MANONMANIAM SUNDARANAR UNIVERSITY

TIRUNELVELI – 627012

M.Sc. BIOCHEMISTRY SYLLABUS

(OUTCOME BASED EDUCATION - CHOICE BASED CREDIT SYSTEM)

(Effective from the academic year 2026-2027 onwards)

MANONMANIAM SUNDARANAR UNIVERSITY, TIRUNELVELI

PG COURSES – AFFILIATED COLLEGES

M.SC. BIOCHEMISTRY

(OUTCOME BASED EDUCATION - CHOICE BASED CREDIT SYSTEM)

(Effective from the academic year 2026-2027 onwards)

1. Vision of the University

To provide quality education to reach the un-reached.

2. Mission of the University

- To conduct research, teaching and outreach programmes to improve conditions of human living.
- To create an academic environment that honours women and men of all races, caste, creed, cultures and an atmosphere that values intellectual curiosity, pursuit of knowledge, academic freedom and integrity.
- To offer a wide variety of off-campus educational and training programs, including the use of information technology, to individuals and groups.
- To develop partnership with industries and government so as to improve the quality of the workplace and to serve as catalyst for economic and cultural development.
- To provide quality/inclusive education, especially for the rural and un-reached segments of economically downtrodden students including women, socially oppressed and differently abled.

3. Preamble

Biochemistry deals with the study of chemical and physical processes of living systems. Biochemistry holds promises in areas of Medical Science, Health Science and Agriculture. The M.Sc. Degree programme aims at providing inclusive conceptual and practical skills in Biochemistry to reach academic and professional excellence. M.Sc. Biochemistry programme has been framed and mapped such that the compilation of the Outcomes of all Courses in the programme ensures the attainment of the programme outcomes in terms of RBT.

4. Programme Educational Outcomes (PEO)

In alignment with the Vision and Mission of the University, the following have been defined as the PEO for the graduates.

PEO1: Developing strong positive attitude to learn independently the concepts in the field of study.

PEO2: Ensuring confidence among the learners to apply the knowledge and skills gained to solve real life issues.

PEO3: Habituating ethical values among the learners to succeed in personal and professional life.

5. Programme Outcomes (PO)

After the successful completion of Postgraduate Programme from the University, the learner should be able to

PO1: Comprehend the knowledge acquired and share the knowledge with others to convince them in a discussion.

PO2: Analyze and compare the factual data / situation and formulate the problem in to a conceptual model to critically evaluate for finding solution.

PO3: Apply the theories and philosophies learned in formulating theoretical research problem with underlying assumptions and solve the problem scientifically.

PO4: Think reflectively on the earlier attempts for applications of the concepts with a sense of inquiring practices and attempt for self directed lifelong learning process.

PO5: Understand the existence of multicultural practices and global viewpoint and utilization of knowledge with the ability to prolong moral/ethical values in personal and professional life.

PO6: Expose the learner to the digital literacy and information explosion with latest technology for enabling the learner to learn through multiple sources

PO7: Prepare the learner to be a responsible player in the varied teams with facilitating capability and formulate teams as a leader for defined purposes.

6. Programme Specific Outcomes (PSO)

On completion of M.Sc. Biochemistry programme, the student should be able to

PSO1: Develop scientific attitude to work in the Biochemistry research field and other fields of their own interest to communicate ideas, concepts and construct arguments scientifically.

PSO2: Employ standard laboratory protocols/procedures in Biochemistry and modern instrumentations to carryout experiments, compile biological information and interpret biological data systematically.

PSO3: Accomplish problem solving skills and creativity through assignments, field work and project work in their focused area of study.

PSO4: Prepare for future career in Biochemistry and other fields by enhancing analytical and critical thinking skills in order to relate the chemistry of biological processes which plays vital role in maintaining human health.

PSO5: Possess and practice right moral features and be aware of ethical and environmental issues to become responsible and competent professionals so as to translate knowledge of biochemistry for social well-being.

