this technique in quantum physics, stochastic systems, statistical physics etc.

4. Outcome of the course: students can apply this technique to a number of systems: such as stochastic systems, random-walk problems, physical systems etc.

5. Course Plan:

Components	Units	Topics for Coverage	Prerequisites
C1	Unit 1	Path integrals in classical theory.	Exposure to calculus and probability theory.
	Unit 2	Wiener path integrals and stochastic processes.	
C2	Unit 3	Path integrals in quantum mechanics, Hamiltonian Path Integral, Applications in scattering theory.	
	Unit 4	Path integral in statistical physics and applications.	

6. **Text Book:** 1. Techniques and applications of path integration, L. T. Schulman.

2. Quantum mechanics and path integrals, R. Feynman and A. R. Hibbs.

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Crystal Physics

1. Name of the Course: Crystal Physics

2. LTP structure of the course: 1-1-0

3. Objective of the course: To expose the B. Tech./M. Tech/ PhD students to crystal structures of materials.

4. Outcome of the course: Students will be able to understand crystal structure and fundamental properties of materials

5. Course Plan:

Component	Unit	Topics for Coverage
C1	Unit 1	Introduction, Lattice point and Space lattice, Unit Cells and Lattice parameter.

	Unit 2	Unit Cells vs Primitive Cell, Crystal system, Crystal symmetry, Combination of Symmetry elements, Space Group, The Bravais Lattice, Metallic crystal structure
C2	Unit 3	Relation between the density of crystal materials, Directions, Places and Miller Indices.
	Unit 4	Imperfections in Crystals, Reciprocal Lattice, X-ray diffraction, Bragg's law, Powder crystal method

6. **Text Book:**
   1. Solid state Physics by S O Pillai
   2. Introduction to solid state physics by Charles Kittel

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Physics of Magnetism and Magnetic Materials

1. Name of the Course: Physics of Magnetism and Magnetic Materials
2. LTP structure of the course: 1-1-0
3. Objective of the course: To expose the B. Tech./M. Tech/ PhD students to magnetic materials and its applications in future technology.
4. Outcome of the course: Students will be able to understand use of magnetic materials/spintronics in device application. They will also able to calculate magnetic moment trough theoretical calculation by programming.
5. Course Plan:

Component	Unit	Topics for Coverage
C1	Unit 1	Introduction, The Origin of Atomic Moments, Paramagnetism of Free Ions, The Magnetically Ordered State, Crystal Fields.
	Unit 2	Diamagnetism, Itinerant-Electron Magnetism, Exchange interactions
C2	Unit 3	Measurement Techniques, Caloric Effects in Magnetic Materials.
	Unit 4	Permanent Magnets, High-Density Recording Materials, Soft-Magnetic Materials

6. **Text Book:**
   1. Physics of Magnetism and Magnetic Materials by K. H. J. Buschow and F. R. de Boer
   2. Introduction to solid state physics by Charles Kittel

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Spintronic and Magnetic Materials

1. Name of the Course: Spintronic and Magnetic Materials
2. LTP structure of the course: 1-1-0
3. Objective of the course: To expose the B. Tech./M. Tech/ PhD students to spintronic materials and its applications in future technology.
4. **Outcome of the course:** Students will be able to understand use of magnetic materials/spintronics in device application. They will also able to calculate magnetic moment trough theoretical calculation by programming
5. Course Plan:

Component	Unit	Topics for Coverage
C1	Unit 1	Relaxation mechanisms, Spin relaxation mechanisms, The spin Galvanic effect, Basic electron transport, Spin-dependent transport, Spin dependent tunneling, Basic theory of Andreev reflections, PointContactAndreevReflection,Ferromagnet/Superconductors/Ferromagnet double junctions, crossed Andreev reflections.

