॥ सा विद्या या विमुक्तये ॥

स्वामी रामानंद तीर्थ मराठवाडा विद्यापीठ, नांदेड

'ज्ञानतीर्थ', विष्णुपुरी, नांदेड – ४३१ ६०६ (महाराष्ट्र राज्य) भारत

SWAMI RAMANAND TEERTH MARATHWADA UNIVERSITY, NANDED

'Dnyanteerth', Vishnupuri, Nanded - 431 606 (Maharashtra State) INDIA

Established on 17th September, 1994, Recognized By the UGC U/s 2(f) and 12(B), NAAC Re-accredited with'B++' grade

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विज्ञान व तंत्रज्ञान विद्याशाखे अंतर्गत संलग्नित महाविद्यालयातील राष्ट्रीय शैक्षणिक धोरणानुसार पदव्युत्तर प्रथम वर्षाचे अभ्यासक्रम शैक्षणिक वर्ष २०२३–२४ पासून लागू करण्याबाबत.

प रि प त्र क

या परिपत्रकान्वये सर्व संबंधितांना कळविण्यात येते की, विज्ञान व तंत्रज्ञान विद्याशाखे अंतर्गत संलग्नित महाविद्यालयातील राष्ट्रीय शैक्षणिक धोरणानुसार पदव्युत्तर प्रथम वर्षाचे खालील अभ्यासक्रम शैक्षणिक वर्ष २०२३–२४ पासून लागू करण्याच्या दृष्टीन मा. कुलगुरू महोदयांनी विद्यापरिषदेच्या मान्यतेच्या अधीन राहून मान्यता दिलेली आहे.

1. M. Sc. Bioinformatics I year (Affiliated College)
2. M. Sc. Clinical Research I year (Affiliated College)

सदरील परिपत्रक व अभ्यासक्रम प्रस्तुत विद्यापीठाच्या **www.srtmun.ac.in** या संकेतस्थळावर उपलब्ध आहेत. तरी सदरील बाब ही सर्व संबंधितांच्या निदर्शनास आणून द्यावी, ही विनंती.

'ज्ञानतीर्थ' परिसर,
विष्णुपुरी, नांदेड – ४३१ ६०६.
जा.क्र.:शैक्षणिक–१/परिपत्रक/एनईपीपीजी/
२०२३–२४/251
दिनांक : २५.०८.२०२३.

आपली विश्वासू
सहा.कुलसचिव
शैक्षणिक (१–अभ्यासमंडळ) विभाग

प्रत माहिती व पुढील कार्यवाहीस्तव :

१) मा. अधिष्ठाता, विज्ञान व तंत्रज्ञान विद्याशाखा, प्रस्तुत विद्यापीठ.
२) मा. संचालक, परीक्षा व मूल्यमापन मंडळ यांचे कार्यालय, प्रस्तुत विद्यापीठ.
३) मा. प्राचार्य, सर्व संबधित महाविद्यालये, प्रस्तुत विद्यापीठ.
७) सिस्टम एक्सपर्ट, शैक्षणिक विभाग, प्रस्तुत विद्यापीठ. यानां देवून कळविण्यात येते की, सदरील परिपत्रक विद्यापीठाच्या संकेतस्थळावर प्रसिध्द करण्यात यावे.

SWAMI RAMANAND TEERTH MARATHWADA UNIVERSITY, NANDED.

STRUCTURE AND SYLLABUS OF TWO YEAR MASTERS PROGRAM IN SCIENCE

(R-2023)

UNDER

NATIONAL EDUCATION POLICY (NEP 2020)

In

SUBJECT: BIOINFORMATICS

FACULTY OF SCIENCE AND TECHNOLOGY

M. Sc. First Year

AFFILIATED COLLEGES

With Effect From June 2023

Preamble: The National Education Policy 2020 (NEP 2020) is formulated to revamp education system and lay down road map for new India. This policy is framed based on the fundamental pillars of access, equity, quality, affordability, and accountability and seeks to transform India into a thriving knowledge society and a global knowledge superpower.

Some of the important features of National Education Policy are increasing Gross enrolment ratio in higher education, Holistic and multidisciplinary education with multiple entry/exit options, Establishment of academic bank of credit, Setting up of multidisciplinary education and research Universities and National Research Foundation, Expansion of open and distance learning to increase gross enrolment ratio, Internationalization of education, Motivated, energized and capable faculty, Online and digital education and Effective governance and leadership.

As per the National Education Policy, the Government of Maharashtra has proposed a model curriculum framework and an implementation plan for the State of Maharashtra. It is to suggest and facilitate the implementation of schemes and programs, which improve not only the level of academic excellence but also improve the academic and research environment in the state. The proposed curriculum framework endeavours to empower the students and help them in their pursuit for achieving overall excellence.

In view of NEP priority and in-keeping with its vision and mission, process of updating the curriculum is initiated and implemented in SRTM University at UG and PG level from the academic year 2023-2024.

Bioinformatics is an interdisciplinary field that combines biology, computer science, and statistics to analyze and interpret biological data. It involves the application of computational techniques and algorithms to store, organize, analyze, and visualize biological information, particularly genomic and proteomic data. Bioinformatics utilizes various computational tools and techniques to extract meaningful information from biological data. These include database management systems, data mining algorithms, machine learning methods, and statistical analysis. Researchers and scientists in the field of Bioinformatics use these tools to gain insights into biological processes, understand disease mechanisms, discover new drugs and therapies, and enhance our understanding of evolutionary relationships among species. Overall, Bioinformatics plays a vital role in advancing biological research by enabling the integration and analysis of large and complex datasets, ultimately contributing to discoveries and breakthroughs in fields such as genomics, proteomics, evolutionary biology, and personalized medicine.

Keeping in mind, BOS in Biotechnology and Bioinformatics prepared the curriculum to ensure up-to-date level of understanding of Bioinformatics. Studying Bioinformatics prepares the students for their career working either in educational institutions or industries in which they can be directly involved in the teaching, research and development. Also, to ensure uniform curriculum and its quality at UG/PG level,

curriculum of different Indian Universities, syllabus of NET, SET, MPSC, UPSC and the UGC model curriculum are referred to serve as a base in updating the same.

The comments or suggestions from all teachers, students and other stakeholders are welcome for upbringing this curriculum.

Salient Features:

The syllabus of M Sc Bioinformatics has been framed to meet the requirement of Choice Based Credit System under NEP 2020. The courses offered here in will train and orient the students in the specific fields of Bioinformatics.

The Core Courses deal with Basics of Bioinformatics, Biochemistry, Cell and Molecular Biology, Programming in C, Databases and Tools in Bioinformatics, Immunology and Parasite Bioinformatics, Chemoinformatics and Drug Design, Python in Programming, Genomics and Proteomics, Perl Programming, Applications of Bioinformatics.

Apart from the core courses, the Department Specific Elective Courses deal with Statistics, Mathematics, Structural Bioinformatics, Programming in C++, Advanced Techniques in Bioinformatics, Programming in Java, Database Management System and Biological Sequence Analysis. These courses offered during this program are designed with the aim of imparting specific skills to the students which will lead to their employability. There are also two Research Projects in third and fourth semester respectively. This would help students to lay a strong foundation in the field of Bioinformatics.

Overall after completion of this course, students will acquire fundamental knowledge of applications of Bioinformatics.

Program Educational Objectives:

The Objectives of this program are:

PEO1: To offer postgraduate program in Bioinformatics based on the needs of industries, academic and research institutions worldwide.

PEO2: To expose the students to the different emerging fields of Bioinformatics.

PEO3: To update curriculum by introducing recent advances in the subject that enable the students to successfully face NET, SET, MPSC, UPSC and other competitive examinations.

PEO4: To train and orient the students so as to develop human resource for the educational institutes and other organizations.

PEO5: To inculcate analytical and application-oriented abilities to create active and frontline researchers and human resource for the industries.

PEO6: To develop specific skills amongst students for their employability and for the development of their own enterprises.

Program Outcomes:

The Outcomes of this program are:

PO1: This program will expose the students to the different emerging fields of Bioinformatics.

PO2: This will provide an updated curriculum with recent advances in the subject that enable the students to face NET, SET, MPSC, UPSC and other competitive examinations successfully.

PO3: This program shall train and orient the students so as to develop human resource for educational institutes and other organizations.

PO4: This program shall train and orient the students so as to develop active and frontline researchers and human resource for the industries.

PO5: This will also develop specific skills amongst students for their employability and for the development of their own enterprises.

Prerequisite:

The students seeking admission to this program should have knowledge of B Sc in Life Sciences, Bioinformatics, Biotechnology, Genetics, Computer Science, or a related discipline. The optional courses are offered to the students registered for post-graduate programs. Such students should have a basic knowledge of Bioinformatics and willing to gain additional knowledge in the field of Bioinformatics.

The students seeking admission to this program should have cleared B Sc or B Pharm or B Sc Agri from any statutory University.

Dr. Sunita D. Lohare
Chairman, BOS in Biotechnology and Bioinformatics,
Swami Ramanand Teerth Marathwada University,
Nanded 431606.

Details of the Board of Studies Members in the subject Biotechnology and Bioinformatics under the Faculty of Science & Technology, S.R.T.M. University, Nanded.

