Revised as per HEC New UEP 2023

SHAHEED BENAZIR BHUTTO WOMEN UNIVERSITY PESHAWAR

DEPARTMENT OF BIOINFORMATICS

CURRICULUM 2023 & ONWARDS
(HEC Revised Curriculum-2015)

Department of Bioinformatics
Main Campus, Charsada Road, Larma
Phone Number: 091-9224790

SHAHEED BENAZIR BHUTTO WOMEN UNIVERSITY PESHAWAR

Title: "REVISED BIOINFORMATICS CURRICULUM 2023"

Approved from Statutory Bodies:

6th Meeting of the Board of Studies held on Wednesday, 15th, March, 2023.
12th Meeting of the Board of Faculty held on Tuesday 24th October, 2023.
19th Meeting of the Academic Council held on 8th November, 2023
49th Meeting of the Syndicate held on 5th & 6th March 2024.

Compiled By:

Dr.Farhat Amin. Associate Professor
Chairperson, Department of Bioinformatics.
Shaheed Benazir Bhutto Women University, Peshawar.

"REVISED BIOINFORMATICS CURRICULUM 2023 & Onwards"

The members of the Board of Studies of Bioinformatics designed the curriculum for Bioinformatics, developed the framework, scheme of Studies, and revised the curriculum in different meetings. The first meeting was held 2nd on Nov 2022 at 9.30 am, the 2nd meeting was held on 15th December 2022 at 10 am, the third meeting was held on 2nd February 2023 at 11 am and the fourth meeting was held on 7th March 2023 at the office of the chairperson, Department of Bioinformatics. The following members attended these meetings and assigned the mentioned courses for course content designing. The courses were presented and approved in the Meeting of BOS (14th March 2023), 12th Meeting of BOF (24th Oct 2023) and 19th Meeting of Academic Council (8th Nov 2023).

	Names and Designation of Faculty.	**Assigned Courses**
1.	Dr, Farhat Amin, Associate Professor, Chairperson, Department Bioinformatics. Shaheed Benazir Bhutto Women University, Peshawar.	1. Fundamentals of Bioinformatics 2. Computational Biochemistry 3. Chemoinformatics. 4. Clinical Bioinformatics 5. Computational Immunology 6. System Biology
2.	Dr.Nousheen Bibi Assistant Professor. Department of Bioinformatics. Shaheed Benazir Bhutto Women University, Peshawar	1. Introduction to Bioinformatics and Computational Biology. 2. Next-Generation Sequencing Data Analysis 3. Biological Sequence Analysis 4. Bionetworks & Genomics
3.	Dr.Aishma Khattak. Assistant Professor Department of Bioinformatics. Shaheed Benazir Bhutto Women University, Peshawar	1. Medical Genetics
4.	Dr.Ambreen Shahnaz, Lecturer Department of Bioinformatics. Shaheed Benazir Bhutto Women University, Peshawar.	1. Bioinformatics Computing, 2. Bioinformatics Software Engineering.
5.	Ms.Asma BiBi Lecturer Department of Bioinformatics. Shaheed Benazir Bhutto Women University, Peshawar.	1.Essentials of Genetics 2.Microbiology and Immunology
6.	Ms.Sidra Qureshi Lecturer Department of Bioinformatics. Shaheed Benazir Bhutto Women University, Peshawar.	1.Cell Biology 2.Molecular Biology
7.	Ms.Aisha Ghani Lecturer Department of Bioinformatics. Shaheed Benazir Bhutto Women University, Peshawar.	1. Bioinformatics I 2. Bioinformatics II 3. Ethical and Legal Issues in Bioinformatics.
8.	Ms.Asima Jamil Lecturer Department of Bioinformatics. Shaheed Benazir Bhutto Women University, Peshawar.	1. Modern Programming languages 2.Data Science.

CONTENTS

SHAHEED BENAZIR BHUTTO WOMEN UNIVERSITY PESHAWAR

INTRODUCTION TO THE DEPARTMENT OF BIOINFORMATICS

Bioinformatics, by its nature, is multidisciplinary. At the University, we have built a core set of bioinformatics faculty, staff, and students from Pre-Medical and Pre-engineering backgrounds.
In the Bioinformatics discipline, faculty members are involved in the acquisition, representation, modeling, integration, interpretation, and transformation of biomedical data.
Their work spans a range of activities including biochemical systems theory, biological process modeling, biomarker identification, machine learning, analysis and interpretation of genomic and proteomic data, text data mining, identification of gene regulatory networks, ontology development, and design and implementation of clinical decision aids. They combine multidisciplinary research and collaborative arrangements with basic and clinical sciences to provide an integrated approach to the development of new ontological approaches and the synthesis of new and existing knowledge in medicine and the biological sciences.
The Department of Bioinformatics is dedicated to advancing the application of computational methods to cutting-edge problems in biology. The new field of Bioinformatics and Computational Biology is making critical contributions to diverse areas such as disease detection, drug design, forensics, agriculture, and environmental sciences through the combination of biological analysis and high-performance computing. The Department offers a variety of undergraduate courses in Bioinformatics.
The Department of Bioinformatics engages in education and research activities in the biological sciences. Methodological and applied research activities provide students with unique opportunities to participate in quantitative research in all aspects of public health sciences, including such areas as medicine, dentistry, nursing, and cancer research.

BACKGROUND:

We are witnessing the birth of a new era in biology and medicine. The confluence of unprecedented measuring capabilities and computational power has dramatically changed the questions that may be addressed in the biological and biomedical sciences and promises to empower clinical practice in fundamental ways.

On the one hand, recent and novel technologies produce biological data sets of ever-increasing resolution that reveal not only genomic sequences, but also RNA and protein abundances, their interactions with each other, their sub-cellular localization, and the identity and abundance of other biological molecules. This requires the development and application of sophisticated computational methods, encompassed by the field of **Bioinformatics.**

Addressing these challenges requires an interdisciplinary research structure dedicated to developing intellectual and human capacity in Bioinformatics. As such, there is an enormous need for trained professionals who are experts in biology, biomedicine, and computing. To address this need, the

Bioinformatics Graduate Program at the Shaheed Benazir Bhutto Women University, Peshawar was founded in 2007.

The Department of Bioinformatics aims to apply its knowledge and expertise to the cost-effective development, implementation, support, and improvement of the Bioinformatics infrastructure to meet the present and future requirements of life sciences & to educate and produce graduate students in the field of bioinformatics and computational biology who are skilled & able to integrate research and education on the use of information technologies by developing/using bioinformatics tools.

VISION

Provide a benchmark to promote the creation & dissemination of knowledge and research that blends life and medical sciences to develop Bioinformatics professionals and researchers with interdisciplinary approaches, enabling them to meet national and international challenges.

MISSION

To accelerate progress in life and health sciences by promoting scientific initiatives that:

- Challenge our understanding of bioinformatics fundamentals through integrated approaches as an interdisciplinary science.
- Allow progress in developing a common framework for the effective and responsible exchange of biological information and related data within clinical treatment and the agri-food industry.
- To ensure collaboration among the academic world, research, healthcare systems, and industry is of the maximum effectiveness especially among the local academic and industries for strengthening the local business.

CURRICULUM

OF

BIOINFORMATICS
BS

(Session 2023 & Onwards)

SHAHEED BENAZIR BHUTTO WOMEN UNIVERSITY PESHAWAR

DEAPRTMENT OF BIOINFORMATICS

UNDERGRADUATE PROGRAM IN BIOINFORMATICS:

One of the first programs of its kind, the Undergraduate Program in Bioinformatics, offers unique interdisciplinary training in the science, engineering, medicine, and ethics of biology. Our curriculum focuses on molecular biology and the physics of the cell and emphasizes the use of advanced mathematics and computation.

The research program includes state-of-the-art topics in systems biology, computational modeling of regulatory and metabolic networks, small-molecule and macromolecule docking, comparative genomics, protein design, genomic and proteomic biotechnology, microarray engineering and analysis, pharmacogenomics, structural biology, large-scale modeling of biological systems, RNA, computational studies of cancer and neurological disorders and functional genomics, synthetic gene networks and molecular computing and genetics.

Our dynamic environment is focused on students and helps them gain field experience through academic and industrial rotations, internships, and a student seminar series. Our students regularly collaborate with faculty to produce publications.

MISSION STATEMENT OF THE BS-PROGRAMME:

The mission of the program is to educate and prepare graduate students to understand the advantages & limitations of molecular biology along with the practical application of bioinformatics tools for the development of human resources in the discipline of Bioinformatics.

PROGRAMME OBJECTIVES: The program objectives are to:

1) Learn the scientific concepts and applications of computational methods in the biological sciences.
2) Adopt practical approaches to IT and computer applications in molecular biology and biotechnology with a focus on major issues concerning the representation and analysis of bimolecular sequences and structural information.
3) Learn investigative methods for research in biosciences with the help of tools of Bioinformatics.
4) Provide knowledge on the development and application of computer software tools of bioinformatics.

OUTCOMES OF THE PROGRAMME: The graduates of BS-Bioinformatics will be able to;

1. Find new and global perspectives into the organization and function of biological systems.
2. Develop software tools, algorithms, and databases for gene identification, protein structural prediction, clustering analysis, and data mining.
3. Articulate the knowledge of computer programming and languages to bioinformatics.

4. Apply the knowledge of bioinformatics to disease diagnosis and treatment.
5. Research the new and novel targets for drug discovery and development; and Find the Genetic/proteomic profiling for pharmaco-genomics or personalized medicine.

ADMISSION REQUIREMENTS:

Higher Secondary School Certificate or equivalent (2nd division with at least 50% marks) in pre-engineering/pre-medical/Intermediate in computer sciences/relevant subjects

ELIGIBILITY (Annex A: Documentary Evidence NCEAC Letter)

The minimum requirement for admission to a bachelor's degree program in any computing program is any of the following:

a) At least 50% marks in Intermediate (HSSC) examination with Mathematics or equivalent qualification with Mathematics, certified by IBCC.

OR

b) At least 50% marks in Intermediate (HSSC) examination with Pre-Medical or equivalent qualification, certified by IBCC.

Deficiency:

"Students with pre-medical must have to pass deficiency courses of Mathematics of 6 credit hours in first two semesters."

"Institute must offer two math courses (attached) as deficiency courses within first year to those students who have not studied math in intermediate. These Math courses will be as Non-Credit courses with only Pass/Fail grade assigned to the students so that overall credit does not affect."

DURATION

- Four years program spread over 8 semesters, two semesters per year.

COURSE AND CREDIT REQUIREMENTS:

A total of 138 credits are required to complete a Bachelor of Science in Bioinformatics.

SHAHEED BENAZIR BHUTTO WOMEN UNIVERSITY PESHAWAR

STRUCTURE

Sr.No	Categories	Credit Hours Min – Max
1.	General Education (Gen Edu) Requirements: Mandatory Courses of General Education.	30 – 30
2.	Major (Disciplinary) Requirements: Area of Study in Which the Degree is offered	*72 ≥
3.	Interdisciplinary/Allied Requirements (To Support Horizon of the Major)	**12 ≥
4.	Field Experience/Internship (Practical Work Experience related to a Student's Field of Study or Career interest)	03 – 03
5.	Capstone Project or Capstone Research Project	03 – 06
	Total	**120 – 144**

***The Credit Hours for the courses of Major Disciplines may vary but not less than 72 Credit Hours.**
****The Credit Hours for Interdisciplinary/Allied Courses may vary but not less than 12 Credit Hours.**

- Total number of Credit hours 120-144
- Duration 4 years
- Semester duration 16-18 weeks
- Semesters 8
- Course Load per Semester 15-18 Cr hr
- Number of courses per semester 4-6 (not more than 3 lab / practical courses)

SCHEME OF STUDIES OF 4-YEAR PROGRAM
(SESSION 2023 & Onwards)

Mapping of BS BI by Accreditation Council (NCEAC) as Per HEC UEP 2023			
S.No	**Course Code**	**Gen Edu Mandatory Course**	**Credit Hours**
1	AH-301	Art & Humanities	2
2	ISL-301	Islamic Studies/Religious Studies	2
3	ENG-303	Functional English	3
4	ENG-304	Expository Writing	3
5	MTH-401	Quantitative Reasoning, I	3
6	MTH-402	Quantitative Reasoning, II	3
7	000	Natural Science (Applied Physics)	3
8	000	Social Science	2
9	PST-313	Ideology and Constitution of Pakistan	2
10	PSC-418	Civic and Community Engagement	2
11	MS-309	Introduction to Entrepreneurship	2
12	CSC-308	Application of Information and Communication Technologies.	3
		Total Credit Hours	**30**
S.No	**Course Code**	**Computing Core**	**Credit Hours**
1	CSC-302	Programming Fundamentals	4
2	CSC-312	Object Oriented Programming	4
3	CSC-524	Database Management System	4
4	CSC-305	Digital Logic Design	3
5	CSC-4232	Data Structure	4
6	CSC-521	Information Security	3
7	CSC-543	Artificial Intelligence	3
8	CSC-515	Computer Networks	3
9	BI-622	Bioinformatics Software Engineering	3
10	CSC-431	Computer Organization & Assembly Language	3
11	CSC-432	Operating System	3
12	CSC-672	Analysis of Algorithms	3
		Total	**40**
S.No	**Course Code**	**Interdisciplinary/Allied Courses**	Credit Hours
1	STAT-402	Probability and Biostatistics	3
2	MTH-404	Multivariable Calculus	3
3	MTH-405	Linear Algebra	3
4	ENG-402	Business Communication	3
		Total	**12**
S.No	**Course Code**	**Domain Core**	Credit Hours
1	BI-303	Introduction to Bioinformatics & Computational Biology	4
2	BI-524	Bioinformatics Computing	4
3	BI-411	Bioinformatics I (Bioinformatics Methods)	3
4	BI-412	Bioinformatics II (Applied Bioinformatics)	3

5	BCHM-302	Introductory Biochemistry (Biochemistry I)	3
6	BCHM-304	Metabolism of Biomolecules (Biochemistry II)	3
7	BIT-303	Cell Biology	3
8	BIT-311	Essentials of Genetics	3
9	BIT-413	Molecular Biology	3
10	BI-502	Ethical and Legal Issues in Bioinformatics	2
11	BI-532	Genomics	3
12	BI-531	Proteomics	3
13	BI-525	NGS Analysis	3
14	BI-526	Clinical Bioinformatics	3
15	BI-641	System Biology	3
16	BI-698	Internship (Mandatory)	3
17	BI-699	Semester Research Project (Capstone Research Project)	6
		Total	**55**
		Total Credit Hours	**138**

SEMESTER WISE SCHEME OF STUDIES

Semester	Category	Course Codes	Course Titles	Lectures	Lab	Cr.Hrs
Semester 1	Art & Humanities	AH-301	Art & Humanities	2	0	2
	Islamic Studies/Religious Studies/Ethics	ISL-301	Islamic Studies	2	0	2
	Interdisciplinary/Allied Course	CSC-308	Application of Information and Communication Technologies.	2	1	3
	Functional English	ENG-303	Functional English	3	0	3
	Major I	BI-303	Introduction to Bioinformatics and Computational Biology	3	1	4
	Major II	BIT-303	Cell Biology	2	1	3
			Total	**14**	**3**	**17**
Semester 2	Social Sciences	000	Social Sciences	2	0	2
	Expository Writing	ENG-304	Expository Writing	3	0	3
	Interdisciplinary/Allied Course	MTH-404	Multivariable Calculus	3	0	3
	Ideology and Constitution of Pakistan	PS-313	Ideology and Constitution of Pakistan	2	0	2
	Major III	BIT-311	Essentials of Genetics	3	1	4
	Major IV(Computing Core)	CSC-302	Programming Fundamentals	3	1	4
			Total	**16**	**2**	**18**
Semester 3	QR I	MTH-401	Quantitative Reasoning (QR I)	3	0	3
	Natural Science	000	Natural Sciences	3	0	3
	Entrepreneurship	MS-309	Introduction to Entrepreneurship	2	0	2
	Major V	BCHM-302	Introductory Biochemistry (Biochemistry I)	2	1	3
	Major VI	BI-411	Bioinformatics I (Bioinformatics Methods)	2	1	3

	Major VII	BIT-413	Molecular Biology	2	1	3
			Total	**14**	**3**	**17**
Semester 4	Civic and Community Engagement	PSC-418	Civic and Community Engagement	2	0	02
	QR II	MTH-402	Quantitative Reasoning (QR II)	3	0	3
	Interdisciplinary/Allied Course	STAT-402	Probability and Statistics	3	0	3
	Interdisciplinary/Allied Course	MTH-317	Linear Algebra	3	0	3
	Major VIII	BCHM-304	Metabolism of Biomolecules (Biochemistry II)	2	1	3
	Major IX	BI-412	Bioinformatics II (Applied Bioinformatics	2	1	3
			Total	**15**	**2**	**17**
Semester 5	Interdisciplinary/Allied Course	ENG-402	Business Communication	3	0	3
	Major X	BI-531	Genomics	3	0	3
	Major XI	BI-524	Bioinformatics Computing	3	1	4
	Major XII(Computing Core)	CSC-312	Object Oriented Programming	3	1	4
	Major XIII(Computing Core)	CSC-524	Database Management System	3	1	4
			Total	**15**	**3**	**18**
Semester 6	Major XIV	BI-532	Proteomics	3	0	3
	Major XV	BI-502	Ethical and Legal Issues in Bioinformatics	2	0	2
	Major XVI	BI-525	NGS Analysis	2	1	3
	Major XVII	BI-526	Clinical Bioinformatics	3	0	3
	Major XVIII(Computing Core)	CSC-305	Digital Logic Design	2	1	3
	Major XIX(Computing Core)	CSC-423	Data Structure	3	1	4
			Total	**15**	**3**	**18**
Semester 7	Internship (Mandatory)	BI-698	Internship (Mandatory)	0	3	3
	Major XX (Computing Core)	BI-622	Bioinformatics Software Engineering	2	1	3
	Major XXI(Computing Core)	CSC-521	Information Security	3	0	3
	Major XXII(Computing Core)	CSC-515	Computer Networks	2	1	3
	Major XXIII(Computing Core)	CSC-432	Operating System	2	1	3
	Capstone Research Project	BI-699	Capstone Research Project (Continue)	0	3	3
			Total	**9**	**9**	**18**
Semester 8	Major XXIV(Computing Core)	CSC-543	Artificial Intelligence	2	1	3
	Major XXV(Computing Core)	CSC-431	Computer Organization & Assembly Language	2	1	3
	Major XXVI(Computing Core)	CSC-672	Analysis of Algorithms	3	0	3
	Major XXVII	BI-641	System Biology	3	0	3
	Capstone Research Project	BI-699	Capstone Research Project	0	3	3
			Total	**10**	**5**	**15**

Total	**I**	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**

Cr.Hrs								
138	**17**	**18**	**17**	**17**	**18**	**18**	**18**	**15**

DETAIL OF COURSES
Semester-I

Course Title: Art and Humanities	**Course Code: AH-301**
Course Structure: Lectures, 2 Hours	**Credit Hours: 2**

Course Objectives: This course is an interdisciplinary survey of human culture, society, and expression. The different disciplines in this course are organized into a series of broad thematic approaches focusing on aesthetics, literature**,** philosophy, history, society, and culture. This course will introduce students to each of these disciplines and some of the aspects and perspectives they take in the study of arts and humanities. The course develops knowledge and skills to understand the different disciplines of art and humanities, their scope, main categories, and their influence on human culture and expressions.

Course Outline: Introduction: What is humanities? Fields of art and humanities. **Art**: Introduction to Art, Art in the Indo-Pak subcontinent, Modern Art in Pakistan. **Literature & Linguistics**: Literature: Definition, Key Concepts, Major Genres. Linguistics: Definition, Key Concepts, Major Categories, **Philosophy:** Meaning and nature of Philosophy, Characteristics of Philosophy, Major area/branches of Philosophy, Metaphysics: Epistemology: Ethics /Moral Philosophy, Logic, Political Philosophy, Philosophy of Science. **History:** Meaning and concept, development of history in ancient, mid level and modern periods. Islamic concept of history .**Society & Culture:** Concept of Society and Culture**,** Pakistani Society: Social institutions (Family, school, religion, government, media)**,** Pakistani Culture: Norms and values; Similarities and difference to the main culture of Pakistan (Punjab, Khyber Pakhtunkhwa, Sindh, Balochistan, Gilgit Baltistan, Kashmir); Factors promoting national integration. Modernization and its impact on society.

Course Outcome: Upon successful completion of this course, students will be:

- Describe the different disciplines of art and humanities.
- Show awareness of the scope and variety of works in the arts and humanities.
- Demonstrate knowledge of the influence of arts, literature, history and philosophy on human culture and expressions.

Recommended Books:

1. Abbs, P. & Richardson, J. *The Forms of Poetry*. (1995). Cambridge University Press.
2. Axelrod, Rise B., and Charles R. Cooper. *The St. Martin's Guide to Writing [with Access Code]*. 2016.
3. Bose, S., & Jalal, A. *Modern South Asia: History, Culture, Political, Economy* (2nd Ed). 2004. Oxford University Press.
4. Chrisman, M., Pritchard, D., Fletcher, G., Mason, E, Lavelle, J. S., Massimi, M., Richmond, A., Ward, D. *Philosophy for Everyone* (2nd Ed.). (2016). Routledge.
5. Davis, H. *An Outline History of the World*.2022. Creative Media Partner.
6. Finch, G. *How to Study Linguistics: A Guide to Understanding Linguistics*. (2004). Palgrave.
7. Husain, M. *Aspects of Art*. 2000. Oxford University Press.
8. Jackson, F., & Smith, J. *The Oxford Handbook of Contemporary Philosophy.* (2005). Oxford

University Press.
9. Qureshi, I. H. *The Pakistani Way of life*. (2016). New Royal *Book*.
10. Raza, R. Being Pakistani: Society, Culture and the Arts. (2018). HarperCollins India.

Course Title:: Islamic Studies	**Course Code:ISL-301**
Course Structure: Lectures	**Credit Hours: 2**
Prerequisites: None	

Description This course is designed to provide students with a comprehensive overview of the fundamental aspect of Islam, its beliefs practices History and influence on society. It will further familiarize the students with a solid foundation in understanding Islam from an academic and cultural perspective. Through this course students will have and enhanced understating of Islam's multifaceted dimensions which will enable them to navigate complex discussions about Islam's Historical and contemporary role fostering empathy respect and informed dialogue .

