Integral University, Lucknow

Effective from Session: 2020-2021							
Course Code	BE-520	**Title of the Course**	BIOINFORMATICS AND BIOLOGICAL DATABASES	**L**	**T**	**P**	**C**
Year	**I**	**Semester**	I	3	1	0	4
Pre-Requisite	None	**Co-requisite**	None				
Course Objectives	The course is aimed to enable students to explain ggenesis of Bioinformatics, theoretical and computational models to study big data. The course is also emphasizing various databases like nucleic acid, DNA and proteins structural databases, including deals with the development of biological databases, display, annotation, and retrieval tools of biological data. The course highlights the applications of bioinformatics in the area of biological sciences, statistical mining of gene and protein databanks.						

Course Outcomes	
CO1	Understand the genesis of Bioinformatics, comparison with its allied disciplines, theoretical and computational models to study big data
CO2	Explain nucleic acid and protein sequence databases, structural databases, literature databases, genome and organism-specific databases
CO3	Understand development of biological databases, display, annotation, and retrieval tools of biological data.
CO4	Describe database similarity searching, biological file formats, and 3D structure visualization of biomacromolecules.
CO5	Explain applications of bioinformatics in the area of biological and biomedical sciences, statistical mining of gene and protein databanks.

Unit No.	**Title of the Unit**	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
1	**Introduction to Bioinformatics**	Introduction to Bioinformatics: The Genesis of Bioinformatics, Bioinformatics Versus Other Disciplines, Developments from Linear Information to Multidimensional Structure Organization, Mathematical and Computational Methods: Need of Mathematical Modeling, Fitting Models to Data.	8	**CO 1**
2	**Concept and types of databases**	Biological databanks: Types, Nucleic Acid and Protein Sequence Databases, Structural Databases, Literature databases, Genome and Organism-specific databases for example OMIM, TAIR, NCBI, TIGR, GOLD.	8	**CO 2**
3	**Access and Management of Database**	Building biological databases, submitting sequences to databases, Database tools for displaying and annotating sequence data, Retrieval of biological data including Entrez, SRS, ARSA and DBGET/Link DB.	8	**CO 3**
4	**Homology modelling and data visualization Tools**	Sequence similarity, identity and homology, definitions of homologues, orthologues, paralogues. Sequence file format: GenBank, Fasta and PIR format, Structure file format: pdb and mmCIF format, Visualization of 3-D structures using PyMOL, RasMol, SPDBV, CHIME, Discovery studio visualizer.	8	**CO 4**
5	**Applications of bioinformatics**	Applications of Bioinformatics: Bioinformatics in Life and Environmental Sciences, Structural Biology Interface, Statistical mining of Gene and Protein Databanks.	8	**CO 5**

Reference Books:

1. Fundamental Concepts of Bioinformatics - Dan E. Krane, Michael L. Raymer, Pearson education.
2. Sequence structure and Database – Des Higgins, Willice Taylor, oxford press
3. Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins, by Andreas D. Baxevanis, B. F. Francis Ouellette, Wiley-Interscience,
4. Sequence and Genome Analysis by David W. Mount - Cold Spring Harbor Laboratory
5. Bioinformatics and Functional Genomics;by Jonathan Pevsner;Wiley-Liss
6. Introduction to Bioinformatics; Arthur M. Lesk; Oxford University Press

e-Learning Source:

PO-PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	1	1	2	3	1	1	1	1	1	0	3	2	2	1
CO2	2	2	1	2	3	1	1	1	2	1	0	3	3	3	3
CO3	1	1	1	2	3	1	1	1	2	1	0	3	3	3	1
CO4	2	2	2	2	3	1	1	1	2	1	0	3	3	3	3
CO5	1	1	2	2	3	1	1	1	3	1	0	3	2	2	3

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Name & Sign of Program Coordinator	**Sign & Seal of HoD**

Integral University, Lucknow

Effective from Session:							
Course Code	MT503	**Title of the Course**	Applied Mathematics and Biostatistics	**L**	**T**	**P**	**C**
Year	1st	**Semester**	1st	**3**	**1**	**0**	**4**
Pre-Requisite	Mathematics and Statistics	**Co-requisite**	Basic concepts of Statistics and Mathematics				
Course Objectives	The course is aimed to develop the basic Mathematical skills of engineering students that are imperative for effective understanding of engineering subjects. The topics introduced will serve as basic tools for specialized studies in many fields of engineering and technology.						

Course Outcomes	
CO1	1. Understand the meaning of the derivative in terms of a rate of change and local linear approximation and should be able to use derivatives to solve a variety of problems. 2. Model a written description of a physical situation with a function, a differential equation, or an integral. 3. Develop an appreciation of calculus as a coherent body of knowledge and as a human accomplishment.
CO2	1. Apply linear algebra concepts to model, solve, and analyze real-world situations. 2. Analyze mathematical statements and expressions (for example, to assess whether a particular statement is accurate, or to describe solutions of systems in terms of existence and uniqueness). 3. Construct, or give examples of, mathematical expressions that involve vectors, matrices, and linear systems of linear equations.
CO3	1. How to translate real-world problems into probability models. 2. Basic probability axioms and rules and the moments of discrete and continuous random variables as well as be familiar with common named discrete and continuous random variables. 3. Apply basic statistical concepts commonly used in Health and Medical Sciences.
CO4	1. Interpret results of commonly used statistical analyses in written summaries. 2. Demonstrate statistical reasoning skills correctly and contextually. 3. Use technology to find coefficient of correlation of a given set of data Interpret the meaning of the correlation coefficient in context.
CO5	1. Use discrete and continuous probability distributions, including requirements, mean and variance, and making decisions. 2. Perform Test of Hypothesis as well as calculate confidence interval for a population parameter for single sample and two sample cases. 3. Learn non-parametric test such as the Chi-Square test for Independence as well as Goodness of Fit.