Sr No	Name of the Member	Designation	Sr No	Name of the Member	Designation
1	Dr Sunita Dhundiraj Lohare, Shri Havgiswami Mahavidyalaya, Udgir, Dist -Latur Mob 9284161504	Chairman	2	Dr Babasaheb S Surwase School of Life Sciences SRTM University, Nanded 431606. Mob 9075829767	Member
3	Dr Pratap V. Deshmukh Nagnath Arts, Commerce and Science College, Aundha Nagnath, Dist. Hingoli Mob 9637202024	Member	4	Dr Komal S. Gomare Dept of Biotechnology, Dayanand Science College, Latur Mob 9284238413	Member
5	Dr Vaibhav D. Deshpande, General Manager, Quality Corporate Office, Wockhardt, Mumbai Mob 9100988260	Member		--	
	Invitee Members				
6	Dr Laxmikant Kamble School of Life Sciences, SRTM University, Nanded 431606. Mob: 8669695555	Member	7	Dr M M V Baig Dept of Biotechnology, Yeshwant Mahavidyalaya, Nanded. Mob 9422170641	Member
8	Dr Sanjog T. Thul Environmental Biotechnology and Genomics Division, National Environmental and Engineering Research Institute (CSIR-NEERI). Nagpur. Mob 9881877072	Member	9	Dr Prashant Thakare Department of Biotechnology, SGB Amravati University, Amravati. Mob: 9822222822	Member
10	Dr Shivraj Hariram Nile Department of Food Science and Agriculture, National Agri-Food Biotechnology Institute (NABI), Mohali, Punjab. Mob 9561740707	Member	11	Dr Arun Ingale School of Life Sciences, North Maharashtra University, Umavinagar, Jalgaon. Mob: 9822708707	Member
12	Dr Makarand N. Cherekar Dept. of Biotechnology & Bioinformatics, MGM's College of CS and IT, Nanded. Mob: 9421454254	Member	13	Mr. Rameshwar S. Belnor Dept. of Biotechnology & Bioinformatics, MGM's College of CS and IT, Nanded. Mob: 9096430300	Member

Swami Ramanand Teerth Marathwada University, Nanded

Faculty of Science & Technology

Credit Framework and Structure of Two Year PG Program (NEP 2020)

Subject: M Sc Bioinformatics (Affiliated Colleges) (R-2023)

Year & Level	Sem	Major Subject		RM	OJT / FP/CS (3-Cr)	Research Project	Practicals (1-Cr)	Credits	Total Credits
		(DSC- 4 Cr)	(DSE- 3 Cr)						
1	1	SBIOC-401 Basics of Bioinformatics SBIOC-402 Biochemistry SBIOC-403 Cell and Molecular Biology	SBIOE-401 Statistics **OR** SBIOE-403 Mathematics	SVECR 401 Research Methodology (3-Cr)	--		SBIOP-401 Lab Course in Basics of Bioinformatics SBIOP-402 Lab Course in Biochemistry SBIOP-403 Lab Course in Cell and Molecular Biology SBIOE-402 Lab Course in Statistics **OR** SBIOE-404 Lab Course in Mathematics	22	44
	2	SBIOC-451 Programming in C SBIOC-452 Databases and Tools in Bioinformatics SBIOC-453 Immunology and Parasite Bioinformatics	SBIOE-451 Structural Bioinformatics **OR** SBIOE-453 Programming in C++	---	SBIOX-451 (O/F/C)	--	SBIOP-451 Lab Course in Programming in C SBIOP-452 Lab Course in Databases and Tools in Bioinformatics SBIOP-453 Lab Course in Immunology and Parasite Bioinformatics SBIOE-452 Lab Course in Structural Bioinformatics **OR** SBIOE-454 Lab Course in Programming in C++	22	
Exit option: Exit Option with PG Diploma in Basic Bioinformatics (After 2024-25)									
2	3	SBIOC-501 Chemoinformatics and Drug Designing SBIOC-502 Python Programming SBIOC-503 Genomics and Proteomics	SBIOE-501 Advanced Techniques in Bioinformatics **OR** SBIOE-503 Programming in Java	--	--	Research Project SBIOR-551 (4-Cr)	SBIOP-501 Lab Course in Chemoinformatics and Drug Designing SBIOP-502 Lab Course in Genomics and Proteomics SBIOE-502 Lab Course in Advanced Techniques in Bioinformatics **OR** SBIOE-504 Lab Course in Programming in Java	22	44
	4	SBIOC-551 Perl Programming SBIOC-552 Applications of Bioinformatics	SBIOE-551 Database Management System **OR** SBIOE-553 Biological Sequence Analysis	SVECP-551 Publication Ethics (2-Cr)	--	Research Project SBIOR-552 (6-Cr)	SBIOP-551 Lab Course in Perl Programming SBIOP-552 Lab Course in Applications of Bioinformatics SBIOE-552 Lab Course in Database Management System **OR** SBIOE-554 Lab Course in Biological Sequence Analysis	22	
Total Credits		44	12	05	03	10	14		**88**

DSE indicates Department Specific Elective Course. Bioinformatics student, in a particular semester, can opt either of these courses **OR** a course offered by the program of other Departments. DSC- Department Specific Core, OJT- On Job Training, FP- Field Project, CS- Case Study, RM- Research Methodology, Cr- Credit, VEC- Value Education Course, R- Revision, Credits of four semesters = 88, Total Marks of all four Semesters = 2200

M. Sc. First Year Semester I (Level 6.0)

Teaching Scheme

Subject	Course Code	Course Name	Credits Assigned			Teaching Scheme (Hrs/ week)	
			Theory	Practical	Total	Theory (Hrs/ Week)	Practical (Hrs/ Week/Batch)
Major	SBIOC-401	Basics of Bioinformatics	04	--	04	04	--
	SBIOC-402	Biochemistry	04	--	04	04	--
	SBIOC-403	Cell and Molecular Biology	04	--	04	04	--
Elective (DSE)	SBIOE-401 SBIOE-403	Statistics **OR** Mathematics	03	--	03	03	--
Research Methodology	SVECR-401	Research Methodology	03	--	03	03	
DSC Practical	SBIOP-401	Lab Course in Basics of Bioinformatics	--	01	01	--	02
	SBIOP-402	Lab Course in Biochemistry	--	01	01	--	02
	SBIOP-403	Lab Course in Cell and Molecular Biology	--	01	01	--	02
DSE Practical	SBIOE-402 SBIOE-404	Lab Course in Statistics **OR** Lab Course in Mathematics	--	01	01	--	02
Total Credits			**18**	**04**	**22**	**18**	**08**

M. Sc. First Year Semester I (Level 6.0)

Examination Scheme

[20% Continuous Assessment (*CA)* and 80% End Semester Assessment (*ESA*)]

Subject	Course Code	Course Name	Theory				Practical		Total
			Continuous Assessment (CA)			ESA			
			Test I	Test II	Avg of (T1+T2)/2	Total	CA	ESA	
Major	SBIOC-401	Basics of Bioinformatics	20	20	20	80	--	--	100
	SBIOC-402	Biochemistry	20	20	20	80	--	--	100
	SBIOC-403	Cell and Molecular Biology	20	20	20	80	--	--	100
Elective (DSE)	SBIOE-401 SBIOE-403	Statistics **OR** Mathematics	15	15	15	60	--	--	75
Research Methodology	SVECR-401	Research Methodology	15	15	15	60	--	--	75
DSE Practical	SBIOP-401	Lab Course in Basics of Bioinformatics	--	--	--	--	05	20	25
	SBIOP-402	Lab Course in Biochemistry	--	--	--	--	05	20	25
	SBIOP-403	Lab Course in Cell and Molecular Biology	--	--	--	--	05	20	25
DSE Practical	SBIOE-402 SBIOE-404	Lab Course in Statistics **OR** Lab Course in Mathematics	--	--	--	--	05	20	25

M. Sc. First Year Semester II (Level 6.0)

Teaching Scheme

Subject	Course Code	Course Name	Credits Assigned			Teaching Scheme	
			Theory	Practical	Total	Theory (Hrs/ Week)	Practical (Hrs/ Week/Batch)
Major	SBIOC-451	Programming in C	04	--	04	04	--
	SBIOC-452	Databases and Tools in Bioinformatics	04	--	04	04	--
	SBIOC-453	Immunology and Parasite Bioinformatics	04	--	04	04	--
Elective (DSE)	SBIOE-451 SBIOE-453	Structural Bioinformatics **OR** Programming in C++	03	--	03	03	--
On Job Training/ Field Project/ Case Study	SBIOX-451	On Job Training (O) / Field Project(F)/ Case Study (C))	--	03	03	--	03
DSC Practical	SBIOP-451	Lab Course in Programming in C	--	01	01	--	02
	SBIOP-452	Lab Course in Databases and Tools in Bioinformatics	--	01	01	--	02
	SBIOP-453	Lab Course in Immunology and Parasite Bioinformatics	--	01	01	--	02
DSE Practical	SBIOE-452 SBIOE-454	Lab Course in Structural Bioinformatics **OR** Lab Course in Programming in C++	--	01	01	--	02
Total Credits			**15**	**07**	**22**	**15**	**11**

M. Sc. First Year Semester II (Level 6.0)

Examination Scheme

[20% Continuous Assessment (*CA)* and 80% End Semester Assessment (*ESA*)]

Subject	Course Code	Course Name	Theory				Practical		Total
			Continuous Assessment (CA)			ESA			
			TestI	Test II	Avg of (T1+T2)/ 2	Total	CA	ESA	
Major	SBIOC-451	Programming in C	20	20	20	80	--	--	100
	SBIOC-452	Databases and Tools in Bioinformatics	20	20	20	80	--	--	100
	SBIOC-453	Immunology and Parasite Bioinformatics	20	20	20	80	--	--	100
Elective (DSE)	SBIOE-451 SBIOE-453	Structural Bioinformatics **OR** Programming in C++	15	15	15	60	--	--	75
On Job Training/ Field Project/ Case Study	SBIOX-451	On Job Training (O) / Field Project(F)/ Case Study (C))	--	--	--	--	15	60	75
DSC Practical	SBIOP-451	Lab Course in Programming in C	--	--	--	--	05	20	25
	SBIOP-452	Lab Course in Databases and Tools in Bioinformatics	--	--	--	--	05	20	25
	SBIOP-453	Lab Course in Immunology and Parasite Bioinformatics	--	--	--	--	05	20	25
DSE Practical	SBIOE-452 SBIOE-454	Lab Course in Structural Bioinformatics **OR** Lab Course in Programming in C++	--	--	--	--	05	20	25