Course outcomes : By the end of this course, Students will be able to :

1. Demonstrate enhanced knowledge of Islamic foundational beliefs, practices historical development spiritual values and ethical principles
2. Describe basic source of Islamic law and their application in daily life
3. Identify and discuss contemporary issue being faced by the Muslims world including social challenges, gender role and interfaith interactions.

Course outline:

Introduction to Islam: Definition of Islam and its core beliefs The Holy Qura'n (Introduction, Revelation and compilation, Hadith and Sunnah (Compilation Classification and Significance) Key theological concepts and themes (Tawhid , Prophet hood Akhiraha etc, **Seerat of Holy Prophet (S.A.W)** Life and legacy of the Holy prophet **(S.A.W** Diverse role of the Holy Prophet (as and individual, educator, peace maker, leader etc**), Islamic History and civilization** World Before Islam Rashidun Caliphate and expansion of Islamic rule, Contribution of Muslim scientists and philosophers in shaping world civilization, **Islamic Jurisprudence: (Fiqh)** Fundamental Sources of Islamic Jurisprudence Pillars of Islam and their significance Major Schools of Islamic Jurisprudence **,** Significance and principles of Ijtihad, **Family and Society in Islam** Status and rights of woman in Islamic Teachings, Marriage, Family, and gender roles in Muslim society, Family structure and values Muslim society, **I**slam & the Modern World.

Suggested Instructional Materials:

1. The five Pillars of Islam: A journey thought the Divene Acts of Worship by Muhammad Mustafa Al Azami
2. The Five Pillars of Islam: A Framework for Islamic Values and Character Building by Musharraif Hussain
3. Towards Understanding Islam By Abul A' la Mawdudi
4. Islami Nazria e Hayat by Khurshid Ahmad
5. An Introduction to Islamic theology by John Rearard
6. Islamic Civilization Foundations Belief and Principles by Abul A la Mawdudi
7. Women and Social Justices An Islamic Paradigm by Dr Anis Ahmad
8. Islam its Meaning and Message " By Khushid Ahmad

Course Title: Applications of Information and Communication Technologies	**Course Code: CSC-308**
Course Structure: Lectures: 2 Lab:1	**Credit Hours: 3**
Prerequisites: None	

Course Objective:

- This course is designed to provide students with an exploration of the practical applications of Information and Communication Technologies (ICT) and software tools in various domains.
- Students will gain hands-on experience with a range of software applications, learning how to leverage ICT to solve daily life problems, enhance productivity and innovate in different fields.
- Through individual and interactive exercises and discussions, students will develop proficiency in utilizing software for communication, creativity, and more.

Course Outline:

Introduction to Information and Communication Technologies: Components of Information and Communication Technologies (basics of hardware, software, ICT platforms, networks, local and cloud data storage etc.). Scope of Information and Communication Technologies (use of ICT in education, business, governance, healthcare, digital media and entertainment, etc.). Emerging technologies and future trends. **Basic ICT Productivity Tools:** Effective use of popular search engines (e.g., Google, Bing, etc.) to explore World Wide Web. Formal communication tools and etiquette (Gmail, Microsoft Outlook, etc.). Microsoft Office Suites (Word, Excel, PowerPoint).Google Workspace (Google Docs, Sheets, Slides).Dropbox (Cloud storage and file sharing), Google Drive (Cloud storage with Google Docs integration) and Microsoft OneDrive (Cloud storage with Microsoft Office integration). Evernote (Note-taking and organization applications) and OneNote (Microsoft's digital notebook for capturing and organizing ideas). Video conferencing (Google Meet, Microsoft Teams, Zoom, etc.). Social Media applications (Linkedln, Facebook, Instagram, etc.). **ICT in Education:** Working with learning management systems (Moodle, Canvas, Google Classrooms, etc.).Sources of online education courses (Coursera, edX, Udemy, Khan Academy, etc.).Interactive multimedia and virtual classrooms. **ICT in Health and Well-being:** Health and fitness tracking devices and applications (Google Fit, Samsung Health, Apple Health, Xiaomi Mi Band, Runkccpcr, etc.).Telemedicine and online health consultations (OLADOC, Sehat Kahani, Marham, etc.).**ICT in Personal Finance and Shopping:** Online banking and financial management tools (JazzCash, Easypaisa, Zong PayMax, Il LINK and MNET, Keenu Wallet, etc.).E-commerce platforms (Daraz.pk, Telcnoart, Shophivc, etc.)Digital Citizenship and Online Etiquette. Digital identity and online reputation. Netiquette and respectful online communication. Cyberbullying and online harassment. **Ethical Considerations in Use of ICT Platforms and Tools:** Intellectual property and copyright issues. Ensuring originality in content creation by avoiding plagiarism and unauthorized use of in fornication sources. Content accuracy and integrity (ensuring that the content shared through ICT platforms is free from misinformation, fake news,

and manipulation).

Practical Requirements

As part of the overall learning requirements, the course will include guided tutorials and exercises to ensure that students are proficient in commonly used software applications such as worcl processing software (e.g., Microsoft Word), presentation software (e.g., Microsoft PowerPoint), spreadsheet software (e.g., Microsoft Excel) among such other tools. Students may be assigned practical tasks that require them to create documents, presentations, and spreadsheets etc. Assigning tasks that involve creating, managing, and organizing files and folders on both local and cloud storage systems. Students will practice file naming conventions, creating directories, and using cloud storage solutions (e.g., Google Drive, OneDrive). The use of online learning management systems (LMS) where students can access course materials, submit assignments, participate in discussion forums, and take quizzes or tests. This will provide students with the practical experience with online platforms commonly used in education and the workplace.

Course Outcomes:

- By the end of this course, students will be able to Explain the fundamental concepts, components, and scope of Information and Communication Technologies (ICT).
- Identify uses of various ICT platforms and tools for different purposes.
- Apply ICT platforms and tools for different purposes to address basic needs in different domains of daily, academic, and professional life.
- Understand the ethical and legal considerations in use of ICT platforms and tools.

Recommended Books: Latest Edition of the Following Books.

1. Vermaat, Shaffer, and Freund, Discovering Computers, 2017, Cengage Learning.
2. Series by Gaskin, Vargas, and McLellan, GO! with Microsoft Office,2013, Pearson.
3. Grauer and Poatsy. Exploring Microsoft Office,2016, Pearson.
4. Morley and Parker Computing Essentials, 2023, McGraw Hill.
5. Evans, Martin, and Poatsy. Technology in Action,2021, Pearson.

Course Title:: Functional English	**Course Code: ENG-303**
Course Structure: Lectures: 3, Labs: 0	**Credit Hours: 3**
Prerequisites: None	

Course Objective: This course will familiarize students with the essential language skills for effective communication in diverse real-world scenarios. It focuses on developing proficiency in English language and usage: word choices, grammar and sentence structure. In addition, the course will enable students to grasp subtle messages and tailor their communication effectively through the application of comprehension and analytical skills in listening and reading. Moreover, the course encompasses a range of practical communication aspects including professional writing, public speaking and everyday conversation ensuring that students are equipped for both academic and professional spheres.

Course Outline: 1. Foundations of Functional English Vocabulary Building (contextual usage, synonyms, antonyms, and idiomatic expressions) Communicative Grammar (subject-verb agreement, verb tenses, fragments, run-ons, modifiers, articles, word classes etc) Word Formation (affixation, compounding, clipping, back formation etc) Sentence Structure (simple, compound, complex and compound-complex). **Comprehension and Analysis.3.** Understanding Purpose, audience and context a. (reading for meaning, descriptive texts versus narrative texts , argumentative texts versus persuasive texts) 3. Contextual Interpretation (tones, biases, stereotypes, assumptions, inferences etc) 4. Reading Strategies (skimming, scanning, SQ4R, critical reading) 5. Active Listening (overcoming listening barriers, focused listening). **Effective Communication** Principles of Communication(clarity, coherence, correctness and courteousness). Structuring Documents (introduction, body, conclusion and formatting). Inclusivity in Communication (gender-neutral language and cross-culturalcommunication). Public Speaking (Speech/presentation: extemporaneous and prepared, public announcements and overcoming stage fright) Presentation Skills: a. (the elements of an effective presentation, using visual displays to present key facts, figures, charts, and graphs , steps to preparing an effective presentation, one-minute presentations and evaluate presentations, Informal Communication (small talk and networking), Professional Writing (business e-mails, memos, reports, formal letters etc).
Course Outcomes: By the end of the course the students will be able to apply the enhanced English skills, comprehend a variety of literary and non-literary texts, and express effectively in spoken and written English in diverse social and cultural contexts.
Recommended Books: Latest Edition of Following Books 1. Murphy, Raymond. Grammar in Use Intermediate Student's Book without Answers. Cambridge University Press, 2018. 2. Kaufman, Lester, and Jane Straus. The Blue Book of Grammar and Punctuation. 2021. 3. Axelrod, Rise B., and Charles R. Cooper. The St. Martin's Guide to Writing [with Access Code]. 2016. 4. 2. Johnson-Sheehan, Richard, and Charles Paine. Writing Today. Pearson, 2019. **5.** https://www.hec.gov.pk/english/services/universities/RevisedCurricula/Documents/2011-2012/Education/English2_Sept13.pdf

Course Name: Introduction to Bioinformatics and Computational Biology	**Course Code: BI-303**
Course Structure: Lectures: 3, Labs: 1	**Credit Hours: 4**
Course Description: The course provides students with a foundational understanding of the principles and techniques in the fields of bioinformatics and computational biology. This course is designed to cover essential topics, including sequence analysis, database searching, structural biology, and data visualization. The course integrates theoretical concepts with practical exercises, enabling students to acquire the skills needed to analyze biological data using computational tools.	

Prerequisites: None (basic knowledge of biology and computer literacy is recommended)

Course Objective: Students will be able to:

1. Understand the role of bioinformatics and computational biology in modern biological research.
2. Utilize common software tools and databases in bioinformatics.
3. Comprehend the structure and function of biological macromolecules.
4. Apply fundamental computational techniques to analyze biological data. Perform basic sequence analysis, interpret biological data, and communicate biological information effectively.

Course Outline: Introduction to Bioinformatics and Computational Biology: Definition and scope of bioinformatics and computational biology, Significance in modern biology and healthcare, Overview of bioinformatics tools and resources, Biological Macromolecules: Structure and function of DNA, RNA, and proteins, Central dogma of molecular biology, Nucleic acid and amino acid properties. Biological Databases: Types of biological databases (genomic, proteomic, structural), Database searching and data retrieval, Sequence, structure, and functional annotations, Sequence Analysis: Sequence alignment: pairwise and multiple sequence alignment, Sequence databases and BLAST searches, Sequence motifs and profiles, Molecular Visualization: Visualization software (e.g., PyMOL, Chimera), Visualization of protein structures and macromolecular complexes, Structural analysis and manipulation: Phylogenetic Analysis, Phylogenetic trees and evolutionary relationships, Phylogenetic software and tools, Interpretation of phylogenetic trees, Genomic Data Analysis: Genomic data types (e.g., DNA sequencing, gene expression) Basic data preprocessing and visualization, Gene annotation and functional analysis, Ethical issues in bioinformatics and data sharing, Limitations and challenges in computational biology, and Validation of computational results with experimental data.

Practicals:

1. Use bioinformatics software and databases to retrieve biological data.
2. Perform basic sequence alignment and homology searches.
3. Analyze and visualize biological data. Analyze and interpret biological data to draw meaningful conclusions.
4. Apply computational methods & tools to explore biological questions.
5. Evaluate the quality of biological data and the accuracy of computational results.
6. Recognize the importance of data validation through experimentation.

Course Outcomes: Upon successful completion of the course, students will be able to:

1. Explain the fundamental concepts and significance of bioinformatics and computational biology.
2. Recognize the role of databases in biological data management and retrieval.
3. Understand the principles of sequence alignment and phylogenetic analysis.
4. Comprehend the basics of structural biology and molecular visualization.

Recommended Books: Latest Edition of Following Books

1. Arthur M. Lesk, **Introduction to Bioinformatics**.5th Edition (2019).Oxford University Press.

2. Andreas D. Baxevanis (Ed), B. F. Francis Ouellette (Ed), **Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins**, 3rd edition, October 2004,Wiley, John & Sons, Incorporated, ISBN: 0471478784

3. S.C.Rastogi, N.Mendiratta,P.Rastogi,**Bioinformatics: Methods and Applications: Genomics, Proteomics and Drug Discovery**. 3rd Edition (2009). PHI Learning Pvt. Ltd.

4. David Mount, **Bioinformatics: Sequence and Genome analysis**.2nd Edition (2004). Cold Spring Harbour Laboratories.

5. Thomas Dandekar, Meik Kunz, **Bioinformatics An Introductory Textbook, (**2023**),** Springer-Verlag GmbH Germany, part of Springer Nature

Course Name: Cell Biology	**Course Code: BIT-303**
Course Structure: Lectures: 2, Labs: 1	**Credit Hours: 2+1**
Prerequisites:	
Course Objective: This course provides the basic concepts of life science, 1. With emphasis on the diversity of life, the physical and chemical nature of living matter, and the form and function of cells and organisms. 2. Introduce students to the internal organization of the prokaryotic and eukaryotic cell, organelle and membrane function, cell-cell signaling, cell movement, cell adhesion, and the extracellular matrix.	
Course Outline: Introduction to cell biology, Form and function of the cell, Types of cells, The Chemical Basis of Life, the chemistry of cell, Cells and organelles overview, The Structure, function, and molecular organization of cellular organelles, Roles of different macromolecules, Enzymes Molecular organization of cells Protoplasm, Cell wall, Cell membrane, transport across membranes, organelles: mitochondria, endoplasmic reticulum, Golgi bodies, plastids, lysosomes, peroxisomes, The Structure and Function of the Plasma Membrane, Cytoplasmic Membrane Systems, cell internal structure, cytoskeleton, microtubules, microfilaments, intermediate filaments, structure of chromosomes, Photosynthesis, Components of Photosynthesis, cell division and cell cycle. The key roles of mitosis and meiosis during the life cycle. Compare and contrast different life cycle strategies, focusing on the human life cycle 13 Stages of mitosis and meiosis, Highlighting similarities and differences. Stages of the cell cycle Apoptosis, cell signaling, Cell visualization techniques. **Practicals:** Microscopy and staining techniques; study of prokaryotic, eukaryotic, plant and animal cells; cell structure in the staminal hair of Tradescantia; study of different types of plastids; cellular reproduction; Mitosis: smear/squash preparation of onion roots.	
Course Outcomes: Upon successful completion of the course, the student will be able to: 1. Acquire the basic concepts of cell biology. 2. Understand the metabolic processes of cells in terms of cellular organelles, membranes, and biological molecules. 3. Ability to understand the role of macromolecules regulating cellular processes. 4. Formulate the critical thinking skills and knowledge on cell.	
Recommended Books: 1. Alberts B and Johnson A, 2006. Molecular Biology of the Cell. 4 th Edition; Garland Publishers, New York. (available at www.ncbi.nlm.nih.gov) 2. Karp, 2002. Cell and Molecular Biology. 3rd Edition; John Wiley and Sons, New York. 3. Bruce Alberts, Rebecca Heald, Alexander Johnson, Molecular Biology of the Cell 7th Edition, 2022. W.W.Norton and Company.	
6.Jin Xiong, **Essential Bioinformatics**,(2006), Cambridge University Press	

4. Alberts et al., 2009. Essential Cell Biology. 3rd Edition; Garland Publishers, New York.
5. Thomas D. Pollard, MD, William C. Earnshaw, PhD, FRS, Jennifer Lippincott-Schwartz, PhD and Graham Johnson, Cell Biology, 4th Edition (2023) ISBN : 9780323758000
6. Lodish et al,. 2007. Molecular Cell Biology. 6th Edition; Freeman and Company, New York. (available at www.ncbi.nlm.nih.gov)
7. Harvey Lodish, Arnold Berk, Chris A. Kaiser- 2016 8th Edition Molecular cell biology
8. Thomas D. Pollard, William C. Earnshaw, Jennifer Lippincott-Schwartz 2007 2nd Edition Cell biology
9. S C Rastogi 2005 3rd Edition, Cell biology. Newage international Publishers.India.

Semester-II

Course Title: Social Sciences	**Course Code:000**
Course Structure: Lectures, 2 Hours	**Credit Hours: 2**
Course Outline: Course content /Course Title will be taken from the Booklet of Approved Mandatory and General Education Courses.	

Course Title: Expository Writing	**Course Code: ENG-304**
Course Structure: Lectures: 3, Labs: 0	**Credit Hours: 3**
Prerequisites: None	
Course Objective: This is a sequential undergraduate course aimed at refining basic writing skills in various contexts. Building upon its pre-requisite, Functional English Course, this course will enhance student's ability to produce clear, concise and coherent texts in English. This course will enable the students to produce well-structured essays and to refine their analytical skills.	
Course Outline: 1. **Introduction to Expository Writing** Definition, Types, Characteristics (clarity, coherence & organization) **2. The Writing Process** Pre-writing Techniques (brainstorming, free-writing, mind-mapping, outlining), Drafting, Revising and Editing, Proof reading, Peer review and Feedback3. **Essay organization and Structure** Introduction, Thesis statement, Body paragraphs, Conclusion, Cohesion & Coherence **4. Different Types of Expository Writing** Description, Illustration, Classification, Cause and Effect, Process analysis, Comparative analysis **9. Writing for Different Purposes and Audiences** Types of purposes (to inform, to analyze, to persuade, to entertain etc), Writing for Academic Audiences, Writing for Public Audiences, Different tones and styles **Ethical Considerations** Plagiarism and Originality, Citation and Referencing	
Course Outcomes: By the end of the course, the students will be able to; 1. Understand the essentials of the writing process (pre-writing, drafting, editing, proof reading etc) 2. Demonstrate mastery of diverse expository types	

3. Uphold ethical practices to maintain originality in expository writing
Recommended Books: Latest Edition of Following Books. 1. Axelrod, Rise B. and Charles Raymond Cooper. The Concise St. Martin's Guide to Writing. Bedford/ St. Martins, 2015. 2. Johnson-Sheehan, Richard, and Charles Paine. Writing Today. Pearson, 2019. 3. Murphy, Raymond. Grammar in Use Intermediate Student's Book without Answers. Cambridge University Press, 2018.

Course Name: Multivariate Calculus	**Course Code: MTH-404**
Course Structure: Lectures: 3, Labs: 0	**Credit Hours:** 3
Prerequisites: Calculus and Analytical Geometry	
Course Objectives: The goals are to develop the skills to have ground knowledge of multivariate calculus and appreciation for their further computer science courses. **Intended Learning Outcomes**: Students will be able: to apply mathematical and computational methods to range of application problems in multivariate calculus, evaluate partial derivations and multiple integrals of multivariate functions. **Course Outline:** - Functions of Several Variables and Partial Differentiation. - Multiple Integrals, Line and Surface Integrals. - Green's and Stoke's Theorem. - Fourier Series: periodic functions, Functions of any period P-2L, Even & odd functions, Half Range expansions, Fourier Transform. - Laplace Transform, Z-Transform.	
Reference Material: 1. Stewart,J. (6th ed.).(2007).*Multivariable Calculus*. Cengage Learning publishers. 2. Swokowski,Olinick,M.,Pence,D.(6th ed.). (1994). Calculus and Analytical Geometry. Thomson Learning EMEA, Ltd. 3. Anton,H ,Herr,A.(5th Ed.).(1995). *Multivariable Calculus*. John Wiley.	

Course Title: Ideology and Constitution of Pakistan	**Course Code: PST-313**
Course Structure: Lectures: 2	**Credit Hours: 2**
Prerequisites:	
Course Objective: This course is designed to provide students with a fundamental exploration of the ideology and the constitution of Pakistan. The course focuses on the underlying principles, beliefs, and aspirations that have been instrumental in shaping the creation and development of Pakistan. Moreover, the course will enable students to understand the core provisions of the	

Constitution of the Islamic Republic of Pakistan concerning the fundamental rights and responsibilities of Pakistani citizens to enable them to function in a socially responsible manner.

Course Outline: 1. Introduction to the Ideology of Pakistan: Definition and significance of ideology. Historical context of the creation of Pakistan(with emphasis on socio-political.religious, and cultural dynamics of British India between 1857 til 1947). Contributions of founding fathers of Pakistan in the freedom movement including but not limited to Allama Muhammad Iqbal,Muhammad Ali Jinnah.,etc. .Contributions of women and students in the freedom movement for separate homeland for Muslims of British India. **2. Two-Nation Theory:** Evolution of the Two-Nation Theor(Urdu-Hindi controversy,Partition of Bengal,Simla Deputation 1906,Allama lqbal's Presidential Address 1930,Congress Ministries 1937, Lahore Resolution 1940). Role of communalism and religious differences. **3. Introduction to the Constitution of Pakistan**. Definition and importance of a constitution. ldeological factors that shaped the Constitution(s) of Pakistan (Objectives Resolution 1949). Overvicw of constitutional developments in Pakistan. **4. Constitution and State Structure:** Structure of Ciovernment(executive,legislature,and judiciary). Distribution of powers between federal and provincial governments. 18th Amendment and its impact on federalism.**5. Fundamental Rights,Principles of Policy and Responsibilities:** Overview of fundamental rights guaranteed to citizens by the Constitution of Pakistan 1973 (Articles 8-28). Overview of Principles of Policy (Articles 29-40). Responsibilities of the Pakistani citizens (Article 5). **6. Constitutional Amendments:** Procedures for amending the Constitution. Notable constitutional amendments and their implications.

Course Outcomes: By the end of this course, students will be able to:

1. Demonstrate enhanced knowledge of the basis of the ideology of Pakistan with special reference to the contributions of the founding fathers of Pakistan.
2. Demonstrate fundamental knowledge about the Constitution of Pakistan 1973 and its evolution with special reference to state structure.
3. Explain about the guiding principles on rights and responsibilities of Pakistani citizens as enshrined in the Constitution of Pakistan 1973.

