॥ 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 राष्ट्रीय शैक्षणिक धोरण २०२० नुसार पदवी द्वितीय वर्षाचे अभ्यासक्रम (Syllabus) शैक्षणिक वर्ष २०२५–२६ पासून लागू करण्याबाबत.

प रि प त्र क

या परिपत्रकान्वये सर्व संबंधितांना कळविण्यात येते की, दिनांक २७ मे २०२५ रोजी संपन्न झालेल्या मा. विद्यापरिषद बैठकीतील विषय क्रमांक १६/६१–२०२५ च्या ठरावानुसार विज्ञान व तंत्रज्ञान विद्याशाखेतील राष्ट्रीय शैक्षणिक धोरण–२०२० नुसारचे पदवी द्वितीय वर्षाचे अभ्यासक्रम (Syllabus) शैक्षणिक वर्ष २०२५–२६ पासून लागू करण्यास मा. विद्यापरिषदेने मान्यता प्रदान केली आहे. त्यानुसार विज्ञान व तंत्रज्ञान विद्याशाखेतील बी. एस्सी द्वितीय वर्षाचे खालील विषयाचे अभ्यासक्रम (Syllabus) शैक्षणिक वर्ष २०२५–२६ पासून लागू करण्यात येत आहेत.

01	B.Sc. II year Zoology
02	B.Sc. II year Chemistry (General)
03	B.Sc. II year Biotechnology (Vocational)
04	B.Sc. II year Dyes & Drugs
05	B.Sc. II year Biotechnology
06	B.Sc. II year Bioinformatics

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.:शै–१/एनइपी/विवत्रंविपदवी/२०२५–२६/134
दिनांक १६.०६.२०२५

सहाय्यक कुलसचिव
शैक्षणिक (१–अभ्यासमंडळ) विभाग

प्रत : माहितीस्तव तथा कार्यवाहीस्तव.

१) मा. कुलगुरू महोदयांचे कार्यलय, प्रस्तुत विद्यापीठ.
२) मा. प्र. कुलगुरू महोदयांचे कार्यलय, प्रस्तुत विद्यापीठ.
३) मा. आधिष्ठाता, विज्ञान व तंत्रज्ञान विद्याशाखा, प्रस्तुत विद्यापीठ.
४) मा. संचालक, परीक्षा व मुंल्यमापन मंडळ, प्रस्तुत विद्यापीठ.
५) मा. प्राचार्य, सर्व संबधित संलग्नित महाविद्यालये, प्रस्तुत विद्यापीठ.
६) सिस्टीम एक्सपर्ट, शैक्षणिक विभाग, प्रस्तुत विद्यापीठ. याना देवून कळविण्यात येते की, परिपत्रक अभ्यासक्रम संकेतस्थळावर प्रसिध्द करण्यात यावेत.

SWAMI RAMANAND TEERTH MARATHWADA UNIVERSITY, NANDED

STRUCTURE AND SYLLABUS OF FOUR YEAR MULTIDISCIPLINARY

DEGREE PROGRAM WITH MULTIPLE ENTRY AND EXIT OPTIONS

UNDER

NATIONAL EDUCATION POLICY (NEP 2020)

In

SUBJECT: BIOINFORMATICS

FACULTY OF SCIENCE AND TECHNOLOGY

B. Sc. Second Year
(Affiliated Colleges)

With Effect from June 2025

From the Desk of the Dean, Faculty of Science and Technology:

Swami Ramanand Teerth Marathwada University, Nanded, enduring to its vision statement "***Enlightened Student: A Source of Immense Power***", is trying hard consistently to enrich the quality of science education in its jurisdiction by implementing several quality initiatives. Revision and updating curriculum to meet the standard of the courses at national and international level, implementing innovative methods of teaching-learning, improvisation in the examination and evaluation processes are some of the important measures that enabled the University to achieve ***the 3Es, the equity, the efficiency*** and ***the excellence*** in higher education of this region. To overcome the difficulty of comparing the performances of the graduating students and also to provide mobility to them to join other institutions, the University has adopted the cumulative grade point average (CGPA) system in the year 2014-2015. Further, following the suggestions by the UGC and looking at the better employability, entrepreneurship possibilities, and to enhance the latent skills of the stakeholders, the University has adopted the Choice Based Credit System (CBCS) in the year 2018- 2019 at the graduate and post-graduate level. This provided flexibility to the students to choose courses of their own interest. To encourage the students to opt for the world-class courses offered on online platforms like NPTEL, SWAYM, and other MOOCS platforms, the University has implemented the credit transfer policy approved by its Academic Council and has also made a provision for reimbursing registration fees of the successful students completing such courses.

SRTM University has been producing a good number of high-caliber graduates; however, it is necessary to ensure that our aspiring students are able to pursue the right education. Like the engineering students, the youngsters pursuing science education need to be equipped and trained as per the requirements of the R&D institutes and industries. This would become possible only when the students undergo studies with an updated and evolving curriculum to match global scenario.

Higher education is a dynamic process, and in the present era, the stakeholders need to be educated and trained in view of the self-employment and self-sustaining skills like start-ups. Revision of the curriculum alone is not the measure for bringing reforms in higher education, but it invite several other initiatives. Establishing industry-institute linkages and initiating internship on job training for the graduates in reputed industries are some of the important steps that the University would like to take in the coming time. As a result, revision of the curriculum was the

need of the hour, and such an opportunity was provided by the New Education Policy 2020. National Education Policy 2020 (NEP 2020) aims at equipping students with knowledge, skills, values, leadership qualities, and initiates them for lifelong learning. As a result, the students will acquire expertise in specialized areas of interest, kindle their intellectual curiosity and scientific temper, and create imaginative individuals.

The curriculum given in this document has been developed following the guidelines of NEP-2020 and is crucial as well as challenging due to the reason that it is a transition from a general science-based to a discipline-specific based curriculum. All the recommendations of the ***Sukanu Samiti*** given in the **NEP Curriculum Framework-2023** have been followed, keeping the disciplinary approach with rigor and depth, appropriate to the comprehension level of learners. All the Board of Studies (BOS) under the Faculty of Science and Technology of this university have put in their tremendous efforts in making this curriculum of an international standard. They have taken care of maintaining logical sequencing of the subject matter with proper placement of concepts with their linkages for better understanding of the students. We take this opportunity to congratulate the Chairman(s) and all the members of various Boards of Studies for their immense contributions in preparing the revised curriculum for the benefit of the stakeholders in line with the guidelines of the **Government of Maharashtra regarding NEP-2020**. We also acknowledge the suggestions and contributions of the academic and industry experts of various disciplines.

We are sure that the adoption of the revised curriculum will be advantageous for the students to enhance their skills and employability. Introduction of the mandatory ***On-Job Training, Internship program*** for science background students is praiseworthy and certainly helps the students to imbibe first hand work experience, team work management. These initiatives will also help the students to inculcate the workmanship spirit and explore the possibilities of setting up their own enterprises.

Dr. M. K. Patil
Dean
Faculty of Science and Technology

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 endeavors 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 has prepared the curriculum to ensure up-to-date level of understanding of Bioinformatics. Studying Bioinformatics prepares the students for their career working in either educational institutions or industries in which they can directly be 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 B.Sc. Bioinformatics Second year 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 deals with Molecular Biochemistry for Bioinformatics, Introduction to Omics Technologies, Applied Statistics and Data Analysis using R, Relational Database Systems and Biological Data Management, Applied Algorithms and Data Structures, Immunoinformatics and Computational Vaccine Design.
Apart from the core courses, the Generic Elective Courses deal with Data Management in Bioinformatics and Ethics in Bioinformatics.