PSO6: Acquaint and apply modern technology in broad areas of interdisciplinary fields such as Medical Biochemistry, Pharmaceutical Chemistry, Forensic Science, Biotechnology, Agriculture, Clinical Research etc. through integration in academic and industrial practice favoring wide range of career options and entrepreneurial ventures.

PSO7: Gain leadership qualities, team spirit and good interpersonal skills in team work by means of integrating themselves in cocurricular and extracurricular activities which aid them in their chosen fields with commitment to novelty and distinction.

7. Credits

The term credit is used to describe the quantum of syllabus for various programmes in terms of study. It indicates differential weightage given according to the contents and duration of the courses in the curriculum design. The total number of credits for M.Sc. Biochemistry is 90.

8. Eligibility for admission to the course and examination

Candidates shall be admitted to the course provided if he/she has obtained a Bachelor's degree in Science in Biochemistry / Chemistry / Microbiology / Biotechnology / Medical Lab Technology / Zoology / Botany / Biology / Nutrition & Dietetics / Life Science / Bioinformatics or any other degree that may be considered as equivalent by the M.S. University.

9. Medium of instruction and examination

The medium of instruction as well as examination will be in English.

10. Duration of the Course

The students shall undergo the prescribed course of study for a period of not less than two academic years (Four semesters). Each semester contains 90 working days.

11. Theory examination

The external evaluation will be based on the examination to be conducted by the university at the end of each semester.

12. Practical examination

Practical examinations will be conducted at the end of each semester.

13. Evaluation

A. Each paper carries an internal component

B. There is a pass minimum of 50% for P.G. external and overall components

Theory External: Internal Assessment = 75:25

Practical External: Internal Assessment = 50:50

Internship/Industrial External: Internal Assessment = 50:50

Extension Activity = 50:50

C. Internal Assessment

Internal marks for Theory shall be allocated in the following manner.

The average of the best two tests from three compulsory tests	15 Marks
Seminar	05 Marks
Quiz/ Interactive group work	05 Marks
Total	**25 Marks**

Note: Each test will be of one hour duration.

D. Practical

Internal marks for practical shall be allotted in the following manner.

Experimental work	20 Marks
Active participation	5 Marks
Record	5 Marks
Model Test	20 Marks
Total	**50 Marks**

E. Project Work

Components	Marks
Project Report	50 Marks
Viva -Voce	50 Marks
Total	**50 Marks**

Note: (i) Students should carry out individual project only.
(ii) Project report will be evaluated and Viva-Voce will be conducted by both the External examiner and the Internal Guide at the end of the 4th semester.

14. The question paper pattern for all theory papers shall be as follows.

Duration of Exam: 3Hours

Section	Type of questions	Mark
Part-A	Multiple choice question (Two question from each unit compulsory)	15×1=15 Marks
Part-B	Internal Choice questions (One question from each unit: either/or)	5×4=20 marks
Part-C	Internal Choice questions (One question from each unit: either/or)	5×8=40 marks
	Total	**75 Marks**

15. The question paper pattern for all practical papers shall be as follows.

Duration of Practical Exam: 6 hours

1	Major experiment	25 Marks
2	Minor Experiment	15 Marks
3	Viva – Voce	05 Marks
4	Record	05 Marks
	Total	**50 Marks**

MANONMANIAM SUNDARANAR UNIVERSITY, TIRUNELVELI

Model Question Paper

M.Sc. DEGREE EXAMINATIONS

Biochemistry – Main

BASICS OF BIOCHEMISTRY

(For those who joined in June 2026 and afterwards)

Time: Three hours Maximum: 75 marks

PART A- (15x1= 15 marks)