Recommended Books: Latest Edition of the Following Books.

1. "The ldea of Pakistan" by Stephen P.Cohen.
2. "ldeology of Pakistan" by Javed lqbal.
3. “The Struggle for Pakistan”by l.H.Qureshi.
4. "Pakistan the Fornmative Phase"by Khalid Bin Sayeed.
5. "Pakistan:Political Rots and Development'”by Safdar Mahmood.
6. "ldeology of Pakistan'”by Sharif-ul-Mujahid.
7. "The Struggle for Pakistan:A Muslim Homeland and Global Politics" by Ayesha Jalal.
8. "Jinnah,Pakistan and Islamic Identity:The Search for Saladin" by Akbar S.Ahmed.
9. "The Making of Pakistan:A Study in Nationalism" by K.K.Aziz.
10. "Pakistan:A New History” by lan Talbot.
11. "Pakistan in the Twentieth Century:A Political History" by Lawrence Ziring.

12. "The Constitution of Pakistan 1973".Original.
13. "Constitutional and Political Development of Pakistan"by Hamid Khan.
14. "The Parliament of Pakistan" by Mahboob Hussain.
15. "Constitutional Development in Pakistan" by G.W.Choudhury.
16. "Constitution-Making in Pakistan:The Dynamics of Political Order" by G.W.Choudhury.

Course Name: Essential of Genetics	**Course Code: BIT-311**
Course Structure: Lectures:3 practical: 1	**Credit Hours: 4**

Prerequisites: Biochemistry I

Course Objective:
This course provides the basic principles of inheritance. Students will gain experience in variety of molecular techniques used in gene analysis. 2. Course will help develop tools aid in the comparison of genetic and genomic data and more generally in the understanding of evolutionary aspects of molecular biology

Course Outline : Genetics introduction, Patterns and principles of inheritance, Mendelian inheritance, modifications in Mendelian genetics, sex determination and sex-linked inheritance. Genetic linkage and gene mapping. Maternal inheritance and organelles. Physical structure of genes, chromosomes structure and aberrations, tetrad analysis, Probability and pedigrees analysis, transgenes. Polygenic inheritance, Mechanisms of Evolution, Population genetics, epigenetics and genetic variation, Hardy-Weinberg principle.

Lab outlines
Determine ABO blood typing.
Problems solving related to Mendelian inheritance.
Problems solving in ABO blood typing in Humans
Problems solving in pedigree analysis

Course outcomes:
1. This genetics course provides a comprehensive foundation in fundamental genetic principles, from Mendelian inheritance patterns to modifications and exceptions.
2. Students will delve into advanced topics such as genetic linkage, gene mapping, and maternal inheritance, gaining insights into chromosomal structures, aberrations, and tetrad analysis.
3. The course covers applied aspects, including probability and pedigrees analysis, transgenes, and polygenic inheritance, preparing students to analyze complex genetic traits.

Recommended Books:

1.Essentials of Genetics 10th Edition by William Klug , Michael Cummings, Charlotte Spencer, Michael Palladino, Darrell Killian. 2019, Publisher: Pearson, ISBN-13: 978-0134898414
2. Gardner, "Principles of Genetics", John Wiley and Sons.
3. Griffith et al., "An Introduction to Genetics analysis", W. H. Freeman. 11 Edition edition (January 12, 2015)
4.James M. and David V. 1997. The Book of Genetics. 2nd Ed.Ser.ELDs Pub.
5.Tortora et al. 2001. Microbiology an introduction. 7 Ed. Benjanium Lumming.

Course Name: Programming Fundamentals	**Course Code: CSC-302**
Course Structure: Lectures: 3, Labs: 1	**Credit Hours: 4**
Prerequisites: None	

Course Objective:

- This course provides fundamental concepts of programming to freshmen. The courses is pre-requisite to many other courses, therefore, students are strongly advised to cover all contentsand try to achieve CLOs to the maximum possible level.
- The course may be taught as language independent. Further, it is up to the university to choose any language for the practical/Lab purpose but that must be latest and market oriented.

Course Outline:

Introduction to problem solving, a brief review of Von-Neumann architecture, Introduction to programming, role of compiler and linker, introduction to algorithms, basic data types andvariables, input/output constructs, arithmetic, comparison and logical operators, conditional statements and execution flow for conditional statements, repetitive statements and execution flow for repetitive statements, lists and their memory organization, multi- dimensional lists, introduction to modular programming, function definition and calling, stack rolling and unrolling, string and string operations, pointers/references, static and dynamic memory allocation, File I/O operations.

Course Outcomes: After completion of the course students will be able to:

1. Understand basic problem-solving steps and logic constructs
2. Apply basic programing concepts.
3. Design and implement algorithms to solve real worldproblems

Recommended Books: Latest Edition of the Following Books

1. Starting out with Programming Logic & Degins, 4th Edition, Tony Gaddis,
2. The C Programming Language, 2nd Edition by Brian W. Kernighan, Dennis M. Ritchie
3. Object Oriented Programming in C++ by Robert Lafore
4. C How to Program, 7th Edition by Paul Deitel & Harvey Deitel
5. Problem Solving and Program Design in C++, 7th Edition by Jeri R. Hanly & Elliot B. Koffman

Semester-III

Course Title: Quantitative Reasoning-I	**Course Code: MTH-401**
Course Structure: Lectures:3	**Credit Hours:** 3
Prerequisites:	

Course Objectives

- Quantitative reasoning (I) as in introductory-level undergraduate course that focuses on the fundamentals related to the quantitative concept and analysis.
- The course is designed to familiarize students with the basic concepts of mathematics and statistics and to develop students' ability to analyze and interpret quantitative information. Through a combination of theoretical concepts and practical exercises
- This course will also enable students cultivate their quantitative literacy and problem-solving skills while effectively expending their academic horizon and breadth of knowledge of their specific major/field of study.

Course Outline: 1. Numerical Literacy : Number system and basic arithmetic operation; Units and their conversion, dimension, area, parameter, and volume;Rates, ratio, proportion, and percentage; Types and sources of data; Measurement scales; Table and graphical presentation of data; Quantitative reasoning exercises using number knowledge;**2.Fundamental Mathematical Concept:**Basic of geometry (lines, angles, circles, polygons etc); Sets and their operations; Relations, functions, and their graphs;Exponent, factoring and simplifying algebraic expression; Algebraic and graphical solutions of linear and quadratic equations and inequalities;Quantitative reasoning exercises using fundamental mathematical concepts;**3. Fundamental Statistical Concepts:**Population and sample; Measure of central tendency, dispersion and data interpretation; Rules of counting (multiplicative, permutation, and combination);Basic probability theory; Introduction to random variables and their probability distribution;Quantitative reasoning exercises using fundamental statistical concept;

Course Outcomes By the end of this course, student shall have:

- Fundamental numerical litracy to enable them work with munbers understand their meaning and present data accurately;
- Understanding of fundamental mathematical and statistical concept;
- Basic ability to interpret data presented and various format including but not limited to tables, graphs, charts, and equations etc.

Recommended Books:

1. "Quantitative Reasoning: Tools for Todays Informs Citizen" by Bernard L. Madison. Lynn and Arthur Steen
2. "Quantitative Reasoning for the Information Age" by Bernard L. Madison. And David M. Bressoud.
3. "Fundamental of Mathematics" by Wade Ellis.
4. "Quantitative Reasoning: Thinking and Numbers" by Eric Zaslow.
5. "Thinking Clearly with Data: A Guide to Quantitative Reasoning and Analysis" by Ethan Bueno De Mesquita and Anthony Fowler.
6. "Using and Understanding Mathematics: A Quantitative Reasoning Approach" by Bennett, J. O., Briggs, W. L., & Badalamenti, A.
7. "Decreet Mathematics and Its Application" by Kenneth H. Rosen.
8. "Statistics for Technologies: A Course in Applied Statistics" by Chatfield, C.
9. "Statistics: Unlocking the Power of Data" by Robin H. Lock, Patti Farzer Lock, Kari Lock, Morgan and Eric F. Lock.

Course Title: Natural Sciences	**Course Code:000**
Course Structure: Lectures, 2 Hours	**Credit Hours: 3**
Course Outline: Course content /Course Title will be taken from the Booklet of Approved Mandatory and General Education Courses.	

Course Title: Introduction to Entrepreneurship	**Course Code: MS-309**
Course Structure: Lectures:	**Credit Hours: 2**
Prerequisites:	
Course Objective: This course is designed to promote entrepreneurial spirit and outlook among students, encouraging them to think critically, identify opportunities, and transform their ideas into successful ventures. It aims at imparting them with the requisite knowledge, skills, abilities, enabling them to seize theidentified opportunities for initiating ventures and successful navigating the challenges that come withstarting a business and managing it. The course covers topics relevant to entrepreneurship including setting up and initiation of business, market research, opportunity identification, business planning, financial literacy for managing finances and securing funding, marketing and sales, team building and innovation.	
Course Outline: Introduction to Entrepreneurship, Entrepreneurial Skills, . Opportunity Recognition and Idea Generation, Opportunity identification, evaluation and exploitation, Innovative idea generation techniques for entrepreneurial ventures, Marketing and Sales, Financial Literacy, Team Building for Startups & Regulatory Requirements to Establish Enterprises in Pakista**n.**	
Course Outcomes: Upon successful completion of the course participants will: • Have a basic understanding of the Islamic World and Muslim beliefs. • Know the origins of the Islamic Banking and Finance. • Appreciate the rationale behind the development of the Islamic finance industry. • Be able to assess the nature and scope of the Islamic finance industry in relation to its conventional counterpart. • Develop an appropriate level of understanding of the main principles of Islamic banking and finance. • Acquire essential knowledge about the key Islamic financial contracts, as used by the industry. • Know about Murabaha and Musharaka contracts, Ijara and Istisna'a financing methods, as well as Salam and Takaful insurance. • Be familiarized with the Islamic financial infrastructure, international financial institutions, and regulatory bodies.	
Recommended Books: 1. Barringer, B. R., & Ireland, R. D. (2012). Entrepreneurship: Successfully Launching New Ventures. Pearson. 2. Kuratko, Donald F. (2017). Entrepreneurship : Theory, Process, Practice (ed.10). United State of America: Cengage Learning. 3. Timmons, J. A., & Spinelli, S. (2003). New venture creation/entrepreneurship for the 21st	

century. Singapore City: McGraw-Hill.
4. Abrams, R. (2017). Entrepreneurship: A Real-World Approach (2nd ed., illustrated). Planning Shop.
5. Read, S., Sarasvathy, S., Dew, N., & Wiltbank, R. (2016). Effectual Entrepreneurship (2nd ed.). Routledge. https://doi.org/10.4324/9781315684826
6. Ries, E. . (2011).The Lean Startup: How Today's Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses.

Course Name: Introductory Biochemistry	**Course Code: BCHM-302**
Course Structure: Lectures: 2, Labs: 1	**Credit Hours: 2+1**
Prerequisites: None	
Course Objective: The course aims to • Course Objectives: • This course aims to provide students with fundamental knowledge of the • molecules of life, as well as their function in the context of a living cell.	
Course Outline: Introduction to biochemistry; water, Ph, buffers, and biochemical composition of cells; carbohydrates – structure and classification; proteins – overview with emphasis on their composition and structure, classification and function; lipids – structure, classification and biological significance; enzymes – properties, nomenclature, classification, and factors affecting enzyme activity including inhibitors and potentiators, basic kinetics, derivation of Km and Vmax; coenzymes and vitamins; nucleic acids – structure and function. **Practical:** Preparation of laboratory solutions and Ph determination; qualitative and quantitative tests for carbohydrates, proteins and lipids; enzyme assays and the effect of Ph, temperature and substrate concentration on enzyme activity.	
Course Outcomes: At the end of this course students will be able to identify and classify the various biomolecules. They will have deep understanding of the function of biomolecules.	
Recommended Books: Latest Edition of Following Books 1. Pollard, T. D., Earnshaw, W. C., Lippincott-Schwartz, J., & Johnson, G. (2022). *Cell biology E-book*. Elsevier Health Sciences. 2. Murphy, M., Srivastava, R., & Deans, K. (2023). *Clinical Biochemistry-E-Book: An Illustrated Colour Text*. Elsevier Health Sciences. 3. Shanmugam, S., Kumar, T. S., & Panneer Selvam, K. (2019). Laboratory handbook on biochemistry. PHI Learning Pvt. Ltd.. 4. Satyanarayana, U., & Chakrapani, U. (2020). Biochemistry, (Updated and Revised Edition)-E-Book. Elsevier India. 5. Lehninger principle of biochemistry by David L.Nelson and Michael M.Cox, 7th latest edition,ISBN-10:1-4641-2611-9,ISBN-13:978-14641-2611-6.	

6. Biochemistry by Jeremy M. Berg , John L. Tymoczko; Lubert Stryer ,ISBN10:1429229365,ISBN-13:97814229229364, Berg, J. M.,Tymoczko,J. L., Lubert Stryer. 2010. Biochemistry. 7th Ed.
7. Lodish, H., Berk, A., Zipursky, S. L., Paul. M., Baltimore D, Darnell, J. 2012. Molecular Cell Biology.
8. Nelson, D. L., Cox, M. M. 2012. Lehninger Principles of Biochemistry. McMillan Worth Publishers, New York.

Course Name: Bioinformatics I (Bioinformatics Methods)	**Course Code:** BI-411
Course Structure: Lectures: 2, Labs: 1	**Credit Hours:** 3
Prerequisites: Computer fundamentals	
Course Objective: The course is designed to introduce the most important and basic concepts, methods, and tools used in Bioinformatics. This course will introduce basic biological database sources, principles and methods for sequence and genome analysis. The overall aims are **a.** To help the students to reach rapidly the frontier of bioinformatics and be able to use the bioinformatics biological Databases. **b.** To convey the importance of bioinformatics for viewing the biomedical information. **c.** To provide hands-on experience using Biological Databases searching, retrieving, critically evaluating results and interpreting their biological significance.	
Course Outline: Introduction to Bioinformatics ,Historical Introduction,Goals,Scope,Applications,Limitations.Databases,Types of Databases, Biological Databases, Sequence Storage, Information retrieval and analysis, Sequence Alignment, Similarity and homology, Types of alignments, local and global alignment,. Methods of Alignment, pairwise and multiple sequence alignments, Significance of Sequence Alignment, Algorithm, Sequence Alignment Methods, dot matrix plots, dynamic programming algorithm, word (k-tuple) methods (BLAST and FASTA), substitution matrices PAM and BLOSUM, significance of scoring, gap penalties. Multiple Sequence Alignment. Uses of Multiple Sequence Alignment, Scoring Functions, Methods of Multiple Sequence Alignment, Position-Specific Scoring Matrices, Relationship of multiple sequence alignment to phylogenetic analysis, Molecular phylogenetic, Phylogenetic Basis, Phylogenetic Tree construction methods and Programs.	
Lab Outline: Accessing NBCI databases, sequence databases, Genbank, EMBL, SWISS-PROT Accessing structure database PDB, SCOP and CATH, Expasy server, using online alignment tools for pair wise and multiple sequence alignment, using BLAST and FASTA,phylogenetic analysis by ClustalW.	
Recommended Books: 1. Arthur M. Lesk, Introduction to Bioinformatics.4th Edition (2008).Oxford University Press. 2. Ignacimuthu SJ. Basic Bioinformatics, 2nd Edition (2005) Narosa Publishing House. 3. S.C.Rastogi, N.Mendiratta,P.Rastogi,Bioinformatics: Methods and Applications: Genomics, Proteomics and Drug Discovery. 3rd Edition (2009). PHI Learning Pvt. Ltd. 4. David Mount, Bioinformatics: Sequence and Genome analysis.2nd Edition (2004). Cold Spring Harbour Laboratories.	

5.Jin Xiong, Essential Bioinformatics,(2006), Cambridge University Press.
6. Jonathan Pevsner , Bioinformatics and Functional Genomics, 3rd Edition(2015). Wiley-Blackwell.

Course Name: Molecular Biology	**Course Code: BIT-413**
Course Structure: Lectures: 2, Labs: 1	**Credit Hours: 3**
Prerequisites: Biochemistry I	

Course Objectives

1. To study classical and molecular aspects of cell.
2. The course emphasizes about the chromosome structure, transfers of genetic information, gene expression and regulation of gene activity.
3. The course is basis for structural biology, it aids in the simulation and modeling of DNA, RNA, and protein structures as well as molecular interactions.

Course Outline

Introduction to Molecular Biology. Basic concepts about DNA, RNA and proteins with special emphasis on nature of genetic material and its organization in viruses, prokaryotes and eukaryotes, Structure function and replication of DNA,DNA as Heritable material structure of DNA, Chromatin and Chromosome organization: physical structure of genes. Gene Expression Genetic Code, Codon, Anticodon, Ribosome, Translation, Gene Expression in Prokaryotes, the lac operon, Gene Expression in eukaryotes, Molecular Basis of Mutation Basis of mutation. DNA damage, DNA Repair Recombination. Types of mutations. Replication errors and their repairs: DNA repair – Single step and multistep: RNA processing, splicing and editing, translation and post-translational modifications, Regulation of gene expression in prokaryotes and eukaryotes. Introduction about plasmids and vectors. Recombinant DNA Technology, CRISPR/CAS9-Targeted Genome Editing. Molecular evolution; DNA based phylogenetic trees and their applications.

Course Outcomes:

1. Equip students with a comprehensive understanding of molecular biology.
2. Preparing them for careers in research, biotechnology, and various fields where molecular biology principles are applied.

Lab Outline: Isolation of DNA from plant cells, Protocols for isolation of DNA from blood. Protocols for Amplification of DNA by PCR. Gel Electrophoresis.

Recommended Books:

1. David M. P. Academic Press London, Methods in Cell Biology Lowery Sekivetz. Cell Structure and Function. John Willey and Sons Publication. 3 edition (October 7, 2011).
2. Jordanka Zlatanova. Molecular Biology: Structure and Dynamics of Genomes and Proteomes 2nd Edition Garland Science ISBN-13: 978-0367678098 April 21, 2023
3. Gerald Karp - Cell and molecular biology concepts and experiments - Hoboken, NJ - John

Wiley - 2010 - 5th Ed.
4. Brown T. A. Gene Cloning and DNA Analysis: An Introduction, 6th Edition, 2010
5. Robert Weaver. Molecular Biology. McGraw Hill, 5th Edition, 2007.
6. James D. Watson, Tania A. Stephen P. Bell, Alexander Gann, Michael Levine, Richard Losick, Molecular Biology of the Gene, Pearson,7th Edition.2014.

Semester-IV

Course Title: Civics and Community Engagement.	**Course Code: PSC-418**
Course Structure: Lectures: 2	**Credit Hours: 2**
Prerequisites:	
Course Objective: This course is designed to provide students with fundamental knowledge about civics,citizenship,and community engagement.In this course,the students will learn about the essentials of civil society, government,civic responsibilities, inclusivity, and effective ways to participate in shaping the society which will help them apply theoretical knowledge to the real-world situations to make a positive impact on their communities.	
Course Outline: **1. Civics and Citizenship:** Concepts of civics, citizenship, and civic engagement, Foundations of modern society and citizenship, Types of citizenship: active, participatory, digital, etc.**2. State, Government and Civil Society:** Structure and functions of government in Pakistan. The relationship between democracy and civil society. Right to vote and the importance of political participation and representation.**3. Rights and Responsibilities**: Overview of fundamental rights and liberties of citizens under the Constitution of Pakistan 1973. Civic responsibilities and duties. Ethical considerations in civic engagement (accountability, non-violence, peaceful dialogue, civility, etc.) **4. Community Engagement:** ·Concept, nature, and characteristics of community. ·Community development and social cohesion. Approaches to effective community engagement. ·Case studies of successful community-driven initiatives.**5. Advocacy and Activism:** Public discourse and public opinion. Role of advocacy in addressing social issues. Social action movements. **6. Digital Citizenship and Technology:** The use of digital platforms for civic engagement Cyber ethics and responsible use of social media. Digital divides and disparities (access, usage, socioeconomic, geographic, etc.) and their impacts on citizenship.**7. Diversity,** Inclusion and Social Justice: Understanding diversity in society (ethnic, cultural,cconomic,political etc.). Youth, women and	

minorities' engagement in social development. Addressing social inequalities and injustices in Pakistan. Promoting inclusive citizenship and equal rights for societal harmony and peaceful co-existence.
Course Outcomes: By the end of this course, students will be able to: 1. Demonstrate fundamental understanding of civics, government, citizenship and civil society 2. Understand the concept of community and recognize the significance of community engagement for individuals and groups. 3. Recognize the importance of diversiy and inclusivity for societal harmony and peaceful co-existence.
Recommended Books: Latest Edition of the Following Books. 1. "Civics Today:Citizenship,Economics,&You" by McGraw-Hill Education. 2 "Citizenship in Diverse Societies" by Will Kymlicka and Wayne Norman. 3."E Fngaaina V Youth in Civic Life" by James Youniss an Peter Levine. 4. "Digital Citizenship in Action:Empowering Students to Engage in Online Com Kristen Mattson. "Globalization and Citizenship:In the Pursuit of a Cosmopolitan Education" by Graham Pike and David Selby. 6. "Community Engagement:Principles,Strategies, and Practices" by Becky J.Feldpausch and Susan M.Omilian. 7. "Creating Social Change:A Blueprint for a Better World" by Matthew Clarke and Marie-Monique Steckel.

Course Title: Quantitative Reasoning II	**Course Code: MTH-402**
Course Structure: Lectures:3	**Credit Hours:** 3
Prerequisites:	
Specific Objectives of Course Quantitative reasoning (II) is a sequential undergraduate course that focuses on logical reasoning supported with mathematical and statistical concepts and modelling/analysis technique to equip student with analytical skills and crtitical thinking abilities necessary to navigate the complexities of the modern world. The course is design to familiarize students with the quantitative concept and technique require to interpret and analyze numerical data to inculcate and ability in students the logical reasoning to construct and evaluate arguments, identify fallacies, and think systematically. Keeping the prerequisite course of quantitative reasoning I and its base, this course will enable students further their quantitative, logical and critical reasoning abilities to complement their specific major/field of study.	