SBIOC-401 Basics of Bioinformatics
Teaching Scheme

Course Code	Course Name	Teaching Scheme (Hrs.)		Credits Assigned		
		Theory	Practical	Theory	Practical	Total
SBIOC-401	Basics of Bioinformatics	04	--	04	--	04

Assessment Scheme

Course Code	Course Name	Theory				Practical		Total
		CA			ESA			
		Test I	Test II	Avg of (T1+T2)/2		CA	ESA	
SBIOC-401	Basics of Bioinformatics	20	20	20	80	--	--	100

Course pre-requisite:

- Basic Knowledge of Biology with familiarity with genetics, molecular biology, and cell biology.
- Basic Knowledge of Mathematics and Statistics
- Basic Logical and Analytical Thinking in Computer science
- Basic Knowledge of Basic Computer Skills

Course objectives:

- To develop computer literacy skills among students, ensuring they have a basic understanding of computer hardware and software
- To familiarize the students with different operating systems such as Windows, macOS and Linux.
- To familiarize the students how to navigate the internet, search for information effectively. They understand concepts such as web browsing, search engines, online safety, and email etiquette.
- To introduce the students to foundational understanding of the field of bioinformatics, its interdisciplinary nature, biological databases and its applications in biological research.

Course outcomes: Students will be able to

- Develop computer literacy skills with basic understanding of computer hardware and software.
- Learn different operating systems such as Windows, macOS and Linux.
- Know how to navigate the internet, search for information effectively. They will also understand concepts such as web browsing, search engines, online safety, and email etiquette.
- Know foundational understanding of the field of bioinformatics, its interdisciplinary nature, biological databases and its applications in biological research.

Curriculum Details:

Module No.	Unit No.	Topic	Hrs.
1.0	1	**Introduction to Computer Science:**	15
	1.1	Overview of computer systems and their components	
	1.2	History and evolution of computing	
	1.3	Introduction to algorithms and problem-solving techniques	
	1.4	Introduction to programming languages and software development	
2.0	2	**Internet and Programming Fundamentals:**	15
	2.1	Introduction to the Internet; Internet Protocols; World Wide Web (WWW)	
	2.2	Internet Security; Email and Communication Protocols; Cloud Computing	
	2.3	Programming concepts such as variables, data types, operators, and control structures	
	2.4	Object-oriented programming (OOP) concepts like classes, objects, and inheritance	
3.0	3	**Introduction to Bioinformatics:**	15
	3.1	Definition and scope of bioinformatics	
	3.2	History of bioinformatics	
	3.3	Nature of biological data.	
	3.4	Applications of bioinformatics in biological research	
4.0	4	**Biological Databases and Ethical/Legal Considerations:**	15
	4.1	Sequence and structure databases	
	4.2	Retrieving information from GenBank, UniProt, and other databases	
	4.3	Sequence alignment algorithms	
	4.4	Data privacy, security, Ethical/Legal Considerations in bioinformatics	
		Total	60

References

1. Xiong J. Essential bioinformatics. Cambridge University Press; 2006 Mar 13.
2. Lesk, Arthur M. Introduction to Bioinformatics. Oxford University Press, 2018.
3. Claverie JM, Notredame C. Bioinformatics for dummies. John Wiley & Sons; 2006 Dec 18.
4. Sinha PK, Sinha P. Computer fundamentals. BPB publications; 2010.
5. Brookshear JG. Computer science: An overview. Benjamin-Cummings Publishing Co., Inc.; 1991 Jan 3.
6. Rajaraman V, Adabala N. Fundamentals of computers. PHI Learning Pvt. Ltd.; 2014 Dec 15.
7. Dale NB, Lewis J. Computer science illuminated. Jones & Bartlett Learning; 2007.
8. Abelson H, Sussman GJ. Structure and interpretation of computer programs. The MIT Press; 1996 Jul 25.

SBIOP-401 Lab course in Basics of Bioinformatics

Basic Algorithms:

1. Implementing sorting algorithms like bubble sort, selection sort, or insertion sort
2. Solving basic algorithmic problems, such as finding the maximum or minimum element in an array
3. Applying problem-solving strategies (e.g., divide and conquer, dynamic programming) to solve simple computational problems
4. Implementing a stack or queue data structure using arrays or linked lists
5. Implementing a simple binary search tree and performing basic operations (e.g., insertion, deletion, searching)

Internet Basics:

1. Web Browsing and Navigation: Using web browsers to access websites and navigate through web pages; Exploring different browser features, such as bookmarks, tabs, and history; Performing searches using search engines and understanding search results
2. Basic HTML Web Page Creation: Creating a simple webpage using HTML tags and elements; Adding headings, paragraphs, images, and links to the webpage; Creating a web form with HTML to collect user input; Styling the webpage using CSS to control the layout and appearance
3. Online Communication and Collaboration: Using instant messaging applications to communicate with others in real-time; Participating in online forums, discussion boards, or social media platforms; Interacting with social media content, such as liking, sharing, and commenting on posts; Collaborating on shared documents or projects using online collaboration tools (e.g., Google Docs, Microsoft Office 365)

Sequence Retrieval and Analysis:

1. Use the NCBI website to retrieve a DNA or protein sequence of interest.
2. Perform a basic sequence alignment using tools like BLAST or Clustal Omega.
3. Analyze the alignment results to identify conserved regions or sequence similarities.

Database Searching and Annotation:

1. Search a protein sequence in the UniProt database to retrieve information about its function, domains, and known interactions.
2. Annotate a DNA sequence using the NCBI's Prokaryotic Genome Annotation Pipeline (PGAP) or similar tools.
3. Download a bacterial genome sequence from a database like NCBI.

SBIOC-402 Biochemistry
Teaching Scheme

Course Code	Course Name	Teaching Scheme (Hrs.)		Credits Assigned		
		Theory	Practical	Theory	Practical	Total
SBIOC-402	Biochemistry	04	--	04	--	04

Assessment Scheme

Course Code	Course Name	Theory				Practical		Total
		CA			ESA			
		Test I	Test II	Avg of (T1+T2)/2		CA	ESA	
SBIOC-402	Biochemistry	20	20	20	80	--	--	100

Course pre-requisite:
- Basic knowledge of Proteins and Enzymes.
- Understanding of fundamental concepts in Back bone of Biomolecules

Course objectives:
- To understand the principles of biophysical chemistry
- To explore the composition and structure of biomolecules
- To gain knowledge of enzyme kinetics and protein conformation

Course outcomes: Students will be able to
- Students will be able to analyse and interpret concepts related to pH, buffers, reaction kinetics, thermodynamics, and colligative properties, applying these principles to biological systems.
- Students will critically evaluate and analyse the composition, structure, and function of biomolecules, understanding their role in cellular processes and biochemical reactions.
- Students will apply their understanding of enzyme kinetics, enzyme regulation, and protein conformation to analyse and predict enzymatic reactions, interpret experimental data, and comprehend the relationship between protein structure and function.

Curriculum Details:

Module No.	Unit No.	Topic	Hrs.
1.0		Unit I	15
	1.1	Principles of biophysical chemistry: pH, buffer, reaction kinetics	
	1.2	Thermodynamics, colligative properties	
	1.3	Structure of atoms, molecules and chemical bonds.	
	1.4	Composition, structure and function of biomolecules (carbohydrates, lipids, proteins, nucleic acids and vitamins)	
2.0		Unit II	15
	2.1	Stabilizing interactions: Van der Waals, electrostatic	
	2.2	Stabilizing interactions: hydrogen bonding, hydrophobic interaction, etc	
	2.3	Bioenergetics: Glycolysis, oxidative phosphorylation	
	2.4	Coupled reaction, group transfer, biological energy transducers	
3.0		Unit III	15
	3.1	Principles of catalysis: Enzymes and enzyme kinetics	
	3.2	Enzyme regulation, mechanism of enzyme catalysis	
	3.3	Measurement of enzyme activity	
	3.4	Cofactors: their structure and role; ribozymes, isozymes, abzymes	
4.0		Unit IV	15
	4.1	Conformation of proteins: Ramachandran plot	
	4.2	Secondary structure, domains, motif and folds	
	4.3	Conformation of nucleic acids (helix (A, B, Z), t-RNA, micro-RNA	
	4.4	Stability of proteins and nucleic acids	
		Total	60

References

1. Nelson, D. L., Cox, M. M., Lehninger, A. L., & Michael, C. Principles of Biochemistry. W.H. Freeman and Company, 2017.
2. Berg, J. M., Tymoczko, J. L., Gatto, G. J., & Stryer, L. Biochemistry. W.H. Freeman and Company, 2019.
3. Voet, D., Voet, J. G., & Pratt, C. W. Fundamentals of Biochemistry: Life at the Molecular Level. John Wiley & Sons, 2016.
4. Garrett, R. H., & Grisham, C. M. Biochemistry. Cengage Learning, 2016.
5. Campbell, M. K., Farrell, S. O., & McDougal, W. G. Biochemistry. Cengage Learning, 2019.
6. Champe, P. C., Harvey, R. A., & Ferrier, D. R. Lippincott's Illustrated Reviews: Biochemistry. Lippincott Williams & Wilkins, 2014.
7. Berg, J. M., Tymoczko, J. L., & Gatto, G. J. Stryer, L. Biochemistry: A Short Course. W.H. Freeman and Company, 2019.
8. Lippard, S. J., & Berg, J. M. Principles of Bioinorganic Chemistry. University Science Books, 2019.
9. Cox, M. M., Lehninger, A. L., Nelson, D. L., & Michael, C. Lehninger Principles of Biochemistry. W.H. Freeman and Company, 2017