The Skill Enhancement Courses like Object-Oriented Programming with C++ and Web Development using HTML, CSS & JavaScript offered during this program are designed with the aim of imparting specific skills to the students, which will lead to the self-employability and development of their own enterprises.
This would help students to lay a strong foundation in the field of Bioinformatics.

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

Program Educational Objectives:

The Objectives of this program are:

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

PEO2: To promote and popularize Bioinformatics at grass root level and attract young and budding talents.

PEO3: To expose the students to the different emerging fields of Bioinformatics.

PEO4: To update curriculum by introducing recent advances in the subject that enable the students to face NET, SET, MPSC, UPSC and other competitive examinations successfully.

PEO5: To train and orient the students so as to develop human resource for the educational institutes and other organizations.

PEO6: To inculcate analytical and application-oriented abilities to create active and frontline researchers and human resource for the industries.

PEO7: To develop specific skills amongst students for self-employability and for the development of their own enterprises.

Program Outcomes:

The Outcomes of this program are:

PO1: This Bioinformatics program shall promote and popularize Bioinformatics at grass root level and shall also attract young and budding talents.

PO2: This program will expose the students to the different emerging fields of Bioinformatics.

PO3: This will provide updated curriculum with recent advances in the subject that enable the students to face NET, SET, MPSC, UPSC and other competitive examinations successfully.

PO4: This program shall train and orient the students so as to develop human resource for the educational institutes and other organizations.

PO5: This program shall train and orient the students so as to develop active and frontline researchers and human resource for the industries.

PO6: This will also develop specific skills amongst students for self-employability and for the development of their own enterprises.

Prerequisite:

Basic knowledge of science at 12^{th} (HSC) level is required. The optional courses of this program are offered to the students registered for under-graduate programs. Such students should have the basic knowledge of Bioinformatics and are willing to gain additional knowledge in the field of Bioinformatics.

Admissions to this program are given as per the University rules.

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

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	Address	Designation
1	Dr. Sunita Dhundiraj Lohare Shri Havgiswami Mahavidyalaya, Udgir, Dist. -Latur Mob. No. 9284161504	Chairman	2	Dr. Babasaheb S. Surwase School of Life Sciences SRTM University, Nanded Mob. No.9075829767	Member
3	Dr. Pratap V. Deshmukh Nagnath Arts, Commerce and Science College, Aundha Nagnath, Dist. Hingoli Mob. No. 9637202024	Member	4	Dr. Komal S. Gomare Dept of Biotechnology Dayanand Science College, Latur Mob. No. 9284238413	Member
5	Dr. Vaibhav D. Deshpande General Manager, Quality Corporate Office, Wockhardt, Mumbai Mob. No. 9100988260	Member	-	--	
	Invitee Members				
6	Dr Laxmikant Kamble School of Life Sciences, SRTM University, Nanded 431606. Mob. No.8669695555	Member	7	Dr M M V Baig Dept of Biotechnology, Yeshwant Mahavidyalaya, Nanded. Mob. No. 9422170641	Member
8	Dr. Sanjog T. Thul Environmental Biotechnology and Genomics Division, CSIR-NEERI). Mob. No. 9881877072	Member	9	Dr. Prashant Thakare Department of Biotechnology, SGB Amravati University, Amravati. Mob. No. 982222822	Member
10	Dr Makarand N. Cherekar Dept. of Biotechnology & Bioinformatics, MGM's College of CS and IT, Nanded. Mob: 9421454254	Member	11	Dr. Dhananjay S. Gond Dept. of Biotechnology & Bioinformatics, MGM's College of CS and IT, Nanded. Mob: 98232 30378	Member
12	Mr. Rameshwar S. Belnor Dept. of Biotechnology & Bioinformatics, MGM's College of CS and IT, Nanded. Mob: 9096430300	Member	13	Dr Sunil Hajare Department of Biotechnology, New Model Degree College, Hingoli . Mob 8378878817	Member

Swami Ramanand Teerth Marathwada University, Nanded

(Three Optional in the First Year)

Credit Framework for Four Year Multidisciplinary Degree Program with Multiple Entry and Multiple Exit

Year & Level	Semester	Optional1 *(From the same Faculty)*	Optional2 *(From the same Faculty)*	Optional3 *(From the same Faculty)*	Generic Elective (GE) (select from Basket 3 of *Faculties other than Science and Technology*)	Vocational & Skill Enhancement Course	Ability Enhancement Course (AEC) (Basket 4) Value Education Courses (VEC)/Indian Knowledge System (IKS) (Basket5) *(Common across all faculties)*	Field Work / Project/Internship/ OJT/Apprenticeship/ Case Study Or Co-curricular Courses (CCC) (Basket6 for CCC) *(Common across all faculties)*	Credits	Total Credits
1	2	3	4	5	6	7	8	9	10	11
1 (4.5)	I	Opt 11 (T 2Cr) Opt 12(P 2Cr) 4Credits	Opt 21 (T 2Cr) Opt 22(P2Cr) 4Credits	Opt 31(T 2Cr) Opt 32(P 2Cr) 4Credits	GE1 2Credits	SEC 1 2Credits	AECENG 1 (2Cr) ACEMIL1 (2Cr) IKS(2Cr) 6Credits	-	22	44
	II	Opt 13(T 2Cr) Opt 14(T 2Cr) 4Credits	Opt 23 (T 2Cr) Opt 24(P 2Cr) 4Credits	Opt 33(T 2Cr) Opt 34(P 2Cr) 4Credits	GE2 2Credits	SEC 2 2Credits	AECENG 2 (2Cr) ACEMIL2 (2Cr) CI(2Cr) 6Credits	--	22	
	Cum. Cr.	08	08	08	04	04	12	00	44	

***Exit option*: UG Certificate in Opt1, Opt2 and Opt3 on completion of 44 credits and additional 4 credits from NSQF/Internship**

2 (5.0)	III	Major 1(T-2cr) Major 2 (T-2cr) Major 3 (P-2cr) Major 4 (P-2cr) 8 Credits	Minor 1 (T-2cr) Minor 2 (P-2cr) 4 Credits		GE 3 2Credits	VSC 1 2Credits	ACEENG3 (2Cr) ACEMIL3 (2Cr) 4Credits	CCC(2Cr) *(NCC/NSS/SPT/ CLS/ HWS/YGE/FIT)* 2Credits	22	88
	IV	Major 5 (T-2cr) Major 6 (T-2cr) Major 7 (P-2cr) Major 8 (P-2cr) 8 Credits	Minor 1 (T-2cr) Minor 2 (P-2cr) 4 Credits	—	GE 4 2Credits	VSC 2 2Credits	ACEENG4 (2Cr) ACEMIL4 (2Cr) EVS (2Cr) 6Credits	---	22	
	Cr	24	16	08	08	08	22	02	88	
Exit option: UG Diploma in Major and Minor on completion of 88 credits and an additional 4 credits NSQF/ Internship in Major Subject										