Course Outline:

1. Logic and Logical Critical Reasoning Introduction and Importance of logic;Inductive, deductive, and abductive approaches of reasoning;Prepositions, arguments (valid; invalid), logical connectives, truth tables and prepositional equivalences;Logical fallacies;Venn diagram;Predicates and quantifiers, Quantitative reasoning exercises using logical reasoning concepts and techniques; **2.Mathematical Modelling and Analysis,** Introduction to deterministic models, Use of linear functions for modelling in real world situations;Modelling with system of linear equation and their solutions;Elementary introduction to derivatives and mathematical modelling;Linear and exponential growth and decay models;Quantitative reasoning exercises using mathematical modelling;**3. Statistical Modelling and Analysis:** Introduction to probabilistic models;Bivariate analysis, scatter plots;Simple linear regression model and correlation analysis; Basics of estimation and confidence interval;Testing of hypothesis (Z-test; T-test);Statistical inference in decision making;Quantitative reasoning exercises and using statistical modelling;

Course Outcomes

By the end of this course, student shall have:

- Understanding of logic and logical reasoning;
- Understanding of basics quantitative modelling and analysis;
- Logical reasoning skills and abilities to apply them to solve quantitative problems and evaluate arguments;
- Ability to critically evaluate quantitative information to make evidence based decisions through appropriate computational tools:

Recommended Books:

1. "Using and Understanding: A Quantitative Reasoning Approach" by Bennett, J.O., Biggs, W. L., and Badalamenti, A.
2."Discrete Mathematics and Its Applications" by Kenneth H. Rosen.
3."Discrete Mathematics with Applications" by Susanna S. Epp.
4."Applied Mathematics for Business, Economics, and Social Sciences" by Frank S. Budnick.
5."Elementary Statistics: A Step by Step Approach" by Allan Bluman.
6."Introductory Statistics" by Prem S. Mann.
7."Applied Statistical Modelling" by Salvatore Babones.
8."Barrons SAT" by Sharvonweiner Green, M. A and Lra K. Wolf.

Course Title: Probability and Statistics	**Course Code: STAT-402**
Course Structure: Lectures: 3, Labs: 0	**Credit Hours: 3**
Prerequisites:	
Course Objective: The course is designed to enable the students to understand basic concepts of Statistics, descriptive statistics and probability, conditional probability, random variables and probability distributions.	

Course Outline:
Introduction to Statistics: Descriptive Statistics, Graphical presentation of data, Histogram, Bar charts, Pie charts, box-plot, stem and leaf plot. Measures of Central Tendency; mean, median and mode. Measure of dispersion; Variance and standard deviation; properties. Co-efficient of variation. Correlation and regression. Hypothesis testing.

Introduction to counting techniques; Permutation, combination. Basic concept of probability, random experiment, event, sample space. Laws of probability, conditional probability, Bayes theorem with application to discrete and continuous random variable. Random variables and Probability Distributions; Discrete Random Variables, Bernoulli trials, Binomial and Poisson distributions. Continuous Random Variable, probability density function and its properties. Normal Distribution and its properties.

Course Outcomes: At the end of the course the students will be able to:

- Demonstrate basic descriptive statistics and analyse and interpret data.
- Demonstrate the basic knowledge of probability and probability distributions.
- Use basic counting techniques (multiplication rule, combinations, and permutations) to compute probability and odds.

Recommended Books: Latest Edition of the Following Books.

1. Clark, G.M. and Cooke, D. (1998), "A Basic Course in Statistics" 4th ed, Arnold, London.
2. Chaudhry. S.M.and Kamal, S. (1996), "Introduction to Statistical Theory" Parts I & II, 6th ed, Ilmi Kitab Khana, Lahore, Pakistan.
3. Mclave, J.T., Benson, P.G. and Snitch, T. (2005) "Statistics for Business & Economics" 9t ed, Prentice Hall, New Jersey.
4. Spiegel, M.R., Schiller, J.L. and Sirinivasan, R.L. (2000) "Probability and Statistics", 2nd ed. Schaums Outlines Series. McGraw Hill. NY.
5. Walpole, RE., Myers, R.H and Myers, S.L. (1998), 'Probability and Statistics for Engineers and Scientist" 6th edition, Prentice Hall, NY.
6. Weiss, N.A. (1997), "Introductory Statistics" 4th ed. Addison-Wesley Pub. Company, Inc.

Course Name: **Linear Algebra**	**Course Code: MTH-317**
Course Structure: Lectures: 3, Labs: 0	**Credit Hours:** 03
Prerequisites: None	

Course Objectives

1. This course introduces matrices, determinants and differential equations for solving linear equations.
2. To enable the students about Practical applications of the in Bio-Informatics.
3. The aim is to provide a practical description of the topics, tools, issues and current trends in the fields including their impact on biology and human health and medicine.
4. Make students to polish their analytical skills.
5. Have well understanding to utilize this course in this program.

Course Outline: Introduction to matrices, elementary row operations and vector spaces: Brief introduction to matrices, system of linear equations, system of non-homogeneous and homogeneous linear equation, determinants, properties of determinants of order, axiomatic definition of a determinant, double and multiple integrals. Differential equations of first order, initial and boundary conditions, methods of solution of differential equation of first order and first degree, separable equation, homogeneous equation, first order linear differential equations, Bernoulli equations, Application of first order differential equations, Higher order linear differential equations, homogeneous linear equations, solution of higher order differential equation.
Recommended Books: 1. Linear Algebra, David C. Lay, Pearson Addison Wesley, 3rd Edition, July 18, 2002. 2. Advanced Engineering Mathematics, Michael Greenberg, and 2nd Edition. 3. Advanced Engineering Mathematics, 7/e, Erwin Kreyszig. John Wiley & Sons, 10th Edition, Seventh edition, August 11, 1992. 4. Text book of mathematics for B.Sc. part1.

Course Name: Metabolism of Biomolecules	**Course Code: BCHM-303**
Course Structure: Lectures: 2, Labs: 1	**Credit Hours: 2+1**
Prerequisites: None	
Course Objective: The course aims to understand the This course is a continuation of Principles of Biochemistry I, and aims to familiarize students with the key concepts of intermediary metabolism of proteins, nucleic acids, carbohydrates and lipids. •	
Course Outline: Introduction to metabolism and basic aspects of bioenergetics and biochemical thermodynamics (endergonic and exergonic reactions); phosphoryl group transfer and ATP production; metabolism, oxidation-reduction; carbohydrate metabolism and regulation (glycolysis, glycogenolysis; gluconeogenesis; pentose phosphate pathway); citric acid cycle (reactions, energetics and control), electron transport chain, oxidative phosphorylation, shuttle mechanisms (glycerol-phosphate shunt), lipid metabolism (energy yield from fatty acid oxidation, ketone bodies, acyl glycerol, compound lipids, cholesterol); photosynthesis; Calvin Cycle; metabolism of nitrogenous compounds (amino acid synthesis, catabolism, purine and pyrimidine synthesis); nucleic acid metabolism and control; urea cycle; integration of metabolism. **Practical:** Basic biochemical methods such as iodine test for polysaccharides, fermentation of sugars by Baker's yeast; isolation of amylose and amylopectin from starch; extraction of glycogen from liver; acid and enzymatic hydrolysis of glycogen; extraction and estimation of lipids from plant tissue/seed and lipid separation from different tissues; fractionation by thin layer chromatography (TLC).	

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Recommended Books: Latest Edition of Following Books

1. Medeiros, D. M., & Wildman, R. E. (2022). Advanced human nutrition. Jones & Bartlett Learning.
2. Yadav, M., & Yadav, H. S. (Eds.). (2021). Biochemistry: fundamentals and bioenergetics. Bentham Science Publishers.
3. Ramesh, V. (Ed.). (2019). Biomolecular and bioanalytical techniques: theory, methodology and applications. John Wiley & Sons.
4. Sawhney, S. K. and Singh, R., 2006. Introductory Practical Biochemistry, 2nd Edition, Narosa Publishing House.
5. Oser, B. L., (Latest Edition). Hawk's Physiological Chemistry, McGraw Hill Book Company.
6. David L. Nelson, and Michael M. Cox, 2005. Lehninger Principles of Biochemistry 4th Edition, Macmillan Worth Publishers, New York.

Course Name: Bioinformatics II (Applied Bioinformatics)	**Course Code:** BI-412
Course Structure: Lectures: 3, Labs: 1	**Credit Hours:** 4
Prerequisites: Bioinformatics I	
Course Objective: This course is design to **a)** to learn and locate various analysis tools for amino acid & nucleotide sequences & set the attributes for each tool and process sequence data & How RNA sequence relates to structure. **b)** How protein sequence information can be used for genome annotation, gene prediction process, protein folding, structure and function prediction. **c)** learn and locate various 2D & 3D protein modeling tools & quantitative methods for predicting 3D structures and gene expression. **d)** develop hands-on experiences using software, critically evaluating results and interpreting their biological significance with the bioinformatics methods through guided exercises	
Course Outline: Introduction to gene prediction, Basis of gene Prediction, Gene Prediction in prokaryotes and eukaryotes, gene Prediction Methods, ORF, TFBS, codon usage table, EST and SNP databases, primer designing, restriction enzyme databases, RNA structure prediction, computational secondary and tertiary protein structure prediction methods, hydrogen bonding, PTMs of proteins, Chou Fasman, PHD and PSIPred, neural network, X-ray crystallography, NMR, ab initio, threading and homology modeling, structure prediction evaluation, protein fold identification using Pfam and other tools.	
Lab Outline: Online tools: Gene finder, ORF finder, EST database, SNP data, Primer 3, protein structure prediction using online server, protein structure visualizing using visualization programs, Secondary structure prediction, using pfam database.	

Recommended Books:

1. Ignacimuthu SJ. Basic Bioinformatics, 2nd Edition (2005) Narosa Publishing House.
2. S.C.Rastogi, N.Mendiratta,P.Rastogi,Bioinformatics: Methods and Applications: Genomics, Proteomics and Drug Discovery. 3rd Edition (2009). PHI Learning Pvt. Ltd.
3. Jin Xiong, Essential Bioinformatics,(2006), Cambridge University Press
4. David Mount, Bioinformatics: Sequence and Genome analysis.2nd Edition (2004). Cold Spring Harbour Laboratories.
5.Des.Higgins,Willie Taylor, Bioinformatics Sequence,Structure & Databanks. (2002) Oxfoard University Press.
6. Jonathan Pevsner , Bioinformatics and Functional Genomics, 3rd Edition(2015). Wiley-Blackwell.

Semester-V

Course Title:: Business Communication	**Course Code: ENG-402**
Course Structure: Lectures: 3	**Credit Hours:** 3
Prerequisites: None	

Course Objectives:

This course aims at describing the process of communication within business organizations, to demonstrate effective listening behaviour, to use language and nonverbal communication to communicate effectively, analyzes realistic business situations and selects the communication strategy or strategies Appropriate to bring about the desired outcome. It also aims at applying correct English grammar, spelling, punctuation, mechanics and usage to write clear, Concise and complete official letters and memorandums. And to utilize information technology effectively, selecting and using tools appropriate to the task describe the influence of cultural diversity in the workforce and Demonstrate effective communication skills to accommodate these differences.

Course Outline:Communication in Organizations (Language, Verbal and non-verbal communication), **Methods of Communication in business** (written, oral, electronic), **Use of Library**, **Effective Presentation Skills** (individual and group presentations), **Interview**, **Conflict Resolution and Negotiation**, Confidence Building, **Technical Report Writing** (long and short reports), **Steps of technical writing** (brainstorming, organizing material, outlining, selection, final organization), **Research Report Writing** (Abstract, draft making, process of writing, notes, bibliography), **Plagiarism**

Course Outcomes: Upon successful completion of this course, students are expected to have improved their:

1. Level of self-awareness and understanding of how self-awareness influences communication.
2. Analytical ability in relation to business communication.
3. Ability to communicate with others and in particular their conflict resolution and negotiation Skills.
4. Ability to communicate as a member of a team and identify and resolve communication Problems in teams.
5. Understanding of communication patterns in organizations
6. Understanding of report writing and the use of plagiarism mechanism

Recommended Books:

1. Sundar Jain. *Technical Report Writing*, Centrum Press, 2013.
2. Overton, Rodney. *Business Communication*. Martin Books, 2018.
3. Saha, Indranil, and Bobby Paul. *Essentials of Biostatistics and Research Methodology*. Academic Publishers, 2013.

Course Name: Genomics	**Course Code:** BI-531
Course Structure: Lectures: 3, Labs: 0	**Credit Hours: 3**
Prerequisites: Biochemistry I/Molecular Biology	

Course Objective:

The goals and objectives of the course is that the students will be trained to grasp knowledge about structural, functional and evolutionary genomics and their applications. Moreover, the students are expected to obtain the knowledge of how organismic diversity and evolution can be understood through comparative approaches of genomic information. In particular, the students will get detailed knowledge of Genome Mapping, Genome assembly and annotation and the major Genome sequencing projects, the use of Bioinformatics tools for studying genomes and genomic data.

Course Outline

Introduction to genomics, **structural Genomics**: Genome Anatomy, Gene Expression, Genome Evolution,

Functional Genomics: Transcriptome assembly, annotation and analysis

Comparative Genomic: Comparative and evolutionary genomics

Gene duplication, Genome duplication, Paralogous and orthologous genes and Neofunctionalization,

Genome Mapping: Gene finding, Promoter identification, DNA markers, Linkage analysis, QTL,

, Microarray, Genevestigators,

Genome assembly and annotation : Deep Sequencing of DNA and RNA, ,Sequencing strategies and the shotgun method, Massive parallel sequencing and its applications

Genome sequencing projects: Human Genome project**,** UK10K project**,** Next generation sequencing projects and applications.Bioinformatic Tools for Understanding Genomes,Ethical Implications of the Genome

Recommended Books:

1. "An Introduction to Genetic Analysis" by A.J.F. Griffiths, J.H. Miller, D.T. Suzuki, R.C. Lewontin, and W.M. Gelbart. 2000. Ch. 14, p. 436. W.H. Freeman and Co., Publishers.
2. "Genetics" by P.J. Russell. 2002. Ch. 9, p. 220. Benjamin Cummings, Publihsers.
3. "Introduction to Genomics" Arthur M. Lesk, Oxford University Press, 2007.
4. ''Principles of Genome Analysis and Genomics (Third Edition)" Sandy B. Primrose and Richard Twyman, Blackwell Publishing, 2008.
5. "Principles of Computational Cell Biology: From Protein Complexes to Cellular Networks" Volkhard Helms, Wiley-VCH, 2008.

Course Name: Bioinformatics Computing	**Course Code:** BI-524
Course Structure: Lectures: 3, Labs: 1	**Credit Hours:** 4
Prerequisites: Programming Fundamentals	
Course Objective: This course aims to introduce the concepts of data representation, searching, security and ownership. Develop techniques for pattern matching, recognition and their applications in bioinformatics.	
Course Outline: Databases: Data management, networks, geographical scope, communications models, transmissions technology, protocols, bandwidth, topology, hardware, contents, security, ownership, implementation, Search engines. Search process, search engine technology, searching and information theory, computational methods, knowledge management, data, sequence and structure visualization, data mining methods and technology, pattern recognition and discovery, pattern matching, dot matrix analysis, substitution matrices, dynamic programming, Scripting. cellular, tissue, organ and system modeling, simulation, analysis using an object oriented programming languages, Bio-inspired computation, evolutionary algorithms, Swarm Intelligence, neural networks, application of neural networks to Bioinformatics, neural computation, approximate matching algorithm and their applications for DNA Matching.	
Lab Outline: Simulation of various bioinformatics entities, application of various bioinformatics methods, scripting languages python, perl and PHP, and their applications in Bioinformatics. Simulation and application of neural network related techniques for bioinformatics, implementation of approximate matching algorithms, DNA matching algorithms and applications.	
Recommended Books: 1. "Bioinformatics Computing" Bryan Borgeron, Pearson Education (US), 19 November 2002 . 2. "Methods in Biotechnology and Bioengineering", Vyas S.P. and Kohli D.V.2002. 3. Bioinformatics Methods and Techniques. Banatao, R. Stanford University, Stanford Center for Professional Development, 2002. 4. "What's Next in High-Performance Computing?" Bell, G. and J. Gray. Communications of the ACM.2002. 5. Essentials of Knowledge Management. Bergeron, B. New York: John Wiley & Sons, 2003. 6. "Bioinformatics Concepts, Skills and Applications" Namita M, CSB Publishers. 7. "Bioinformatics Managing Scientific Data", Lacroix Zor, Morgan Kauffmann Publishers.	

Course Name: Object Oriented Programming	**Course Code: CSC-312**
Course Structure: Lectures: 3, Labs: 1	**Credit Hours:4**
Prerequisites: Programming Fundamentals	
Course Objective: 1. The course aims to focus on object-oriented concepts, analysis and software	

development.
2. The basic concept of OOP is covered in this course.

Course Outline:

Introduction to object oriented design, history and advantages of object oriented design, introduction to object oriented programming concepts, classes, objects, data encapsulation, constructors, destructors, access modifiers, const vs non-const functions, static data members& functions, function overloading, operator overloading, identification of classes and their relationships, composition, aggregation, inheritance, multiple inheritance, polymorphism, abstract classes and interfaces, generic programming concepts, function & class templates, standard template library, object streams, data and object serialization using object streams,exception handling.

Course Outcomes: After completion of the course students will be able to:

1. Understand principles of object-oriented paradigm.
2. Identify the objects & their relationships to build objectoriented solution
3. Model a solution for a given problem using objectoriented principles
4. Examine an object oriented solution

Recommended Books: Latest Edition of the Following Books

1. Paul Deitel, Java: How to Program, 9th Edition, 2011,Pearson College Div.
2. Ivor Horton, Beginning Java 2, 7th Edition, 1999, Apress
3. C. ThomasWu , An Introduction to Object Oriented Programming with Java, 5th Edition,2009,McGeraw Hills
4. Tony Gaddis, Starting Out with C++ from Control Structures to Objects, 9th Edition, 2017,Pearson.
5. Deitel & Deitel, C++ How to Program, 10th Edition, 2005, Prentice Hall
6. Robert Lafore, Object Oriented Programming in C++, 3rd Edition,2008,Sams.

Course Name: Database Management Systems	**Course Code: CSC-524**
Course Structure: Lectures: 3, Labs: 1	**Credit Hours:** 4

Prerequisites: None

Course Objective:

1. The course aims to introduce basic database concepts, different data models, data storage and retrieval techniques and database design techniques.
2. The course primarily focuses on relational data model and DBMS concepts.

Course Outcomes:

1. After completing the course, the students will be familiar with data modelling concepts used in DB development.
2. Undertake and successfully complete logical data base design tasks.
3. Be familiar with a broad range of data management issues, including data integrity, concurrency and security.

Course Outline: Basic database concepts; Entity Relationship modeling, Relational data model and algebra,Structured Query language; RDBMS; Database design, functional dependencies and normal forms;query optimization concepts,Transaction processing and optimization concepts; concurrency control and recovery techniques; Database security and authorization. Small Group Project implementing a database. Physical database design: Storage and file structure; indexed files; b-trees; files with dense index; files with variable length records; Database efficiency and tuning.
Lab Outline: Structured Query Language commands, creating and populating tables, design of simple databases, database normalization techniques, query optimization, indexing techniques, partial and full recovery techniques, developing GUI techniques, implementation of database security mechanisms.
Recommended Books: Latest Edition of the Following Books. 1. Jeffrey A. Hoffer, V. Ramesh, Heikki Topi. Modern Database Managment 11th Edition, 2012, Prentice Hall. 2. Connolly,R., Begg,P. Database Systems: A Practical Approach to Design, Implementation and Management, 5th Edition, 2009, Addison-Wesley Pub. Co. 3. Ramez Elmasri and Shamkant B. Navathe. Fundamentals of Database Systems. 6th Edition, 2010, Pearson. 4. C.J.Date,. An Introduction to Database System, 8th Edition, 2004, Addison-Wesley.

Semester-VI

Course Name: Proteomics	**Course Code:** BI-532
Course Structure: Lectures: 3, Labs: 0	**Credit Hours:** 3
Prerequisites: Biochemistry I /Molecular Biology	
Course Objective This course intends toprovide knowledge regarding identification and to characterize all the proteins synthesized in a cell or a tissue. Further to understand how individual proteins or protein collectives function within an organism. This course seeks to provide basic concepts regarding proteome and protein chemistry with special focus on protein identification techniques. After taking this module, students would be able to have knowledge of proteomics work flow and techniques used in isolation,purification and identification of proteins.	
Course Outline: Introduction to proteomics and protein chemistry, Proteomics in relation to genomics and bioinformatics, Techniques for identification and separation of proteins. bioinformatics tools for analysis of proteomics data, proteomics databases, NMR and X-ray crystallography, 1D-SDS-PAGE ,2D-SDS PAGE. Gel electrophoresis, Detection and quantitation of proteins in gels. Basics of mass spectrometry. Malditof and ESI, and their application in proteomics. Tandem MS/MS spectrometry. Peptide sequencing by tandem mass spectrometry,Chromatography and its types, Microarrays,Proteomics of protein modification, Interactomes, Applications and future development of proteomics.	

Recommended Books:
1. Introduction to Proteomics: Principles and Applications by Nawin C. Mishra, Günter Blobel ISBN: 978-0-471-75402-2 **, 2011 edition** **2.** HEYER, L. -- CAMPBELL, A. Discovering Genomics, Proteomics and Bioinformatics. USA: Cold Spring Harbor Lab. Press, 2006. 352 p. ISBN 0-8053-4722-4 **3.** Rastogi et al. Bioinformatics methods and applications. Genomics, Proteomics and Drug discovery. **4.** Mass Spectrometry - A Textbook, 1st Ed., Springer-Verlag: Berlin, Heidelberg, 2004. ISBN-10 3-540-40739-1; ISBN-13 978-3-540-40739-3. E. de Hoffmann and V. Stroobant 5.Principles of Proteomics Advanced Texts by Richard Twyman, Publisher Garland Science, 2004, ISBN 0203507398, 9780203507391 6. Introducing Proteomics by Josip Lovric, edition 1, 2011, Publisher Wiley-Blackwell, ISBN: 978-0-470-03524-5.