Answer ALL questions, Choose the correct answer

Question No.	Questions	Course Outcome	Cognitive level
1	The storage polysaccharide in animals is a) Cellulose b) Glycogen c) Agar d) Pectin	CO1	K1
2	Glycosaminoglycans are important in connective tissues because a) They provide rigidity and lubrication b) They synthesize proteins c) They digest lipids d) They transport oxygen	CO1	K2
3	The polysaccharide that is identified in a plant cell wall sample a) Glycogen b) Cellulose c) Dextran d) Heparin	CO2	K3
4	The major phospholipid component of cell membrane is a) Cholesterol b) Triacylglycerol c) Phospholipid d) Wax	CO1	K1
5	Prostaglandins belong to a) Lipoproteins b) Eicosanoids c) Glycoproteins d) Steroids	CO2	K3
6	Which lipoprotein is mainly involved in reverse cholesterol transport? a) HDL b) LDL c) VLDL d) Chylomicron	CO2	K3

7	Secondary protein structure mainly depends on a) Peptide bond sequencing b) Ionic bond only c) Hydrogen bonding d) Disulphide bonds only	CO3	K4
8	The protein structure level that is most important for biological activity is a) Primary b) Secondary c) Tertiary d) Quaternary	CO4	K5
9	Identify the part containing error: O – linked glycoproteins / contain carbohydrate attached / through oxygen atom / to fatty acids	CO4	K5, K6
10	Integral membrane proteins are usually ……..in nature	CO3	K4
11	Arrange the following according to membrane organization. a) Cell membrane b) b) Phospholipid c) Lipid bilayer d) Fluid mosaic model i) a→ b →c →d ii) b→ c→ a→ d iii) d →a →c→ b iv) b→ c →d→ a	CO4	K6
12	Assertion: Molecular chaperons assist in proper protein folding Reason: They prevent misfolding and aggregation of proteins Choose the correct answer using the codes below: a) Both assertion and reason are true and reason is the correct explanation of assertion b) Both assertion and reason are true but reason is not the correct explanation of assertion c) Assertion is true, but reason is false d) Assertion is false, but reason is true	CO4	K6
13	Arrange the stages of DNA organization: a) Double helix b) Nucleotide c) Chromatin d) Chromosome i) b→ a →c →d ii) b→ c→ a→ d iii) d →a →c→ b iv) b→ c →d→ a	CO4	K5
14	A biochemist wants to study protein synthesis in cells. Which type of RNA should be primarily analysed?	CO4	K6
15	(Give an infograph of different RNA s) a) Which RNA carries genetic message? b) Which RNA helps in proteinsynthesis? c) Which RNA has clover-leaf structure?	CO4	K6

PART B (5x5 = 25 marks)

Answer ALL questions choosing either (a) or (b).

Question No.	Questions	Course Outcome	Cognitive level
11.a	Differentiate homo and heteropolysaccharide with suitable example.	CO3	K4
11.b	Analyze the biological significance of glycosaminoglycans.	CO3	K4
12.a	Compare the endogenous and exogenous pathway of lipoprotein transport.	CO4	K5
12.b	Assess the role of eicasanoids in biological system.	CO4	K5
13.a	Classify amino acids based on structure.	CO1	K2
13.b	Discuss the super secondary structures of protein.	CO1	K2
14.a	Interpret Ramachandran plot and it's significance.	CO2	K3
14.b	Illustrate fluid mosaic model of membranes.	CO2	K3
15.a	Differentiate mitochondrial and chloroplast DNA.	CO3	K4
15.b	Evaluate cot curve and it's importance.	CO3	K4

PART C – (5x8= 40marks)

Answer ALL questions choosing either (a) or (b).

Question No.	Questions	Course Outcome	Cognitive level
16.a	Describe disaccharides and it's properties.	CO4	K6
16.b	Explain the features of bacterial cell wall polysaccharides.	CO4	K6
17.a	Illustrate the physiological role of non-protein amino acids.	CO3	K4
17.b	Outline the structure and function of prostaglandins.	CO3	K4
18.a	Categorize proteins based on its biological functions.	CO4	K5
18.b	Elucidate the structure of hemoglobin and it's functions.	CO4	K5
19.a	Summarize the chemical synthesis of peptides	CO4	K5
19.b	Evaluate the types of membrane proteins and it's significance.	CO4	K5
20.a	Discuss the structure of B DNA	CO1	K2
20.b	List different types of RNA and it's biological roles.	CO1	K2