Unit No.	Title of the Unit	Content of Unit	Contact Hrs.	Mapped CO
1		Differential calculus Function, Limit, Continuity and Differentiability, Differentiation of standard functions, Methods of Differentiation, Maxima and Minima. Integral Calculus- Indefinite integration of standard functions, Integration by substitution, by parts, by partial fractions	8	1
2		Definition, Types of Matrix, Properties of Matrices. Addition, subtractions and multiplications, Inverse of Matrix, Determinants:- Properties of Determinants, Eigen Value and Eigen Vectors, solution of simultaneous equations by Matrix Method and Cramer's rule.	8	2
3		Sample Space and Events, Axioms of Probability, Conditional Probability, Independent Events, Bayes Theorem. Numerical Description of Data; Discrete and Continuous variable, Mean, Median, Mode, Range Quartiles, Standard Deviation Variance, Coefficient of Variation. Measures of skewness and Kurtosis by moments	8	3
4		Scatter diagram, Karl Pearson's Correlation coefficient, Spearman's Rank Correlation Coefficient. Regression Coefficients and Regression lines. Method of least square, straight line, Parabola, exponential curve.	8	4
5		Binomial, Poisson and Normal distributions, Chi-Square test, Student's t-Test, F-test, Z-test. Analysis of variance: one way ANOVA, Two-way ANOVA.	8	5

Reference Books:

1. Shanti Narayan and P.K Mittal : Differential Calculus, S. Chand Publication.
2. Shanti Narayan and P.K Mittal : Integral Calculus, S. Chand Publication.
3. Linear Algebra : Schaum Outlines. 6th edition
4. Banerjee Pranab Kumar: Introduction to Bio – Statistics, S. Chand Publication.

e-Learning Source:

Course Articulation Matrix: (Mapping of COs with POs and PSOs)															
PO-PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	3	2	1	2	1	1	2	2	1	1	2	2	3	2
CO2	3	2	3	2	2	3	3	3	3	2	3	1	1	1	2
CO3	2	1	2	3	3	1	1	1	1	1	1	3	3	3	1
CO4	1	1	3	2	1	3	1	3	2	3	1	3	2	1	3
CO5	3	3	2	3	2	2	2	1	1	2	2	1	1	2	3

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Name & Sign of Program Coordinator	**Sign & Seal of HoD**

Integral University, Lucknow

Effective from Session: 2020-21							
Course Code	BE521	**Title of the Course**	Biochemistry & Molecular Biology	**L**	**T**	**P**	**C**
Year	1st	**Semester**	1st	3	1	0	4
Pre-Requisite	None	**Co-requisite**	None				
Course Objectives	This course is designed to introduce the basic concepts of Biochemistry of living systems mainly dealing with biomolecules like carbohydrates, proteins, lipids, nucleic acids and their metabolic pathways that governed the entire metabolism. The course is also designed to make the students understand the concepts of DNA replication, Transcription and translation in prokaryotes and eukaryotes.						

Course Outcomes	
CO1	The students will learn about the carbohydrate metabolism, and its regulation; understand how the body meets the carbohydrate requirements, and how the carbohydrate metabolism is essential for synthetic pathways of other biomolecules.
CO2	The students will learn about structure and metabolism of lipids and its synthesis and degradation.
CO3	The students will understand about the mechanism and regulation of proteins and nucleotide synthesis and degradation.
CO4	The students will learn about the concepts of DNA replication in both prokaryotes and eukaryotes.
CO5	The students will learn about the concepts of Transcription, Protein synthesis and post translational modifications

Unit No.	**Title of the Unit**	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
1	**Carbohydrates**	Overview of metabolism, high energy compounds, the reactions of glycolysis, the anaerobic fate of pyruvate, control of glycolysis. The pentose phosphate pathway, glycogen breakdown and synthesis, control of glycogen metabolism, gluconeogenesis. Overview of citric acid cycle. Synthesis of acetyl coenzyme A, enzymes of the citric acid cycle, regulation of the citric acid cycle, reactions related to the citric acid cycle.	8	CO1
2	**Lipids**	Lipid metabolism: fatty acid oxidation, ketone bodies, fatty acid biosynthesis, regulation of fatty acid metabolism. The mitochondrion, electron transport, oxidative phosphorylation.	8	CO2
3	**Proteins and Nucleic Acids**	Protein degradation, amino acid deamination, the urea cycle, breakdown of amino acids, amino acid biosynthesis, nucleotide biosynthesis by de novo and salvage pathways, nucleotide degradation.	8	CO3
4	**DNA replication**	Roles of DnaA, Helicase, HD protein, Primase, DNA gyrase, Topoisomerase, DNA Polymerase III, DNA Polymerase I, DNA ligase, Fidelity, DNA replication in eukaryotes: Autonomously replicating sequence, Origin recognition complex, DNA polymerases α, δ, ε, Nucleases, DNA ligase, Telomeres	8	CO4
5	**Transcription and Translation**	Transcription in prokaryotes: Outline of process, Promoter, RNA polymerase; Transcription in eukaryotes: Outline of process, Promoters, Enhancers, RNA polymerase I, II, III; Post transcriptional modifications: End modifications (Addition of 5′ cap and 3′ Poly A tail in mRNA). Translation in prokaryotes and eukaryotes: Outline of process, Types of RNA, Structure of ribosome, Aminoacyl RNA transferase, Genetic codes, Wobble hypothesis.	8	CO5