Course Name: Ethical & Legal Issues in Bioinformatics	**Course Code:** BI-502
Course Structure: Lectures: 2, Labs: 0	**Credit Hours:** 2
Prerequisites: None	
Course Objective: This course introduces the ethical and legal aspects related to bioinformatics practices and products.	
Course Outline Social context of computing and biology, Intellectual property, Privacy and civil liberties, Economic issues in bioinformatics, monopolies and their economic implications, effect of skilled labor supply and demand on the quality of bioinformatics products, pricing strategies in the bioinformatics domain, differences in access to bioinformatics resources and the possible effects thereof. Health, psychological and legal issues in GMOs. Biosafety and Bio-security issues.	
Recommended Books: Latest editions of following books 1. Legal and Ethical Issues in Acquisitions. Edited by Katina Strauch. A Bruce Strauch. 2. Computer Ethics: Cautionary Tales and Ethical Dilemmas in Computing By Tom Forester, Perry Morrison. 3. Public Management Information Systems**.** By Bruce A Rocheleau. 4. Security in Computing**.** By Willis H. Ware, Charles P. Pfleeger, Shari Lawrence Pfleeger. 5. Computer Ethics: Cautionary Tales and Ethical Dilemmas in Computing By Tom Forester, Perry Morrison.	

Course Name: Next-Generation Sequencing Data Analysis	**Course Code: BI-525**
Course Structure: Lectures: 2, Labs: 1	**Credit Hours: 3**

Prerequisites: Basic understanding of molecular biology and genomics, Basic Knowledge of R and Python programming languages
Course Objective: This course provides an in-depth understanding of the principles, tools, and techniques for processing and analyzing NGS data
Course Content: Introduction to NGS technologies, Experimental design, NGS data types (FASTQ, SAM/BAM, VCF), usage of important NGS toolkits, NGS data pre-processing and quality control, Read mapping, Visualization of mapped reads (IGV, UCSC), Variant Calling and annotation, SNP analysis in targeted resequencing data, Structural variants analysis in whole genome sequencing data, Differential gene expression analysis in RNAseq data, Downstream analysis such as pathway analysis, clustering, and Gene ontology. **Tools and Software:** Students will gain hands-on experience with popular NGS analysis tools such as BWA, STAR, GATK, BEDTools, and R/Bioconductor.
Course Outcomes: Students will gain the skills to handle diverse NGS datasets, perform quality control, map sequences, and interpret biological insights.
Recommended Books: Latest Edition of Following Books 6. Buffalo, V. (2015). Bioinformatics Data Skills: Reproducible and Robust Research with Open Source Tools. O'Reilly Media. ISBN: 9789352131402 7. Brown S. M. (2015). Next-generation DNA sequencing informatics (Second). Cold Spring Harbor Laboratory Press. 8. S.C.Rastogi, N.Mendiratta,P.Rastogi,Bioinformatics: Methods and Applications: Genomics, Proteomics and Drug Discovery. PHI Learning Pvt. Ltd. 9. 4. David Mount, Bioinformatics: Sequence and Genome analysis. Cold Spring Harbour Laboratories.

Course Name: Clinical Bioinformatics	**Course Code: BI-526**
Course Structure: Lectures: 3, Labs: 0	**Credit Hours: 3**
Course Description: The course is designed to equip students with the knowledge and skills required to apply bioinformatics techniques to clinical settings. It covers the principles, methods, and tools essential for the analysis of clinical and medical data, including genomics, proteomics, and clinical informatics. This course is particularly relevant for students aspiring to work in clinical research, healthcare, and personalized medicine, where bioinformatics plays a critical role in diagnostics and treatment.	
Prerequisites: None	
Course Objective: Students will be able to: 1. Understand the role of bioinformatics in clinical practice and research. 2. Apply bioinformatics techniques to analyze clinical and medical data. 3. Analyze and interpret genomics and proteomics data for clinical decision-making. 4. Recognize the ethical and regulatory considerations in clinical bioinformatics. 5. Demonstrate the ability to communicate clinical bioinformatics results effectively.	
Course Outline: Introduction to Clinical Bioinformatics: Role of bioinformatics in clinical practice and research,	

Significance in personalized medicine and healthcare, Overview of clinical informatics and electronic health records, Clinical Data Management: Types of clinical data (e.g., patient records, medical imaging) Clinical data standards and ontologies, Data storage, security, and privacy, Genomics in Clinical Practice: Genomic data in clinical decision-making, Next-generation sequencing (NGS) and clinical genomics, Variant calling and interpretation, Proteomics in Clinical Applications: Role of proteomics in disease biomarker discovery, Mass spectrometry and protein identification, Proteomics data analysis for clinical diagnostics, Clinical Data Analysis: Statistical techniques for clinical data analysis, Visualization of clinical data, Integration of genomics and proteomics data, Clinical Bioinformatics Software and Tools, Tools for variant annotation and interpretation: Electronic health record (EHR) systems, Clinical data analysis software, Ethical and Regulatory Considerations, Ethical issues in clinical bioinformatics, Regulatory frameworks (e.g., HIPAA), Informed consent and patient privacy.

Course Outcomes: Upon successful completion of the course, students will be able to:

1. Explain the role of clinical bioinformatics in healthcare and research.
2. Describe the principles of clinical data collection, storage, and management.
3. Recognize the significance of clinical informatics in electronic health records (EHR).
4. Understand the basics of genomics and proteomics in the clinical context.
5. Comprehend the ethical and regulatory issues surrounding clinical bioinformatics.

Recommended Books: (Min5-8Max) Latest Edition of Following Books

1. Paul S. Ganney, Introduction to Bioinformatics and Clinical Scientific Computing, Taylor & Fracis Group.
2. György Marko-Varga, Genomics and Proteomics for Clinical Discovery and Development , Springer
3. Xiangdong Wang, Christian Baumgartner, Denis C. Shields, Application of Clinical Bioinformatics, Springer
4. Rajneesh Prajapat and Ijen Bhattacharya Medical Bioinformatics and Biochemistry (Diabormatics) Faculty of Medical Science, Department of Medical Biochemistry, Rama Medical College and Hospital, Rama University, Kanpur (U.P.), India

Course Name: Digital Logic and Design	**Course Code: CSC-305**
Course Structure: Lectures: 2, Labs: 1	**Credit Hours: 3**
Prerequisites: None	

Course Objective:

- The course introduces the concept of digital logic, gates and the digital circuits.
- It focuses on the design and analysis combinational and sequential circuits.
- It also serves to familiarize the student with the logic design of basic computer hardware components.

Course Outline:

Number Systems, Logic Gates, Boolean Algebra, Combination logic circuits and designs, Simplification Methods (K-Map, Quinn Mc-Cluskey method), Flip Flops and Latches, Asynchronous

and Synchronous circuits, Counters, Shift Registers, Counters, Triggered devices & its types. Mealy machines and Moore machines. Binary Arithmetic and Arithmetic Circuits, Memory Elements, State Machines. Introduction Programmable Logic Devices (CPLD, FPGA) Lab Assignments using tools such as Verilog HDL/VHDL, MultiSim.

Course Outcomes:

- Acquire knowledge related to the concepts, tools and techniques for the design of digital electronic circuits .
- Demonstrate the skills to design and analyze both combinational and sequential circuits using a variety of techniques.
- Apply the acquired knowledge to simulate and implement small-scale digital circuits.
- Understand the relationship between abstract logic characterizations and practical electrical implementations.

Recommended Books: Latest Edition of the Following Books.

1. Floyd, Digital Fundamentals.2014, Pearson.
2. Verilog Design, Stephen Brown, Fundamental of Digital Logic, 2013, McGraw Hill

Course Name: Data Structures	**Course Code: CSC-423**
Course Structure: Lectures: 3, Labs: 1	**Credit Hours: 4**

Prerequisites: Object Oriented Programming

Course Objective:

- The course is designed to teach students structures and schemes, which allow them to write programmer to efficiently manipulate, store, and retrieve data.
- Students are exposed to the concepts of time and space complexity of computer programs.

Course Outline

Abstract data types, complexity analysis, Big Oh notation, Stacks (linked lists and array implementations), Recursion and analyzing recursive algorithms, divide and conquer algorithms, Sorting algorithms (selection, insertion, merge, quick, bubble, heap, shell, radix, bucket), queue, dequeuer, priority queues (linked and array implementations of queues), linked list & its various types, sorted linked list, searching an unsorted array, binary search for sorted arrays, hashing and indexing, open addressing and chaining, trees and treetraversals, binary search trees, heaps, M-way tress, balanced trees, graphs, breadth-first anddepth-first traversal, topological order, shortest path, adjacency matrix and adjacency list implementations, memory management and garbage collection.

Course Outcomes: After completion of the course students will be able to:

1. Implement various data structures and their algorithmsand apply them in implementing simple applications.
2. Analyze simple algorithms and determine theircomplexities.
3. Apply the knowledge of data structure to other applicationdomains.
4. Design new data structures and algorithms to solveproblems.

Recommended Books: Latest Edition of the Following Books

1. Mark A. Weiss , Data Structures and Algorithm Analysis in Java,2011,Pearson.
2. Frank M. Carrano & Timothy M. Henry ,Data Structures and Abstractions with Java,2014,Pearson.
3. Adam Drozdek, Data Structures and Algorithms in C++ ,2012,Cengage Learning.
4. Mark Allen Weiss, Data Structures and Algorithm Analysis in C++ ,2013,Pearson.
5 John Lewis & Joseph Chase Java Software Structures: Designing and Using Data Structures, 2013, Pearson.

Semester-VII

Course Name: Internship (Mandatory)	**Course Code:** BI-698
Course Structure: Lectures: 0, Labs: 3	**Credit Hours:**3
Prerequisites: None	
Course Outlines: Field Experience/Internship (Practical Work Experience related to a Student's Field of Study or Career interest).The Internship will be supervised and directed by a full time faculty member of the department.	

Course Name: Bioinformatics Software Engineering	**Course Code: BI-622**
Course Structure: Lectures: 2, Labs: 1	**Credit Hours: 3**
Prerequisites: None	
Course Objective: This course introduces the software engineering principles and methodologies with the goal of developing bioinformatics applications	
Course Outline: Software development methodology, waterfall model, iterative model, rapid application development, prototyping, software life cycle. Development of software projects for bioinformatics problems, overview of software architecture, web based applications architecture, developing front end applications.	
Lab Outline: Introduction to software development techniques, implementation of various software models using simple case studies, introduction to HTML, XML, use of front end application tool.	
Recommended Books: 1.Ian Sommerville, Software Engineering, Eighth Edition, Addison-Wesley, 2001 2.Roger S. Pressman,Software Engineering: A Practitioner's Approach, Seventh Edition.McGraw-Hill, 2001	

3.Bioinformatics software engineering by Paul Weston.

4.Namita M . 2003. Bioinformatics concepts, skills and applications.CSB publishers and distributors.

Course Name: Information Security	**Course Code: CSC-521**
Course Structure: Lectures: 2, Labs: 1	**Credit Hours: 3**

Prerequisites: None

Course Objective:

- This course provides a broad overview of the threats to the security of information systems, the responsibilities and basic tools for information security, and the levels of training and expertise needed in organizations to reach and maintain a state of acceptable security.
- It covers concepts and applications of system and data security. Areas of particular focus include secure network design, implementation and transition issues, and techniques for responding to security breaches.

Course Outlines:

Information security foundations, security design principles; security mechanisms, symmetric and asymmetric cryptography, encryption, hash functions, digital signatures, keymanagement, authentication and access control; software security, vulnerabilities and protections, malware, database security; network security, firewalls, intrusion detection; security policies, policy formation and enforcement, risk assessment, cybercrime, law and ethics in information security, privacy and anonymity of data.

Course Outcomes: After completion of the course students will be able to:

- Explain key concepts of information security such as design principles, cryptography, risk management, andethics
- Discuss legal, ethical, and professional issues ininformation security
- Apply various security and risk management tools forachieving information security and privacy
- Identify appropriate techniques to tackle and solve problems in the discipline of information security

5.

Recommended Books: Latest Edition of the Following Books

1. Computer Security: Principles and Practice, 3rd edition by William Stallings
2. Principles of Information Security, 6th edition by M. Whitman and H. Mattord
3. Computer Security, 3rd edition by Dieter Gollmann
4. Computer Security Fundamentals, 3rd edition by William Easttom
5. Official (ISC)2 Guide to the CISSP CBK, 3rd edition

Course Name: Computer Networks	**Course Code: CSC-515**

Course Structure: Lectures: 2, Labs: 1	**Credit Hours: 3**
Prerequisites: None	
Course Objective: This course introduces the basic concept of computer network to the students. Networklayers, Network models (OSI, TCP/IP) and protocol standards are part of the course.	
Course Outlines: Introduction and protocols architecture, basic concepts of networking, network topologies, layered architecture, physical layer functionality, data link layer functionality, multiple access techniques, circuit switching and packet switching, LAN technologies, wireless networks, MAC addressing, networking devices, network layer protocols, IPv4 and IPv6, IP addressing, sub netting, CIDR, routing protocols, transport layer protocols, ports and sockets, connection establishment, flow and congestion control, application layer protocols,latest trends in computer networks.	
Course Outcomes: After completion of the course students will be able to: • Describe the key terminologies and technologies ofcomputer networks • Explain the services and functions provided by each layerin the Internet protocol stack. • Identify various internetworking devices and protocolsand their functions in a networking • Analyze working and performance of key technologies,algorithms and protocols • Build Computer Network on various Topologies	
Recommended Books: Latest Edition of the Following Books 1. Computer Networking: A Top-Down Approach Featuring the Internet, 6th edition by James F. Kurose and Keith W. Ross 2. Computer Networks, 5th Edition by Andrew S. Tanenbaum 3. Data and Computer Communications, 10th Edition by William Stallings 4. Data Communication and Computer Networks, 5th Edition by Behrouz A. Forouzan	

Course Name: Operating Systems	**Course Code: CSC-432**
Course Structure: Lectures: 2, Labs: 1	**Credit Hours: 3**
Prerequisites: Data Structures	
Course Objective: • To help students gain a general understanding of the principles and concepts governing the functions of operating systems. • To acquaint students with the layered approach thatmakes design, implementation and operation of the complex OS possible.	
Course Outlines: Operating systems basics, system calls, process concept and scheduling, inter-process communication, multithreaded programming, multithreading models, threading issues, process scheduling algorithms, thread scheduling, multiple-processor scheduling, synchronization, critical section, synchronization	

hardware, synchronization problems, deadlocks, detecting and recovering from deadlocks, memory management, swapping, contiguous memory allocation, segmentation & paging, virtual memory management, demand paging, thrashing, memory-mapped files, file systems, file concept, directory and disk structure, directory implementation, free space management, disk structure and scheduling, swap space management, system protection, virtual machines, operating systemsecurity.
Course Outcomes: After completion of the course students will be able to: • Understand the characteristics of different structures of the Operating Systems and identify the core functions ofthe Operating Systems • Analyze and evaluate the algorithms of the core functions of the Operating Systems and explain the major performance issues with regard to the core functions • Demonstrate the knowledge in applying system software and tools available in modern operating systems.
Recommended Books: Latest Edition of the Following Books 1. Operating Systems Concepts, 9th edition by Abraham 2. 2. Silberschatz 2.Modern Operating Systems, 4th edition by Andrew S. Tanenbaum 3. Operating Systems, Internals and Design Principles, 9th edition by William StallingsWu

Semester-VIII

Course Name: Artificial Intelligence	**Course Code: CSC-543**
Course Structure: Lectures: 2, Labs: 1	**Credit Hours: 3**
Prerequisites: Object Oriented Programming	
Course Objective: • Artificial Intelligence has emerged as one of the most significant and promising areas of computing. • This course focuses on the foundations of AI and its basic techniques like Symbolic manipulations, Pattern Matching, Knowledge Representation, Decision Making and Appreciating the differences between Knowledge, Data and Code. • AI programming language Python has been proposed for the practical work of this course.	
Course Outlines: An Introduction to Artificial Intelligence and its applications towards Knowledge Based Systems; Introduction to Reasoning and Knowledge Representation, Problem Solving by Searching (Informed searching, Uninformed searching, Heuristics, Local searching, Min- max algorithm, Alpha beta pruning, Game-playing); Case Studies: General Problem Solver, Eliza, Student, Macsyma; Learning from examples; ANN and Natural Language Processing;Recent trends in AI and applications of AI algorithms. Python programming language will be used to explore and illustrate various issues and techniques in Artificial Intelligence.	
Course Outcomes: After completion of the course students will be able to: • Understand the fundamental constructs of Pythonprogramming language.	

- Understand key concepts in the field of artificialintelligence
- Implement artificial intelligence techniques and casestudies

Recommended Books: Latest Edition of the Following Books

1. Russell, S. and Norvig, P. "Artificial Intelligence. A Modern Approach", 3rd ed, Prentice Hall, Inc., 2015.
2. Norvig, P., "Paradigms of Artificial Intelligence Programming: Case studies in Common Lisp", Morgan Kaufman Publishers, Inc., 1992.
3. Luger, G.F. and Stubblefield, W.A., "AI algorithms, data structures, and idioms in Prolog, Lisp, and Java", Pearson Addison-Wesley. 2009.
4. Severance, C.R., 2016. "Python for everybody: Exploring data using Python 3." CreateSpace Independent Publ Platform.
5. Miller, B.N., Ranum, D.L. and Anderson, J., 2019. "Python programming in context." Jones & Bartlett Pub.
6. Joshi, P., 2017. "Artificial intelligence with python." Packt Publishing Ltd.

Course Name: Computer Organization and Assembly Language	**Course Code: CSC-431**
Course Structure: Lectures: 2, Labs: 1	**Credit Hours: 3**
Prerequisites: Digital Logic and Design	

Course Objective:

- The main objective of this course is to introduce the organization of computer systems and usage of assembly language for optimization and control.
- Emphasis should be given to expose the low-level logic employed for problem solving while using assembly language as a tool.
- At the end of the course the students should be capable of writing moderately complex assembly language subroutines and interfacing them to any high level language.

Course Outline:

Introduction to computer systems: Information is bits + context, programs are translated byother programs into different forms, it pays to understand how compilation systems work, processors read and interpret instructions stored in memory, caches matter, storage devices form a hierarchy, the operating system manages the hardware, systems communicate with other systems using networks; Representing and manipulating information: information storage, integer representations, integer arithmetic, floating point; Machine-level representation of programs: a historical perspective, program encodings, data formats, accessing information, arithmetic and logical operations, control, procedures, array allocation and access, heterogeneous data structures, putting it together: understanding pointers, life in the real world: using the gdb debugger, out of-bounds memory references and buffer overflow, x86-64: extending ia32 to 64 bits, machine-level representations of floating-point programs; Processor architecture: the Y86 instruction set architecture, logic design and the Hardware Control Language (HCL), sequential Y86 implementations, generalprinciples of pipelining, pipelined Y86 implementations

Course Outcomes: After completion of the course students will be able to:

1. Acquire the basic knowledge of computer organizationcomputer architecture and assembly language

2. Understand the concepts of basic computer organization, architecture, and assembly language techniques

3. Solve the problems related to computer organization andassembly language

Recommended Books: Latest Edition of the Following Books

1. Computer System Architecture, M. Morris Mano, Latest Edition,
2. Assembly Language Programming for Intel- Computer, Latest Edition
3. Computer Systems: A Programmer's Perspective, 3/E (CS:APP3e), Randal E. Bryant and David R.O' Hallaron, Carnegie Mellon University
4. Robert Britton, MIPS Assembly Language Programming, Latest Edition

Course Name: Analysis of Algorithms	**Course Code: CSC-672**
Course Structure: Lectures: 3, Labs: 0	**Credit Hours: 3**

Prerequisites: Data Structures

Course Objective:

Detailed study of the basic notions of the design of algorithms and the underlying data structures. Several measures of complexity are introduced. Emphasis on the structure, complexity, and efficiency of algorithms.

Course Outlines:

Introduction; role of algorithms in computing, Analysis on nature of input and size of input Asymptotic notations; Big-O, Big Ω, Big Θ, little-o, little-ω, Sorting Algorithm analysis, loop invariants, Recursion and recurrence relations; Algorithm Design Techniques, Brute Force Approach, Divide-and-conquer approach; Merge, Quick Sort, Greedy approach; Dynamic programming; Elements of Dynamic Programming, Search trees; Heaps; Hashing; Graph algorithms, shortest paths, sparse graphs, String matching; Introduction to complexityclasses.

Course Outcomes: After completion of the course students will be able to:

- Explain what is meant by “best”, “expected”, and “worst”case behavior of an algorithm
- Identify the characteristics of data and/or other conditionsor assumptions that lead to different behaviors.
- Determine informally the time and space complexity ofsimple algorithms
- List and contrast standard complexity classes
- Use big O, Omega, Theta notation formally to give asymptotic upper bounds on time and space complexity ofalgorithms
- Use of the strategies(brute-force, greedy, divide-and- conquer, and dynamic programming) to solve an appropriate problem
- Solve problems using graph algorithms, including single- source and all-pairs shortest paths, and at least one minimum spanning tree algorithm
- Trace and/or implement a string-matching algorithm

Recommended Books: Latest Edition of the Following Books
1. Introduction to Algorithms (3rd edition) by Thomas H. Corman, Charles E. Leiserson, Ronald L. Rivest and Clifford Stein 2. Algorithm Design, (1st edition, 2013/2014), Jon Kleinberg, Eva Tardos, 3. Algorithms, (4th edition, 2011), Robert Sedgewick, Kevin Wayne

Course Name: System Biology	**Course Code:Bio-641**
Course Structure: Lectures: 3, Labs: 0	**Credit Hours:** 03
Prerequisites: Probability & Statistics, Linear Algebra & Differential Equations, Genomics	
Course Objective: The purpose of the course is to introduce the students to the field of systems biology and to provide an understanding of the cell at systems level.	
Course Outline: Introduction to systems biology; modeling of biochemical systems; kinetic modeling of enzymatic reactions; law of mass action; Michaelis-Menten Kinetics; rate equation; model systems: lac operon, phages, plasmids and chemotaxis; analysis of high throughput data; gene expression models; stochastic modeling of biological systems; chemical master equation. stochastic simulation, fluctuations in gene expression; biological networks; network structure, network dynamics and function; network motifs, network modularity.	
Recommended Books: Latest editions of following books 1. Klipp, E., Wolfram L., Christoph W., Axel K., Hans L., and Ralf H., "Systems biology", Wiley. 2. Ullah, M., and Olaf W., "Stochastic approaches in systems biology", Springer. 3. Newman M., "Networks: An Introduction", Oxford University Press, USA. 4. Alon U., "An introduction to systems biology: design principles of biological circuits. Boca Raton", Chapman & Hall/CRC.	