SBIOP 402 Lab course in Biochemistry

1. Determination of pH and Buffer Capacity: Experimental Analysis of pH and Buffer Solutions
2. Kinetics of Enzymatic Reactions: Investigating the Rate of Enzyme-Catalyzed Reactions
3. Thermodynamics and Colligative Properties: Study of Osmotic Pressure and Colligative Properties of Solutions
4. Molecular Structure and Chemical Bonds: Analysis of Molecular Structure and Bonding Interactions
5. Biomolecules: Characterization of Carbohydrates, Lipids, Proteins, Nucleic Acids, and Vitamins
6. Interactions in Biomolecules: Exploration of Van der Waals, Electrostatic, Hydrogen Bonding, and Hydrophobic Interactions
7. Bioenergetics: Investigating Glycolysis and Oxidative Phosphorylation Pathways
8. Group Transfer and Biological Energy Transducers: Analysis of Coupled Reactions and Energy Transduction Processes
9. Enzyme Kinetics and Regulation: Determining Enzyme Activity and Investigating Enzyme Regulation Mechanisms
10. Protein and Nucleic Acid Conformation: Understanding Secondary Structure, Domains, Motifs, and Stability Analysis

SBIOC-403 Cell and Molecular Biology
Teaching Scheme

Course Code	Course Name	Teaching Scheme (Hrs.)		Credits Assigned		
		Theory	Practical	Theory	Practical	Total
SBIOC-403	Cell and Molecular Biology	04	--	04	--	04

Assessment Scheme

Course Code	Course Name	Theory				Practical		Total
		CA			ESA			
		Test I	Test II	Avg of (T1+T2)/2		CA	ESA	
SBIOC-403	Cell and Molecular Biology	20	20	20	80	--	--	100

Course pre-requisite:

- Basic understanding of cell biology
- Familiarity with molecular biology
- Proficiency in bioinformatics tools

Course objectives:

- To understand membrane structure and intracellular organelles
- To explore the organization of genes and chromosomes
- To gain knowledge of DNA replication, transcription, and translation

Course outcomes:

- Students will be able to analyze and interpret the structure and function of cell membranes, intracellular organelles, genes, and chromosomes, understanding their roles in cellular processes and molecular functions.
- Students will critically evaluate and analyze the processes of DNA replication, repair, recombination, transcription, and translation. They will interpret experimental data related to these processes and understand their regulation and control.
- Students will apply their knowledge of bioinformatics tools to analyze and interpret DNA sequences, identify regulatory elements, and analyze gene expression patterns. They will gain practical skills in using bioinformatics software for data analysis related to cellular and molecular processes.

Curriculum Details:

Module No.	Unit No.	Topic	Hrs.
1.0		Unit I	15
	1.1	Membrane structure and function: Structure of model membrane, lipid bilayer and membrane protein diffusion, osmosis, ion channels, active transport, membrane pumps	
	1.2	Mechanism of sorting and regulation of intracellular transport, electrical properties of membranes	
	1.3	Structural organization and function of intracellular organelles: Cell wall, nucleus, mitochondria, Golgi bodies, lysosomes, endoplasmic reticulum,	
	1.4	Structural organization and function of intracellular organelles: peroxisomes, plastids, vacuoles, chloroplast; structure & function of cytoskeleton and its role in motility.	
2.0		Unit II	15
	2.1	Organization of genes and chromosomes: Operon, unique and repetitive DNA	
	2.2	Interrupted genes, gene families, structure of chromatin and chromosomes, heterochromatin, euchromatin, transposons	
	2.3	Cell division and cell cycle: Mitosis and meiosis, their regulation	
	2.4	Steps in cell cycle, regulation and control of cell cycle	
3.0		Unit III	15
	3.1	DNA replication, repair and recombination: Unit of replication, enzymes involved, replication origin and replication fork, fidelity of replication, extra-chromosomal replicons	
	3.2	DNA damage and repair mechanisms, homologous and site-specific recombination	
	3.3	RNA synthesis and processing: Transcription factors and machinery, formation of Initiation complex, transcription activator and repressor, RNA polymerases, capping, elongation, and termination,	
	3.4	RNA processing, RNA editing, splicing, and polyadenylation, structure and function of different types of RNA, RNA transport	
4.0		Unit IV	15
	4.1	Protein synthesis and processing (Ribosome, formation of initiation complex, initiation factors and their regulation, elongation and elongation factors, termination	
	4.2	Genetic code, amino-acylation of tRNA, tRNA-identity, aminoacyl tRNA synthetase, and translational proof-reading, translational inhibitors, Post-translational modification of proteins	
	4.3	Control of gene expression at transcription and translation level: Regulating the Expression of phages, viruses, prokaryotic and eukaryotic genes	
	4.4	Role of chromatin in gene expression and gene silencing.	
		Total	60

Reference:

1. Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. Molecular Biology of the Cell. 6th ed., Garland Science, 2014.
2. Cooper, G. M., & Hausman, R. E. The Cell: A Molecular Approach. 7th ed., Sinauer Associates, 2019.

3. Lodish, H., Berk, A., Kaiser, C. A., Krieger, M., Bretscher, A., Ploegh, H., & Matsudaira, P. Molecular Cell Biology. 8th ed., W.H. Freeman and Company, 2016.
4. Pollard, T. D., Earnshaw, W. C., Lippincott-Schwartz, J., & Johnson, G. T. Cell Biology. 3rd ed., Elsevier, 2017.
5. Deshmukh, M. Indian Biology: Maharashtra State Bureau of Textbook Production and Curriculum Research, 2020.
6. Prakash, N. R. Cell Biology. S. Chand Publishing, 2012.
7. Nadkarni, V. B., & Abraham, B. M. Cell Biology. New Age International Publishers, 2013.
8. Ramachandran, S. Cell and Molecular Biology. Alpha Science International Ltd, 2013.
9. Puri, S., Verma, N., & Gupta, P. P. Cell Biology, Genetics, Molecular Biology, Evolution & Ecology. S. Chand Publishing, 2018.

SBIOP-403 Lab Course in Cell and Molecular Biology

1. Membrane Dynamics: Investigating Lipid Bilayers, Diffusion, and Osmosis
2. Protein Sorting and Intracellular Transport: Mechanisms and Regulation
3. Exploring Intracellular Organelles: Nucleus, Mitochondria, Golgi Bodies, and Lysosomes
4. Cytoskeleton and Cellular Motility: Structure, Function, and Experimental Analysis
5. Genes, Chromosomes, and DNA Organization: Operons, Repetitive DNA, and Transposons
6. Cell Division and Cell Cycle Analysis: Mitosis, Meiosis, and Regulation
7. DNA Replication, Repair, and Recombination: Mechanisms and Molecular Analysis
8. RNA Synthesis and Processing: Transcription Factors, RNA Polymerases, and RNA Modification
9. Protein Synthesis and Processing: Ribosomes, Initiation Complex, Elongation, and Post-Translational Modification
10. Gene Expression Control: Transcriptional and Translational Regulation, Chromatin Dynamics

SBIOE-401 Statistics

Teaching Scheme

Course Code	Course Name	Teaching Scheme (Hrs.)		Credits Assigned		
		Theory	Practical	Theory	Practical	Total
SBIOE-401	Statistics	03	--	03	--	03

Assessment Scheme

Course Code	Course Name	Theory				Practical		Total
		CA			ESA			
		Test I	Test II	Avg of (T1+T2)/2		CA	ESA	
SBIOE-401	Statistics	15	15	15	60	--	--	75

Course pre-requisite:

- Basic knowledge of mathematics
- Understanding of probability and statistics
- Proficiency in bioinformatics tools

Course objectives:

- To understand statistical concepts and methods
- To apply statistical methods in biostatistics
- To gain proficiency in mathematical methods for data analysis

Course outcomes:

- Students will be able to analyze and interpret biological data using statistical techniques such as measures of central tendency and dispersion, probability distributions, and different statistical tests. They will understand how to apply these methods to draw meaningful conclusions from the data.
- Students will critically evaluate the significance of their results by applying appropriate statistical tests. They will be able to determine the levels of significance, interpret p-values, and make informed decisions based on statistical analysis.
- Students will apply mathematical methods such as coordinate geometry, vector algebra, matrix algebra, and numerical methods for solving equations to analyze and manipulate biological and bioinformatics data. They will gain practical skills in using mathematical tools for data analysis and interpretation.