Reference Books:

1. Voet and Voet, Biochemistry,Wiley : ISBN: 978-0-471-19350-0.
2. Nelson and Cox, Lehninger Principles of Biochemistry, W H Freeman & Co, ISBN: 978- 0- 716-77108-1.
3. Baltimore- Molecular Biology of the Cell
4. Benjamin Levin – Genes, latest ed.
5. Albert B, Bray Denis et al.: Molecular Biology of The Cell, latest ed.
6. Watson, Hopkin, Roberts et al.: Molecular Biology of the Gene, latest ed.

e-Learning Source:

https://drive.google.com/file/d/1nG5TjtIU2XmALLQTlkg4V_salq2V2f_S/view?usp=sharing

	Course Articulation Matrix: (Mapping of COs with POs and PSOs)														
PO-PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	3		1	1	1				3	1	2	2
CO2	3	3	2	3		1	1	1				3	2	2	2
CO3	3	3	2	3		1	1	1				3	2	2	2
CO4	3	3	2	3		1	1	1				3	2	2	2
CO5	3	3	2	3		1	1	1				3	2	2	2

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Name & Sign of Program Coordinator	**Sign & Seal of HoD**

Integral University, Lucknow

Effective from Session: 2020-21							
Course Code	**CS 532**	**Title of the Course**	**Bioinformatics And Ipr Related Issues**	**L**	**T**	**P**	**C**
Year	**I**	**Semester**	I	**3**	**1**	**0**	**4**
Pre-Requisite	None	**Co-requisite**	None				
Course Objectives	The objective of this course is to get acquainted with C, Perl & Python language for the simulation of biological data. It also focuses on the IPR and its related issues for proper scientific conscience and ethical values among learners						

Course Outcomes	
CO1	Understand the basics of programming syntaxes
CO2	Perform and write programs in C language and understanding the basics of file handling, exception handling.
CO3	Understand and apply the different concepts of Perl Programming languages with its various features and properties.
CO4	Apply the knowledge of PHP language and HTML tags for web page designing and its development.
CO5	Distinguish and Explain various forms of IPRs,.identify criteria's to fit one's own intellectual work in particular form of IPRs and apply statutory provisions to protect particular form of IPRs.

Unit No.	Title of the Unit	Content of Unit	Contact Hrs.	Mapped CO
1	**Introduction to programming languages**	Introduction - Flowcharts - Algorithms - Pseudocodes – Programming languages: data types, variables, constants, operators, input output, expressions, control flow constructs (conditional and loop statements) -functions, arrays, structures and unions - Pointers - Data structures - File handling.	8	CO1
2	**Procedural languages**	Programming in C Procedural languages - C language introduction: Variables, Data Types - Arrays (one and two dimensional arrays)- Functions: Types, Parameters, Recursion, Function prototype, Standard C library - Structures. Pointers: Introduction, Pointer with variables, Arrays and Strings, Pointers and structures, Pointers and linked list - Unions - File handling: File I/O, File opening modes - C Preprocessor - Graphical Interfaces: Dialog Boxes, Dynamic Memory Allocation	8	CO2
3	**PERL & PYTHON**	Perl doc - Data types: scalar data (numbers and strings), lists, arrays, variables, operators, expressions, operators, control flow constructs (conditional and loop statements), miscellaneous control flow built in functions, associative arrays hashes, functions, Basic I/O, file handling.	8	CO3
4	**Introduction to Web Technology**	Developing web pages with HTML, PHP: Tags, Links, Tables, Forms, Frames - ASP variables and data types, language syntax, controls, structures, functions, strategies and tools for handling input and generating output, error handling.	8	CO4
5	**IPR**	General Introduction, Patent Claims, the Legal Decision-Making Process, Ownership of Tangibleand Intellectual Property. Patentable Subject Matter, Novelty and the Public Domain, Nonobviousness. Disclosure Requirements, Collaborative Research, Competitive Research, Recent Developments in Patent System and Patentability of Biotechnological invention, IPR issues in the Indian Context. Patents in Bioinformatics	8	CO5

Reference Books:

1. B.W. Kernighan and D. Ritchie. The C Programming Language, Prentice Hall of India. ISBN: 0131103628.
2. E. Balagurusamy. Programming in ANSI C, Tata McGrawHill Publishing Company Limited.
3. James Tisdall Beginning PERL for Bioinformatics – an introduction to perl biologist. O'Reilly publications.
4. Robert W. Sebesta, Concepts of Programming Languages, Addison-Wesley
5. Fundamentals oflP for Engineers: K.Bansl& P.Bans

e-Learning Source:

	Course Articulation Matrix: (Mapping of COs with POs and PSOs)														
PO-PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO4
CO1	2	2	2	2	1	1	3	2	3	1	1	2	2	1	2
CO2	3	2	1	1	1	2	3	2	2	2	3	1	3	2	2
CO3	1	2	2	3	1	2	1	3	1	2	1	2	1	2	2
CO4	3	2	1	2	3	1	1	3	2	2	3	3	2	3	1
CO5	3	1			3	3	1	2					3	1	1

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Name & Sign of Program Coordinator	**Sign & Seal of HoD**

Integral University, Lucknow

Effective from Session: 2020-21							
Course Code	BE523	**Title of the Course**	Biochemistry and Molecular Biology Lab	**L**	**T**	**P**	**C**
Year	I	**Semester**	I	**0**	**0**	**4**	**2**
Pre-Requisite	None	**Co-requisite**	None				
Course Objectives	To understand the concept of various techniques required for quantification of carbohydrates, proteins and nucleic acids in known and unknown samples. Basic concept of separation techniques for biological samples like chromatography and electrophoresis are also included here. To learn the techniques used in molecular biology related to DNA isolation and its qualitative and quantitative analysis are also a part of this course.						