Course Name: Capstone Research Project	**Course Code:** BI-699
Course Structure: Lectures: 0, Labs: 6	**Credit Hours:6**
Prerequisites: BS Courses	
Course Outlines: The student will opt a research project. The research project will be supervised and directed by a full time faculty member of the department.	

The following courses enlisted will be offered as General Courses for other departments.

1. Introduction to Bioinformatics.
2. Fundamentals of Bioinformatics
3. Computational Biochemistry.

Course Name: Introduction to Bioinformatics	**Course Code: BI-401**
Course Structure: Lectures: 3, Labs: 0	**Credit Hours: 3**
Prerequisites: None	
Course Objective: This course is designed for students with little to no prior experience in bioinformatics. It provides a foundational understanding of the core concepts, tools, and techniques in bioinformatics.	
Course Outline: Introduction to Bioinformatics, Biological Databases, Types of Biological databases, Human genome and browsers, Genome sequencing methods, sequencing of human genome, DNA, RNA, and protein sequences retrieval and analysis, Sequence alignment and BLAST, Pairwise and Multiple Sequence Alignment, Sequence Polymorphism, What is Phylogenetics, Phylogenetic tree construction and analysis, Structural Bioinformatics, Introduction to protein structure, PDB (Protein Data Bank), Protein structure visualization, Primer designing, Genomics and Proteomics, students Projects. **Lab Outline:** Introduction to NCBI, Navigating the NCBI website, Comparison of sequences using Basic Local Alignment Search Tool (BLAST), Interpretation of BLAST search results, UCSC genome browser, Pairwise and multiple sequence alignment using ClustalW, Protein Data Bank, Swiss Prot, Pymol viewer or any available protein structure visualizer, Primer 3 and Oligo analyzer 3.1.	
Course Outcomes: By the end of the course, students will be able to analyze biological data, perform basic sequence analysis, and grasp key principles in genomics and proteomics.	
Recommended Books: Latest Edition of Following Books 1. **Bioinformatics Sequence and Genome Analysis**, D.W. Mount, Cold Spring Harbor Laboratory Press 2001 ISBN 0-87969-597-8. 2. Zvelebil, M. J., & Baum, J. O. (2008). **Understanding bioinformatics**. New York (N.Y.): Garland science. 3. Arthur M. Lesk, Introduction to Bioinformatics.4th Edition (2008).Oxford University Press. 4. Jin Xiong, Essential Bioinformatics,(2006), Cambridge University Press	

Course Name: Fundamentals of Bioinformatics	**Course Code: BI-409**
Course Structure: Lectures: 2, Labs: 1	**Credit Hours: 3**
Prerequisites:	
Course Objective: The course is designed to introduce the most important and basic concepts, methods, and tools used in Bioinformatics. This course will introduce basic biological database sources, principles and methods for sequence and genome analysis. The overall aims are	

a. To help the students to reach rapidly the frontier of bioinformatics and be able to use the bioinformatics biological Databases. b. To convey the importance of bioinformatics for viewing the biomedical information. c. To provide hands-on experience using Biological Databases searching, retrieving, critically evaluating results and interpreting their biological significance.
Course Outline: Introduction,Goals,Scope, Applications,Limitations.Databases,Types of Databases, Biological Databases, Sequence Storage, Information retrieval and analysis, Sequence Alignment, Similarity and homology, Types of alignments, local and global alignment,. Methods of Alignment, pairwise and multiple sequence alignments, Significance of Sequence Alignment, Algorithm, Sequence Alignment Methods, Relationship of multiple sequence alignment to phylogenetic analysis, DNA sequence Analysis, Protein Sequence Analysis. Motif Search, Molecular phylogenetic, Phylogenetic Basis, Phylogenetic Tree construction methods and Programs. Molecular Modeling and Drug Designing and Discovery.
Lab Outline: Accessing NBCI databases, sequence databases, Genbank, EMBL, SWISS-PROT Accessing structure database PDB, SCOP and CATH, Expasy server, using online alignment tools for pair wise and multiple sequence alignment, using BLAST and FASTA, phylogenetic analysis. Molecular Modeling and Drug Designing.
Recommended Books: 1. Arthur M. Lesk, Introduction to Bioinformatics.4th Edition (2008).Oxford University Press. 2. Ignacimuthu SJ. Basic Bioinformatics, 2nd Edition (2005) Narosa Publishing House. 3. S.C.Rastogi, N.Mendiratta,P.Rastogi,Bioinformatics: Methods and Applications: Genomics, Proteomics and Drug Discovery. 3rd Edition (2009). PHI Learning Pvt. Ltd. 4. David Mount, Bioinformatics: Sequence and Genome analysis.2nd Edition (2004). Cold Spring Harbour Laboratories. 5.Jin Xiong, Essential Bioinformatics,(2006), Cambridge University Press

Course Name: Computational Biochemistry	**Course Code: BI-527**
Course Structure: Lectures: 2, Labs: 1	**Credit Hours: 3**
Course Description: This course introduces students to the fundamental principles and applications of computational tools and techniques in the field of biochemistry. The course explores the principles and applications of computational methods to understand biological systems, analyze biomolecular structures, and simulate biochemical processes. Students will gain a strong foundation in using computational tools to analyze and model biochemical systems.	
Course Objective: The Students will be able to 1. Understand the fundamental principles of computational biochemistry and its role in modern biochemistry research. 2. Analyze and interpret bioinformatics data, including DNA and protein sequences, structural information, and biochemical pathways. 3. Apply computational methods to predict and analyze the structure and function of biomolecules.	

Course Outline:

Introduction to Computational Biochemistry, the importance and role of computational methods in biochemistry. Identify various software and tools used in computational biochemistry Bioinformatics and. Sequence Analysis: Use bioinformatics tools to analyze DNA, RNA and protein sequences. Predict open reading frames, gene structures, and motifs. Perform sequence alignment and phylogenetic analysis. Structural Bioinformatics: Understand protein structure determination methods. Utilize molecular modeling software to visualize and manipulate biomolecular structures. Analyze protein structures using molecular visualization techniques and software like PyMOL. Predict protein secondary structure and solvent accessibility. Predict the impact of mutations on protein structure and function. Explain the role of structural biology in understanding biomolecular function. Analyze protein-ligand complexes and their structural features. Interpret experimental structures and their relevance to biochemistry. Molecular Dynamics Simulations, Explain the principles of molecular dynamics simulations. Perform basic simulations of biomolecules. Analyze and visualize molecular dynamics trajectories. Apply simulation techniques to understand protein folding and conformational changes. Docking and Drug Discovery, Understand molecular docking techniques. Perform protein-ligand docking. Analyze and interpret docking results for drug discovery. Ligand Binding and Drug Design, Calculate binding energies and predict ligand-receptor interactions. Design small molecules and drugs targeting specific biomolecules. Evaluate the principles of structure-based drug design. Systems Biology and Pathway Analysis, Explore metabolic and signaling pathways. Analyze and model biochemical pathways. Understand network properties and their role in biological processes. Special Topics in Computational Biochemistry: Cover advanced topics such as protein-ligand interaction analysis, homology modeling, and structural bioinformatics of nucleic acids.

Course Outcomes: By the end of this course, students should be able to:

1.Explore the relationship between structure and function in biochemical systems.

2. Gain hands-on experience in using computational tools for practical research in biochemistry.

Recommended Books: Latest Edition of Following Books

1. Christopher J. Cramer, Essentials of Computational Chemistry: Theories and Models.1st edition, May 2002. Wiley, John & Sons.
2. Stan Tsai, An Introduction to Computational Biochemistry, Wiley, John & Sons.
3. Paul Harrison, Computational Methods in Physics, Chemistry and Biology: An Introduction , Wiley, John & Sons.
4. Eberhard O. Voit, Antonio E. Ferreira, Computational Analysis of Biochemical Systems: A Practical Guide for Biochemists and Molecular Biologists, Cambridge University Press
5. Frank Jensen, Introduction to Computational Chemistry, Wiley, John & Sons.

RECOMMENDED BOOKS:

The latest editions of:

Cell and Molecular Biology: Concepts and Experiments Gerald Karp John Wiley and Sons

Introduction to Computational Molecular Biology Setubal, Meidanis Brooks/Cole

Principles and Techniques of Biochemistry and Molecular Biology Keith Wilson, John Walker Cambridge University Press

Instant Notes: Biochemistry B D Hames Viva Books Pvt. Ltd.

Basics of Theoretical and Computational Chemistry BM Rode John Willey and Sons

Instant Notes: Genetics P C Winter Viva Books Pvt. Ltd.
Instant Notes: Molecular Biology P C Turner Viva Books Pvt. Ltd.
Molecular Cloning: A laboratory manual Sambrook Cold Dpring Harbor, Laboratory Press.
Instant Notes: Bioinformatics David R. Westhead, J. Howard Parish and Richard M. Twyman Viva Books Pvt. Ltd.
Bioinformatics for Dummies Jean-Michel Claverie,Cedric Notredame Wiley Publishing, Inc.
Essential Bioinformatics Jin Xiong Cambridge University Press.
Bioinformatics Bal Tata McGraw-Hill.
Bioinformatics Andrzej Polański, Marek Kimmel Springer.
Bioinformatics: An Introduction Jeremy Ramsden Springer.
Bioinformatics: A Concept-based Introduction Venkatarajan Subramanian Mathura, Pandjassarame Kangueane Springer.
Bioinformatics: Tools and Applications David Edwards, Jason Eric Stajich, David Hansen Springer.
Bioinformatics: Principles and Basic Internet Applications Hassan A. Sadek Trafford Publishing, Canada.
Bioinformatics: Applications in Life and Environmental Sciences M. H. Fulekar Springer.
Bioinformatics: A Practical Approach Shui Qing Ye Chapman & Hall / CRC.
Applied Bioinformatics: An Introduction Paul M. Selzer, Richard J. Marhöfer, Andreas Rohwer Springer.
Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins Andreas D. Baxevanis, B. F. Francis Ouellette John Wiley and Sons, USA.
Bioinformatics: a Swiss perspective Ron D. Appel, Ernest Feytmans World Scientific, Singapore.
Bioinformatics: Genomics and Post-genomics Frédéric Dardel, François Képès, Translated by Noah Hardy John Wiley and Sons, France.
Bioinformatics: Methods and Applications: Genomics, Proteomics and Drug Discovery S. C. Rastogi, Namita Mendiratta, Parag Rastogi PHI Learning Pvt. Ltd.
Bioinformatics and drug discovery Richard S. Larson Humana Press.
Computational molecular biology: an algorithmic approach Pavel Pevzner MIT Press.
Bioinformatics algorithms: techniques and applications Ion Măndoiu, Alexander Zelikovsky Wiley-Interscience.
Bioinformatics: problem solving paradigms Volker Sperschneider, Jana Sperschneider, Lena Scheubert
Springer.
Parallel computing for bioinformatics and computational biology Zomaya A. Y. John Wiley & Sons, Inc.
Research and trends in data mining technologies and applications David Taniar Idea Group Inc (IGI).
Machine learning in bioinformatics Yan-Qing Zhang, Jagath Chandana Rajapakse John Wiley and Sons.
Computational Intelligence in Bioinformatics Árpád Kelemen, Ajith Abraham, Yuehui Chen Springer.
Bioinformatics and the Cell: Modern Computational Approaches in Genomics, Proteomics and Transcriptomics Xuhua Xia Springer.
Bioinformatics for Dummies 2nd Edition Jean-Michel Claverie and Cerdric Notredame

Bioinformatics-Sequence and Genome Analysis David W. Mount.
Introduction to Bioinformatics T K Attwood and D J Parry-Smith.
Bioinformatics-Gene, Proteins and Computers C. A. Orengo, D. T. Jones and J. M. Thornton.

CURRICULUM

OF

BIOINFORMATICS
MS

(Session 2023 Onwards)

MASTER OF SCIENCE (MS)
IN
BIOINFORMATICS

INTRODUCTION:

Graduates of the MS in Bioinformatics program should feel equipped to engage in productive bioinformatics research and effectively communicate research projects and findings to multidisciplinary project teams. The purpose of the MS degree program in bioinformatics is to provide students with advanced knowledge and practices that will train them to decipher biological processes

with the help of computational tools. The exponential growth and complexity of biological data can be translated effectively into knowledge by the use of computer-based approaches.

MISSION STATEMENT OF PROGRAM:
The MS in Bioinformatics program is dedicated to advancing knowledge and expertise in the dynamic field of bioinformatics. Our mission is to provide a rigorous and comprehensive education, equipping students with the essential skills to excel in bioinformatics research, data analysis, and computational biology. We aim to empower our graduates to make meaningful contributions to scientific discovery, healthcare, and the broader global challenges in the life sciences.

GENERAL OBJECTIVES:
The enormous influx of biological data can only be handled with better and faster computational approaches together with advanced knowledge in functional genomics and proteomics. Advanced concepts, structures, algorithms, and tools are required for effective processing and analysis. Specialized courses in molecular biology, bioinformatics, and computation are needed to achieve these objectives.

PROGRAM OBJECTIVES:
At the end of the MS program, the graduates should be able to:
1. Develop innovative computer applications to solve biological problems.
2. Facilitate the researchers using bioinformatics tools and databases.
3. Undertake problem-based research.

LEARNING OUTCOMES
After completion of the MS program in bioinformatics, the graduates will be able to:
● Process and clean, store, analyze, and model large volumes of biological data from multiple sources.
● Use bioinformatics skills to predict functions from structures, networks, complexes, transcriptome, and proteome data. Independently and collaboratively provide insights into complex biological systems through data synthesis, experimental design, and applications of a wide range of computational biology approaches.
● Develop advanced computational applications related to bioinformatics and effectively communicate and present bioinformatics concepts to multidisciplinary project teams.

Admission Requirements:
Eligibility:
1. BS in Bioinformatics/Biological Sciences/Computer Sciences/ Biotechnology or equivalent in relevant disciplines (deficiency courses to be completed if needed).
2. 2nd Division or GPA 2.50 or above.

Duration:
2 years (course work may be completed in two semesters and one year for research work).

Total Credit Hrs: 30 (24 credit hours course work + 6 credit hours thesis).

Scheme of Studies for MS Program in Bioinformatics Semester I and II

Note:
Students coming from computer and physical sciences background must take 1-2 courses from group A and may take at most one course from group B. Similarly, students coming from biological sciences background must take 1-2 courses from group B and may take at most one course from group A.

Students coming from bioinformatics background may take at most 1 course each from groups A and B.

Remaining credit hours for all students must be completed from group C.

Group A- Biological Sciences

1. Advance Molecular Biology
2. Cell Biology
3. Genomics
4. Proteomics
5. Metabolomics
6. Microbial Genetics
7. Biochemistry
8. Gene Manipulation
9. Enzymology
10. Epigenetics.
11. Immunology
12. Biostatistics
13. Advance System biology
14. DNA microarrays and integrative genetics
15. Functional genomics
16. Clinical Epidemiology
17. Research Method in Biological Sciences
18. Gene regulation and expression
19. Principles and application of proteomics
20. Medical genetics
21. Introduction and Applications of Biotechnology.
22. Molecular Biophysics
23. Advance Molecular Techniques
24. Molecular Biology, Genetics, and Disease.
25. Molecular Profiling and Biomarker Discovery

Group B- Computer Sciences

1. Fundamentals of Programming
2. Object Oriented Programming
3. Data structure
4. Database Design
5. Software engineering
6. Graphics and visualization
7. Probability and Statistics
8. Data warehousing and Data mining
9. Molecular dynamics simulation
10. Intelligent systems
11. Advance topics in information systems
12. Neural Computing
13. Data Mining
14. Advanced Computer Programming
15. Advanced Database Systems
16. Agile Software Development
17. Design and Analysis of Algorithms
18. Natural Language Processing

19. Numerical Computing
20. Advanced Digital Image Processing
21. Information Processing.
22. Modern Programming Languages.

Group C- Bioinformatics

1. Genome Informatics/Computational Genomics
2. Advanced Bioinformatics/Computational Biology
3. Computational Systems Biology
4. Protein Informatics/Computational Proteomics
5. Computational Drug Design
6. Computational Molecular Evolution
7. Biophysics
8. Molecular Modelling and Simulation
9. Mathematical Models in Biology
10. Machine Learning
11. Metagenomics
12. Data Mining
13. Stochastic Modeling
14. Computational Neuroscience
15. Synthetic Biology
16. Chemo-informatics
18. Health informatics
19. Big data analysis and management
20. Current trends in bioinformatics
23. Mathematical modeling and Simulation
24. Neural Computing and Genetics Algorithms
25. Pathways and Networks in Biology
26. Bioinformatics Scripting and Programming
27. R for Bioinformatics
28. Statistical Methods for Computational Biology
29. Advances in Molecular Dynamics.
30. Pattern Recognition and Matching.
31. Bioinformatics Algorithms.
32. Medical Image Processing.
33. Translation Bioinformatics.
34. Bioinformatics Scripting and Databases with Python.
35. Biological Sequence Analysis.
36. Biomedical Statistics with R.
37. Mathematical Modeling for Bioinformatics.
38. Structural Bioinformatics.
39. Drug Discovery and Development
40. Statistical Genetics
41. Research Topics in Computational Biology

Scheme of Studies for MS Program in Bioinformatics

Semester I and II
***MS Semester I and II**

Course Code	*Semester I (Credit Hours)		Course Code	*Semester II (Credit Hours)	
	Courses	Credit Hours		Courses	Credit Hours
BI-78X	Elective I From the List of Group A/B/C	3	BI-78X	Elective II From the List of Group A/B/C	3
BI-72X	Major	3	BI-72X	Major	3
BI-72X	Major	3	BI-72X	Major	3

BI-72X	Major	3	BI-72X	Major	3
Total Credit Hours		**12**	**Total Credit Hours**		**12**
Semesters III & IV (Credit Hours)					
BI-799	Research/Thesis	**6**			
	Total Credit Hours	**30**			

**Note: The department has the option to offer any course from the list of Courses subject to the availability of the resources. Course codes for the offered courses will be assigned at the time of offering the course chosen for the upcoming session. In addition to the above, the university can offer any course relevant to the discipline which they feel is necessary subject to the availability of resources.*

Semester III and IV
Research Thesis (6 Credit Hours)

Research Project

1. The duration of the research project will be at least two regular semesters. An independent research topic chosen by the student and supervised by a full-time faculty member of the department is required for all students in MS Bioinformatics.
2. The research work of each student will be reviewed periodically by the supervisor/head of the department to ensure the objectives laid down for the study are being met.
3. All students must present and defend their research work before the panel of examiners as per the rules of the university.

CURRICULUM

OF

BIOINFORMATICS
Ph.D

(Session 2023 Onwards)

DOCTORATE in PHILOSOPHY (Ph.D)
BIOINFORMATICS

INTRODUCTION:
The Ph.D. in Bioinformatics program offers unique interdisciplinary training for graduate students in the science, engineering, medicine, and Biological Sciences. The program aims to prepare researchers for careers in both academia and industry in the areas of molecular life sciences. In order to be

admitted, students need at least a Master's degree in a field related to bioinformatics, preferably one with a strong component in mathematics and computer science.

MISSION STATEMENT OF PROGRAM: The mission of the PhD in Bioinformatics program is to cultivate exceptional scholars and researchers at the forefront of bioinformatics and computational biology. Our mission includes preparing PhD scholars to be influential leaders, driving advancements in bioinformatics and shaping the future of the field to fostering a rich intellectual environment that encourages rigorous inquiry, innovation, and interdisciplinary collaboration.

GENERAL OBJECTIVES:

The emphasis of the Ph.D. in Bioinformatics program is preparation for careers that involve using bioinformatics in research or in the biotechnology or pharmaceutical industries. In order to be admitted, students need at least a bachelor's degree in a field related to bioinformatics. Typically, students enrolling in the Ph.D. program have strength in either the computational area or in biochemistry/molecular biology, but not both.

PROGRAM OBJECTIVES:

At the end of the program, the graduate should be able to:

- Demonstrate mastery of the core concepts of Bioinformatics: These include (a) advanced methods in computational biology, (b) the chemical principles that underlie biochemistry, molecular biology, and genomics, (c) the design and implementation of relational databases, (d) fundamental methods in probability and statistics, and (e) the construction of predictive mathematical models of biological systems.
- Be capable of using critical thinking and research methods in Bioinformatics to understand computational and experimental data. In addition to formal coursework, this ability will be learned and demonstrated in (a) dissertation research and (b) presentations at scientific meetings, graduate seminars, student seminars, and qualifying examinations.

LEARNING OUTCOMES:

Students graduating with a PhD in Bioinformatics are expected to:

- Demonstrate the ability to produce and present original research in Bioinformatics. The most important manifestation of this outcome is publication of peer-reviewed research papers on dissertation research, and, in particular, papers with the trainee as first author. The Challenge Project, seminar presentations, and presentations at meetings also demonstrate this outcome.
- Conduct scholarly activities in a professional and ethical manner.
- Develop the ability to communicate clearly the meaning, potential impacts, and risks associated with one's research activities to a non-technical audience in ways that confer a sense for its value to society.

Admission Requirements:

Eligibility:

1. MS/MPhil in Bioinformatics/Biological Sciences/Computer Sciences/ Biotechnology or equivalent in relevant disciplines (deficiency courses to be completed if needed).
2. GPA 3.00 or above in their MS/MPhil courses.