3 (5.5)	**V**	**Major19**(T 3Cr) **Major20**(T3Cr) **Major21**(T2Cr) **Major 22** (P 2Cr) **Major 23** (P 2Cr) **12 Credits**	**Major E1** 4 Credits	-		--	**VSC3** **2 Credits**	--	**FP** **4 Credits**	**22**	
	VI	**Major24**(T3Cr) **Major25**(T 3Cr) **Major26**(T2Cr) **Major27**(P 2Cr) **Major28**(P2Cr) **12Credits**	**Major E2** **4 Credits**	--		--	**VSC4** **2Credits**	-	**OJT** **4 Credits**	**22**	**13 2**
	Cr.	**56**		**16**	**08**	**08**	**4+ 8 =12**	**22**	***04+08***		**13 2**
***Exit option*: B.Sc. (Bachelor in Science) With a Major in DSC and a Minor in DSM**											

4 (6.0)	VII	**Major29**(T4Cr) **Major30**(T4Cr) **Major31**(T 2Cr) **Major32**(P4Cr)	**Major E1 Major E2 4Cr**	**RM** 4Cr		--	--	--	--	22	**44**
	VIII	**Major33**(T4Cr) **Major34**(T4Cr) **Major35**(T 2Cr) **Major36**(P4Cr)	**MajorE3 Major E4 4Cr**	--		--	--	--	**OJT 4Credits**	22	
	Cum Cr	**Honours:92**		**16+4**	**08**	**08**	**VSC-8, SEC-4**	**AEC-8,MIL-8 VEC-4,IKS-2**	**16**		176
***Exit option*: B.Sc. (Hons) with Major in DSC and Minor in DSM**											
4 (6.0)	VII	**Major29**(T3Cr) **Major30**(T3Cr) **Major31**(T4Cr) **10Credits**	**MajorE1 Major E2 4Cr**	**RM** 4 Cr		--	--	--	Research Project **RP1 4Credits**	22	**44**
	VIII	**Major29**(T3Cr) **Major30**(T3Cr) **Major31**(T4Cr) **10 Credits**	**MajorE3 Major E4 4Cr**	--		--	--	--	Research Project **RP2 8Credits**	22	
***Exit option*: B.Sc. (Hons with Research) in DSC and Minor in DSM**											
Total Credits		**Major-92/84**		**Minor1–16, RM-04**	**Minor-2 08**	**GE-08**	**VSC-8, SEC-6 14**	**AEC-8,MIL-8, VEC-4, IKS-2 22**	**CC-2,FP/CS-4, OJT-4, RP-12 30**	**176**	

B. Sc. Second Year Semester III (Level 5.0)

Teaching Scheme

	Course Code	Course Name	Credits Assigned			Teaching Scheme	
			Theory	Practical	Total	Theory (Hrs/ Week)	Practical (Hrs/ Week)
Major 1	SBIOCT-1201	Molecular Biochemistry for Bioinformatics	02	--	02	02	--
	SBIOCP-1201	Lab Course based on Molecular Biochemistry for Bioinformatics	--	02	02	--	04
Major 2	SBIOCT-1202	Introduction to Omics Technologies	02	--	02	02	--
	SBIOCP-1202	Lab Course based on Introduction to Omics Technologies	--	02	02	--	04
Major 3	SBIOCT-1203	Applied Statistics and Data Analysis using R	02	--	02	02	--
	SBIOCP-1203	Lab Course based on Applied Statistics and Data Analysis using R	--	02	02	--	04
Generic Elective (GE) (From Other Faculty)	SBIOGE-1201	Data Management in Bioinformatics	02	--	02	02	--
Vocational &Skill Enhancement Course (Related to Major)	SBIOVC-1201	Object-Oriented Programming with C++	--	02	02	--	04
Ability Enhancement Course	AECENG-1201	L1 – Compulsory English	02	--	02	02	--
Ability Enhancement Course (MIL)	AECXXX-1201	L2–Second Language Marathi (MAR), Hindi (HIN), Urdu (URD), Kannada (KAN), Pali (PAL)	02	--	02	02	--
Co-curricular Courses (CCC)	CCCXXX-1201	Any one of NCC/ NSS/Sports (SPT)/ Culture Studies (CLS) /Health Wellness (HWS) /Yoga Education (YGE)/ Fitness (FIT)	--	02	02	--	04
Total Credits			**12**	**10**	**22**	**12**	**20**

B. Sc. Second Year Semester III (Level 5.0)

Examination Scheme

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

Subject	Course Code	Course Name	Theory				Practical		Total
			Continuous Assessment(CA) Avg. of			ESA			
			Test I	Test II(5)	(T1+T2)/2	Total	CA	ESA	
Major 1	SBIOCT-1201	Molecular Biochemistry for Bioinformatics	10	10	10	40	--	--	50
	SBIOCP-1201	Lab Course based on Molecular Biochemistry for Bioinformatics	--	--	--	--	20	30	50
Major 2	SBIOCT-1202	Introduction to Omics Technologies	10	10	10	40	--	--	50
	SBIOCP-1202	Lab Course based on Introduction to Omics Technologies	--	--	--	--	20	30	50
Major 3	SBIOCT-1203	Applied Statistics and Data Analysis using R	10	10	10	40	--	--	50
	SBIOCP-1203	Lab Course based on Applied Statistics and Data Analysis using R	--	--	--	--	20	30	50
Generic Elective (GE) (From Other Faculty)	SBIOGE-1201	Data Management in Bioinformatics	10	10	10	40	--	--	50
Vocational &Skill Enhancement Course (Related to Major)	SBIOVC-1201	Object-Oriented Programming with C++	--	--	--	--	20	30	50
Ability Enhancement Course	AECENG-1201	L1 – Compulsory English	10	10	10	40	--	--	50
Ability Enhancement Course (MIL)	AECXXX-1201	L2–Second Language Marathi (MAR), Hindi (HIN), Urdu (URD), Kannada (KAN), Pali (PAL)	10	10	10	40	--	--	50
Co-curricular Courses (CCC)	CCCXXX-1201	Any one of NCC/ NSS/Sports (SPT)/ Culture Studies (CLS) /Health Wellness (HWS) /Yoga Education (YGE)/ Fitness (FIT)	--	--	--	--	20	30	50

B. Sc. Second Year Semester IV (Level 5.0)

Teaching Scheme

	Course Code	Course Name	Credits Assigned			Teaching Scheme	
			Theory	**Practical**	**Total**	**Theory** (Hrs/ Week)	**Practical** (Hrs/ Week)
Major 1	SBIOCT-1251	Relational Database Systems and Biological Data Management	02	--	02	02	--
	SBIOCP-1251	Lab Course based on Relational Database Systems and Biological Data Management	--	02	02	--	04
Major 2	SBIOCT-1252	Applied Algorithms and Data Structures	02	--	02	02	--
	SBIOCP-1252	Lab Course based on Applied Algorithms and Data Structures	--	02	02	--	04
Major 3	SBIOCT-1253	Immunoinformatics and Computational Vaccine Design	02	--	02	02	--
	SBIOCP-1253	Lab Course based on Immunoinformatics and Computational Vaccine Design	--	02	02	--	04
Generic Elective (GE) (From Other Faculty)	SBIOGE-1251	Ethics in Bioinformatics	02	--	02	02	--
Vocational & Skill Enhancement Course (Related to Major)	SBIOVC-1251	Web Development using HTML, CSS & JavaScript	--	02	02	--	04
Ability Enhancement Course	AECENG-1251	L1 – Compulsory English	02	--	02	02	--
Ability Enhancement Course (MIL)	AECXXX-1201	L2–Second Language Marathi (MAR), Hindi (HIN), Urdu (URD), Kannada (KAN), Pali (PAL)	02	--	02	02	--
Value Education Course (VEC)	VECEVS-1251	Environmental Studies	02	--	02	02	--
		Total Credits	**14**	**08**	**22**	**14**	**16**