Course Outcomes	
CO1	Learn and perform the techniques to determine the concentration of biomolecules such as carbohydrates and proteins from a given sample.
CO2	Learn and perform the estimation of the nucleic acids (DNA and RNA) in unknown samples and determination of the melting temperature of the nucleic acids.
CO3	Understand and perform the different types of chromatography techniques such as TLC and Paper Chromatography.
CO4	Comprehend and perform DNA isolation and its visualization through electrophoresis from different sources such as bacteria and plant.
CO5	Perform the quantitative estimation of genomic DNA by determining the absorption spectra of genomic DNA and tell about the purity of the DNA.

Unit No.	**Title of the Experiment**	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
1	Protein estimation	Estimation of protein by Folin's-Lowry's method.	4	CO1
2	Carbohydrate estimation	Estimation of glucose by anthrone method.	4	CO1
3	Nucleic acid estimation	Estimation of DNA by DPA method and RNA by Orcinol method.	4	CO2
4	Melting temperature determination	Determination of Tm of DNA and RNA.	4	CO2
5	Chromatography	Chromatography: Separation of amino acids, and sugars by TLC & paper chromatography.	4	CO3
6	Bacterial DNA isolation	Isolation and characterization of plasmid and genomic DNA from Bacteria followed by Agarose Gel Electrophoresis.	4	CO4
7	Plant DNA isolation	Isolation of plant DNA followed by Agarose Gel Electrophoresis.	4	CO4
8	Absorption spectra determination	Quantitative Estimation of genomic DNA: Determination of Absorption Spectra of genomic DNA.	4	CO5

Reference Books:

1. Keith Wilson John Walker John M. Walker "Principles and Techniques of Practical Biochemistry"
2. Chirikjian "Biotechnology Theory & Techniques"
3. Joseph Sambrook David W. Russell Joe Sambrook "Molecular Cloning: A Laboratory Manual"
4. William M., Ph.D. O'Leary Robert Dony Wu "Practical Handbook of Microbiology"
5. Brown, TA "Gene cloning: An introduction"

e-Learning Source:

https://vlab.amrita.edu/?sub=3&brch=77&sim=1375&cnt=2870

	Course Articulation Matrix: (Mapping of COs with POs and PSOs)																	
PO-PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	1	3	2	3	2	1		1	3			3	3					
CO2	1	3	2	3	2	1		1	3			3	3					
CO3	1	3	2	3	3	1		1	3			3	3					
CO4	1	3	2	3	3	2		1	3			3	3					
CO5	1	3	2	3	2	1		1	3			3	3					

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Name & Sign of Program Coordinator	**Sign & Seal of HoD**

Integral University, Lucknow

Effective from Session:							
Course Code	BE-524	**Title of the Course**	BIOINFORMATICS AND PROGRAMMING LANGUAGE LAB	**L**	**T**	**P**	**C**
Year	**I**	**Semester**	I	**0**	**0**	**4**	**2**
Pre-Requisite	None	**Co-requisite**	None				
Course Objectives	After completion of the course, students will be able to work on bioinformatics-based programming and perform different visualization tools.						

Course Outcomes	
CO1	Perform text **based** search of NCBI Entrez and EMBL-EBI SRS.
CO2	Retrieve the protein or nucleotide sequence of an organism in GenPeptformat and convert it to FastA format.
CO3	Retrieve 3-D structure of a protein from PDB and visualize it in PyMol, RasMol or DS Visualizer.
CO4	Write programs in C language based on basic Biological problems and Perform Python Programming.

Unit No.	Title of the Unit	Content of Unit	Contact Hrs.	Mapped CO
1	Experiment No. 1	To perform text based search of **a.** NCBI Entrez **b.** EMBL-EBI SRS	8	1
2	Experiment No. 2	To retrieve protein sequence or nucleotide sequence of an organism in GenPept format followed by its conversion into FastA format.	8	2
3	Experiment No. 3	To retrieve 3-D structure of a protein from PDB and visualize it in PyMol, RasMol or DS Visualizer.	8	3
4	Experiment No. 4 and 5	To write programs in C language based on basic Biological problems. Perl Programming: **a.** Perl basics and variables **b.** Control and loop statements **c.** Functions and subroutines **d.** Regular expressions **e.** Modules: LWP	8	4

Reference Books:

1. Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins, by Andreas D. Baxevanis, B. F. Francis Ouellette, Wiley-Interscience,
2. E. Balaguruswami, "Programming with ANSI "C", Tata McGraw Hill.
3. Beginning Perl for Bioinformatics- James Tisdall, O'Reily Publication
4. Python course in Bioinformatics by Katja Schuerer and Catherine Letondal

e-Learning Source:

	Course Articulation Matrix: (Mapping of COs with POs and PSOs)														
PO-PSO CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	1		1	3			1				1	3	2	2
CO2	3	1	2	1	3			1	1			1	3	3	1
CO3	2	1	2	2	3				1			1	2	2	1
CO4	3	3	2	1	3			1	1			2	3	2	2

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Name & Sign of Program Coordinator	**Sign & Seal of HoD**

Integral University, Lucknow

Effective from Session: 2021-2022							
Course Code	BE525	**Title of the Course**	Biomolecular modeling and simulation	**L**	**T**	**P**	**C**
Year	I	**Semester**	II	**3**	**1**	**0**	**4**
Pre-Requisite	None	**Co-requisite**	None				
Course Objectives	The objective of the course is to learn and understand the entire concepts of in silico drug design through molecular modeling and simulation. The application of the course focuses on current trends and recent developments in the modeling of biological macromolecules.						