MANONMANIAM SUNDARANAR UNIVERSITY, TIRUNELVELI

Model Question Paper
M.Sc. DEGREE EXAMINATIONS
Biochemistry – Main

Skill Enhancement II: Practical - III

Lab Course in Enzymology, Microbiology and Cell Biology

(For those who joined in June 2026 and afterwards)

Sub Code:

Time: Six hours Maximum: 50 marks

Question No.	Questions	Course Outcome	Cognitive level
1	Evaluate the Optimum pH of Alkaline phosphatase isolated from Goat kidney Write the principle and graphically interpret the result & significance of the experiment. (25 Marks).	CO4	K1, K2, K5, K6
2	Prepare Gram staining technique of the bacterial smear and interpret the results of the sample. (15 Marks)	CO1	K3, K6
3	Viva-Voce (5 marks)	CO2	K2, K5
4	Record (5 marks)	CO3	K3, K4

MANONMANIAM SUNDARANAR UNIVERSITY, TIRUNELVELI

M.Sc. Biochemistry

(Outcome Based Education - Choice Based Credit System)

Effective from the academic year 2026-2027 onwards

Programme Structure

Sub. No	Subject Status	Subject Title	Credits (C)	Contact hrs/ week	Marks		
					CIA	ESE	Total
	SEMESTER I						
1	Core - I	Basics of Biochemistry	5	7	25	75	100
2	Core - II	Biochemical and Molecular Biology Techniques	5	7	25	75	100
3	Core - III	Physiology and Cell Biology	4	6	25	75	100
4	Elective - I Discipline Centric	Microbiology and Immunology	3	5	25	75	100
5	Elective - II Generic - Soft Skill: Practical - I	Laboratory Course on Biochemistry Techniques	3	5	50	50	100
		Subtotal	**20**	**30**			
	SEMESTER II						
6	Core - IV	Enzymology	5	6	25	75	100
7	Core - V	Cellular Metabolism	5	6	25	75	100
8	Core - VI	Clinical Biochemistry	4	6	25	75	100
9	Elective - III Discipline Centric	Energy and Drug Metabolism	3	4	25	75	100
10	Elective – IV Generic	Nutritional Biochemistry	3	4	25	75	100
11	Skill Enhancement I: Practical - II	Laboratory Course on Biomolecules and Biochemical Techniques	2	4	50	50	100
	* Internship in Clinical Laboratory (Summer vacation of first year)						
		Subtotal	**22**	**30**			
	SEMESTER III						
12	Core - VII	Industrial Microbiology	5	6	25	75	100
13	Core - VIII	Molecular Biology	5	6	25	75	100

14	Core - IX	Gene Editing, Cell and Gene Therapy	5	6	25	75	100
15	Core - X	Biostatistics and Data Science	4	5	25	75	100
16	Elective - V Discipline Centric	Molecular Basis of Diseases and Therapeutic Strategies	3	3	25	75	100
17	Skill Enhancement II: Practical - III	Lab Course on Enzymology, Microbiology and Cell Biology	2	4	50	50	100
18	Internship/ Industrial Activity	*Internship - Clinical Laboratory/ Industrial Visit - Biotech (Summer vacation of first year)	2	-	50	50	100
		Subtotal	**26**	**30**			
	SEMESTER IV						
19	Core - XI	Pharmaceutical Biochemistry	5	6	25	75	100
20	Core - XII	Biochemical Toxicology	5	6	25	75	100
21	Elective - VI (Industry / Entrepreneurship) 20% Theory 80% Practical	Bio Safety, Lab Safety, IPR and Research Methods	3	4	25	75	100
22	Project and Viva	Project with Viva-Voce	6	10	50	50	100
23	Skill Enhancement course / Professional Competency Skill: Practical - IV	Laboratory Course on Clinical Biochemistry	2	4	50	50	100
24	Extension activity	Industrial visit – Pharma or Food Processing	1	-	50	50	100
		Subtotal	**22**	**30**			
		Total	**90**	**120**			

***** Internship will be carried out during the summer vacation of the first year and marks should be sent to the University by the College and the same will be included in the Third Semester Marks Statement.