B.Sc. Second Year Semester IV (Level 5.0)

Examination Scheme

[20%Continuous Assessment (CA) and80% End Semester Assessment (ESA)]

Subject	Course Code	Course Name	Theory				Practical		Total
			Continuous Assessment (CA)Avg. of			ESA			
			Test I	Test II(5)	(T1+T2)/2	Total	CA	ESA	
Major 1	SBIOCT-1251	Relational Database Systems and Biological Data Management	10	10	10	40	--	--	50
	SBIOCP-1251	Lab Course based on Relational Database Systems and Biological Data Management	--	--	--	--	20	30	50
Major 2	SBIOCT-1252	Applied Algorithms and Data Structures	10	10	10	40	--	--	50
	SBIOCP-1252	Lab Course based on Applied Algorithms and Data Structures	--	--	--	--	20	30	50
Major 3	SBIOCT-1253	Immunoinformatics and Computational Vaccine Design	10	10	10	40	--	--	50
	SBIOCP-1253	Lab Course based on Immunoinformatics and Computational Vaccine Design	--	--	--	--	20	30	50
Generic Elective (GE) (From Other Faculty)	SBIOGE-1251	Ethics in Bioinformatics	10	10	10	40	--	--	50
Vocational &Skill Enhancement Course (Related to Major)	SBIOVC-1251	Web Development using HTML, CSS & JavaScript	--	--	--	--	20	30	50
Ability Enhancement Course	AECENG-1251	L1 – Compulsory English	10	10	10	40	--	--	50
Ability Enhancement Course (MIL)	AECXXX-1251	L2–Second Language Marathi (MAR), Hindi (HIN), Urdu (URD), Kannada (KAN), Pali (PAL)	10	10	10	40	--	--	50
Value Education Course (VEC)	VECEVS-1251	Environmental Studies	10	10	10	40	--	--	50

Major 1

SBIOCT-1201-: Molecular Biochemistry for Bioinformatics

Marks: 50 **B.Sc. Bioinformatics** **Hours: 30**

Course pre-requisite: Basic knowledge about biomolecules and enzymes.
Course objectives:

- To impart foundational knowledge of biomolecular structures and metabolic functions.
- To introduce enzymology and biochemical kinetics in the context of bioinformatics.
- To enable students to link biochemistry with bioinformatics tools and databases.

Course Outcomes: After completing this course, students shall be able to

1. Understand the molecular structure and function of biomolecules essential for life.
2. Analyze enzymatic functions, kinetics, and their relevance to biological databases.
3. Apply biochemical knowledge in bioinformatics areas such as structure prediction and drug design.

Curriculum Details:

Module No.	Unit No.	Topic	Hrs.
1.0	**1.0**	**Biomolecules and Molecular Structure**	08
	1.1	Carbohydrates: Classification, structure, biological role	
	1.2	Proteins: Structure (primary to quaternary), types, biological functions	
	1.3	Lipids: Classification, functions, role in membranes	
	1.4	Nucleic Acids: DNA & RNA structure and properties	
2.0	**2.0**	**Enzymes and Coenzymes**	08
	2.1	Enzyme structure and classification	
	2.2	Mechanism of enzyme action, enzyme kinetics (Michaelis-Menten)	
	2.3	Factors affecting enzyme activity	
	2.4	Bioinformatics databases for enzymes (BRENDA, ExPASy)	
3.0	**3.0**	**Metabolism and Bioenergetics**	08
	3.1	Overview of metabolic pathways	
	3.2	Electron transport chain	
	3.3	ATP generation and energy currency of the cell	
	3.4	Metabolic pathway databases (KEGG, MetaCyc)	
4.0	**4.0**	**Application of Biochemistry in Bioinformatics**	06
	4.1	Protein structure-function relationship	
	4.2	Use of biochemical knowledge in drug design	
	4.3	Molecular docking and structure prediction tools	

	4.4	Integration of biochemistry with genomics and proteomics	
		Total	
			30

Reference Books

1. Lehninger, A. L., Nelson, D. L., & Cox, M. M. (2005). *Lehninger principles of biochemistry*. Macmillan.
2. Voet, D., & Voet, J. G. (2010). *Biochemistry*. John Wiley & Sons.
3. Satyanarayana, U. (2013). *Biochemistry*. Elsevier Health Sciences.
4. Vasudevan, D. M., Sreekumari, S., & Vaidyanathan, K. (2013). *Textbook of biochemistry for medical students*. JP Medical Ltd.

Supplementary & Online Resources

1. BRENDA (The Comprehensive Enzyme Information System) – www.brenda-enzymes.org
2. KEGG Pathway Database – www.kegg.jp
3. ExPASy Bioinformatics Resource Portal – www.expasy.org
4. PDB (Protein Data Bank) – www.rcsb.org

SBIOCP-1201: Lab Course based on Molecular Biochemistry for Bioinformatics

B.Sc. Bioinformatics **Marks: 50**

Sr. No.	List of Experiments:
1	Qualitative tests for carbohydrates, proteins, and lipids
2	Extraction and quantification of DNA/RNA
3	Study of enzyme activity (e.g., amylase or catalase)
4	Effect of temperature and pH on enzyme activity
5	Introduction to BRENDA and ExPASy enzyme databases
6	Demonstration of glycolysis using pathway simulation tools (e.g., KEGG Mapper)
7	Use of MetaCyc database to map metabolic pathways
8	Using PDB for visualizing enzyme structures
9	Case study: Protein-ligand interaction using docking software
10	Exploring UniProt for biochemical functions of proteins

Major 2

SBIOCT-1202: Introduction to Omics Technologies

Marks: 50 **B.Sc. Bioinformatics** **Hours: 30**

Course pre-requisite:

- Basic knowledge of central dogma, metabolism.

Course objectives:

- To introduce the fundamentals of various omics technologies and their biological significance.
- To provide an understanding of experimental and computational approaches in genomics, transcriptomics, proteomics, and metabolomics.
- To familiarize students with publicly available omics databases and bioinformatics tools used for analysis.

Course Outcomes: After completing this course, students shall be able to

1. Describe the concepts and technologies associated with major omics disciplines.
2. Identify experimental and computational tools used in omics data generation and analysis.
3. Understand the interdisciplinary integration of omics data for solving biological problems.

Curriculum Details:

Module No.	Unit No.	Topic	Hrs.
1.0	**1.0**	**Overview of Omics Technologies**	08
	1.1	Introduction to Genomics, Transcriptomics, Proteomics, Metabolomics	
	1.2	Central Dogma and its connection to Omics	
	1.3	Importance of Omics in systems biology	
	1.4	Applications in personalized medicine and biotechnology	
2.0	**2.0**	**Genomics and Transcriptomics**	08
	2.1	Introduction to genome structure and sequencing methods (NGS basics)	
	2.2	Genome browsers and transcriptome databases (NCBI, ENSEMBL, GTEx)	
	2.3	Gene expression and transcriptome analysis	
	2.4	Functional annotation and comparative genomics	
3.0	**3.0**	**Proteomics and Metabolomics**	08

	3.1	Protein expression, post-translational modifications	
	3.2	Techniques: 2D Gel, MALDI-TOF, LC-MS/MS	
	3.3	Databases: UniProt, PRIDE, HMDB	
	3.4	Applications in diagnostics and drug development	
4.0	**4.0**	**Integration and Bioinformatics Tools in Omics**	06
	4.1	Omics data analysis and integration tools (Galaxy, DAVID, Cytoscape)	
	4.2	Network biology and pathway databases (KEGG, Reactome)	
	4.3	Case studies in cancer and infectious disease research methods.	
	4.4	Case studies in agriculture.	
		Total	30

Reference Books

1. Barh, D., & Azevedo, V. A. D. C. (Eds.). (2017). *Omics technologies and bio-engineering: volume 1: towards improving quality of life*. Academic Press.
2. Campbell, A. M., & Heyer, L. J. (2003). *Discovering genomics, proteomics, and bioinformatics*. San Francisco, CA: Benjamin Cummings.
3. Pevsner, J. (2015). *Bioinformatics and functional genomics*. John Wiley & Sons.