Course Outcomes	
CO1	Explain the concepts of secondary and tertiary structure prediction of proteins.
CO2	Understand the principle of molecular docking and its applications to biological R&D.
CO3	Understand the concept and applications of protein modeling and its implications for biological research.
CO4	Understand the basic concept of Monte Carlo (MC) and molecular dynamic (MD) simulation and their applications.
CO5	Describe nucleic acid secondary structure prediction and its relevance in RNA-based drug design and development

Unit No.	**Title of the Unit**	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
1	Protein Modeling	Basic concepts, Generations of secondary structure prediction methods, Chou-Fasman, and GOR algorithms, Knowledge- and Ab-initio-based methods of tertiary structure prediction, 3D model evaluations and visualization.	8	CO1
2	Molecular Interactomics	Basic principles and concepts, Rigids and flexible molecular docking, Molecular scoring functions, Analysis of molecular interactions, Common software used in molecular docking viz., AutoDock Tools, GOLD, FlexX, ICM, and Dock. Implications of molecular docking concepts in Biomedical and Life Science R&D.	8	CO2
3	Concepts of Molecular Modeling	Molecular mechanics, Simulations of Free Energy changes, Force fields, Common force fields, and their uses. Energy minimization, Programs, and Web Servers useful in energy minimization. The implication of energy minimization in protein modeling.	8	CO3
4	Molecular Dynamics Simulation	Basic concepts, Molecular forces stabilizing 3D structure of biological macromolecules, Simulation methods for conformational analysis, Design constraints, Recent trends, Applications, Pros, and Cons.	8	CO4
5	Nucleic acid Structure prediction	Basic concepts, Current algorithms for RNA secondary structure prediction, Methods viz., Ab-initio, and Comparative approach, Performance evaluation of RNA prediction programs. Applications in context to Proteogenomics	8	CO5

Reference Books:

Andrew R. Leach. Molecular Modelling Principles and applications. Prentice Hall.

Fenniri, H. “Combinatorial Chemistry – A practical approach”, Oxford University Press, UK.

Lednicer, D. “Strategies for Organic Drug Discovery Synthesis and Design”; Wiley International Publishers.

Gordon, E.M. and Kerwin, J.F “Combinatorial chemistry and molecular diversity in drug discovery”. Wiley-Liss Publishers

Bioinformatics: Sequence and Genome Analysis, David W. mount, CSH Laboratory Press, 2001, ISBN 9780879695972.

e-Learning Source:

https://vlab.amrita.edu/index.php?sub=3&brch=275&sim=1427&cnt=1

https://vlab.amrita.edu/index.php?sub=3&brch=275&sim=1443&cnt=1

https://www.sib.swiss/bioinformatics-for-all/

	Course Articulation Matrix: (Mapping of COs with POs and PSOs)														
PO-PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	1	1	2	2	1	1	2	1	1	1	3	2	3	3
CO2	2	2	1	2	3	1	1	2	1	1	1	1	2	2	3
CO3	2	2	2	2	3	1	1	1	1	1	2	1	3	3	3
CO4	1	2	2	2	2	1	3	2	2	1	2	3	3	3	2

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Name & Sign of Program Coordinator	**Sign & Seal of HoD**

Integral University, Lucknow

Effective from Session: 2020 -21							
Course Code	BE 526	**Title of the Course**	Algorithms in Molecular Biology	**L**	**T**	**P**	**C**
Year	I	**Semester**	II	**3**	**1**	**0**	**4**
Pre-Requisite	None	**Co-requisite**	None				
Course Objectives	The objective of the course is to get a detailed overview of various universal sets of algorithms available for solving complex prediction problems. It mainly introduces with Genetic algorithm, Artificial Neural Network, Hidden markov model with Fuzzy logic as a part of search, prediction and optimization strategies.						

Course Outcomes	
CO1	Explain the basics of genetic algorithms, genetic operators and schema theorem.
CO2	Understand the proper application and execution of genetic algorithms.
CO3	Understand the concept and applications of Artificial neural networks in biological sciences.
CO4	Understand the concept and functionality of Hidden Markov modelsand its application in the field of bioinformatics.
CO5	Understand the basics of fuzzy logic and its applications.