Course – PSO Mapping

Title of the course	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	Total score
Basics of Biochemistry	2.5	2.5	2.25	3	1.25	2.5	1.25	15.25
Biochemical and Molecular Biology Techniques	3	3	2.5	2.75	1.25	3	1.25	16.75
Physiology and Cell Biology	2.25	2	2.75	3	1.25	3	1.25	15.5
Microbiology and Immunology	2.25	2.25	2.25	3	1.5	3	1	15.25
Laboratory Course on Biochemistry Techniques	2.75	3	2.5	2.75	1	3	1.5	16.5
Enzymology	2.5	2.25	2.5	3	1.25	2.75	1.25	15.5
Cellular Metabolism	2.5	1.75	2.5	3	1.25	2.5	1	14.5
Clinical Biochemistry	2.25	3	2.75	3	1.75	3	1	16.75
Energy and Drug Metabolism	2.5	1.25	2.5	3	1.25	2.25	1	13.75
Nutritional Biochemistry	2.5	1.5	2.75	3	2.25	2.75	1.25	16.0
Laboratory Course on Biomolecules and Biochemical Techniques	3	3	2.5	2.75	1.25	3	1.5	17
Total score of all courses contributing to PSO	28	25.5	27.75	32.25	15.25	30.75	13.25	172.75

Level of contribution of the Course towards attaining PSOs
0 – No Contribution 1 – Low Level 2 – Medium Level 3 – High Level

Course	CORE - I		
Title of the Course	BASICS OF BIOCHEMISTRY		
Credits	5		
Hours/Week	7		
	L	P	T
	7	-	-

COURSE OUTCOMES

CO	On completion of this course, students will be able to
CO1 (K1, K2)	Recall about carbohydrates and its derivatives and summarize the types of polysaccharides and their importance in biological system
CO2 (K3)	Apply the knowledge of proteins in cell-cellinteractions
CO3 (K4)	Categorize the properties of amino acids and examine the formation of peptides and their chemical synthesis
CO4 (K5, K6)	Determine the structure, properties, synthesis and sequencing of nucleic acids and apply in various advanced biological research.

Units	
I	Carbohydrates - Classification, structure, function and properties of monosaccharides, mutarotation, Disaccharides and oligosaccharides with suitable examples. Polysaccharides - Homopolysaccharides (starch, glycogen, cellulose, inulin, dextrin, agar, pectin, dextran). Heteropolysaccharides - Glycosaminoglycans– source, structure, functions of hyaluronic acid, chondroitin sulphates, heparin, keratan sulphate. Glycoproteins - proteoglycans. O- Linked and N-linked glycoproteins. Biological significance of glycan. Blood group polysaccharides. Bacterial cell wall (peptidoglycans, teichoic acid) and plant cell wall carbohydrates.
II	Lipids - Classification of lipids, Structure, properties and functions of fatty acids, triacylglycerols, phospholipids, glycolipids and sphingolipids. Eicosanoids- classification, structure and functions of prostaglandins, thromboxanes, leukotrienes. Steroids – structure, functions, properties and biological importance. Lipoproteins – Classification, structure, transport (endogenous and exogenous Pathway) and their biological significance.
III	Overview of Amino acids - classification, structure and properties of amino acids, biological role. Non-Protein aminoacids and their biological