	Unit 2	Intuitive picture of spin-transfer torques, spin-transfer drive magnetic dynamics, Current-driven switching of magnetization and domain wall motion, Domain wall scattering and Current-Induced switching in ferromagnetic wires.
C2	Unit 3	Spin injection, spin accumulation, and spin current, Spin hall effect, Silicon based spin electronic devices, Spin LEDs: Fundamental and applications, Spin photoelectronic devices based on Heusler alloy, Electron spin filtering, Monolithic and Hybrid Spintronics, Materials for spin electronics.
	Unit 4	Nanostructures for spin electronics, Deposition techniques, micro and nanofabrication techniques. Spin-Valve and spin-tunneling devices: Read Heads, MRAMS, Field Sensors, Spintronic Biosensors, Quantum Computing with spins.

6. **Text Book:**

1. Physics of Magnetism and Magnetic Materials by K. H. Buschow and F R de Boer
2. Introduction to magnetic materials by B. D. Cullity and C D Graham
3. S. Bandyopadhyay, M. Cahay, Introduction to Spintronics, CRC Press, 2008.
4. M. Johnson, Magnetoelectronics, Academic Press 2004.
5. D. J. Sellmyer, R. Skomski, Advanced Magnetic Nanostructures, Springer, 2006.
6. S. Maekawa, Concepts in Spin Electronics, Oxford University Press, 2006.
7. D.D. Awschalom, R.A. Buhrman, J.M. Daughton, S.V. Molnar, and M.L. Roukes, Spin Electronics, Kluwer Academic Publishers, 2004.
8. Y.B. Xu and S.M.Thompson, Spintronic Materials and Technology, Taylor & Francis, 2006
9. The magnetocaloric effect and its applications by A M Tishin and Y I Spichkin

Note: For this course basic knowledge of magnetism required.

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Physics of Solar Cells

1. Name of the Course: Physics of Solar Cells

2. LTP structure of the course: 1-1-0

3. Objective of the course: To expose the B. Tech./M. Tech/ PhD students to physics of solar cell, materials (green technology).

4. Outcome of the course: Students will be able to understand use of green energy and application of semiconducting materials.

5. Course Plan:

Component	Unit	Topics for Coverage
C1	Unit 1	Problems of the Energy Economy, Photons, Semiconductors,
	Unit 2	Conversion of Thermal Radiation into Chemical Energy, Conversion of Chemical Energy into Electrical Energy
C2	Unit 3	Basic Structure of Solar Cells, Limitations on Energy Conversion in Solar Cells
	Unit 4	Concepts for Improving the Efficiency of Solar Cells, Prospects for the Future

6. **Text Book:**

1. Physics of Solar Cells: From Basic Principles to Advanced Concepts, 2nd Edition by Peter Würfel (ISBN: 978-3-527-40857-3)
2. Solar Energy: The physics and engineering of photovoltaic conversion, technologies and systems by by Arno Smets, Klaus Jager, Olindo Isabella , Rene van Swaaij

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Modeling, Simulation and Information Technology for Space

1. Name of the Course: Modeling, Simulation and Information Technology for Space
2. LTP structure of the course: 1-1-0
3. Objective of the course: To expose the B. Tech. (IT) /M. Tech (IT)/ PhD students to this new technology area which includes computing, modeling, simulation and information processing for future Space Engineering technologies.
4. Outcome of the course: The students may know about the modeling and simulation for space, where the zero gravity effects may be included in the models.
5. Course Plan:

Component	Unit	Topics for Coverage
C1	Unit 1	Introduction to the Fundamentals of system Modeling and Simulation.
C2	Unit 2	Space engineering breakthroughs, scientific discoveries, robotics for space, remotely sensed observations.
	Unit 3	Data transport and data knowledge transformation.
	Unit 4	Flight computing and ground computing, Science modeling and simulation, distributed simulation.