Unit No.	**Title of the Unit**	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
1	**Genetic Algorithms**	Genetic Algorithms: Basic concepts and applications; Encodings and optimization problems, Search Spaces as Hypercubes, Hyperplane sampling, GA Operators and Schemata; The Schema Theorem, Concept of Reduced Surrogates.	8	CO1
2	**An Executable Model of the genetic algorithm**	A generalized form based on Equation Generators, Generating String Losses for 1-point crossover, Generating String Gains for 1-point crossover. Other Models of Evolutionary Computation: Genitor, CHC; Hill-climbers or Hyperplane Samplers.	8	CO2
3	**Artificial Neural Networks**	A Simple Neuron, Firing rule, Network layers, Architectures of Artificial Neural Network: Feed-Forward networks, Feed-Back networks, Perceptrons, Pattern recognition problems, Back Propagation Algorithm, Applications of Neural Networks.	8	CO3
4	**Hidden Markov Models**	Applications of HMM: finding CpG islands in long DNA sequence, Solution of the decoding problem: Viterbi Algorithm and its complexity, Posterior decoding through forward and backward algorithms, Profile HMM: ungapped profile alignment. Derivation of profile HMM for multiple sequence alignments; Alignment of the sequences to a Profile HMM.	8	CO4
5	**Fuzzy Logic**	An Introduction of Fuzzy Logic, Fuzzy Vs Non-Fuzzy, K-Mean Clustering, Fuzzy C-Mean Clustering, Basic tipping problems.	8	CO5

Reference Books:

Mount DW ‘Bioinformatics: Sequence and genome analysis’, CBS publications.

Andrew Leach; Molecular Modelling: Principles and Applications (2nd Edition), Prentice Hall, 2001, ISBN 13: 9780582382107

Lesk ‘Introduction to Bioinformatics’, Oxford publications.

Page G ‘Algorithms in Bioinformatics’.

e-Learning Source:

Artificial Intelligence & Molecular Biology Lawrence Hunter http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.104.662&rep=rep1&type=pdf

National Center for Biotechnology Information, www.ncbi.nlm.nih.gov

	Course Articulation Matrix: (Mapping of COs with POs and PSOs)														
PO-PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	2	2	2	2	1	1	1	1	1	1	2	3	1	1
CO2	3	3	3	3	3	1	1	1	1	2	2	2	3	2	3
CO3	3	2	3	3	3	2	1	2	1	1	2	2	3	2	2
CO4	3	3	3	3	2	2	1	1	1	2	1	2	3	2	3
CO5	3	3	3	3	2	2	1	1	1	2	1	2	2	2	3

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Name & Sign of Program Coordinator	**Sign & Seal of HoD**

Integral University, Lucknow

Effective from Session: 2021-2022							
Course Code	BE527	**Title of the Course**	Metabolomics	**L**	**T**	**P**	**C**
Year	I	**Semester**	II	**3**	**1**	**0**	**4**
Pre-Requisite	None	**Co-requisite**	None				
Course Objectives	The objective of the course is to learn and understand the metabolic process of various Biomolecules along with the knowledge of their respective databases. It also underlines the basic Engineering and Reconstructional strategies for crucial metabolic pathways.						

Course Outcomes	
CO1	Understand the concept of metabolic pathways for the biomolecules such as carbohydrates and lipid and their feedback control.
CO2	Understand the enzymes and their classification. The students will also learn about databases and information systems related to enzymes.
CO3	Understand and learn about the various metabolic pathway databases related to the enzymes.
CO4	Understand the concepts related to the engineering of the metabolic pathways through the mathematical and dynamic representation of these
CO5	pathways.

Unit No.	**Title of the Unit**	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
1	Metabolism	Carbohydrate metabolism, Lipid metabolism, Transport metabolism; Significance of anaplerotic reactions and amphibolic pathways; Feedback control of metabolic pathways..	8	CO1
2	Enzymes	Classification of enzymes; Enzymes, Compounds and Reactions databases: LIGAND-Biochemical compounds and reactions, ENZYME–Enzymes, BRENDA-Comprehensive Enzyme Information System.	8	CO2
3	Metabolic Pathway	Classification of metabolic pathways (with respect to enzymes); Metabolic Pathway databases: KEGG, EMP, Malaria parasite metabolic pathways, EcoCyc, Boehringer Mannheim-Biochemical Pathways.	8	CO3
4	Engineering of metabolic pathways	Mathematical representation of metabolic pathways, Generation and dynamic representation of metabolic pathways, Deriving common principles from the metabolic pathways knowledge: Deriving sets of enzymes specific for various reactions..	8	CO4
5	Reconstruction of metabolic pathway	Predicting regulatory elements, Identifying targets; Full genome annotation through knowledge of metabolic pathways.	8	CO5

Reference Books:

Bioinformatics A Practical Guide to the Analysis of Genes and Proteins. Ed. Andreas D. Baxevanis and B. F. Francis Ouellette. John Wiley & Sons, Inc., Publications (For Micro array).

Charles M. Perou, 2000. Molecular portraits of human breast tumors. Nature, 406: 747-752.

Christopher H. Schilling et al. 1998. The underlying pathway structure of biochemical reaction networks. PNAS. 95:4193-8.

Christopher H. Schilling et al. 1999. Towards metabolic phenomics: Analysis of Genomics Data Using Flux Balances, Biotechnology. Prog. 15: 288-295.