Duration:

3 Years (course work may be completed in two semesters and Two years for research work).

Total Credit Hrs: 18 credit hours course work + 9 credit hours thesis

Scheme of Studies for Ph.D. Program in Bioinformatics

***PhD Semester I and II**

Course Code	*Semester I (Credit Hours)		Course Code	*Semester II (Credit Hours)	
	Courses	Credit Hours		Courses	Credit Hours
BI-88X	Elective I From the List of Group A/B/C	3	BI-88X	Elective II From the List of Group A/B/C	3
BI-82X	Major	3	BI-82X	Major	3
BI-82X	Major	3	BI-82X	Major	3
Total Credit Hours		**09**	**Total Credit Hours**		**09**
Semesters III, IV & V, VI (Credit Hours)					
BI-899	Research/Thesis **Total Credit Hours**		**9-12** **30**		

**Note: The department has the option to offer any course from the list of Courses subject to the availability of the resources. Course codes for the offered courses will be assigned at the time of offering the course chosen for the upcoming session. In addition to the above, the university can offer any course relevant to the discipline which they feel is necessary subject to the availability of resources.*

Note
In addition to the above, the universities can offer any other course in the respective groups according to their specialization.

Research Thesis (9-12 Credit Hours)

Research Project
1. Duration of the research project will be at least Three Years. An independent research topic chosen by the student and supervised by a full-time faculty member of the department is required for all students in Ph.D. Bioinformatics.
2. The research work of each student will be reviewed periodically by the supervisor/head of the department to ensure the objectives laid down for the study are being met.
3. All students must present and defend their research work before the panel of examiners as per the rules of the university.

List of Major Courses:

Course Title: Advance Bioinformatics		**Course Code: BI-721**
S.No	**Course Code**	**Course Titles**
1	BI-721	Advance Bioinformatics
2	BI-722	Genome Informatics
3	BI-723	Protein Informatics
4	BI-724	Computational Drug Design
5	BI-725	Transnational Bio-informatics
6	BI-726	Modern Programming languages
7	BI-727	Data mining
8	BI-781	Fundamentals of Programming
9	BI-782	Current Trends in Bioinformatics
10	BI-783	Research Method in Biological Sciences
11	BI-784	Enzymology
12	BI-785	Medical Genetics
13	BI-786	Graphics and Visualization
14	BI-821	Computational Immunology
15.	BI-822	Chemoinformatic
16.	BI-823	Biological Sequence Analysis and Structural Bioinformatics
17.	BI-824	Bionetworks and Genomics

Content of Major Courses for MS/PhD Bioinformatics (2023 Onwards)

Course Structure: Lectures: 3, Labs: 0	**Credit Hours: 3**
Prerequisites: This course equips students with the skills necessary to address complex biological questions and to conduct cutting-edge bioinformatics research.	
Course Objective: By the end of the course, students will be able to: 1. Demonstrate advanced proficiency in analyzing high-throughput biological data. 2. Utilize structural bioinformatics tools to analyze biomolecular structures. 3. Recognize the potential applications of advanced bioinformatics in genomics, proteomics, and systems biology.	
Course Outline: This course builds upon the foundational principles of bioinformatics and delves into advanced topics and techniques. Students will gain expertise in high-throughput data analysis, omics integration, structural bioinformatics, and machine learning in biological data analysis. Advanced techniques for analyzing high-throughput data (e.g., RNA-Seq, ChIP-Seq, proteomics), Quality control, data preprocessing, and normalization, Advanced statistical methods for differential expression and functional analysis. Multi-Omics Data Integration: Principles of integrating genomics, transcriptomics, proteomics, and metabolomics data, Network-based approaches for omics data integration, Case studies in systems biology and personalized medicine. Structural Bioinformatics: Structural data analysis using tools like PyMOL and VMD, Homology modeling and protein structure prediction, Ligand-receptor interaction analysis and drug discovery, Applications in sequence analysis, functional annotation, and disease prediction, Advanced Genomics and Functional Genomics	
Course Outcomes: Upon successful completion of the course, students will be able to: 1. Explain advanced bioinformatics concepts and their significance in contemporary research. 2. Recognize the role of structural bioinformatics in biomolecular analysis.	
Recommended Books: 1. Bioinformatics: A practice Guide to Analysis of Gene and Proteins Andreas Baxevnis, B. F. Francis Ouellet. 2. Essentials of Genomics and Bioinformatics, C.W Sensen. 3. S.C.Rastogi, N.Mendiratta,P.Rastogi,Bioinformatics: Methods and Applications: Genomics, Proteomics and Drug Discovery. 3rd Edition (2009). PHI Learning Pvt. Ltd. 4. David Mount, Bioinformatics: Sequence and Genome analysis.2nd Edition (2004). Cold Spring Harbour Laboratories. 5.Jin Xiong, Essential Bioinformatics,(2006), Cambridge University Press. 6. Jonathan Pevsner , Bioinformatics and Functional Genomics, 3rd Edition(2015). Wiley-Blackwell.	

Course Title: Genome Informatics	**Course Code: BI-722**
Course Structure: Lectures: 3, Labs: 0	**Credit Hours: 3**
Prerequisites:	

Course Objective: By the end of the course, students will be able to:

1. Understand the principles of genome informatics and its role in genomics research.
2. Apply computational techniques to process, analyze, and interpret genomic data.
3. Utilize specialized software tools and databases commonly used in genome informatics.
4. Conduct genome annotation, variant analysis, and functional genomics studies.

Course Outline: This advanced course delves into the principles, methods, and applications of genome informatics, with a focus on large-scale genomic data analysis. Students will learn how to harness the power of informatics to interpret, annotate, and analyze genomes, as well as explore various applications, such as functional genomics, comparative genomics, and personalized medicine

Introduction to Genome Informatics Overview of genome informatics and its role in genomics research, Significance in personalized medicine and comparative genomics, Genomic informatics resources and tools, **Genomic Data Types and Sources:** Genomic data types (e.g., DNA sequencing, RNA-Seq, ChIP-Seq), Genomic data repositories and public databases, Data retrieval and data preprocessing. Genome Annotation and Comparative Genomics, **Principles of genome annotation and gene prediction.** Comparative genomics and evolutionary analysis. Genomic synteny and ortholog identification. Structural Variants and Genomic Variation. **Gene Identification and Prediction**: Basis Of Gene Prediction, pattern Recognition, Gene Prediction Methods, and Gene prediction Tools. Categories of Gene Prediction Programs, Gene Prediction in Prokaryotes. Gene Prediction in Eukaryotes, **Promoter and Regulatory Element Prediction**. Promoter and Regulatory Elements in Prokaryotes. Promoter and Regulatory Elements in Eukaryotes. Prediction Algorithms. **RNA Structure Prediction:** Introduction, Types of RNA Structures, RNA Secondary Structure Prediction Methods. Ab Initio Approach, Comparative Approach, Performance Evaluation, **Genome Mapping, Assembly, and Comparison** Genome Mapping. Genome Sequencing, Genome Sequence Assembly, Genome Annotation. Comparative Genomics, Functional Genomics, Gene Expression.

Course Content: Upon successful completion of the course, students will be able to:

1. Explain the fundamental concepts and significance of genome informatics.
2. Describe the structure and function of genomes.
3. Recognize the role of genome informatics in genomics research.
4. Understand the principles of genome annotation, variant analysis, and functional genomics.

Recommended Books:

1. David Mount, Bioinformatics: Sequence and Genome analysis.2nd Edition (2004). Cold Spring Harbour Laboratories.

2.Jin Xiong, Essential Bioinformatics,(2006), Cambridge University Press.

3. Jonathan Pevsner , Bioinformatics and Functional Genomics, 3rd Edition(2015). Wiley-Blackwell.

Course Title: Protein Informatics	**Course Code: BI-723**
Course Structure: Lectures: 3, Labs: 0	**Credit Hours: 3**

Prerequisites:

Course Objective: The aim of this module is to acquire a detailed knowledge of the processes shaping protein structure, function and evolution and to apply this knowledge to the design and development of new and improved protein-based therapeutics.
Course Outline: Introduction to Protein informatics, Levels of protein expression and organization, Protein Domains, Folds and Motifs, Prediction of Protein Secondary Structure and function, 3D Comparative Modelling, abinitio, fold recognition approach, Protein structure optimization and validation using bioinformatics tools and software, Protein engineering to improve protein therapeutics, Evolutionary relationship between sequence, structure and function of protein. Protein profiling for disease association studies, Protein interactomics, and Protein networking.
Learning Outcomes: On successful completion of this course the learner will be able to; Appraise the mechanisms underlying protein structure, function, evolution and engineering for therapeutic purposes, Analyse the most common empirical approaches to protein structure, critically assess the impact of protein research on biomedicine and biotechnology
Recommended Books: 1. Janusz M. Bujnicki 2009, Prediction of Protein Structures, Functions, and Interactions [ISBN: 9780470517673] 2. J. Rigden, Daniel (Ed.) 2017, From Protein Structure to Function with Bioinformatics, 2 Ed., Springer Netherlands [ISBN: 978-94-024-10]

Course Title: Computational Drug Design	**Course Code: BI-724**
Course Structure: Lectures:3 Lab: 0	**Credit Hours: 3**
Prerequisite:	
Course Objectives: By the end of the course, students will be able to: 1. Understand the principles of CADD and its role in pharmaceutical research. 2. Apply computational techniques to analyze biological targets and drug candidates. 3. Recognize the potential applications of CADD in drug discovery and personalized medicine.	
Course Outlines: This course provides advanced training in the application of computational methods and informatics tools for the discovery and design of novel pharmaceutical agents. Students will learn to integrate concepts from molecular biology, structural biology, chemistry, and informatics to expedite drug discovery and development processes. Introduction to Computer-Aided Drug Design (CADD):Overview of CADD and its role in pharmaceutical research,Significance in drug discovery, personalized medicine, and pharmacology, CADD software, resources, and databases, Drug Discovery and Development, Phases of drug discovery and development, Targets, lead compounds, and clinical trials, Drug discovery pipelines	

and timelines, Biomolecular Targets in Drug Design:Understanding biological targets (e.g., enzymes, receptors),Structural biology and target identification, Molecular modeling and protein-ligand interactions, Molecular Docking: Principles of molecular docking, Docking algorithms and scoring functions, Virtual screening and binding affinity predictions, Ligand-Based Drug Design, Pharmacophore modeling and quantitative structure-activity relationships (QSAR), Molecular dynamics simulations, Structure-based virtual screening, ADME and Toxicity Assessment: Absorption, distribution, metabolism, excretion (ADME) properties, Toxicity prediction and assessment, Optimizing drug candidates for safety and efficacy, CADD Software Tools, CADD software and suites (e.g., AutoDock, Schrödinger),Molecular modeling and structure-based drug design tools,Toxicity prediction and ADMET assessment software.CADD Applications.

Course Outcomes: Upon successful completion of the course, students will be able to:

1. Explain the fundamental concepts and significance of CADD in pharmaceutical research.
2. Describe the processes of drug discovery and development.
3. Understand the principles of molecular docking, virtual screening, and drug design.

Recommended Books:

1. Introduction to Molecular Modeling and Molecular Dynamics for Computational Drug Discovery" by J. Andrew McCammon and Ruben Abagyan

2. Drug Design: Structure- and Ligand-Based Approaches" by Kenneth M. Merz Jr., Dagmar Ringe, and Charles H. Reynolds.

3. Computational Drug Discovery and Design" by Xiaodong Cheng,

4.Computer-Aided Drug Design and Delivery Systems" by Ahindra Nag

Course Title: Transnational Bio-informatics	**Course Code: BI-725**
Course Structure: Lecture: 3 Lab:0	**Credit Hours: 3+0 =3**

Course Objectives: By the end of the course, students will be able to:

1. Describe and apply a broad range of bioinformatics algorithms
2. Apply informatics techniques to retrieve, store, and analyze biomedical data
3. Use open-source tools and open-access databases to find and analyze data of translational and clinical importance
4. Describe bioinformatics's current trends and problems and how they relate to clinical issues, population health and public health.

Course Outlines: This course covers the fundamental issues of bioinformatics and how they apply to translational and clinical problems. The course is organized into 4 parts: sequence analysis, databases and ontologies, genome-wide association and linkage analysis, and networks. Each part will include coverage of the computing and mathematical concepts used, motivated by the underlying bioinformatics questions.

Overview of bioinformatics and principal applications: sequencing, Microarray, 'omics' fields, systems biology, data mining. Relationships to diseases and health. Translational Bioinformatics: Past, Present, and Future: Biomedical Knowledge Integration. Data, Molecules, and Diseases. Sequencing, Assembly, Interpretation. Genome-Wide Association Studies. Network Approaches to Diseases. Analyses Using Disease Ontologies. Human Microbiome Analysis. Cancer and Translational Bioinformatics. Regression / multiple regression / mixed effects / logistic models. Hierarchal clustering, WCGNA. Functional Analysis using DAVID, GATHER, GSEA software's, Connectivity Map. NGS and mutations. Drug discovery

Course Outcome: Gaining research experience and writing skills in translational bioinformatics.

Recommended Books:

1. Translational Bioinformatics, Wang, Xiangdong, ISSN: 2213-2775
2. J. Rigden, Daniel (Ed.) 2017, From Protein Structure to Function with Bioinformatics, 2 Ed., Springer Netherlands [ISBN: 978-94-024-10]
3. Kann M, Lewitter F, eds. Translational Bioinformatics. Open Access, and available online at http://collections.plos.org/translational-bioinformatics.
4. Journal articles, handouts and other miscellaneous readings will be handed out during the course

Course Name: Modern Programming Languages	**Course Code: BI-726**
Course Structure: Lectures: 3	**Credit Hours: 3**
Course Objectives: This course provides a practical introduction to two programming languages: Perl, and Python. The programming skills learnt in this course will enable the students to apply them in the domain of bioinformatics.	
Course Outline : Introduction to Perl programming, data types, Input and output, subroutines in Perl, Control structures, Comparisons. Introduction to Python, data types, file handling, flow control, modularizing code in Python, introduction to Biopython..	
Course Out Come: After the end of the course students should be able to: • write, modify, and run Perl, and Python scripts. • create stand-alone programs to process biological data. • work with biological data using libraries.	
Recommended Books: Recent Editions of following books 1. James Tisdall, Beginning Perl for Bioinformatics, O'Reilly Publisher, ISBN: 0-596-00080-4. 2. James Tisdall, Mastering Perl for Bioinformatics, O'Reilly Publisher, ISBN: 0-596-00307-2 3. Sebastian Bassi, Python for bioinformatics, Chapman & Hall/CRC Taylor & Francis Group, ISBN 978- 1- 58488-929-8.	

Course Name: Data Mining	**Course Code: BI-727**
Course Structure: Lectures: 2, Labs: 1	**Credit Hours: 3**
Prerequisites: Advance Statistics, Introduction to Data Science	
Course Objective: • Expand on the student's understanding and awareness of the concepts of data mining basics, techniques, and application. • Introduce the concepts of Data Pre-processing and Summary Statistics. • Introduce the concepts of Frequent Item Set Generation, Associations and Correlations measures. • Introduce the concepts of Classification, Prediction, and Clustering algorithms. Build on the programming and problem-solving skills developed in previous subjects studied by the student, to achieve an understanding of the development of Classification, Prediction, and Clustering pplications.	
Course Outlines Introduction to data mining and basic concepts, Pre-Processing Techniques & Summary Statistics, Association Rule mining using Apriori Algorithm and Frequent Pattern Trees, Introduction to	

Classification Types, Supervised Classification (Decision trees, Naïve Bae Classification, K-Nearest Neighbors, Support Vector Machines etc.), Unsupervised Classification (K Means, K Median, Hieratical and Divisive Clustering, Kohonan Self Organizing maps), outlier & anomaly detection, Web and Social Network Mining, Data Mining Trends and Research Frontiers. Implementing concepts using Python
Course Outcomes: After completion of the course students will be able to: • Apply preprocessing techniques on any given raw data. • Select and apply proper data mining algorithm to discover interesting patterns • Analyze and extract patterns to solve problems and point out how to deploy solution • Evaluate systematically supervised, semi supervised and unsupervised models and algorithms with respect to their accuracy
Recommended Books: Latest Edition of the Following Books 1. Jiawei Han & Micheline Kamber, Jian Pei, Data Mining: Concepts andTechniques, 3rd Edition, 2011, Moran-Kaufmann. 2. Pang-Ning Tan, Michael Steinbach, and Vipin Kumar, Introduction to DataMining, 2005,Pearson. 3. Charu C. Aggarwal, Data Mining: The Textbook, 2015, Springer. 4. D. Hand, H. Mannila, P. Smyth, Principles of Data Mining, 2001, MIT Press.

Course Name: Fundamentals of Programming	**Course Code:** BI-781
Course Structure: Lectures: 3	**Credit Hours:** 3
Course Objectives: This course covers fundamental programming concepts that are essential to building C++ programs. At the end of this course students should be able to: Manipulate various C++ data types, such as arrays, strings, and pointers. Write computer programs using control structures, arrays, functions. Understand basic object-oriented principles. Implement class member functions.	
Course Outline Basic Computer Organization, evolution of programming languages, data types, control structures, repetition structures. Arrays, strings, pointers, structures, user-defined functions. Introduction to object oriented programming, classes and objects, member functions of classes, constructors, destructors.	
Recommended Books: Recent Editions of following books 1. C++ Programming: Program Design Including Data Structures, Eighth Edition, D.S. Malik,	

Cengage Learning, ISBN: 978-1-337-11756-2.
2. C++: The Complete Reference, Fourth Edition, Herbert Schildt, Osborne McGraw-Hill.
3. C++ How to Program, 10th Edition, Paul J. Deitel, Deitel & Associates, Inc. Pearson.

Course Title: Current Trends in Bioinformatics	**Course Code: BI-782**
Course Structure: Lecture: 3 Lab:0	**Credit Hours: 3+0 =3**
Course Objectives: The objective of this course is to train students with stat of the art bioinformatics methods and techniques to deal with disease and health.	
Course Outline: The era of omics. Transcriptomics. Genomics, Proteomics, Transcription profiling by different methods. Biomarker discovery, Role of bioinformatics in translational research and clinical practices, Next generation sequence and its impact on clinical practice, Biological networks and human diseases, Genetic variations and personalized medicine, Genome wide association studies, role of bioinformatics in epigenetics. The current state and future of CRISPR-case9 technology.	
Course Outcome: To the end of this course students will be able to do genome, transcriptome and proteome profiling and their use in clinical practice. Students will gain experience with the use of Bioinformatics data analysis pipelines.	
Recommended Books: 1. Discovering Genomics, Proteomics & Bioinformatics http://www.amazon.com/Discovering-Genomics-Proteomics-Bioinformatics2nd/dp/0805382194/ref=sr_1_1_title_0_main?s=books&ie=UTF8&qid=1375976286&sr=11&keywords=discovering+genomics+proteomics+and+bioinformatics 2. NCBI Bookshelf—there are many books that can be searched for concepts and descriptions. http://www.ncbi.nlm.nih.gov/books/ 3. Bioinformatics and Functional Genomics, By Jonathan Pevsner http://www.amazon.com/dp/0470085851/ref=rdr_ext_tmb	

Course Title: Research Method in Biological	**Course Code: BI-783**

Sciences	
Course Structure: Lecture: 3 Lab:0	**Credit Hours: 3+0 =3**

Course Objectives: Upon completion of the course, students will be able to:

- carry out literature search and acquire knowledge from scientific articles.
- Think critically about biological questions and evidence.
- Design appropriate experiments to address biological questions.
- Select appropriate analyses to answer biological questions.
- Interpret results of statistical tests in biologically relevant terms.

Course Outlines: An introduction to research methods in biology, with specific focus on critical thinking, scientific skepticism, experimental design, and working with data relevant to biological questions. Students will develop an understanding of the logical and philosophical underpinnings of the scientific method, learn how biological research is commonly conducted and disseminated, and develop a skillset of data analysis techniques in relation to experimental questions and hypotheses in biology.

Concepts of basic and applied research and their usefulness, formulation of research objectives. Communications in Biosciences, sources of scientific information, qualitative, quantitative and mix method research. How to write research proposal. Reading scientific Papers. How to write scientific paper, applying the scientific methods, types of projects and idea for the research. How to write research project. Critical analysis of the research results. Biostatistical methods used in data analysis. Presenting Information: How to communicate outcome and conclusions, presenting figures and tables Presenting results, writing reports development of writing skills, how to manage references using RefWorks and Mendeley. How to publish in the academic journals.

Recommended Books:

1. Research Methodology by Getu Degu Tegbar Yigzaw lecture Notes for Health Sciences Students.

https://docplayer.net/13016696-Research-methodology.html

2. Patton, M., 2002. Qualitative Research and Evaluation Methods 3rd ed. Sage Publications Inc., Thousand Oakes, CA.
3. Ann Bowling, A. and Ebrahim S. 2005. Handbook of Health Research Methods. Open University Press, Two Penn Plaza, New York, NY.
4. Journal articles, handouts and other miscellaneous readings will be handed out during the course

Course Title: Enzymology	**Course Code: BI-784**
Course Structure: Lecture: 3 Lab:0	**Credit Hours: 3+0 =3**

Course Objectives: The objective of this course is to provide in depth knowledge of how enzymes work as biological catalysts and how the rates of reactions are impacted by a variety of different factors and environmental conditions.

Course Outline

Enzymes Nomenclature and classification of enzymes; Holoenzyme, apoenzyme, cofactors, coenzyme, prosthetic groups, metallo enzymes, monomeric and oligomeric enzymes Activation energy and transition state theory, enzyme activity, specific activity, common features of active sites, enzyme specificity: types and theories Factors affecting enzyme activity, E, S, temp and pH

Enzyme substrate complex: Michaelis- Menten equation and its derivation; Two substrate reactions (random, ordered and ping pong mechanisms), enzyme inhibition, types of inhibition, determination of Ki, suicide inhibitor; Qualitative description of concerted and sequential models; Enzyme regulation.