6**. Text Book:**

1. System modeling and Simulation by Gordon Geoffrey,
2. System Simulation and Digital Computer by Narsingh Deo, PHI, 2013
3. 2010 & 2012 NASA Space technology Road map in Information Technology 13354

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Biomedical Engineering for Space

1. Name of the Course: Biomedical Engineering for Space
2. LTP structure of the course: 1-1-0
3. Objective of the course: To expose the B. Tech. /M. Tech / PhD students to this new technology area of Space, this includes the effects of low gravity on human body and its consequences on biomedical Engineering technologies.
4. Outcome of the course: The students may know about the effect of the space travel or walk on the biological systems, and also, where the zero gravity effects may be included in the models.
5. Course Plan:

Component	Unit	Topics for Coverage
C1	Unit 1	Introduction to Humans in Space, Fundamentals of effects in micro-gravity, Exploration in Extreme Environments, Bone changes in space.
	Unit 2	Muscle mechanisms, Motor Control Optimization, Musculoskeletal Dynamics and Control.

C2	Unit 3	Cardiovascular System, Cardiovascular Control, Cardiovascular Simulation, Countermeasures and Artificial Gravity, Countermeasures and Artificial Gravity, Extravehicular Activity (EVA),
	Unit 4	EVA II: Research, Teaching and Outreach I & II

6. **Reference books & Articles:**

1. Human Anatomy Manual: The Skeleton." Gatesville, TX: Medical Plastics Laboratory, Inc., 1997
2. Beckers, Frank, Bart Verheyden, Andre E. Aubert. "Space Physiology." *Wiley Encyclopedia of Biomedical Engineering*. Hoboken, NJ: John Wiley and Sons, Inc., 2006. ISBN: 9780471740377
3. Schaffner, Grant. "Bone Changes in Weightlessness."
4. Brubakk, A. "Man in Extreme Environments." *Aviat. Space Env. Med.* (September 2000): A126-A130
5. Aubert, A.E., F. Beckers, and B. Verheyden. "Cardiovascular Function and Basics of Physiology in Microgravity." *Acta Cardiol* 60, no. 2 (2005): 129-151.
6. Diamandis, Peter H. "Countermeasures and Artificial Gravity." Chapter 12 in *Fundamentals of Space Life Sciences*. Edited by Susanne Churchill. Malabar, FL: Krieger Publishing Co., 1997. ISBN: 9780894640513 .
7. Newman, Dava, and Michael Barratt. "Life Support and Performance Issues for Extravehicular Activity (EVA)." Chapter 22 in *Fundamentals of Life Sciences*. Edited by Susanne Churchill. Malabar, FL: Krieger Publishing Co., 1997. ISBN: 9780894640513 .

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Workshop on Physics Principles -1

1. Name of the Course: Workshop on Physics principles-1
2. LTP structure of the course: 0-0-2
3. Objective of the course: All the students will get hand on experience on Physics Law's. .
4 Outcome of the course: All the students will get better understanding about physics
5. Course Plan:

Component	Unit	Topics or Coverage
C1	Unit 1	Total Internal reflection of Light, Bending of Light, Centre of mass.
	Unit 2	Magnetic field lines, Surface Tension, Energy salt water, Conductivity, Induction cooker
C2	Unit 3	Air track [Inverse square law's, Shape of potential], Bernoulli's Principle, Distance measurement using ultrasonic waves.
	Unit 4	Conservation of energy, Standing wave, Magnetic effect of current

6. Text Books: Manuals will be provided at the workshop.
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Workshop on Physics principles-2

1. Name of the Course: Workshop on Physics principles-2
2. LTP structure of the course: 0-0-2
3. Objective of the course: All students will interface physics experiments with computer
4 Outcome of the course: All the students will get better understanding about physics after interfacing the experiment with computer.
5. Course Plan:

Component	Unit	Topics or Coverage
C1	Unit 1	RC,RL, LCR circuits, Dielectric constant, rectifier, clipper, clapper.
	Unit 2	Oscillator, amplifier, diodes, CRO etc.
C2	Unit 3	X-ray diffraction, Thin film Deposition [Thermal evaporator, DC/RF sputtering].
	Unit 4	Hall effect, Spin coater, thermoelectric experiment, etc.