Chu et al. 1998. The Transcriptional program of sporulation in budding yeast. Science. 282:699-705.

e-Learning Source:

https://vlab.amrita.edu/index.php?sub=3&brch=276&sim=1456&cnt=1

https://vlab.amrita.edu/index.php?sub=3&brch=276&sim=1487&cnt=1

https://www.sib.swiss/bioinformatics-for-all/

	Course Articulation Matrix: (Mapping of COs with POs and PSOs)														
PO-PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	1	1	1	1	1	1	1	1	1	1	3	2	3	3
CO2	1	1	1	1	1	1	1	1	1	1	1	3	2	2	3
CO3	1	1	1	1	1	1	1	1	1	1	1	3	3	3	3
CO4	1	1	1	1	2	1	1	1	1	1	1	3	3	3	2

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Name & Sign of Program Coordinator	**Sign & Seal of HoD**

Integral University, Lucknow

Effective from Session: 2020-21							
Course Code	BE528	**Title of the Course**	Sequence Analysis and Phylogenetics	**L**	**T**	**P**	**C**
Year	I	**Semester**	II	**3**	**1**	**0**	**4**
Pre-Requisite	None	**Co-requisite**	None				
Course Objectives	The objective of the course focuses on the various strategies available for Pairwise and Multiple sequence alignment studies. The course also outlines the detailed overview of phylogenetic studies as an important application of the multiple sequence alignment approach.						

Course Outcomes	
CO1	Understand the sequence alignment, and compare with its other sequences available in specific databases, theoretical and computational analysis of the algorithm.
CO2	Understand the different approaches of matrices and problem solving, construction of PAM and BLOSSOM matrices, and their applications
CO3	Understand the uses of various software and tools to validate the sequence search and similarity to others sequences and display, annotation, and retrieval tools of biological data.
CO4	Understand and development of the Phylogenetics and phylogenetic trees; Reconstruction of Phylogenetic trees by using bioinformatics tools.
CO5	Explain applications of algorithms in the area of biological and biomedical sciences, applications and overview of MEGA software.

Unit No.	**Title of the Unit**	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
1	Sequence Alignment	Hamming Distance, Dot-plot Matrix, Dynamic programming strategies and their complexities: Global alignment (Needleman and Wunsch algorithm), Global alignment in linear space: Divide and Conquer algorithm, Local alignment (Smith and Waterman algorithm), End space free alignment, Gap penalties.	8	CO1
2	Database similarity searching	FASTA and BLAST, PSI- BLAST, PHI- BLAST, Amino acid substitution matrices and their applications: Construction of PAM matrix, BLOSUM matrix.	8	CO2
3	Multiple sequence alignment	Introduction and significance of MSA, Algorithms for MSA: Center Star algorithm, Multiple alignments with Consensus; Alignment of string to a profile; Pairwise and Iterative Multiple Alignment strategies, Common MSA tools: Clustal W, Pile Up.	8	CO3
4	Phylogenetics	Distance-based methods: Ultrametric property and Additive property, UPGMA and Neighbor-joining methods, Jukes-Cantor model, Bootstrapping.	8	CO4
5	Character based methods	Character-based methods: Occam's Razor; Parsimony: Small parsimony (Fitch's Algorithm), Weighted parsimony (Sankoff's Algorithm) and large parsimony problems. Probabilistic approaches like the Maximum likelihood method, Overview of MEGA software.	8	CO5

Reference Books:

A.D. Baxevanis et al., Current Protocols in Bioinformatics, Wiley Publishers.

David W. Mount Bioinformatics, Cold Spring Harbor Laboratory Press, ISBN 0-87969-608-7.

Computational Molecular Biology by P. A. Pevzner, Prentice Hall of India Ltd, ISBN 81-203-2550-8.

D.E. Krane and M.L. Raymer Fundamental concepts of Bioinformatics, Pearson Education ISBN 81-297-0044-1.

N. Gautham, Bioinformatics Narosa publications. ISBN-13: 9781842653005.

	Course Articulation Matrix: (Mapping of COs with POs and PSOs)														
PO-PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	1	1	2	2	1	1	2	1	1	1	3	2	3	3
CO2	2	2	1	2	3	1	1	2	1	1	1	1	2	2	3
CO3	2	2	2	2	3	1	1	1	1	1	2	1	3	3	3
CO4	1	2	2	2	2	1	3	2	2	1	2	3	3	3	2

Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Name & Sign of Program Coordinator	**Sign & Seal of HoD**

Integral University, Lucknow

Effective from Session: 2021-2022							
Course Code	CS513	**Title of the Course**	Database Management System	**L**	**T**	**P**	**C**
Year	I	**Semester**	II	**3**	**1**	**0**	**4**
Pre-Requisite	None	**Co-requisite**	None				
Course Objectives	The course curriculum helps to understand the designing of the database models, understanding of the relationships between different records and databases. Its major objective is storage, manipulation, and working with transactions. It helps in the connectivity of large databases with various webpages and also introduces the concept of several technologies, which help in resolving the integrity, and atomicity problems. It helps in the transformation of one type into different types. It removes multiple duplicacy, allows access to multiple users and helps in data protection						

Course Outcomes	
CO1	Know about the concepts of database, their types, design concepts and ER-models.
CO2	Know about the concepts of relational databases, working with SQL for frontend development.
CO3	Know about the concepts of query optimization, transaction processing and concurrency control.
CO4	Know about the concepts of database technologies, distributed database environment.
CO5	Know about the concept of data warehouse, data cleaning and data integration.