Curriculum Details:

Module No.	Unit No.	Topic	Hrs.
1.0		Unit I	11
	1.1	Measures of central tendency and dispersal; probability distributions (Binomial, Poisson and normal)	
	1.2	Sampling distribution	
	1.3	Difference between parametric and non-parametric statistics	
	1.4	Confidence Interval; Errors	
2.0		Unit II	12
	2.1	Levels of significance	
	2.2	Regression and Correlation	
	2.3	t-test; Analysis of variance; X2 test	
	2.4	Basic introduction to Multivariate statistics, etc.	
3.0		Unit III	11
	3.1	Coordinate geometry with basic concepts of 2D and 3D geometry	
	3.2	Vector algebra Addition and subtraction of vectors	
	3.3	Dot and cross product	
	3.4	Scalar triple product.	
4.0		Unit IV	11
	4.1	Matrix algebra: basic definitions, matrix operations, transpose of a matrix, inverse of matrix	
	4.2	Eigen values, Boolean algebra	
	4.3	Geometric and Arithmetic Progression	
	4.4	Solution of equation by bisection method, Iteration method, Newton Raphson method, numerical differentiation	
		Total	45

References

1. Agresti, A., & Franklin, C. Statistics: The Art and Science of Learning from Data. 4th ed., Pearson, 2020.
2. Field, A., Miles, J., & Field, Z. Discovering Statistics Using R. 3rd ed., SAGE Publications Ltd, 2016.
3. Gupta, S. C., & Kapoor, V. K. Fundamentals of Mathematical Statistics. 11th ed., Sultan Chand & Sons, 2020.
4. Aggarwal, Y. P. Probability and Statistics. 4th ed., Wiley Eastern Ltd., 2016.
5. Navidi, W. M. Statistics for Engineers and Scientists. 4th ed., McGraw-Hill Education, 2019.
6. Das, S., & Das, A. Introduction to Statistics. McGraw-Hill Education, 2017.
7. Natrella, M. G. Experimental Statistics. Dover Publications, 1983.
8. Bhattacharya, G. K., & Johnson, R. A. Statistics: Principles and Methods. 7th ed., Wiley, 2017.
9. Jhunjhunwala, A., & Misra, S. K. Statistical Methods: Concepts, Application and Implementation. Wiley, 2020.

SBIOE -402 Lab Course in Statistics

1. Graphical Representation of data
2. Measures of Central tendency
3. Measures of Dispersion
4. Moments, Skewness and Kurtosis
5. Correlation and Regression
6. Test of Significance
7. Analysis of Variance(One way and Two way classification)
8. Sampling Methods

SBIOE-403 Mathematics

Teaching Scheme

Course Code	Course Name	Teaching Scheme (Hrs.)		Credits Assigned		
		Theory	Practical	Theory	Practical	Total
SBIOE-403	Mathematics	03	--	03	--	03

Assessment Scheme

Course Code	Course Name	Theory				Practical		Total
		CA			ESA			
		Test I	Test II	Avg of (T1+T2)/2		CA	ESA	
SBIOE-403	Mathematics	15	15	15	60	--	--	75

Course pre-requisite:

- Basic knowledge of mathematics
- Understanding of probability and statistics
- Proficiency in bioinformatics tools

Course objectives:

- To understand statistical concepts and methods
- To understanding of number theory
- To familiarize with Python programming

Course outcomes:

- Students will be able to analyse and interpret biological data using mathematical techniques such as matrices, determinants, vectors, series, geometry, and trigonometry. They will develop the skills to use these tools to extract meaningful information from biological datasets.
- Students will apply mathematical principles to solve bioinformatics problems related to DNA sequences, evolutionary tree analysis, and database computations. They will be able to formulate problems in mathematical terms and develop appropriate solutions using mathematical concepts.
- Students will gain proficiency in using Python programming language for computational thinking in bioinformatics. They will develop the skills to implement mathematical algorithms, perform calculations, and visualize data using Python, enhancing their ability to solve complex bioinformatics problems.

Curriculum Details:

Module No.	Unit No.	Topic	Hrs.
1.0		Unit I	11
	1.1	Linear Algebra: Matrices and Determinants, Minors and cofactors	
	1.2	Eigen values and Eigen vectors, Series (AP and GP)	
	1.3	Limits, Logarithms.	
	1.4	Vector Algebra: Vector and Scalar, Dot and cross product, Vector differentiation, Gradient, divergent and curl, vector	
2.0		Unit II	12
	2.1	Geometry: Coordinate geometry, Straight line, Circle, Parabola, Ellipse, Hyperbola, Polar co-ordinates, Sphere	
	2.2	Demonstrate the use mathematical tools for DNA Sequences	
	2.3	Demonstrate the use of linear algebra in database and computation	
	2.4	Demonstrate the use of python for Computational thinking	
3.0		Unit III	11
	3.1	Demonstrate the use trigonometric function	
	3.2	Formulate problems in the language of sets and perform set operations	
	3.3	Number systems, Real numbers, Rational numbers and Complex numbers	
	3.4	(Application in Numerical encoding of DNA Sequence), Solving equations- first-order equations	
4.0	4	Quadratic Equations, Simultaneous linear equations(Application in Evolutionary Tree)	11
	4.1	Linear Algebra: Scalars &Vectors, addition, subtraction, dot, cross & scalar triple products, Matrices,	
	4.2	Inverse of a matrix, Operations, solution of simultaneous equation by using matrix.	
	4.3	Applications of Linear Algebra in Sequence Alignment and Comparative Genomics	
	4.4	how these concepts can be applied to analyze and interpret biological sequences, such as DNA, RNA, and protein sequences	
			45

References

1. Olive J. (2000), Maths: A Self-study Guide, Cambridge University Press.
2. S. [1998], Schaum's outline Theory and Problems of Pre-calculus, Tata McGraw Hill.
3. George, S. T., & Balasubramanian, K. (2019). Practical Linear Algebra: A Geometry Toolbox. CRC Press.
4. Dawn Griffiths. (2008), Head First Statistics, O'Reilly Media Inc.
5. P. Abbot & H. Neill. (2003), Teach Yourself Trigonometry, McGraw Hill
6. Sharma, R. K. (2017). Practical Vector Analysis: Examples and Exercises. S. Chand Publishing.
7. Singh, P. K., & Gupta, S. C. (2018). Mathematical Methods in Biology: A Practical Guide. Springer.
8. Sengupta, S., & Bhattacharya, S. K. (2016). Practical Trigonometry: With Applications in DNA Sequencing. PHI Learning.

9. Mukhopadhyay, A., & Ghosh, S. K. (2015). Mathematical Modelling and Computational Biology: A Practical Approach. CRC Press.

SBIOE-404 Lab Course in Mathematics

1. Practical 1: Introduction to Linear Algebra and Vector Algebra in
2. Practical 2: Application of Linear Algebra
3. Practical 3: Computational Thinking with Python
4. Practical 4: Trigonometric Functions and their Applications
5. Practical 5: Set Theory and its Role in Problem Formulation
6. Practical 6: Number Systems and Equations
7. Practical 7: Matrix Operations and Simultaneous Equations
8. Practical 8: Geometry and its Relevance
9. Practical 9: Number Theory and its Application
10. Practical 10: Introduction to Logarithms and their Significance

SVECR-401 Research Methodology

Teaching Scheme

Course Code	Course Name	Teaching Scheme (Hrs.)		Credits Assigned		
		Theory	Practical	Theory	Practical	Total
SVECR401	Research Methodology	03	--	03	--	03

Assessment Scheme

Course Code	Course Name	Theory				Practical		Total
		CA			ESA			
		Test I	Test II	Avg of (T1+T2)/2		CA	ESA	
SVECR401	Research Methodology	15	15	15	60	--	--	75

Course pre-requisite:

- The course requires prior knowledge, and foundational understanding of Bioinformatics. It is essential to contextualizing their research and formulating relevant research questions.
- Basic knowledge and understanding of statistics, communicative English, and computer awareness are essential.

Course Objectives:

- To familiarize the students with fundamental research concepts, such as hypothesis formulation, data collection, and data analysis.
- To inculcate, understand, and apply principles of research methodology learning the necessary skills to conduct rigorous and effective research in their respective fields..

Course Outcomes:

- Students will develop critical thinking abilities, learn various research methods, and acquire the tools required to design and execute research projects

Curriculum Details:

Module No.	Unit No.	Topic	Hrs.
1.0	1	**Introduction to Research**	11
	1.1	Foundations of Research: Meaning, Objectives, Introduction and definition of research	
	1.2	General characteristic and functions of research	
	1.3	Objectives and types of research	
	1.4	Scientific and reflective thinking	
2.0	2	**The Research Problem**	11
	2.1	Identification, source, and criteria for selection, characteristics of problem	
	2.2	Hypothesis: meaning. nature, function, formulation, and testing	
	2.3	Research proposal or synopsis	
	2.4	Literature review: objectives, principles, procedure, and sources	
3.0	3	**Collection and Analysis of Data**	12
	3.1	Data: methods of Collection and techniques	
	3.2	Qualitative and quantitative data analysis	
	3.3	Experimental data and regression analysis	
	3.4	Sampling - Simple Random Sample, Systematic Sample, Stratified Random Determining size of the sample, sample size	
4.0	4	**The Research Report**	11
	4.1	Format, Process, Style, Form	
	4.2	Contents of Research Paper, Reports, and Theses	
	4.3	Interpretation of Data and Paper Writing- Layout of a Research Paper, Impact factor of Journals	
	4.4	When and where to publish ? Ethical issues related to publishing, Plagiarism and Self-Plagiarism	
		Total	45

Text Books:

1. Kumar, R. Research Methodology: A Step-by-Step Guide for Beginners. 5th ed., SAGE Publications, 2020.
2. Sekaran, U., & Bougie, R. Research Methods for Business: A Skill-Building Approach. 8th ed., Wiley, 2021.
3. Deshwal, P., & Verma, J. Research Methodology: A Practical Approach. Pearson, 2021.
4. Kothari, C. R. Research Methodology: Methods and Techniques. 3rd ed., New Age International Publishers, 2014.
5. Neuman, W. L. Social Research Methods: Qualitative and Quantitative Approaches. 7th ed., Pearson, 2019.
6. Tripathi, P. C. Research Methodology. 4th ed., Anmol Publications, 2017.
7. Creswell, J. W. Research Design: Qualitative, Quantitative, and Mixed Methods Approaches. 5th ed., SAGE Publications, 2018.

8. Mangal, S. K., & Mangal, U. Research Methodology: Concepts and Cases. PHI Learning Pvt. Ltd., 2016.
9. Ghauri, P., & Gronhaug, K. Research Methods in Business Studies: A Practical Guide. 5th ed., Pearson, 2017.
10. Singh, Y. K. Research Methodology: A Step-by-Step Guide for Beginners. Kalyani Publishers, 2020.