6. Text Books: Manuals will be provided at the workshop.
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Basics of Group Theory

1. Name of the Course: Basics of Group Theory
2. LTP structure of the course: 2-0-0
3. Objective of the course: To have the knowledge of groups and their properties.
4. Outcome of the course: Upon successful of this course, one will be able to understand the structure of finite abelian group, analyze examples of subgroups, normal subgroups and quotient groups, and use of the concepts of homomorphism and isomorphism.
5. Course Plan:

Component	Unit	Topics for Coverage
C1	Unit 1	Group, subgroup, Lagrange's theorem, homomorphism, normal subgroup, quotient group, cyclic group.
	Unit 2	Cayley's theorem, group action, Sylow's theorem, direct product, structure theorem of finite abelian group.
C2	Unit 3	Simple group, solvable group, nilpotent group, composition series, Jordan Holder theorem.
	Unit 4	Semi-direct product, free group, frees abelian group.

6. Text Book: D. S. Dummit and R. M. Foote, Abstract Algebra, John Wiley \& Sons, Inc., 2004.
7. References Books:
1) I. N. Herstein, Topics in Algebra, John Wiley & Sons,Pte. Ltd., 2006..
2) Ramji Lal, Algebra 1 (Groups, Rings, Fields and Arithmetic), Springer International Publishing AG., 2017
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Field Theory

1. Name of the Course: Field Theory
2. LTP structure of the course: 2-0-0
3. Objective of the course: To have the knowledge of field, field extension, Galois group and solvability of polynomial equations.
4. Outcome of the course: Upon successful of this course, one will be able to understand the construction of finite field and use of the concept of Galois group of polynomial for solvability of polynomial equations.

5. Course Plan:

Component	Unit	Topics for Coverage
C1	Unit 1	Field, field extension, algebraic extension, irreducible polynomial of an algebraic element, splitting field and their uniqueness.
	Unit 2	finite field extension and sub fields of finite field, construction and representation of finite field.
C2	Unit 3	Group of automorphisms of fields, Galois extension, the fundamental theorem of Galois Theory.
	Unit 4	The Galois group of a polynomial, solvability of polynomial equations.

6. Text Book: D. S. Dummit and R. M. Foote, Abstract Algebra, John Wiley & Sons, Inc., 2004.

7. References Books:

1) Josheph Rotman, Galois Theory, Springer - Verlag New York, Inc., 2010.
2) Rudolf Lidl and Harald Niederreiter, Introduction to finite fields and their applications, Cambridge University Press 1986.

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Ordinary Differential Equations

1. Name of the Course: Ordinary Differential Equations

2. LTP structure of the course: 2-0-0

3. Objective of the course: The course objective is to achieve an elementary knowledge of ordinary differential equations.

4. Outcome of the course: At the end of the course students will have acquired basic knowledge of differential equations and methods of solving them.

5. Course Plan:

Component	Unit	Topics for Coverage
C1	Unit 1	First order linear differential equations, Exact differential equations and integrating factors.
	Unit 2	Second order linear differential equations (homogeneous and non-homogeneous. Equation with constant coefficients,
C2	Unit 3	Examples of non-uniqueness, non-existence, importance of existence uniqueness theory, Picard's iteration.
	Unit 4	Methods of solving linear equations of arbitrary order, Applications.

6. Text Book: G. F. Simmons, Differential Equations with Applications and Historical Notes, Second edition, Tata Book House, 1991.

7. References Books: E.A. Coddington and N. Levinson, Theory of ordinary Differential Equations, Tata-McGraw Hill, 1972

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Complex Analysis

1. Name of the Course: Complex Analysis

2. LTP structure of the course: 2-0-0

3. Objective of the course: The course introduces the concepts of complex functions and the related notions, such as: analytic function, complex integration, calculus of residues etc.

4. Outcome of the course: The students will be able to: evaluate limit and checking continuity and differentiability of complex functions, evaluate the integration in complex plane, understand residues and their application in integration.

5. Course Plan:

Component	Unit	Topics for Coverage
C1	Unit 1	Complex numbers, Modulus, Argument, Curves and regions in complex plane.

	Unit 2	Functions, Limits, Derivatives, Analytic functions, Cauchy-Riemann equations.
C2	Unit 3	Complex exponential, logarithms and trigonometric function.
	Unit 4	Cauchy's theorem, Cauchy integral formula, Taylor and Laurent series.