Unit No.	**Title of the Unit**	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
1	DBMS	Introduction - concepts and overview - Types DBMS- Relational and transactional Database, Database planning and Design concepts: General Database Planning and Design – Documentor forms - preparation and architecture. Entity-Relational ship Model- entities, Attributes, keys, tables design, relationships, roles and dependencies. Advanced E-R model. - concepts.	8	CO1
2	Relational DB	Introduction to relational DB and transactions. SQL-statements-Data Definition-Manipulation-control-Objects, - Views, sequences and Synonyms. Working with code and forms- Frontend development-query sublanguage-modifying relations in SQL.	8	CO2
3	Internals of RDBMS	Physical data structures, query optimization. Join algorithm statistics and cost base optimization. Transaction processing. Concurrency control and recovery management. Transaction model properties, state serializability, lock base protocols, two phase locking.	8	CO3
4	Database technologies	JDBC, ODBC standard and CORBA - extended entity relationship model, object data model UML diagram. File organizations and data structures. Distributed database environment and its overview. Different databases and internet. Use of XML.	8	CO4
5	Datawarehouse	Descriptive Data Summarization, Data Cleaning, Data Integration and Transformation, Data Reduction, Data Discretization and Concept Hierarchy Generation, Data Warehouse and OLAP technology - A Multidimensional Data Model - From Data Warehousing to Data Mining - Efficient Methods for Data Cube Computation - Further Development of Data Cube and OLAP Technology.	8	CO5

Reference Books:

Abraham Silberschatz, Henry F. Korth and S. Sudhashan, Database system concepts. McGraw Hill Publications.

Elmasri Ramez and Novathe Shamkant, “Fundamentals of Database systems”, Benjamin cummings Publishing Company. ISBN-10: 0321369572.

P.Ramakrishnan Rao: Database Management system, McGraw Hill Publications. 9780071230575

Jim Gray and A.Reuter “Transaction processing : Concepts and Techniques” Morgan Kaufmann Press. ISBN-10: 1558601902

V.K .Jain. Database Management system. Dreamtech Press ISBN 8177222279

Date C.J. “Introduction to database management” Wesley.

Ullman, JD “Principles of Database systems” Galgottia publication

	Course Articulation Matrix: (Mapping of COs with POs and PSOs)														
PO-PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	2	2	3	1	2	1	3	1	2	1	2	2	2	2
CO2	3	2	1	1	1	2	3	2	2	2	3	1	2	3	3
CO3	2	2	2	2	1	1	3	2	3	1	1	2	3	3	2
CO4	3	2	1	2	3	1	1	3	2	2	3	3	3	3	2

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Name & Sign of Program Coordinator	**Sign & Seal of HoD**

Integral University, Lucknow

Effective from Session: 2020-2021							
Course Code	BE529	**Title of the Course**	Modeling and Phylogenetics Lab	**L**	**T**	**P**	**C**
Year	I	**Semester**	II	**0**	**0**	**8**	**4**
Pre-Requisite	None	**Co-requisite**	None				
Course Objectives	Develop a know-how of the modeling of proteins and the procedures involved in the phylogenetic analysis.						

Course Outcomes	
CO1	To be able to make chemical structures of simple and complex molecules using multiple tools.
CO2	To examine the effects of energy minimization and mutations of protein molecules through the respective tools.
CO3	Develop an understanding of predicting/modeling and validating protein secondary, tertiary and quaternary structures.
CO4	To appreciate the applications of multiple sequence alignment tools.
CO5	Develop a thorough understanding of phylogenetic analysis and its evaluation using various tools.

Unit No.	**Title of the Unit**	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
1	ChemSketch	To draw the 2D and 3D structures of chemical compounds in the ChemSketch software.	4	CO1
2	Argus Lab	To build the dipeptides, tripeptides and oligonucleotides molecules in the Argus Lab.	4	CO1
3	Energy minimization	To carry out the Energy minimization studies of the biological molecules using SPDB viewer by applying the GROMOS force field.	4	CO2
4	Molecular dynamics	To virtually mutate the small parts of protein molecules and carry out its Molecular dynamics studies with the help of GROMACS.	8	CO2
5	Secondary structure prediction	To perform the secondary structure prediction studies of the given protein using GOR and nnPredict tools available at ExPASy sever.	4	CO3
6	Homology modeling	To perform the homology based comparative protein modeling of the given protein using MODELER.	8	CO3
7	Model Validation	To validate the Homology based predicted model using following tools: a. WHATIF b. PROSA c. PROCHECK d. VERIFY 3D	4	CO3
8	Multiple sequence alignment	To carry out multiple sequence alignment of the given nucleotide sequences using Clustal W and T-Coffee tools and draw out the important inferences.	4	CO4
9	Phylogenetic analysis	To perform the phylogenetic analysis of the given protein sequences of a protein family using MEGA/PHYLIP package and draw the important inferences.	8	CO5

Reference Books:

1. Baxevanis A.D and Ouellette B.F.F, Bioinformatics – A Practical Guide to the Analysis of Genes and Proteins, 3rd edition, New York: John Wiley & Sons Inc. Pub, 2006.
2. Mani K.and Vijayaraj, Bioinformatics A practical Approach, Coimbatore : Aparna Publication, 2004.

e-Learning Source:

1. https://vlab.amrita.edu/index.php?sub=3&brch=274
2. https://vlab.amrita.edu/index.php?sub=3&brch=275

	Course Articulation Matrix: (Mapping of COs with POs and PSOs)														
PO-PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	2	1	1	3	2	1	1	3	1	0	3	3	3	2
CO2	2	2	3	2	3	3	1	1	3	1	0	3	3	3	2
CO3	2	3	3	3	3	3	1	1	3	1	0	3	3	3	2
CO4	2	3	3	3	3	3	1	1	3	1	0	3	3	3	3
CO5	2	2	3	2	3	3	1	1	3	1	0	3	3	3	2

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Name & Sign of Program Coordinator	**Sign & Seal of HoD**