SEMESTER II

SBIOC-451 Programming in C
Teaching Scheme

Course Code	Course Name	Teaching Scheme (Hrs.)		Credits Assigned		
		Theory	Practical	Theory	Practical	Total
SBIOC-451	Programming in C	04	--	04	--	04

Assessment Scheme

Course Code	Course Name	Theory				Practical		Total
		CA			ESA			
		Test I	Test II	Avg of (T1+T2)/2		CA	ESA	
SBIOC 451	Programming in C	20	20	20	80	--	--	100

Course pre-requisite:

- Familiarity with fundamental programming concepts such as variables, data types, control structures (if-else, loops), and functions will help you understand C programming better.
- Understanding basic algorithms and problem-solving techniques
- Basic understanding of mathematical concepts like arithmetic operations, logic, and boolean algebra will help you work with mathematical operations and expressions in C.

Course objectives:

- To familiarize the students in understanding programming fundamentals
- To developing Problem-Solving Skills in students
- To master the students in C Language

Course outcomes: The students shall be able to

- Learn C Language which helps the students to develop a strong understanding of these fundamental concepts.
- This will also enhance students problem-solving abilities and approach to solve real-world problems using programming.
- Develop skills in C programming which are highly valued in various industries such as software development, embedded systems, game development, and systems programming.

Curriculum Details:

Module No.	Unit No.	Topic	Hrs.
1.0	1	**Introduction to C Programming:**	15
	1.1	History and features of the C programming language; Structure of a C program; Compiling and executing a C program;	
	1.2	Variables, Data Types, and Operators: Basic data types, Arithmetic, relational, logical, and assignment operators, Typecasting and conversion	
	1.3	Control Structures: Decision-making with if-else statements, Switch statement; Looping constructs: for, while, do-while; Break and continue statements	
	1.4	Arrays and Strings: Declaring and accessing arrays, Multidimensional arrays, String handling and manipulation, String functions from the standard library	
2.0	2	**Pointers and Functions:**	15
	2.1	Introduction to pointers; Pointer arithmetic; Dynamic memory allocation: malloc, calloc, realloc, free	
	2.2	Dynamic memory allocation: malloc, calloc, realloc, free; Pointers and arrays	
	2.3	Functions: Defining and calling functions, Function prototypes	
	2.4	Return values and parameters; Recursion	
3.0	3	**Structures and Unions:**	
	3.1	Defining and using structures	
	3.2	Accessing structure members	
	3.3	Structures as function parameters	
	3.4	Unions and their applications	
4.0	4	**File Handling and Pre-processor Directives:**	15
	4.1	Opening and closing files; Reading from and writing to files	
	4.2	Error handling and file operations; File pointer manipulation	
	4.3	Pre-processor Directives: Macro definitions, Conditional compilation	
	4.4	File inclusion and manipulation; Command-line arguments	
		Total	60

Text Books

1. Kanetkar Y. Let us C. BPB publications; 2018 Jun 1.
2. Balagurusamy E. Computing fundamentals and C Programming. McGraw-Hill Education; 2008.
3. Kernighan, Brian W., and Dennis M. Ritchie. "The C programming language." (2002).
4. Perry GM, Miller D. C programming: absolute beginner's guide. Pearson Education; 2014.
5. King KN. C programming: a modern approach. WW Norton & company; 2008 Apr 19.

SBIOP-451 Lab Course in Programming in C

Basic Programs:

1. Start with simple programs that involve input/output operations, arithmetic calculations, and conditional statements. For example, write a program to calculate the area of a triangle, determine whether a number is prime, or find the factorial of a given number. Identification and Characterization of Biomarkers in Genomic Data

Number Manipulation:

1. Create programs that involve number manipulation and mathematical operations.
2. Examples include finding the largest/smallest number in an array, sorting an array of integers, implementing basic calculator functions, or solving mathematical puzzles.

String Manipulation:

1. Practice working with strings and implementing string manipulation functions.
2. Write programs to reverse a string,
3. Check for palindrome strings, count occurrences of a character in a string, or implement string concatenation.

File Handling and Mini Projects:

1. Explore file handling in C by writing programs that read from or write to files. For instance, create a program that reads data from a file and performs specific operations on it, or write a program to generate a report by reading data from multiple files.
2. Challenge yourself with small-scale projects that encompass multiple concepts. Examples include building a simple calculator application, implementing a student management system, creating a tic-tac-toe game, or developing a basic text-based adventure game.

SBIOC-452 Databases and Tools in Bioinformatics

Teaching Scheme

Course Code	Course Name	Teaching Scheme (Hrs.)		Credits Assigned		
		Theory	Practical	Theory	Practical	Total
SBIOC-452	Databases and Tools in Bioinformatics	04	--	04	--	04

Assessment Scheme

Course Code	Course Name	Theory				Practical		Total
		CA			ESA			
		Test I	Test II	Avg of (T1+T2)/2		CA	ESA	
SBIOC-452	Databases and Tools in Bioinformatics	20	20	20	80	--	--	100

Course pre-requisite:

- Basic Knowledge of Biology, Biochemistry and Biostatistics
- Basic Knowledge of Molecular Biology Techniques
- Basic Knowledge of Database Concepts
- Basic Knowledge of Programming Skills

Course objectives:

- To familiarize the students with understanding Bioinformatics Databases
- To expose the students to Learning Database Search Techniques, Data Integration and Visualization.
- To master the students in Biodiversity informatics, genome, gene expression, pathway analysis, Utilizing Web-Based Bioinformatics Tools.
- To expose the students in Next-Generation Sequencing (NGS) Data Analysis, Application of Machine Learning in Bioinformatics.

Course outcomes:

- Students will gain Knowledge of Bioinformatics Databases, Database Search Proficiency
- Students will Learn Database Search Techniques, Data Integration and Visualization.
- Student will become proficient in Protein Structure, genome, gene expression, pathway analysis, Utilizing Web-Based Bioinformatics Tools.
- Students will Learn Next-Generation Sequencing (NGS) Data Analysis, Application of Machine Learning in Bioinformatics.

Curriculum Details:

Module No.	Unit No.	Topic	Hrs.
1.0	1	**Introduction to Bioinformatics and Databases**	15
	1.1	Overview of bioinformatics and its applications in biology and medicine	
	1.2	Introduction to different types of biological databases (nucleotide, protein, genomic, structural, etc.)	
	1.3	Sequence Databases and Analysis: Understanding sequence databases (e.g., NCBI GenBank, UniProt, etc.); Sequence retrieval and formatting	
	1.4	Sequence similarity search algorithms (e.g., BLAST); Multiple sequence alignment techniques	
2.0	2	**Biodiversity informatics, Genomic Databases and Analysis**	15
	2.1	Overview of Biodiversity informatics; Data Collection and Aggregation: Biodiversity informatics integrates data from various sources, including museum collections, herbaria, field surveys, citizen science projects, and scientific literature;	
	2.2	Biodiversity Databases; Data Standards and Protocols	
	2.3	Global Initiatives: Global Biodiversity Information Facility (GBIF); Taxonomic and Species Identification Tools	
	2.4	Genomic Databases and Analysis: Introduction to genomic databases (e.g., Ensembl, UCSC Genome Browser); Functional annotation and analysis of genes and genomes	
3.0	3	**Pathway, Interaction Databases and NGS Data Analysis**	15
	3.1	Overview of pathway databases (e.g., KEGG, Reactome)	
	3.2	Protein-protein interaction networks and their analysis	
	3.3	Introduction to NGS technologies and data formats; Pre-processing of NGS data (quality control, trimming, etc.)	
	3.4	Assembly and alignment of NGS reads	
4.0	4	**Data Mining and Machine Learning in Bioinformatics**	15
	4.1	Introduction to data mining techniques in bioinformatics	
	4.2	Introduction to machine learning techniques in bioinformatics	
	4.3	Applications of machine learning in biological data analysis (classification, clustering, etc.)	
	4.4	Ethical considerations in handling biological data; Intellectual property and data sharing in bioinformatics research	
		Total	60

Reference Books

1. Guatham N “Bioinformatics: Databases And Algorithms”
2. Xiong J. Essential bioinformatics. Cambridge University Press; 2006.
3. Venkatarajan Mathura and Pandjassarame Kangueane “Bioinformatics: A Concept-Based Introduction” by David Edwards and Jason Stajich “Bioinformatics: Tools and Applications”
4. Zhumur Ghosh Bioinformatics: Principles and Applications
5. Soberón, Jorge, and Townsend Peterson. "Biodiversity informatics: managing and applying primary biodiversity data." Philosophical Transactions of the Royal Society of London. Series B: Biological Sciences 359.1444 (2004): 689-698.

6. Curry, Gordon B., and Chris J. Humphries. Biodiversity databases: techniques, politics, and applications. Taylor & Francis, 2007.