6. Text Book: J. Brown and R. Churchill, Complex Variables and Application, McGraw-Hill.
7. References:
1) Dennis G. Zill and Patrick D. Shanahan, A First Course in Complex Analysis with Applications, Jones & Bartlett.
2) S Ponnusamy, Foundation of Complex Analysis, Narosa.

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Introduction to Topology

1. Name of the Course: Introduction to Topology
2. LTP structure of the course: 2-0-0
3. Objective of the Course: To understand the notion of topological spaces and related terms such as open set, close set, neighborhood and convergence in more generalized sense.
4. Outcome of the course: To be able to work within topological spaces, generating new topological spaces from existing ones, finding topological properties.
5. Course Plan:

Component	Unit	Topics for Coverage
C1	Unit 1	Topological spaces, Open set, Close set, Neighborhood, Closure and interior of a set, Boundary of a set.
	Unit 2	Basis for a topology, Construction of topological spaces: Subspace topology
C2	Unit 3	Continuous functions and homeomorphism, open and close map.
	Unit 4	Product topology, Quotient topology, Connectedness, path-connectedness.

6. Text Book: J. R. Munkres, Topology, Prentice-Hall.
7. References Books:
1) Colin Adams, Robert Franzosa, Introduction to Topology pure and Applied, Pearson.
2) M.A. Armstrong, Basic Topology, Springer.

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Topological Graph Theory

1. Name of the Course: Topological Graph Theory
2. LTP structure of the course: 2-0-0
3. Objective of the Course: To study topological spaces using graph theory. Understanding graphs, maps, functions between two graphs (or maps), graph (map) isomorphism, graph embeddings and generalization of maps on the Platonic solids and Archimedean solids to the surfaces other than the sphere.
4. Outcome of the Course: To able to work within maps on surfaces, classifying close surfaces, identifying orientable and non orientable surfaces. Computing Euler characteristic of a map, genus of graph and number of non-isomorphic embeddings of a graph into particular surface.
5. Course Plan:

Component	Unit	Topics for Coverage
C1	Unit 1	Graphs, Sub graphs, Connected graphs, Cycle, Graph isomorphism.
	Unit 2	Euler graph, Hamiltonian paths and circuits, Tree, Spanning tree.
C2	Unit 3	Topological spaces, Surfaces: Classification of surfaces, Orientable and non-orientable surfaces, Normal forms of close surfaces.
	Unit 4	Map, Map isomorphism, Triangulation of a surface, Map operations, Euler characteristic of map, Genus of a graph, Polyhedron: Regular and semi-regular polyhedron.

6. Text Book: J. L. Gross, T. W. Tucker, Topological Graph Theory, Dover Publications Inc..
7. Reference Book: B. Mohar and C. Thomassen, Graphs on Surfaces, Johns Hopkins University Press.
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Basics of Convex Analysis

1. Name of the Course: Basics of Convex Analysis
2. LTP structure of the course: 2-0-0
3. Objective of the Course: to understand the theory of convex sets and convex functions.
4. Outcome of the Course: To recognize and characterize convex functions and sets, characterize the subdifferential of a convex function.
5. Course Plan:

Component	Unit	Topics for Coverage
C1	Unit 1	Convex Sets: Affine and convex sets, Operations that preserve convexity
	Unit 2	Generalized inequalities, Separating and supporting hyperplanes, Dual cones
C2	Unit 3	Convex Functions: Basic properties and examples, Operations that preserve convexity
	Unit 4	The conjugate function, Quasiconvex functions, Log-concave and log-convex functions.

6. Text Book: S. Boyd and L.Vandenberghe, Convex Optimization. Cambridge University Press, 2004.
7. References Books:
1) R. T. Rockafellar. Convex Analysis. Princeton University Press, 1996.
2) G. C. Calafiore and L. El Ghaoui, Optimization Models, Cambridge University Press, 2014.