Online Resources

1. NCBI Genomics and GEO – www.ncbi.nlm.nih.gov
2. UniProt Knowledgebase – https://www.uniprot.org
3. KEGG Database for Pathway Integration – https://www.kegg.jp
4. GTEx Portal for Transcriptomics – www.gtexportal.org
5. HMDB - Human Metabolome Database – www.hmdb.ca
6. Cytoscape Bioinformatics Tool – www.cytoscape.org
7. Galaxy Project for Omics Analysis – usegalaxy.org

SBIOCP-1202: Lab Course based on Introduction to Omics Technologies

B.Sc. Bioinformatics **Marks: 50**

Sr. No.	List of Experiments:
1	Virtual demo of NGS workflow
2	Familiarization with major omics databases (NCBI, Ensembl, UniProt)
3	Exploring NCBI GenBank and retrieving genome data
4	Introduction to genome browsers (UCSC, Ensembl)
5	Accessing protein data using UniProt and PRIDE
6	Introduction to metabolite databases like HMDB and KEGG Compound
7	Exploring omics relationships using online interactive visualizations (like KEGG or WikiPathways)
8	Visualizing biological networks using Cytoscape

9	Using Galaxy platform to analyze a sample genomics/proteomics dataset
10	Case study analysis: Multi-omics approach in cancer genomics

Major 3

SBIOCT-1203: Applied Statistics and Data Analysis using R

Marks: 50 **B.Sc. Bioinformatics** **Hours: 30**

Course pre-requisite:

- Students have a basic understanding of fundamental of statistics, programming.

Course Objective:

- To introduce basic statistical concepts with real biological applications.
- To enable students to perform data analysis using common statistical tests.
- To teach students the use of R programming for analyzing and visualizing biological data.

Course Outcomes:

- Understand statistical principles and apply them to analyze biological data.
- Perform hypothesis testing, correlation, regression, and ANOVA for biological datasets.
- Use R for data handling, visualization, and statistical computation relevant to bioinformatics.

Curriculum Details:

Module No.	Unit No.	Topic	Hrs.
1.0	**01**	**Introduction to Statistics**	08
	1.1	Importance of statistics in biology and bioinformatics	
	1.2	Types of data: qualitative & quantitative, scales of measurement	
	1.3	Data collection, sampling techniques, frequency distribution	
	1.4	Measures of central tendency and dispersion	
2.0	**02**	**Probability and Statistical Distributions**	08
	2.1	Basic probability concepts and rules	
	2.2	Normal, binomial, and Poisson distributions	
	2.3	Hypothesis testing: null and alternative hypotheses	
	2.4	p-value, confidence interval, types of errors	
3.0	**03**	**Statistical Testing and Data Analysis**	08
	3.1	t-test, Chi-square test, ANOVA	
	3.2	Correlation and regression analysis	
	3.3	Case studies in biological research	
	3.4	Introduction to statistical result interpretation in biomedical	

		papers	
4.0	**04**	**Basics of R Programming for Data Analysis**	06
	4.1	Introduction to R environment and RStudio	
	4.2	Data types, importing and exporting biological data in R	
	4.3	Descriptive statistics and plotting (boxplot, histogram, scatterplot)	
	4.4	Running statistical tests in R	
		Total	30

Reference Books:

- Daniel, W. W. (2009). *Biostatistics: A foundation for analysis in the health sciences*. John Wiley & Sons.
- Pagano, M., Gauvreau, K., & Mattie, H. (2022). *Principles of biostatistics*. Chapman and Hall/CRC.
- Nordhausen, K. (2009). *Introductory Statistics with R*, by Peter Dalgaard.
- Altman, D. G. (1990). *Practical statistics for medical research*. Chapman and Hall/CRC.

SBIOCP-1203: Lab Course based on Applied Statistics and Data Analysis using R

B.Sc. Bioinformatics **Marks: 50**

Sr. No.	List of Experiments:
1	Calculating mean, median, mode, variance, and standard deviation using sample biological data
2	Constructing frequency distributions and drawing bar charts & pie charts
3	Visualizing binomial and normal distributions using R
4	Calculating probabilities using R functions
5	Performing t-test and chi-square test in R
6	One-way ANOVA and post-hoc analysis using biological datasets
7	Simple linear regression and correlation analysis with R
8	Importing CSV datasets of gene expression data into R
9	Data visualization using boxplot, histogram, and scatterplots in R
10	Summary statistics and basic exploratory data analysis in R

Generic Elective (Group A)

SBIOGE-1201: Data Management in Bioinformatics

Marks: 50 **B.Sc. Bioinformatics** **Hours: 30**

Course Prerequisite:

- Basic understanding of bioinformatics principles, including data analysis and computational methods.
- Familiarity with key molecular biology concepts such as DNA, RNA, proteins.

Course Objectives:

- To introduce students to the fundamentals of data management in bioinformatics and its significance in biological research.
- To familiarize students with biological databases and tools for data retrieval and processing.
- To equip students with skills to manage, clean, and secure bioinformatics data effectively.

Course Outcomes: The student at the end of the course will:

- Understand the principles of data management and the importance of standardized bioinformatics data.
- Utilize biological databases and retrieval tools for accessing genomic and proteomic data.
- Apply data preprocessing, organization, and security techniques to handle large-scale bioinformatics datasets.

Curriculum Details:

Module No.	Unit No.	Topic	Hrs.
1.0	**01**	**Introduction to Bioinformatics Data Management**	08
	1.1	Overview of data in bioinformatics: Genomic, proteomic, and metabolomic data.	
	1.2	Data storage challenges and solutions.	
	1.3	Importance of data integrity and standardization.	
	1.4	Data formats in bioinformatics: FASTA, FASTQ, GenBank, PDB.	
2.0	**02**	**Biological Databases and Data Retrieval**	08
	2.1	Major biological databases: NCBI, EMBL-EBI, DDBJ.	
	2.2	Specialized databases: GenBank, UniProt, KEGG, Pfam.	
	2.3	Data retrieval tools: Entrez, BLAST.	
	2.4	Data mining and querying in bioinformatics.	
3.0	**03**	**Data Processing and Management Techniques**	08
	3.1	Data cleaning and preprocessing: Removing duplicates, handling missing data.	

	3.2	Metadata and annotation standards in bioinformatics.	
	3.3	Data organization and indexing methods.	
	3.4	Tools for managing large-scale biological data: Hadoop, Spark.	
4.0	**04**	**Data Security, Ethics, and Future Trends**	
	4.1	Data privacy and security challenges.	
	4.2	Ethical considerations in bioinformatics data sharing.	06
	4.3	Cloud computing for bioinformatics data management.	
	4.4	Emerging trends: AI-driven data analysis, big data in genomics.	
		Total	30

Reference Books:

1. Attwood TK, Parry-Smith DJ. (1999). Introduction to Bioinformatics. Pearson Education.
2. Mount DW. (2004). Bioinformatics: Sequence and Genome Analysis. Cold Spring Harbor Laboratory Press.
3. Xiong J (2007). Essential Bioinformatics, Cambridge University Press.