	significance. Proteins - classification based on composition, structure and functions. Primary, secondary, super secondary (motifs) (Helix-turn –helix, helix-loop-helix, Beta-alpha-beta motif, Rossmann fold, Greek key), tertiary and quaternary structure of proteins. Structural characteristics of collagen and hemoglobin. Isolation, characterization and purification of proteins.
IV	Determination of amino acid sequence, Chemical synthesis of a peptide, Forces involved in stabilization of protein structure. Ramachandran plot. Folding of proteins. Molecular chaperons – Hsp 70 and Hsp 90 - biological role. Membrane Proteins - Types and their significance. Cytoskeleton proteins - actin, tubulin, intermediate filaments. Biological role of cytoskeletal proteins. Membrane structure-fluid mosaic model.
V	Nucleic acids – types and forms (A, B, C and Z) of DNA. Watson-Crick Model-Primary, secondary and tertiary structures of DNA. Triple helix and quadruplex DNA. Mitochondrial and chloroplast DNA. DNA supercoiling (calculation of Writhe, linking and twist number). Determination of nucleic acid sequences by Maxam Gilbert and Sanger's methods. Forces stabilizing nucleic acid structure. Properties of DNA and RNA. C-value, C-value paradox, Cot curve. Structure and role of nucleotides in cellular communications. Major and minor classes of RNA, their structure and biological functions.
Reading List (Print and Online)	1. https://bio.libretexts.org/Bookshelves/Biochemistry/Book%3A_Biochemistry_Online_(Jakubowski) 2. https://www.thermofisher.com/in/en/home/life-science/protein-biology/protein-biology-learning-center/protein-biology-resource-library/pierce-protein-methods/protein-glycosylation.html 3. https://ocw.mit.edu/courses/biology/7-88j-protein-folding-and-human-disease-spring-2015/study-materials/ 4. https://www.open.edu/openlearn/science-maths-technology/science/biology/nucleic-acids-and-chromatin/content-section- 3.4.2 5. https://www.genome.gov/genetics-glossary/Cell-Membrane 6. https://nptel.ac.in/content/storage2/courses/102103012/pdf/mod3.pdf
Self-Study	1. Classification of Sugars 2. Nutritional classification of fatty acids

Recommended Texts	1. David L. Nelson and Michael M. Cox (2012) Lehninger's Principles of Biochemistry (6th ed) W.H. Freeman. 2. Voet. D & Voet. J.G (2010) Biochemistry, (4th ed), JohnWiley & Sons, Inc. 3. Metzler D.E (2003). The chemical reactions of livingcells (2nd ed), Academic Press. 4. Zubay G.L (1999) Biochemistry, (4th ed), Mc Grew-Hill. 5. Lubert Stryer (2010) Biochemistry, (7th ed), W.H. Freeman 6. Satyanarayan, U (2014) Biochemistry (4th ed), ArunabhaSen Books & Allied (P) Ltd, Kolkata.

MAPPING of COs with POs

CO-PO Mapping (Course Articulation Matrix)

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	2	2	2	2	2	1	1
CO2	2	3	3	3	2	1	2
CO3	2	3	3	3	3	1	2
CO4	3	3	3	3	3	2	3
Total Score	9	11	11	11	10	5	8

Level of

Correlation between COs and POs

0 – No Correlation 1 – Low 2 – Medium 3 – High

MAPPING of COs with PSOs

CO-PSO Mapping (Course Articulation Matrix)

CO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	2	2	1	3	1	2	1
CO2	2	2	1	3	1	3	1
CO3	3	3	3	3	1	2	1
CO4	3	3	3	3	2	3	1
Total Score	10	10	9	12	5	10	5

Level of Correlation between COs and POs

0 – No Correlation 1 – Low 2 – Medium 3 – High

Course	CORE - II		
Title of the Course	BIOCHEMICAL AND MOLECULAR BIOLOGY TECHNIQUES		
Credits	5		
Hours/Week	7		
	L	P	T
	7	-	-

COURSE OUTCOMES

CO	On completion of this course, students will be able to
CO1 (K1, K2)	Attain good knowledge used in modern biochemical techniques and microscopy to carry out simple investigations in biological research.
CO2 (K3)	Demonstrate knowledge to implement the theoretical basis of chromatography to apply in research laboratories
CO3 (K4)	Analyse and interpret data from various spectroscopic techniques to perform analysis of biomolecular structure
CO4 (K5, K6)	Design a suitable method for separation and analysis of biomolecules by learning concepts, fundamentals and techniques that are pertinent to research work