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Calculus of Several Variables

1. Name of the Course: Calculus of Several Variables
2. LTP structure of the course: 2-0-0
3. Objective of the Course: Develop a solid understanding of the concept of limit, continuity and differentiability of functions of multivariable, understand partial derivatives, directional derivatives of several variable function, Statement of Implicit Function Theorem and Inverse Function Theorem.
4. Outcome of the Course: To compute limits and derivatives of functions of two and three variables, apply Implicit Function Theorem and Inverse Function Theorem in various problems.
5. Course Plan:

Component	Unit	Topics for Coverage
C1	Unit 1	Functions of several variables and examples; continuity, concept of distances in higher dimension, Directional derivatives
	Unit 2	Definition of differentiable functions of several variable, matrix of a linear transformation; Jacobian matrix
C2	Unit 3	Chain rule, MVT, higher derivatives and Taylor's formula, Sufficient condition for equality of mixed derivatives

	Unit 4	Extremas for real valued function and special case for functions with two variables.

6. Text Book: Principles of Mathematical Analysis, Walter Rudin.

7. References Books:

1) T. Apostol, Mathematical Analysis.

2) Spivak, Michael, Calculus on Manifolds; a Modern Approach to Classical Theorems of Advanced Calculus, New York, W.A. Benjamin, 1965. Print.

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Introduction to Laplace Transform

1. Name of the Course: Laplace Transform

2. LTP structure of the course: 2-0-0

3. Objective of the Course: To study Laplace transform, inverse Laplace transform, Basic Properties of the Laplace Transform, Differentiation and Integration of the Laplace Transform.

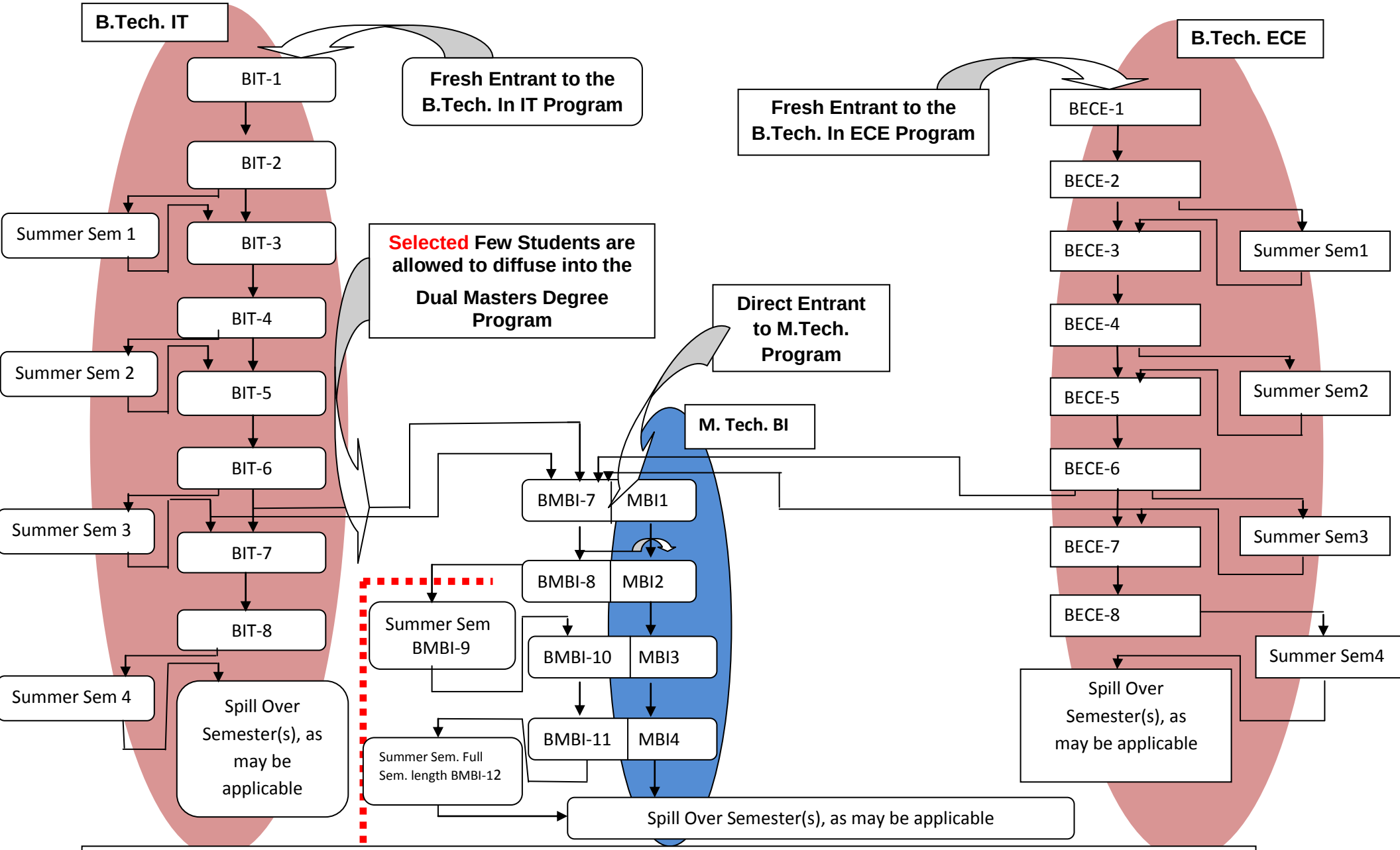
4. Outcome of the Course: To be able to find the Laplace and the inverse Laplace transform of various functions, to solve ordinary differential and integro-differential equations by the Laplace transform method.