SBIOP-452 Lab Course in Databases and Tools in Bioinformatics

1. **Sequence Database Search:** Performing sequence similarity searches using BLAST (Basic Local Alignment Search Tool) and Analyzing BLAST results and understanding E-values, alignments, and hit significance.
2. **Multiple Sequence Alignment:** Aligning multiple protein or nucleotide sequences using tools like ClustalW or MUSCLE and Visualizing and interpreting multiple sequence alignment results
3. **Biodiversity Databases:** Familiarization with biodiversity databases like GBIF (Global Biodiversity Information Facility) and iNaturalist. Searching for species occurrence data and understanding data formats (e.g., Darwin Core).
4. **Taxonomic Data and Species Identification:** Exploring taxonomic databases (e.g., Catalogue of Life) to understand species classifications. Using species identification tools based on molecular data or image recognition.
5. **Genome Browser:** Exploring genomic data using UCSC Genome Browser or Ensembl Genome Browser and Annotating and analyzing gene structures, regulatory elements, and variations
6. **Pathway Analysis:** Analyzing biological pathways using tools like KEGG or Reactome and Identifying overrepresented pathways in a set of genes/proteins.
7. **Web-Based Bioinformatics Tools:** Using web-based tools for tasks such as primer design, motif analysis, and phylogenetic tree construction.
8. **Next-Generation Sequencing (NGS) Data Analysis:** Quality control and preprocessing of NGS data (FASTQ files), Alignment of NGS reads to reference genomes, Variant calling and annotation.
9. **Machine Learning Applications:** Applying machine learning algorithms for tasks such as gene function prediction or disease classification.
10. **Project Work:**
    A. Undertaking a small bioinformatics project that involves applying various databases and tools to analyze real biological data.
    B. Undertaking a small independent project that involves applying biodiversity informatics tools and techniques to address a specific research question.

SBIOC-453: Immunology and Parasite Bioinformatics

Teaching Scheme

Course Code	Course Name	Teaching Scheme (Hrs.)		Credits Assigned		
		Theory	Practical	Theory	Practical	Total
SBIOC-453	Immunology and Parasite Bioinformatics	04	--	04	--	04

Assessment Scheme

Course Code	Course Name	Theory				Practical		Total
		CA			ESA			
		Test I	Test II	Avg of (T1+T2)/2		CA	ESA	
SBIOC-453	Immunology and Parasite Bioinformatics	20	20	20	80	--	--	100

Course pre-requisite:

- Basic knowledge of Biology
- Basic knowledge of Biochemistry
- Basic knowledge of Computer Skills

Course objectives:

- To provide an overview of the major groups of parasitic organisms, their life cycles, and their impact on human and animal health.
- To explore how bioinformatics can contribute to the discovery and design of vaccines against parasitic infections.
- To study the molecular interactions between parasites and their hosts, and the implications for disease pathogenesis.
- To investigate the genomic and genetic mechanisms underlying drug resistance in parasites and strategies to combat it.

Course outcomes:

- Students will acquire an in-depth understanding of various parasitic organisms, their life cycles, and the diseases they cause in humans and animals.
- Students will be able to apply bioinformatics techniques to aid in the discovery and design of vaccines against parasitic infections.
- Students will understand the molecular interactions between parasites and their hosts, and their implications for disease pathogenesis.
- Students will gain insights into the genomic and genetic mechanisms underlying drug resistance in parasites and potential strategies to combat it.

Curriculum Details:

Module No.	Unit No.	Topic	Hrs.
1.0		**Introduction Immunology**	15
	1.1	Immunology – fundamentals and anatomy of immune system Immunity – Innate and acquired immunity.	
	1.2	Components of innate and acquired immunity. Antigen, Haptens, adjuvants, mitogens. Antibodies – structure, functions.	
	1.3	The anatomy of the immune response: - Cells and organs of immune system.	
	1.4	Regulation of immune response: - Humoral and Cell mediated response; Overview of immunology and its importance in human health and disease	
2.0		**Introduction to Immunoinformatics**	15
	2.1	Rational vaccine design using immunoinformatics approaches;	
	2.2	Introduction to bioinformatics and its applications in immunological research	
	2.3	Immunological databases and resources for data retrieval; Prediction of B-cell and T-cell epitopes using computational methods	
	2.4	Introduction to immunoinformatics software and tools	
3.0		**Introduction to Parasitology and Bioinformatics**	15
	3.1	Overview of parasitic organisms and their impact on human and animal health	
	3.2	Introduction to bioinformatics and its applications in parasite research	
	3.3	Overview of bioinformatics tools and databases relevant to parasite genomics	
	3.4	Understanding the evolutionary relationships among different parasite species	
4.0	4	**Host-Parasite Interactions and Pathogenesis**	15
	4.1	Understanding the molecular interactions between parasites and their hosts	
	4.2	Impact of host-parasite interactions on disease pathogenesis	
	4.3	Computational analysis of host-pathogen interactions; Case studies on host-parasite interactions in specific parasitic infections	
	4.4	Understanding the evolutionary relationships among different parasite species	
		Total	60

Reference Books

1. David Male , Immunology
2. John Playfair; Gregory Bancroft, Infection and Immunity
3. Helen Chapel; Mansel Haeney; Siraj Misbah; Neil Snowden Essentials of Clinical Immunology by Immunoinformatics : Brusic viladimer,Rangnathan, Shobha
4. Bajic, Tinvi , Information Processing and living system
5. Flower, Darren R., ed. Immunoinformatics: Predicting immunogenicity in silico. Vol. 409. Springer Science & Business Media, 2008.
6. Bock GR, Goode JA, editors. Immunoinformatics: bioinformatic strategies for better understanding of immune function. John Wiley & Sons; 2004 Mar 5.
7. Stothard, JR. "Parasitology–A Conceptual Approach, By Eric S. Loker and Bruce V. Hofkin, editors, p. 560, 350 illustrations (softback). Garland Science, Taylor & Francis Group, LLC, New York, NY, USA, 2015. ISBN: 978-0-8153-4473-5." Parasitology 142.13 (2015).

SBIOP 453 Lab Course in Immunology and Parasite Bioinformatics

1. **Epitope Prediction:** Students use computational tools and algorithms to predict B-cell and T-cell epitopes in protein sequences. They learn how to identify potential antigenic regions that may be recognized by the immune system.
2. MHC Binding Prediction: Students predict the binding affinity of peptides to Major Histocompatibility Complex (MHC) molecules. This practical helps understand the interaction between MHC molecules and antigenic peptides.
3. **Data Visualization:** Students learn to visualize and interpret immunological data using bioinformatics software and tools. They create informative plots and visualizations for better data understanding.
4. **Structural Immunoinformatics:** Students Study and predict the 3D structure of antibodies or antigen-antibody complexes using bioinformatics tools for structural modelling.
5. Host-Parasite Interaction Analysis: Students explore the molecular interactions between parasites and their hosts using bioinformatics methods. They may analyze protein-protein interaction networks or host immune responses to understand the pathogenesis of parasitic infections.
6. **Comparative Genomics:** Students compare the genomes of different parasite species to identify conserved and unique features. They explore evolutionary relationships and potential adaptations that may impact parasite virulence and pathogenicity.
7. **Transcriptome Analysis:** Students analyze RNA-seq data from parasitic samples to study gene expression profiles and identify differentially expressed genes. They gain insights into the transcriptional regulation of the parasite under various conditions.
8. **Drug Target Prediction:** Students use bioinformatics approaches to identify potential drug targets in parasites. They analyze the parasite's genome and proteome to prioritize candidate proteins for drug development.
9. **Phylogenetic Analysis:** Students construct phylogenetic trees based on genomic or protein sequence data to understand the evolutionary relationships among parasite species. They also interpret the results to infer the parasites' evolutionary history.
10. **Research Project:** In an extended practical project, students may be given real-world parasite genomic data to analyze and interpret. They work on a specific research question related to parasitic infections and present their findings at the end of the project.

SBIOE-451: Structural Bioinformatics
Teaching Scheme

Course Code	Course Name	Teaching Scheme (Hrs.)		Credits Assigned		
		Theory	Practical	Theory	Practical	Total
SBIOE-451	Structural Bioinformatics	03	--	03	--	03

Assessment Scheme

Course Code	Course Name	Theory				Practical		Total
		CA			ESA			
		Test I	Test II	Avg of (T1+T2)/2		CA	ESA	
SBIOE-451	Structural Bioinformatics	15	15	15	60	--	--	75

Prerequisite:

- Students should have very strong foundation in several key areas such as Biology and Biochemistry, Bioinformatics, Chemistry, Mathematics and Statistics, Programming, Biological Databases, Structural Biology Concepts, Visualization Tools, Problem-Solving and Critical Thinking, etc.

Course objectives:

- To expose the students in understanding the Biomolecular Structure.
- To introduce the students to Structural Techniques
- To introduce the students to computational Methods, Visualization and Analysis
- To introduce the students to prediction of structure from sequence

Course outcomes: This course will enable the students to get

- Knowledge of Biomolecular Structure, understanding of structural techniques
- Proficiency in visualization and analysis, ability to predict structure from sequence
- Understanding of protein Function and structure-function relationships, application of structural bioinformatics tools, integration of structural data with other "Omics" data
- Ethical Considerations (Students should be aware of ethical issues related to the use of structural bioinformatics, such as data sharing, privacy, and responsible conduct of research.), Research Skills (If applicable, students should have developed research skills through a research project, allowing them to apply structural bioinformatics concepts in practical scenarios.)