Units	
I	General approaches to biochemical investigation, cell culture techniques and microscopic techniques. Organ and tissue slice technique, homogenization techniques, cell sorting, and cell counting. Cryopreservation, Biosensors- principle and applications. Principle, working and applications of light microscope, dark field, phase contrast and fluorescent microscope. Electron microscope- Principle, instrumentation of TEM and SEM, Specimen preparation and applications-shadow casting, negative staining and freeze fracturing.
II	Chromatographic Techniques: Basic principles of chromatography - adsorption and partition techniques. Principle, instrumentation and applications of paper, thin layer and gas

	liquid chromatography. Principle, instrumentation and applications of ion exchange, molecular exclusion and affinity chromatography. HPLC-principle, materials, instrumentation and applications. Reverse HPLC, capillary electro chromatography and perfusion chromatography.
III	Electrophoretic Techniques: General principles of electrophoresis, supporting medium, factors affecting electrophoresis, Isoelectric focusing-principle, ampholyte, development of pH gradient and application. PAGE-gel casting-horizontal, vertical, slab gels, sample application, detection-staining using CBB, silver, fluorescent stains. SDS PAGE-principle and application in molecular weight determination. 2D PAGE. Electrophoresis of nucleic acids-agarose gel electrophoresis of DNA, pulsed field gel electrophoresis- principle, apparatus, application. Capillary electrophoresis.
IV	Spectroscopic techniques: Basic laws of light absorption- principle, instrumentation and applications of Visible Spectrophotometry, UV spectrophotometry, IR, ESR, NMR, Mass spectroscopy, Turbidimetry and Nephelometry. Luminometry (Luciferase system, chemiluminescence). X - ray diffraction. Atomic absorption spectroscopy - principle and applications - Determination of trace elements
V	Radiolabeling Techniques and Centrifugation: Nature of radioactivity-detection and measurement of radioactivity, methods based upon ionisation (GM counter) and excitation (scintillation counter), autoradiography and applications of radioactive isotopes, Biological hazards of radiation and safety measures in handling radioactive isotopes. Basic principles of Centrifugation. Preparative ultracentrifugation - Differential centrifugation, Density gradient centrifugation. Analytical ultracentrifugation - Molecular weight determination.
Reading List (Print and Online)	1. Principles and techniques of biochemistry and molecular biology: 2. https://www.kau.edu.sa/Files/0017514/Subjects/principals%20and%20techiniques%20of%20biochemistry%20and%20molecular%20biology%207th%20ed%
Self-Study	1. Types of rotors 2. Colorimetry – principle and applications
Recommended Texts	1. Keith Wilson, John Walker (2010) Principles and Techniques of Biochemistry and Molecular Biology (7th ed) Cambridge University Press 2. David Sheehan (2009), Physical Biochemistry: Principles and

	Applications (2nd ed), Wiley-Blackwell 3. David M. Freifelder (1982) Physical Biochemistry: Applications to Biochemistry and Molecular Biology,W.H.Freeman 4. Rodney F.Boyer (2012), Biochemistry Laboratory: Modern Theory and techniques, (2nd ed), Prentice Hall 5. Kaloch Rajan (2011), Analytical techniques in Biochemistry and Molecular Biology, Springer 6. Segel I.H (1976) Biochemical Calculations (2nd ed),John Wiley and Sons 7. Robyt JF (2015) Biochemical techniques: Theory and Practice (1st ed), CBS Publishers & Distributors

MAPPING of COs with POs

CO-PO Mapping (Course Articulation Matrix)

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	2	2	3	2	1	2	1
CO2	2	3	3	3	1	2	1
CO3	2	3	3	3	1	3	1
CO4	3	3	3	3	2	3	2
Total Score	9	11	12	11	5	10	5

Level of Correlation between COs and POs

0 – No Correlation 1 – Low 2 – Medium 3 – High

MAPPING of COs with PSOs

CO-PSO Mapping (Course Articulation Matrix)