5. Course Plan:

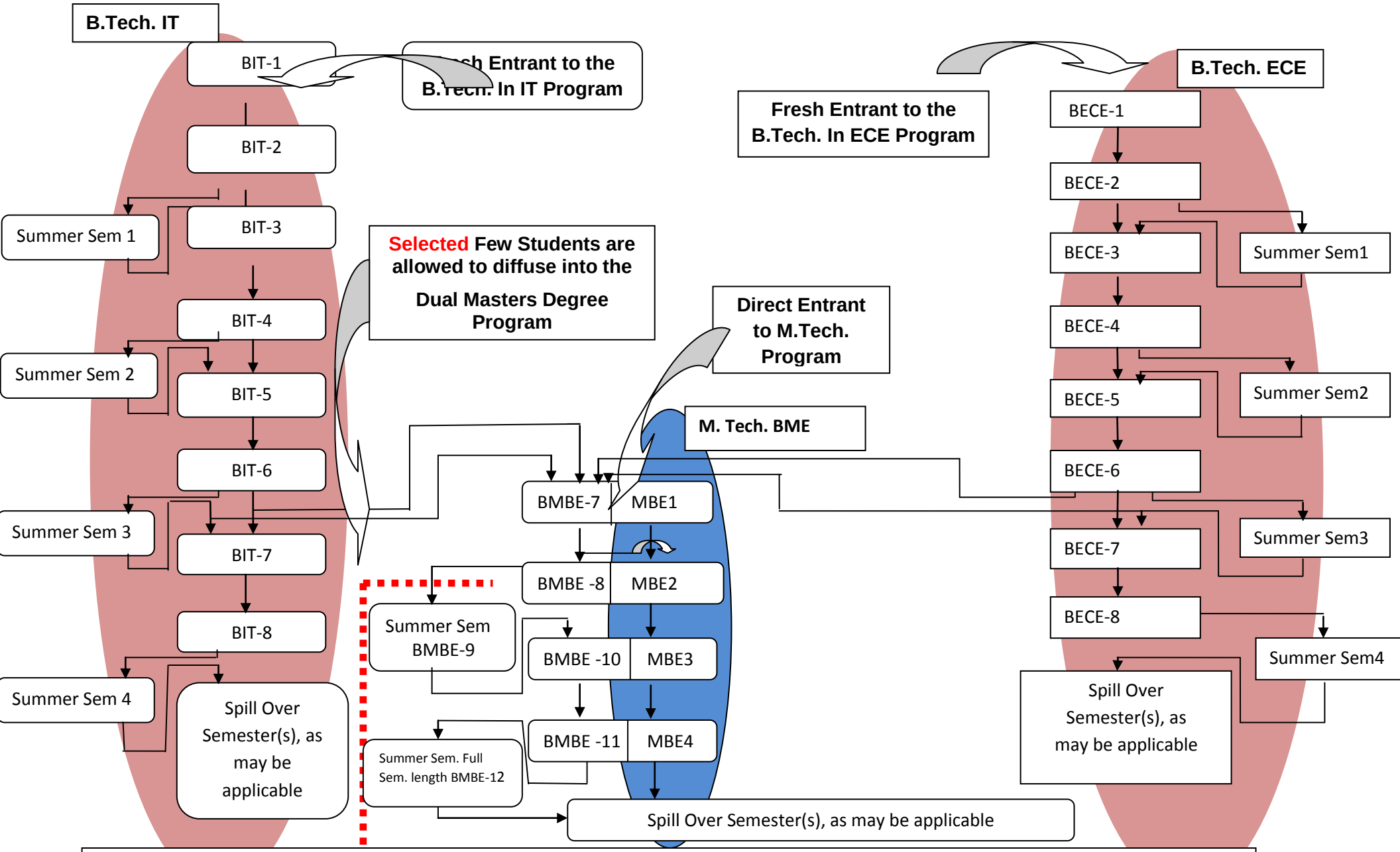
Component	Unit	Topics for Coverage
C1	Unit 1	Definition and properties of Laplace transform, Sufficient condition of Existence of Laplace transform, Inverse Laplace Transforms
	Unit 2	Exponential shifts, Derivatives and integrals of transforms
C2	Unit 3	Transforms of derivatives and integrals, Convolutions
	Unit 4	Applications: Differential and Integral Equations.