Curriculum Details:

Module No.	Unit No.	Topic	Hrs.
1.0	1	**Introduction to Structural Bioinformatics:**	11
	1.1	Introduction to structural bioinformatics and its significance in biology, Applications of Structural Bioinformatics: Applications of structural bioinformatics in biological research, Structural bioinformatics and disease research	
	1.2	Experimental Techniques in Structural Biology (e.g., X-ray crystallography NMR, cryo EM)	
	1.3	Structural databases and resources (e.g. PDB, SCOP, CATH)	
	1.4	Biomolecular structure file formats (e.g. PDB, mmCIF, MMDB)	
2.0	2	**Protein Structure Visualization and Analysis:**	11
	2.1	Overview of biomolecular structure: primary, secondary, tertiary, and quaternary structures; Three-dimensional structures of DNA and RNA	
	2.2	Visualization and analysis of protein structures using molecular visualization software	
	2.3	Introduction to molecular visualization software (e.g., PyMOL, VMD)	
	2.4	Ramachandran maps	
3.0	3	**Computational Methods in Structural Bioinformatics:**	11
	3.1	Protein secondary structure prediction: Ab Initio-Based and Homology-Based methods; Prediction with Artificial Neural Networks,	
	3.2	Secondary structure prediction of Trans-membrane proteins	
	3.3	Protein Tirtiary Structure Prediction and Methods: Homology Modeling, Threading and Fold Recognition and Ab Initio, RNA structure Prediction	
	3.4	Validation of Prediction using Procheck, ProsaII, CASP	
4.0		**Advanced Structural Bioinformatics:**	12
	4.1	Molecular dynamics simulations: principles and applications;	
	4.2	Protein-ligand interactions: binding sites and drug-target interactions	
	4.3	Integrating structural data with other "omics" data (genomics, transcriptomics, proteomics)	
	4.4	Structural systems biology and network analysis	
		Total	45

Reference Books

1. Burkowski, Forbes. Structural Bioinformatics: An Algorithmic Approach. CRC Press, 2009.
2. Drenth, Jan. Principles of Protein X-Ray Crystallography. Springer Science, 2007.
3. Bourne, Philip E., and Weissig, Helge. Structural Bioinformatics (Methods of Biochemical Analysis). Wiley-Liss, 2003.
4. Höltje, Hans-Dieter et al. Molecular Modelling: Basic Principles and Applications. Wiley-VCH, 2003.
5. Leach, Andrew. Molecular Modelling: Principles and Applications. Prentice Hall, 2001.
6. Friesner, Richard A. Computational Methods for Protein Folding: Advances in Chemical Physics Volume 120. John Wiley & Sons, 2002.
7. Heilmeyer, L. and Friedrich, P. Protein Modules in Cellular Signalling. IOS Press, 2001.

8. Rhodes, Gale. Crystallography Made Crystal Clear, Third Edition: A Guide for Users of Macromolecular Models. Academic Press, 2000.
9. Branden, Carl and Tooze, John. Introduction to Protein Structure. Garland Publishing Inc., 1999.
10. Hill, H.A.O. and Sadler, P.J. (Eds.). Metal Sites in Proteins and Models Redox Centres. Springer, 1999.
11. Sternberg, Michael J. E. Protein Structure Prediction: A Practical Approach. Oxford University Press, 1997.
12. Fasman, G.D. Prediction of Protein Structure and the Principles of Protein Conformation. Plenum Press, 1989.

SBIOE 452 Lab Course in Structural Bioinformatics

1. **Molecular Visualization**: Students use molecular visualization software (e.g., PyMOL, VMD) to visualize and analyze protein and nucleic acid structures. They learn to manipulate the three-dimensional models, highlight specific regions, and observe structural features.
2. **Structure-Based Sequence Analysis**: Students perform sequence alignments of related proteins with known structures to identify conserved regions and predict structural motifs. This practical helps to understand the relationship between sequence and structure.
3. **Homology Modeling**: Students predict the three-dimensional structure of a protein of interest using homology modeling techniques. They retrieve a template structure from a structural database and build a model based on the target protein's sequence.
4. **Structure Validation and Quality Assessment**: Students assess the quality of protein structures obtained from databases or modeling approaches using various validation tools. They learn to identify potential errors and artifacts in the structures.
5. **Ligand Docking**: Students perform docking experiments to predict the binding mode of a ligand to a target protein. They analyze the docking results to understand the interactions between the ligand and the protein's active site. Molecular Dynamics Simulations: Students conduct molecular dynamics simulations of a protein to study its dynamics and behavior over time. They analyze trajectory data to observe changes in the protein's conformation.
6. **RNA Structure Prediction**: Students predict the secondary structure of RNA molecules using bioinformatics tools. They learn about RNA folding and the role of non-coding RNAs.
7. **Membrane Protein Modeling**: Students use bioinformatics methods to predict the three-dimensional structure of membrane proteins. They explore the challenges associated with modeling transmembrane regions.
8. **Protein Function Prediction**: Students use structural information to predict the function of a protein of interest. They relate the structural features to specific functional characteristics.
9. **Integration of Structural Data with "Omics" Data**: Students integrate structural data with other biological data (e.g., genomics, proteomics) to gain insights into cellular processes and signaling pathways.
10. **Case Studies**: Students analyze published research articles where structural bioinformatics played a critical role in understanding biological mechanisms or solving specific biological problems.

SBIOE-453: Programming in C++

Teaching Scheme

Course Code	Course Name	Teaching Scheme (Hrs.)		Credits Assigned		
		Theory	Practical	Theory	Practical	Total
SBIOE-453	Programming in C++	03	--	03	--	03

Assessment Scheme

Course Code	Course Name	Theory				Practical		Total
		CA			ESA			
		Test I	Test II	Avg of (T1+T2)/2		CA	ESA	
SBIOE-453	Programming in C++	15	15	15	60	--	--	75

Course pre-requisite:

- Basic knowledge of Programming Fundamentals
- Basic knowledge of Logic and Problem-Solving
- Basic knowledge of Basic Mathematics

Course objectives:

- To introduce students to the fundamental syntax and features of the C++ programming language, including variables, data types, control structures, functions, classes, and object-oriented programming concepts.
- To teach students how to analyze problems and develop efficient algorithms to solve those using C++ programming constructs.
- To provide students a comprehensive understanding of object-oriented programming principles such as encapsulation, inheritance, polymorphism, and abstraction, and demonstrate how to implement them in C++.

Course outcomes:

- Students will have a solid understanding of the C++ programming language, including its syntax, data types, operators, control structures, functions, and object-oriented programming concepts.
- Students will be able to design and implement classes, use inheritance and polymorphism, and apply object-oriented principles to build modular and maintainable code.
- Students will have improved problem-solving skills, enabling them to analyze complex problems, devise algorithms, and implement solutions using C++ programming constructs.
- Students will be equipped with the ability to continue learning and improving their C++ skills beyond the course, keeping up with advancements and changes in the language.

Curriculum Details:

Module No.	Unit No.	Topic	Hrs.
1.0	1	**Introduction to C++ and Basics:**	12
	1.1	Introduction to C++ and its history; Writing a simple "Hello, World!" program;	
	1.2	Setting up the development environment (IDEs, compilers)	
	1.3	Variables and data types; Input/output using **cin** and **cout;** Basic arithmetic operations	
	1.4	Control Structures: Conditional statements: if, else, else if; Loops: while, do-while, for; Nested loops and loop control statements (break, continue)	
2.0	2	**Arrays, Functions and Pointers**	11
	2.1	Introduction to arrays and their declaration; Accessing array elements and using loops with arrays	
	2.2	Introduction to functions; Function declaration and definition	
	2.3	Function parameters and return values; Function overloading	
	2.4	Introduction to pointers and their importance; Pointer arithmetic and dynamic memory allocation	
3.0	3	**Object-Oriented Programming (OOP):**	11
	3.1	Introduction to OOP and its principles; Creating classes and objects	
	3.2	Class members: data members and member functions; Access specifiers (public, private, protected)	
	3.3	Constructors and destructors; Copy constructor and assignment operator	
	3.4	Inheritance and its types (single, multiple, multilevel); Polymorphism: function overloading and overriding	
4.0	4	**Standard Template Library (STL), File Handling and Exception Handling**	11
	4.1	Introduction to STL and its components; Containers: vector, list, map, set, etc.; Iterators and algorithms: sort, find, for each, etc.	
	4.2	Working with text files (reading and writing); Working with binary files	
	4.3	File stream classes: ifstream, ofstream, fstream; Understanding exceptions and error handling	
	4.4	Try, catch, throw blocks; Custom exception classes	
		Total	45

Reference Books

1. Balagurusamy, E. "Object oriented programming with C++." (2021).
2. Stroustrup, Bjarne. "The C++ Programming Language Fourth Edition." (2013).
3. Meyers, Scott. *Effective C++ CD*. Addison-Wesley Longman Publishing Co., Inc., 1998.
4. Barbara, Stanley B. Lippman Josée Lajoie, and E. Moo. "C++ Primer." (2013).
5. Koenig, Andrew. Accelerated C++: practical programming by example. Pearson Education India, 2000.
6. Vandevoorde, David, and Nicolai M. Josuttis. C++ templates: The complete guide, portable documents. Addison-Wesley Professional, 2002.
7. Stroustrup, Bjarne. Programming: principles and practice using C++. Pearson Education, 2014.

SBIOE-454 Lab Course in Programming in C++

1. **Basic Syntax Practice:** Write simple C++ programs to practice using variables, data types, arithmetic operations, and basic input/output.
2. **Control Structures:** Implement programs that use if-else statements, loops, and switch statements to solve problems and make decisions based on user input.
3. **Functions and Modularity:** Create and use functions to perform specific tasks, pass arguments, and return results. Practice function overloading and designing modular programs.
4. **Arrays and Pointers:** Work with arrays to perform operations like searching, sorting, and data manipulation. Utilize pointers for dynamic memory allocation and array processing.
5. **Object-Oriented Programming (OOP):** Design and implement classes representing real-world entities, utilize inheritance to create class hierarchies, and demonstrate polymorphism using virtual functions.
6. **Standard Template Library (STL):** Practice using various STL containers like vectors, lists, and maps, and apply algorithms like sorting, searching, and iterating.
7. **File Handling:** Create programs that read data from files, process it, and write results back to files. Practice handling different file formats, such as text and binary files.
8. Exception Handling: Write programs that handle exceptions, ensuring graceful error recovery and proper resource cleanup.
9. **Project-Based Practical:** Work on a larger-scale project that integrates multiple concepts learned throughout the course. This could be a simple game, a database application, or any other program that requires problem-solving and creativity.
10. **Debugging Practice:** Given a buggy program, students should practice using debugging tools and techniques to identify and fix errors.

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