Enzyme- enzyme interaction, protein ligand binding; Measurement analysis of binding isotherm, cooperativity, Hilland Scatchard plots Kinetics of allosteric enzymes Allosteric enzymes with special reference to aspartate transcarboxylases and phosphofructokinase

Mechanism of enzyme action; Factors associated with catalytic efficiency, proximity, orientation and distortion of strain Collision and transition state theories, significance of activation energy and free energy Acid base. Nucleophilic and covalent catalysis

Isolation, crystallization and purification of enzymes Test of homogeneity of enzyme preparation, methods of enzyme analysis; Detailed view of techniques for studying Enzyme assay; Chemical modification of active site groups, chymotrypsin, Lysozyme, RNase, Carboxypeptidase, GPDH, Aldolase, alcohol dehydrogenase

Enzyme technology: Methods for large scale production of enzymes, immobilized enzymes and their comparison with soluble enzymes; Methods of immobilization of enzyme; Application of immobilized and soluble enzymes in health and industry, application to fundamental studies of biochemistry, enzyme electrodes; Thermal stability and catalytic efficiency of enzyme, site directed mutagenesis and enzyme engineering-selected examples.

RECOMMENDED BOOKS:

Biochemistry (2011) 8th edition by J.M. Berg, J.L. Tymoczko& L. Stryer W.H. Freeman & Co.
Fundamentals of Biochemistry (2010) 5th Ed. by D. J. Voet, G.J. Voet and C. W. Pratt. J. Wiley & Sons Inc.
Lehninger Principles of Biochemistry 5th Ed. by D. L. Nelson, M. M. Cox. W. H. Freeman Publishers.
Biochemistry. (1999) 3rd Ed. by C. K. Mathews, K. E. Van Holde, & K.G. Ahern. Prentice Hall.
Harper's Illustrated Biochemistry, 27th Ed. By R.K. Murray, D.K. Grannar, V.W. Rodwell. McGraw-Hill.

Course Name: Medical Genetics	**Course Code: BI-785**
Course Structure: Lectures: 3, Labs: 0	**Credit Hours: 3**

Course Objective:

The goals of this course are to:

• Prepare students to be proficient in medical genetics by understanding the principles identified in Genetics.

• Prepare students to be able to utilize emerging genetic technologies in the care of patients

Course Outline:

Introduction to Medical Genetics and Genomic variation, Molecular basis of human DNA and types of mutation, Mutagens and Mutagenesis, Types of mutation, Structural effects of mutation on proteins, Functional effects of mutation on protein; Mendelian inheritance and Population Genetics, The role of genes in development and features of genes on the X chromosome, Chromosome nomenclature and disorders, Patterns of inheritance; Single gene inheritance, polygenetic inheritance; Genetic disorders, Single gene disorders, Biochemical genetics; DNA techniques, Nucleic acid probes, Nucleic acid hybridization, Restriction mapping, DNA Sequencing, Mutation screening techniques; Cytogenetics, Chromosome abnormalities, Numerical abnormalities, Structural abnormalities, Methods of chromosome analysis; Immunoinformatics; Clinical genetics, prenatal and preimplantation diagnosis of genetic diseases, Genetic councling,Treatment of genetic diseases, Ethical issues in medical genetics

Recommended Books: (Min5-8Max)

1. Connor, J. M. and Malcolm Ferguson-Smith. Essential medical genetics. Oxford, Eng., Malden, MA, Blackwell Science, **2005**.
2. Gelehrter, Thomas D., Francis S. Collins and David Ginsburg. Principles of medical genetics. Baltimore, Williams & Wilkins.
3. Molecular Biology of the Cell (5th edition, **2004**) by B Alberts, J Lewis et al, Published by

Garland
Genes VI (6th edition, 1997) by B Lewin, Published by Oxford University Press.
4. Chromosome Abnormalities and Genetic Counselling by RJM Gardner, GR Sutherland, Published by Oxford University Press Clinical Atlas of Human Chromosomes (6th edition, **2008**) J De Grouchy & J Turleau, Published by John Wiley

Course Title: Computational Immunology	**Course Code: BI-821**
Course Structure: Lecture: 3 Lab:0	**Credit Hours: 3+0 =3**

Course Objectives: By the end of the course, students will be able to:

1. Understand the principles of computational immunology and its significance in modern healthcare and research.
2. Apply computational techniques to analyze immune system data, including immune receptor sequences and immune response dynamics.
3. Recognize the potential applications of computational immunology in vaccine development, immunotherapy, and disease control.

Course Outlines: This course focuses on the application of computational techniques to the study of the immune system, covering topics such as immune informatics, immune receptor analysis, immune response modeling, and applications in vaccine design and immunotherapy.

Introduction to Computational Immunology: Overview of computational immunology and its role in healthcare and research, Significance in vaccine development, immunotherapy, and disease control. **Immunological databases and software tools: Immune System Components:** Cellular and molecular components of the immune system, Immune cell signaling and interactions, Immunological pathways and processes. **Immuno-informatics:** Analysis of immune receptor sequences (TCR and BCR),Sequence motif recognition and alignment, Immune receptor data mining and retrieval,Immune Response Modeling, Mathematical modeling of immune response dynamics, Predicting immune responses to pathogens and antigens, Systems immunology and network analysis. **Vaccine Design and Immunotherapy:** Principles of vaccine design and development, Computational methods for vaccine antigen selection, Immunotherapeutic strategies and immune modulation. **Computational Immunology Software Tools:** Immuno-informatics software (e.g., VDJtools, IMGT), Immunological modeling and simulation software, Vaccine design tools and immunotherapy modeling, **Applications of Computational Immunology:** Immunotherapy applications in cancer and autoimmune diseases, Disease control and outbreak analysis

Course Outcome: Upon successful completion of the course, students will be able to:

1. Recognize the role of computational immunology in vaccine design, immunotherapy, and disease control.
2. Understand the principles of immune receptor analysis and immune response modeling.

Recommended Books:

1.Computational Immunology: Applications 1st Edition, by Shyamasree Ghosh, CRC Press; 1st edition (February 4, 2020)

2, Computational Immunology: Models and Tools by Josep Bassaganya-Riera 2016, Science Direct.

3.Bioinformatics and Computational Biology: A Primer for Biologists Basant K. Tiwary Springer Nature, 23-Nov-2021

Course Title: Chemoinformatics	**Course Code: BI-822**
Course Structure: Lecture: 3 Lab:0	**Credit Hours: 3+0 =3**

Course Objectives: By the end of the course, students will be able to:
1. Understand the principles and significance of chemoinformatics in various scientific domains.
2. Apply chemoinformatics techniques to process, analyze, and interpret chemical and molecular data.
3. Utilize specialized software tools and databases commonly used in cheminformatics.

Course Outlines: This course covers the principles and techniques essential for the handling, analysis, and interpretation of chemical and molecular data. Students will learn how to use computational tools to make data-driven decisions in various domains of chemistry and biology.

Introduction to Chemoinformatics: Overview of cheminformatics and its role in scientific research, Significance in drug discovery, chemical biology, and materials science, Chemoinformatic resources and tools, Chemical Structure Representation, Molecular structure representation (SMILES, InChI), Chemical file formats (SDF, MOL), Structure drawing and visualization tools, Molecular Descriptors and Fingerprints, Types of molecular descriptors (physicochemical, topological, etc.): Molecular fingerprints for compound comparison, Calculation and interpretation of molecular descriptors, Chemical Databases: Chemical databases and their applications, Data retrieval, data curation, and data mining, Chemical database searching and compound retrieval, Virtual Screening and Drug Discovery,Principles of virtual screening,Structure-activity relationship (SAR) analysis,Molecular docking and ligand-based drug design, cheminformatics Software Tools, cheminformatics software and libraries (e.g., RDKit, ChemAxon), Software for molecular descriptor calculation and database searching, Virtual screening and compound analysis software, Chemical Biology and Materials Science, Chemoinformatics in chemical biology and target identification, Materials informatics and property prediction, Ethical issues in chemoinformatics and data sharing, Limitations and challenges in chemoinformatics modeling and predictions, Validation of chemoinformatic results with experimental data.

Course Outcome: Upon successful completion of the course, students will be able to:
1. Explain the fundamental concepts and significance of cheminformatics.
2. Describe the principles of chemical structure representation and molecular descriptors.

Recognize the role of chemical databases and their applications. 3. Comprehend the relevance of cheminformatics in chemical biology and materials science.
Recommended Books: 1. Computational Medicinal Chemistry for Drug Discovery" by Patrick Bultinck, Tom De Winter, Willem Herrebout, et al. 2. Chemoinformatics in Drug Discovery" by Lukasz Konieczny and Beata Tarnowska. 3. Computational Approaches in Cheminformatics and Bioinformatics" by Jian Wang. **4.** Pharmacophore Perception, Development, and Use in Drug Design" by Osman F. Güner

Course Title: Bionetworks and Genomics	**Course Code: 823**
Course Structure: Lectures: 3	**Credit Hours: 3**
Prerequisites: Biochemistry/Molecular Biology	
Course Objective: 1. To provide students with a comprehensive introduction to the field of genomics, covering key concepts such as genome composition, organization, and genomic technologies. 2. To equip students with a deep understanding of advanced genomic topics, including gene duplication, comparative genomics, functional genomics, and their relevance to evolutionary biology. 3. To introduce students to the emerging field of biological networks and their significance in modern biology.	
Course Outline Introduction to genomics, Genome composition and organization, Genomic Technologies 1st, second and third generation sequencing, Genomic data analysis, Gene Duplication and Co-Option, Comparative Genomics, orthologs, paralogs and evolutionary genomics, Functional genomics, Genomics in healthcare, precision medicine, and diagnostics, Overview of biological networks, Importance of bionetworks in modern biology, Gene Regulatory Networks, Cellular Communication Networks,Disease-gene networks, Network-based drug discovery, Personalized medicine and network pharmacology, Tools for bionetwork analysis.	
Learning Outcomes: By the end of the course, students will be able to: 1. Apply their knowledge to critically analyze and interpret genomic data and research findings. 2. understand the role of genomics in addressing medical and clinical challenges. 3. importance of biological networks in modern biology and the potential impact of network-based approaches in various scientific disciplines.	

Recommended Books

1. Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2014). *Molecular Biology of the Cell*. Garland Science.
2. Brown, T. A. (2019). *Genomes*(4th ed.). Wiley.
3. Klug, W. S., Cummings, M. R., Spencer, C. A., & Palladino, M. A. (2019). *Concepts of Genetics*(12th ed.). Pearson.
4. Journal articles for lectures and homework assignments will be provided.

Course Name: Graphics and Visualization	**Course Code: CSC-786**
Course Structure: Lectures: 3, Labs: 0	**Credit Hours: 3**
Prerequisites: Programming Fundamentals	

Course Objective

- This course is designed to provide a comprehensive introduction to computer graphics, learn concepts of computer graphics and its algorithms.
- The aim is to learn concepts of illumination, animation, shading and geometrical transformations. This will lead to the ability to understand contemporary terminology, progress, issues, and trends in computer graphics.

Course Outcomes:

After completion of the course students will be able to:

- Have an understanding of the concepts of computer graphics
- Be able to implement the concepts of computer graphics on a suitable platform

Course Outline:

Introduction, Applications of Computer Graphics, Overview of Image Representation, Graphics Hardware, Applications of Graphics, Image resolution, Image quality issues, Cathode Ray Tubes, Vector Display Devices, Colour Lookup Table, LCD Technology, Plasama, classes of logical input devices, Physical input devices, Interactive Devices,Scan-converting point, lines, ellipse, arcs and sectors, polygon, characters and circles,Line Drawing Algorithm: Digital Differential Analyzer, Bresenham's, Circle Drawing: mid-point, Line Algorithms, Scaling, Rotation, Translation, composite transformations: 2D and 3D,Region Filling, aliasing effects, anti-aliasing, image compression, Window to Viewport mapping, 2-D Clipping, point clipping, line clipping, polygon clipping, Panning and Zooming, Projections: Taxonomy of projection, perspective projection orthogonal projection, Advanced geometric and Raster Algorithms, Clipping scan converting primitives, special problems with text, making copy Pixel fast, Page description languages, Hidden Surfaces, depth comparisons, Z-buffer algorithm, Back-Face Removal, Scan-line algorithm, Hidden Line Elimination, Rendering of mathematical surfaces, Curve and Surface Design, simple geometric forms, wireframe models, curved surfaces, curve design, polynomial basis function, curved-surface design, Rendering, Shading, Phong Model, Colour and Animation, basic rules of animation, Ray tracing, the Pinhole Camera, Ray-surface intersection, A recursive ray tracer, Hardware for interactive graphics: fundamental graphics unit, rasterizer, pixel driver, Segmentation, two and three dimensional image geometry and transformation

Lab Outline:
Line drawing techniques, clipping effects, 2D and 3D representations and transformations using open GL, development of graphical user interface with various blocks and modules, elliptical and curve creation exercises.

Recommended Books: Latest Edition of the Following Books.

1. Foley, J.D., Dam,A.V., Feiner,S.K., Hughes,J.F. (Latest edition) Computer Graphics, Principles and Practice. Addison-Wesley .
2. Hill,. F.S.(Latest edition) Computer Graphics.MacMillan.
3. Burger,P., Gillies,D.F. (Latest edition). Interactive Computer Graphics: Functional, Procedural and Device-level methods. Addison-Wesley.
4.Computer Graphics (C Version), by Donald Hearn and M. Pauline Baker (Prentice Hall, 1997)
5.Graphics & Visualization Principles and Algorithms by Theoharis, Georgios Papaioannou.
6.Matthew Ward,Georges Grinstein, Daniel Keim. Interactive Data Visualization: Foundations, Techniques, and Applications. (May, 2010).

LIST OF COURSES:

1.Bioinformatics Scripting and Programming
2.R for Bioinformatics
3.Statistical Methods for Computational Biology
4.Advances In Molecular Dynamics.
5.Pattern Recognition and Matching.
6.Bioinformatics Algorithms.
7.Medical Image Processing.
8.Translation Bioinformatics.
9.Bioinformatics Scripting and Databases with Python.
10. Biological Sequence Analysis.
11. Biomedical Statistics with R.
12. Mathematical Modeling for Bioinformatics.
13. Structural Bioinformatics.
14. Drug Discovery and Development
15. Statistical Genetics
16. Research Topics in Computational Biology
17. Advance Molecular Biology
18. Cell Biology
19. Genomics
20. Proteomics
21. Metabolomics
22. Microbial Genetics
23. Biochemistry
24. Gene Manipulation
25. Enzymology
26. Epigenetics.
27. Immunology
28. Biostatistics
29. Advance System biology
30. DNA microarrays and integrative genetics.
31. Functional genomics
32. Clinical Epidemiology
33. Research Method in Biological Sciences
34. Gene regulation and expression
35. Principles and application of proteomics
36. Medical genetics
37. Introduction and Applications of Biotechnology.
38. Molecular Biophysics.
39. Advance Molecular Techniques
40. Molecular Biology, Genetics, and Disease.
41. Molecular Profiling and Biomarker Discovery
42. Fundamentals of Programming
43. Object Oriented Programming
44. Data structure
45. Database Design
46. Software engineering
47. Graphics and visualization
48. Probability and Statistics
49. Data warehousing and Data mining

50. Molecular dynamics simulation
51. Intelligent systems
52. Advance topics in information systems
53. Neural Computing
54. Data Mining
55. Advanced Computer Programming
56. Advanced Database Systems
57. Agile Software Development
58. Design and Analysis of Algorithms
59. Natural Language Processing
60. Numerical Computing
61. Advanced Digital Image Processing
62. Information Processing.
63. Modern Programming Language
64. Genome Informatics/Computational Genomics
65. Advanced Bioinformatics/Computational Biology
66. Computational Systems Biology
67. Protein Informatics/Computational Proteomics
68. Computational Drug Design
69. Computational Molecular Evolution
70. Biophysics
71. Molecular Modelling and Simulation
72. Mathematical Models in Biology
73. Machine Learning
74. Metagenomics
75. Data Mining
76. Stochastic Modeling
77. Computational Neuroscience
78. Synthetic Biology.
79. Chemo-informatics
80. Health informatics
81. Big data analysis and management
82. Current trends in bioinformatics
83. Mathematical modeling and Simulation
84. Neural Computing and Genetics Algorithms
85. Pathways and Networks in Biology
86. Multicore Computing
87. Bio Networks & Genomics
88. Machine Learning Biosciences
89. Computational Biology: Genomes, Networks, Evolution
90. Molecular Bioengineering
91. Dynamics and Evolution of Biological Networks
92. Predictive Health Genomics
93. Software Generation, Testing and Maintenance
94. Clinical Bioinformatics
95. Statistical Methods for Computational Biology
96. Computational Immunology
97. Pathways and Networks in Biology
98. Biological Sequence Analysis and Structural Bioinformatics
99. Computational Gene Expression Analysis
100. Software Architecture and Design

Recommended Text Books For MS Bioinformatics Programme

1. Bioinformatics: sequence and Genome Analysis, David W. Mount.
2. Bioinformatics: A practice Guide to Analysis of Gene and Proteins Andreas Baxevnis, B. F. Francis Ouellet.
3. Developing Bioinformatics Computer Skills, Cynthia Gibbs, Per Jambeck.

4. Discovering Genomics, Proteins and Bioinformatics, A. Makom Cambell, Laurie J. Heyer.
5. Microarray Bioinformatics, Dov Stekel, Ed Southern.
6. Introduction to Bioinformatics, Arthur M. Lesk.
7. Bioinformatics Computing, Bryan P. Bergeron.
8. A Primer of Genome Sequencing, Greg Gibson.
9. Instant Notes on Bioinformatics, Howard J. Parish.
10. Bioinformatics and functional Genomics, Donis Marshall, Jonathan Persner.
11. Bioinformatics: The Machine learning approach, Pierre Baldi, Sren Brunak, Soren Brunak.
12. An introduction to Bioinformatics, Algorithims Neil C. Jones, Pavel A. Persner.
13. Essentials of Genomics and Bioinformatics, C.W Sensen.
14. Bioinformatics, Biocomputing and Perl. An introduction to Bioinformatics Computing Skills and Practice Michael Moorhouse, Paul Berry.
15. Statistical Methods in Bioinformatics Warren Ewens, Gregory Grant.
16. Microarray for An Integrative Genomics S. Isaac, J-Atul, Alvin Khd
17. Bioinformatics; Sequence and Databanks: A Practical Approach Des Higgins, Willie Taylor.
18. Genomic Perl: From Basic To Workinf Code Rex A.Dwyer
19. Bioinformatics: From Genome To Drugs, Vol 1: Basic Technologies
Vol 2: Application Thomas Lengauer.
20. Biotechnology, Genomics and Bioinformatics Teresa Atwood, David Perry-Smith
21. Introduction To Bioinformatics Teresa Atwood, David Perry-Smith
22. Structured Bioinformatics Philip Bourne, Helge Weissig
23. Bioinformatics Methods and Protocols Stephen Misener, Stephen Krawetz.
24. New Biology for Engineers and scientists, Aydin Tozeren, Stephen W.Byers.
25. Computational Molecular Biology: An Introduction, Peter Clote, RlfBackofen.
26. Bioinformatics in Post-Genomic Era: Genomic Transcription, Proteome and Information Based Medicine Jeffery Augen.
27. Bioinformatics: Using Computational Intelligence Paradims U. Seiffert, L.C.Jain, Pschwetzer
28. Introduction To Bioinformatics: a theoretical and Practical Approach Stephen Krawetz, David D.Womble.
29. Bioinformatics for Geneticsts, Michaeal R.Barens, Ian C.Gray.
30. Immunological Bioinformatics, Lund Ole Nielsen.
31. Bioinformatics Basics Hooman Rashidi, Lukas Buehler.
32. Bioinformatics: Genes, Proteins and Computers C.Orengo, D.Jones, J.Thornton.
33. Bioinformatics and Molecular Evolution Paul G. Higgs.
34. The Application of Bioinformatics in Cancer Detection Asad Umar
35. Bioinformatics, Ralf Hofestadt.
36. Bioinformatics, Genomics and Proteomics: Getting the Bio PictureAnn Batiza, Bernice Schacter
37. Knowledge Discovery in Proteomics Igor Jerisca, Dennis Wigle
38. Proteomics and Protein-Protein Introductions:
Biology, Chemistry, Bioinformatics and Drug Design, Gabreil Waksman
39. An introduction to Bioinformatics Jermy Ramsden.
40. Bioinformatics Basics: Application in Biological Science and Medicine Hookman Rashidi, Lukas Buehler.
41. Medical Genetics Lynn B.Jorde, Jhon C.Carey, Micheal .Bamshad, Raymound L. White
42. Essential of Genetics, William S.Klug, Michel R.Cummings.

43. Thompson & Thompson Genetics in Mediccine Robert I.Nussbaum, Rodreick R.Mclnnes. Huntington F. Willard.
44. Medical Molecular Genetics, Patrick A.Hoffe.
45. Genomics, Sandy Primose, Richard Twyman
46. Essential of Medical Genetics Alan Emery, Robert Mueller.
47. Gene VIII Benjamin Lewin.
48. Understanding Biotechnology,George Acquaah.
49. Concept of Genetics, William Klug, Michael Cumming
Charlotte Spencer
50. Essential Genes, Benjamin Lewin.
51. Cell and Molecular Gerald Karp
52. Microbiology; A Human Perspective Eugene Nester, Denise Anderson, C. Evans Robert Jr.
53. Genetics, Benjamin A. Pierce.
54. Ethics from a Faith Perspective, Jack Hanford.
55. A companion to Genetics Justine Burrley, John Harris
56. Understanding Medical Statistics David Mathews, Vernon Farewell
57. Molecular Biology, Robert Weaver.
58. Lipincot's Biochemistry Champe; Harvey; Ferrier.
59. Harper's; Biochemistry, Murray. Grammer, Mayes, Rodwell
60 Lehninger; Principles of Biochemistry Nelson , Cox.
61 Biochemistry Donlad Voet
62 Pattern Recognition, Statistical, Structural & Neural Approached Robert Schalkoff
63 Pattern Recognition with neural networks in C++ Pandya/Macy
64 Pattern Classification Duda, Hart and Stork.
65 Fundamentals of Pattern Recognition, Monique Pavel.
66 Texture Analysis in Machine Vision, M.K. Pietikainen.
67 Genetic Algorithms for Pattern Recognition, Pal/Wang.
68 Digital Image Processing R.C. Gonzales
69 Digital Image Processing using Matlab R.C. Gonzales
70 Hand Book of Image Processing John C.Russ
71 Algorithms for Image Processing & Computer Vision, J.R. Parker.