6. Text Book: J. Schiff, The Laplace Transform: Theory and Applications, Springer.

7. Reference Book: N. W. McLachlan, Laplace Transforms and Their Applications to Differential Equations, Dover Publications.



Prior to this stage the Student continues to be considered as a UG student. S/he pays the Fees as applicable to UG student. w.e.f. BMBI – 9. S/He shall be considered as a PG student and shall also be liable for M.Tech. Stipend iff, s/he possesses a valid GATE Score, For BMBI - 9 & 12 (Summer Semesters), ADDITIONAL fees, commensurating the courses enrolled in/ Credit Hrs. enrolled in, shall be payable. BMBI-12 is Summer Semesters of FULL 16 Wks duration and therefore liable to pay for as per the FULL Semester Fees. Dual Degree students will thus complete their requirements by September & awarded Degree in the Next Years Convocation.



Prior to this stage the Student continues to be considered as a UG student. S/he pays the Fees as applicable to UG student. w.e.f. BMBE – 9. S/He shall be considered as a PG student and shall also be liable for M.Tech. Stipend iff, s/he possesses a valid GATE Score, For BMBE - 9 & 12 (Summer Semesters), ADDITIONAL fees, commensurating the courses enrolled in/ Credit Hrs. enrolled in, shall be payable. BMBE-12 is Summer Semesters of FULL 16 Wks duration and therefore liable to pay for as per the FULL Semester Fees. Dual Degree students will thus complete their requirements by September & awarded Degree in the Next Years Convocation.

Selected Few who are allowed to diffuse from B.Tech. to B.Tech. - M.Tech. Dual Degree Program shall be based on the following Criterion:

1) The Student MUST have completed at least 16 Credits per Semester consistently, with an SGPI of 7.00 in each Semester.
2) Till the end of the Fifth Semester of the enrolled B.Tech. Degree Program, s/he MUST have earned at least 90 Credits..

The student shall further have scored a CGPI of 7.50 till the end of the Fifth Semester of the enrolled B.Tech. Degree Program.

Sl. No.	Course	Credits	Min. Sem Nos.	Min. Course Length in Yrs.
1	B.Tech.	160	8	4
2	M.Tech.	64	4	2
3	B.Tech. - M.Tech. Dual Degree	160 + 64 = 224	10 Regular + 3 Summer	5+