Online Resources:

- NCBI Handbook
- EMBL-EBI Training Resources

Vocational Skill Course
SBIOVC-1201: Object-Oriented Programming with C++

Marks: 50 **B.Sc. Bioinformatics** **Hours: 30**

Course pre-requisite: Computer programming basics, C programming.

Course Objectives:

- To develop a strong foundation in object-oriented programming concepts using C++.
- To enable students to write modular and reusable code using classes and objects.
- To expose students to file handling and basic bioinformatics data operations using C++.

Course Outcomes:

- Understand and apply the fundamental concepts of C++ programming in bioinformatics.
- Develop object-oriented programs for managing and analyzing biological data.
- Implement data structures and file handling techniques for bioinformatics applications.

Curriculum Details:

Module No.	Unit No.	Topic	Hrs.
1.0	**1.0**	**Introduction to Object-Oriented Programming**	08
	1.1	Basic concepts of OOP: classes, objects, abstraction, encapsulation,	
	1.2	inheritance, polymorphism	
	1.3	Difference between C and C++	
	1.4	Structure of a C++ program	
2.0	**2.0**	**Classes, Objects and Constructors**	08
	2.1	Defining classes and creating objects	
	2.2	Access specifiers: private, public, protected	
	2.3	Constructors and destructors	
	2.4	Static members and friend functions	
3.0	**3.0**	**Inheritance and Polymorphism**	06
	3.1	Types of inheritance: single, multiple, hierarchical	
	3.2	Function overloading and operator overloading	
	3.3	Virtual functions and runtime polymorphism	
	3.4	Abstract classes and interfaces	
4.0	**4.0**	**File Handling and Application in Bioinformatics**	08
	4.1	File streams: ifstream, ofstream, fstream	
	4.2	Reading/writing files	
	4.3	Practical use-cases: reading sequence files, parsing data	
	4.4	Mini project using classes for sequence/data handling	
		Total	30

References:

1. Lafore, R. (2001). *Object-oriented programming in Turbo C++*. Galgotia publications.
2. Dewhurst, S. C., & Stark, K. T. (1989). Programming in C++. Prentice-Hall, Inc.
3. Balagurusamy, E. (2016). Object oriented programming with C++.
4. Schildt, H. (2000). *C/C++ Programmer's Reference*. McGraw-Hill, Inc..
5. Pohl, I. (1996). *Object-oriented programming using C++*. Addison-Wesley Longman Publishing Co., Inc.
6. Oualline, S. (2003). *Practical C++ programming*. " O'Reilly Media, Inc.".
7. Gogol-Döring, A., & Reinert, K. (2009). *Biological sequence analysis using the SeqAn C++ library*. CRC Press.

8. Hauswedell, H. (2022). *Sequence Analysis and Modern C++*. Springer.

Online Resources:

1. C++ programming and OOP tutorials – https://www.geeksforgeeks.org/c-plus-plus/
2. Bio++ Library for Computational Biology – www.bio++.org
3. C++ for Bioinformatics Tutorials – Rosalind – http://rosalind.info/problems/locations/

Sr. No.	List of Experiments:
1	Write a program to demonstrate class, object, and member functions
2	Program for using constructors and destructors
3	Implement a program using static data members and functions
4	Use friend functions for accessing private data
5	Program demonstrating single and multiple inheritance
6	Use of operator overloading and virtual functions
7	Program to read and write biological sequences from a text file
8	Program to count GC content or nucleotide frequencies from a FASTA-like file
9	Mini project: Create a class for storing and manipulating DNA sequences

SEMESTER IV

Major 1

SBIOCT-1251: Relational Database Systems and Biological Data Management

Marks: 50 **B.Sc. Bioinformatics** **Hours: 30**

Course Prerequisite:

- Fundamental knowledge of database concepts.

Course Objectives:

- To introduce relational database systems and their application in managing biological data.
- To teach students how to design normalized schemas and write SQL queries.
- To provide hands-on exposure to querying and managing real biological datasets.

Course Outcomes: The student at the end of the course:

- Explain the structure and working of relational database systems.
- Design normalized relational databases for biological datasets.
- Perform database operations and biological data retrieval using SQL.

Module No.	Unit No.	Topic	Hrs.
1.0	**01**	**Introduction to Databases and DBMS**	08
	1.1	Concepts of data, database, DBMS, and RDBMS	
	1.2	Types of databases: hierarchical, network, relational	
	1.3	Database system architecture and data models	
	1.4	Overview of biological databases (GenBank, PDB, UniProt, EMBL)	
2.0	**02**	**Relational Model and Database Design**	08
	2.1	Relational model: tables, attributes, tuples, keys	
	2.2	Entity-Relationship (ER) modeling	
	2.3	Normalization (1NF, 2NF, 3NF)	
	2.4	Designing a relational schema for biological data	
3.0	**03**	**Structured Query Language (SQL)**	08
	3.1	Introduction to SQL syntax and commands	
	3.2	Creating and managing tables, inserting and updating data	
	3.3	Querying with SELECT, WHERE, ORDER BY, GROUP BY, and JOIN	
	3.4	SQL queries using biological datasets	
4.0	**04**	**Biological Data Management and Applications**	06
	4.1	Data integration in bioinformatics	

	4.2	Use of databases in genome projects and drug discovery	
	4.3	Introduction to NoSQL and biological big data challenges	
	4.4	Case studies: Gene expression databases, PDB queries, etc.	
		Total	30

Reference Books:

1. Silberschatz, A., Korth, H. F., & Sudarshan, S. (2011). Database system concepts.
2. Elmasri, R. (2008). *Fundamentals of database systems*. Pearson Education India.
3. Mount, D. W., & Mount, D. W. (2001). *Bioinformatics: sequence and genome analysis* (Vol. 564). Cold Spring Harbor, NY: Cold spring harbor laboratory press. (for bio-data references)

Research Articles and Online Resources

1. https://www.mysql.com – MySQL Documentation
2. https://www.sqlite.org – SQLite for lightweight use
3. [NCBI, PDB, UniProt Databases](https://www.ncbi.nlm.nih.gov/, https://www.rcsb.org/, https://www.uniprot.org)
4. Mode SQL tutorials – Beginner SQL with examples

SBIOCP-1251: Lab Course based on Relational Database Systems and Biological Data Management

Marks: 50 **B.Sc. Bioinformatics** **Hours: 30**

Sr. No.	List of Experiments:
1	Explore and document key features of biological databases (PDB, GenBank)
2	Install and configure MySQL or SQLite
3	Draw ER diagrams for gene/protein databases
4	Convert ER diagrams into normalized relational schemas
5	Create a database and tables for biological sequences and metadata
6	Insert records and perform SELECT queries with filters
7	Write JOIN queries to combine data from multiple biological tables
8	Retrieve PDB data fields using SQL
9	Store and query FASTA-like sequence data in a relational table
10	Create a mini-project: Design and manage a bio-database of sequences or gene annotations

Major 2

SBIOCT-1252: Applied Algorithms and Data Structures

Marks: 50 **B.Sc. Bioinformatics** **Hours: 30**

Course pre-requisite:

- Understand the fundamental concepts of data, algorithm, and data structures.

Course objectives:

- To introduce fundamental data structures and algorithms with bioinformatics context.
- To develop problem-solving skills using structured programming techniques.
- To apply algorithms in biological sequence handling, searching, and analysis tasks.

Course Outcomes: After completing this course, students shall be able to

- Understand and implement various linear and non-linear data structures.
- Analyze algorithmic efficiency using complexity notations.
- Apply algorithms and data structures to solve biological data analysis problems.

Curriculum Details:

Module No.	Unit No.	Topic	Hrs.
1.0	**1.0**	**Introduction to Data Structures and Algorithms**	08
	1.1	Basic concepts: Algorithm definition, characteristics, and complexity	
	1.2	Asymptotic notations: Big O, Ω, and Θ	
	1.3	Types of data structures: linear and non-linear	
	1.4	Applications of Algorithms and Data Structures in Bioinformatics	
2.0	**2.0**	**Linear Data Structures**	08
	2.1	Arrays, Linked lists	
	2.2	Stacks, and Queues	
	2.3	Their Implementation and Applications	
	2.4	Arrays and String Manipulations (including DNA/RNA sequences)	
3.0	**3.0**	**Non-Linear Data Structures and Searching Algorithms**	08
	3.1	Trees and Binary Search Tree (BST): Structure, Creation, Traversals	
	3.2	Graphs: Representation, BFS and DFS	
	3.3	Searching Algorithms: Linear Search and Binary Search	
	3.4	Applications in Genome Annotation and Phylogenetic Tree Construction	

4.0	**4.0**	**Sorting, Hashing and Bioinformatics Applications**	06
	4.1	Sorting Techniques: Bubble, Selection, Insertion, and Quick Sort	
	4.2	Hashing and Hash Tables: Concepts and Bioinformatics Use Cases	
	4.3	Recursion: Concept, Examples in Biological Pattern Finding	
	4.4	Case Study: Sequence Alignment, Genome Browsers, and Algorithm Selection	
		Total	30

Reference Books

1. Langsam, Y., Augenstein, M. J., & Tenenbaum, A. M. (1996). *Data Structures using C and C++*. Prentice Hall Press.
2. Hopcroft, J. E., Ullman, J. D., & Aho, A. V. (1983). Data structures and algorithms (Vol. 175). Boston, MA, USA: Addison-wesley.
3. Jones, N. C., & Pevzner, P. A. (2004). *An introduction to bioinformatics algorithms*. MIT press.

Online Resources

1. GeeksforGeeks – DSA
2. Coursera/edX – Algorithms Courses
3. Rosalind platform for bioinformatics problems: http://rosalind.info

SBIOCP-1252: Lab Course based on Applied Algorithms and Data Structures

B.Sc. Bioinformatics **Marks: 50**

Sr. No.	List of Experiments:
1	Write algorithms and calculate time complexity for sample problems
2	Implement a program to compare linear and binary search
3	Implement stack and queue operations using arrays
4	Create and traverse singly linked list storing nucleotide data
5	Create and display a linked list storing gene names or accession numbers
6	Create a binary search tree of gene IDs and perform traversals
7	Graph traversal (DFS, BFS) for biological network analysis
8	Sort gene expression values using bubble and quick sort
9	Use hashing to store and retrieve gene names
10	Mini-project: Develop a sequence indexing and searching tool using arrays and trees

Major 3

SBIOCT-1253: Immunoinformatics and Computational Vaccine Design

Marks: 50 **B.Sc. Bioinformatics** **Hours: 30**

Course pre-requisite: Understanding key concepts in immunology, vaccines.

Course Objectives:

- To understand the basics of immune system components and their relevance in computational analysis.
- To introduce epitope prediction, vaccine design tools, and databases for immunological data.
- To develop skills in designing subunit and multi-epitope vaccines using computational approaches.

Course Outcomes:

- Explain immunological principles and identify tools and databases relevant to immunoinformatics.
- Predict epitopes and analyze antigenic properties using web-based tools.
- Design computational vaccine constructs and evaluate their efficacy through simulations and structural studies.

Curriculum Details:

Module No.	Unit No.	Topic	Hrs.
1.0	**01**	**Fundamentals of Immunoinformatics**	08
	1.1	Introduction to Immunoinformatics and its Applications	
	1.2	Overview of Immune System: Antigens, Antibodies, T and B cells	
	1.3	Immunological Databases (IEDB, IMGT, Vaxijen)	
	1.4	Tools for Sequence-Based Immunological Analysis	
2.0	**02**	**Epitope Prediction and Evaluation**	08
	2.1	Antigen Processing and MHC Presentation Mechanisms	
	2.2	MHC Class I and II Binding Prediction	
	2.3	B-cell and T-cell Epitope Prediction Tools	
	2.4	Prediction of Antigenicity, Allergenicity, and Toxicity	
3.0	**03**	**Computational Vaccine Design**	08

	3.1	Subunit and Multi-Epitope Vaccine Design Principles	
	3.2	Use of Linkers, Adjuvants, and PADRE Sequences	
	3.3	Molecular Docking in Vaccine Development	
	3.4	Reverse Vaccinology and In Silico Cloning	
4.0	**04**	**Structure Modeling and Immune Simulation**	06
	4.1	Structural Modeling of Vaccine Constructs (SWISS-MODEL, Robetta)	
	4.2	Protein-Protein Docking (TLR-Vaccine Complex)	
	4.3	Immune Response Simulation using C-ImmSim	
	4.4	Case Studies: COVID-19, HPV, TB, Dengue Vaccine Design	
		Total	30

Reference Books:

1. Roitt, I. M. (1971). *Essential immunology* (pp. ix+-220pp).
2. Flower, D., & Timmis, J. (Eds.). (2007). *In silico immunology*. Boston, MA: Springer US.
3. Flower, D. R. (Ed.). (2007). *Immunoinformatics: predicting immunogenicity in silico*. Springer Science & Business Media.
4. Flower, D. D., Davies, M., & Ranganathan, S. (Eds.). (2009). *Bioinformatics for Immunomics* (Vol. 3). Springer.
5. Flower, D. R. (2008). *Bioinformatics for vaccinology*. John Wiley & Sons.
6. Ghosh, S. (2019). *Computational Immunology: Basics*. CRC Press.

Online References:

Web Tools:

1. IEDB - https://www.iedb.org/
2. VaxiJen - http://www.ddg-pharmfac.net/vaxijen/VaxiJen/VaxiJen.html
3. AllerTOP - https://www.ddg-pharmfac.net/AllerTOP
4. C-ImmSim - http://kraken.iac.rm.cnr.it/C-IMMSIM/
5. SWISS-MODEL - https://swissmodel.expasy.org
6. ClusPro - https://cluspro.bu.edu

SBIOCP-1253: Lab Course based on Immunoinformatics and Computational Vaccine Design

B.Sc. Bioinformatics **Marks: 50**

Sr. No.	List of Experiments:
1	Explore and retrieve antigen data from IEDB and IMGT databases.
2	Analyze antigenic protein sequences using VaxiJen and ProtParam.
3	Predict antigenic peptides from pathogen proteins.
4	Use ABCpred and BepiPred for B-cell epitope prediction.

5	Predict MHC-I and MHC-II binding using NetMHCpan and IEDB tools.
6	Assess allergenicity and toxicity of predicted epitopes using AllerTOP and ToxinPred.
7	Visualize and validate the 3D structure using tools like SWISS-MODEL or Robetta.
8	Dock the vaccine construct with TLR receptor using ClusPro or PatchDock.
9	Simulate immune response using C-ImmSim server.
10	Study a recent research paper on in silico vaccine design for SARS-CoV-2 or TB.

Generic Elective

SBIOGE-1251: Ethics in Bioinformatics

Marks: 50 **B.Sc. Bioinformatics** **Hours: 30**

Course pre-requisite: A fundamental understanding of biology, bioinformatics, and ethics

Course Objectives:

- To introduce students to the ethical challenges and responsibilities in bioinformatics research and data handling.
- To familiarize students with legal frameworks and intellectual property rights related to bioinformatics.
- To equip students with knowledge of ethical concerns in AI applications and genomic research.

Course Outcomes:

- Understand ethical principles in bioinformatics and their impact on research and data management.
- Analyze data privacy, security, and intellectual property issues in bioinformatics.
- Evaluate ethical considerations in AI-driven bioinformatics research and real-world case studies.

Curriculum Details:

Module No.	Unit No.	Topic	Hrs.
1.0	**01**	**Introduction to Ethics in Bioinformatics**	08
	1.1	Overview of ethics in bioinformatics and computational biology.	
	1.2	Importance of ethical guidelines in biological data usage.	
	1.3	Ethical principles: Privacy, security, and consent.	
	1.4	Role of bioethics committees and regulatory bodies.	
2.0	**2.0**	**Data Privacy, Security, and Intellectual Property**	08
	2.1	Data ownership and sharing policies in bioinformatics.	
	2.2	Ethical issues in genetic and genomic data privacy.	
	2.3	Intellectual property rights (IPR) and patents in bioinformatics	

		research.	
	2.4	Open-access databases vs. proprietary data sources.	
3.0	**3.0**	**Ethical Considerations in AI and Computational Biology**	08
	3.1	AI-driven research and its ethical implications.	
	3.2	Bias in machine learning models for bioinformatics.	
	3.3	Ethical use of AI in drug discovery and personalized medicine.	
	3.4	Case studies on ethical dilemmas in AI-based bioinformatics research.	
4.0	**4.0**	**Global Policies, Future Trends, and Case Studies**	06
	4.1	International bioethics policies: GDPR, HIPAA, UNESCO bioethics guidelines.	
	4.2	Ethical concerns in bio-banks and large-scale genome projects.	
	4.3	Future challenges in bioinformatics ethics.	
	4.4	Case studies on ethical issues in genomic research.	
		Total	30

Reference Books

1. Veatch, R. M. (2016). *The basics of bioethics*. Routledge.
2. Fletcher, J. (1980). Principles of Biomedical Ethics. By Tom L. Beauchamp and James F. Childress. New York, Oxford University Press, 314 pp.
3. Patel, M. B., Patel, J., Patel, D., Prajapati, P., & Prajapati, J. (2023). Basic Ethical Issues in Bioinformatics and Chemoinformatics. In *Ethical Issues in AI for Bioinformatics and Chemoinformatics* (pp. 12-38). CRC Press.

Research Papers and Reviews:

1. UNESCO Bioethics Guidelines – *www.unesco.org*
2. HIPAA and Genetic Data Privacy – *www.hhs.gov*
3. AI and Bioethics in Drug Discovery – *Nature Bioethics Journal*
4. CRISPR Ethics Case Studies – *www.genomeweb.com*

Vocational Skill Course
SBIOVC-1251: Web Development using HTML, CSS & JavaScript

Marks: 50 **B.Sc. Bioinformatics** **Hours: 30**

Course pre-requisite: Basic programming computing skills, web development basics.

Course Objectives:

- To introduce fundamental concepts of web technologies and client-side scripting.
- To develop web pages using HTML, CSS for structure and styling.

- To integrate basic interactivity and validation using JavaScript for bioinformatics use cases.

Course Outcomes:

- Design structured and responsive web pages using HTML and CSS.
- Implement interactivity and validation in web forms using JavaScript.
- Develop basic web tools for displaying or collecting bioinformatics data (e.g., gene search, sequence input).

Curriculum Details:

Module No.	Unit No.	Topic	Hrs.
1.0	**1.0**	**Introduction to Web Technologies**	08
	1.1	Basics of Internet, Web Servers and Web Browsers	
	1.2	Introduction to Static and Dynamic Websites	
	1.3	Understanding URLs, HTTP, HTTPS, and Web Hosting	
	1.4	Overview of Client-Side vs Server-Side Scripting	
2.0	**2.0**	**HTML – Structure and Content**	08
	2.1	Basic Tags, Page Structure, Headings, Lists, Tables	
	2.2	Forms, Input Types, Buttons, and Media Embedding	
	2.3	Hyperlinks, Anchors, iframes and Meta Tags	
	2.4	Semantic HTML5 Elements	
3.0	**3.0**	**CSS – Styling Web Pages**	06
	3.1	Introduction to CSS: Syntax, Selectors, and Types	
	3.2	Applying Styles: Colors, Fonts, Backgrounds, Borders	
	3.3	Layout Design using Box Model, Flexbox and Grid System	
	3.4	Responsive Web Design and Media Queries	
4.0	**4.0**	**JavaScript – Interactivity for Web**	08
	4.1	Basics of JavaScript: Variables, Operators, and Data Types	
	4.2	Functions, Events, and DOM Manipulation	
	4.3	Form Validation using JavaScript	
	4.4	Intro to Bioinformatics Web App Elements (e.g., sequence input)	
		Total	30

References:

1. Duckett, J. (2011). HTML and CSS: Design and Build Websites, John Willey & Sons. *Inc. Indianappolis*.
2. Duckett, J. (2014). *Web design with HTML, CSS, JavaScript and jQuery set*. Wiley Publishing.
3. Duckett, J. (2011). *Beginning html, xhtml, css, and javascript*. John Wiley & Sons.
4. Duckett, J. (2014). *Javascript and jquery: Interactive front-end web development*. Wiley Publishing.
5. York, R. (2011). *Beginning JavaScript and CSS development with jQuery*. John Wiley & Sons.

Online Resources:

1. W3Schools – HTML, CSS, JS tutorials - https://www.w3schools.com/
2. MDN Web Docs – Official HTML/CSS/JS documentation - https://developer.mozilla.org/en-US/
3. CSS-Tricks – Layout and design ideas - https://css-tricks.com/
4. GitHub Pages – Free web hosting - https://pages.github.com/
5. JSFiddle – Online testing of web code - https://jsfiddle.net/

Sr. No.	List of Experiments:
1	Create a simple webpage with bio and academic info using HTML.
2	Design a webpage to showcase gene or protein information using lists and tables.
3	Create a form to input DNA or protein sequences.
4	Apply external and internal CSS to an HTML page.
5	Create a two-column layout for a bioinformatics topic page (e.g., Genome vs Proteome). Use Flexbox or Grid to design a tool interface layout.
6	Apply responsive design to make the page mobile-friendly.
7	Add interactivity: Create a JavaScript function that counts nucleotides in a sequence. Validate user input (e.g., only A, T, G, C allowed) in a DNA form using JavaScript.
8	Use JavaScript to dynamically update search results on typing (basic).
9	Display alert messages based on input sequence length or quality.
10	**Mini Project** • Design a static website for a bioinformatics lab or gene database. • Create a DNA Sequence Analyzer webpage using HTML + CSS + JavaScript. • Simulate a "BLAST-like" search UI with mock results. • Host your webpage locally or on GitHub Pages.

**********16.06.2025**********