CO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	3	3	2	2	1	3	1
CO2	3	3	2	3	1	3	1
CO3	3	3	3	3	1	3	1
CO4	3	3	3	3	2	3	2
Total Score	12	12	10	11	5	12	5

Level of Correlation between COs and POs

0 – No Correlation 1 – Low 2 – Medium 3 – High

Course	CORE - III		
Title of the Course	PHYSIOLOGY AND CELL BIOLOGY		
Credits	4		
Hours/Week	6		
	L	P	T
	6	-	-

COURSE OUTCOMES

CO	On completion of this course, students will be able to
CO1 (K1, K2)	Relate the communications of cells with other cells and to the environment
CO2 (K3)	Discover the causes and biochemical findings in acid base imbalance, absorption of biomolecules in the human system by the action of various secretions and examine the mechanism of excretory function
CO3 (K4)	Distinguish the divisions of nervous system, nerve impulse transmission and examine the cardiac cycle, its changes during myocardial infarction
CO4 (K5, K6)	Create novel methods for analysis of cell and specific cellular components and apply the same in biological research to aid medical diagnosis and treatment

Units	
I	Major classes of cell junctions- anchoring, tight and gap junctions. Major families of cell adhesion molecules (CAMs)- cadherins, integrins. Types of tissues. Epithelium- organization and types. The basement membrane. Cell cycle- mitosis and meiosis, Cell cycle-phases and regulation. Cell death mechanisms- an overview-apoptosis, necrosis.
II	Reproductive system - sexual differentiation and development; sperm transport, sperm capacitation, semen analyses and Acrosome reaction. Clinical relevance of female reproductive physiology- menstrual cycle, pregnancy and menopause. Fertilisation and infertility issues. Hormones – Classification, Mechanism of hormone action, Target cell concept. Hormones of Hypothalamus, pituitary, Pancreatic, thyroid & parathyroid, adrenal and gonadal hormones. Synthesis, secretion, physiological actions and feedback regulation of synthesis.
III	Digestive system- structure and functions of different components of

	digestive system, digestion and absorption of carbohydrates, lipids and proteins, role of bile salts in digestion and absorption, mechanism of HCl formation in stomach, role of various enzymes and hormones involved in digestive system. Composition of blood, lymph and CSF. Blood cells - WBC, RBC and energy metabolism of RBC, Blood clotting mechanism and blood groups- ABO and Rhesus system.
IV	Respiratory system-Gaseous transport and acid-base homeostasis. Mechanism of the movement of O2 and CO2 through lungs, arterial and venous circulation. Bohr effect, oxygen and carbon dioxide binding haemoglobin. pH maintenance by cellular and intracellular proteins. Phosphate and bicarbonate buffers, Metabolic acidosis and alkalosis. Respiratory acidosis and alkalosis. Regulation of fluid and electrolyte balance. Structure of Nephron, Mechanism of urine formation, Renal threshold, GFR, Renal regulation of acid-base balance.
V	Sensory transduction, Nerve impulse transmission- nerve cells, synapses, reflex arc structure, resting membrane potential, Nernst equation, action potential, voltage gated ion-channels, impulse transmission, neurotransmission, neurotransmitter receptors, synaptosomes, synaptotagmin, rod and cone cells in the retina, changes in the visual cycle, photochemical reaction and regulation of rhodopsin, odour receptors, learning and memory. Chemistry of muscle contraction – actin and myosin filaments, theories involved in muscle contraction, mechanism of muscle contraction, energy sources for muscle contraction.
Reading List (Print and Online)	1. https://www.genome.gov/genetics-glossary/Cell-Cycle 2. https://my.clevelandclinic.org/health/diseases/16083-infertility-causes 3. https://www.webmd.com/heartburn-gerd/reflux-disease 4. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5760509/ 5. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3249628/
Self-Study	1. Variation in cell differentiation and progression 2. Lesch Nyhan syndrome, orotic aciduria and GERD

Recommended Texts	1. Karp, G. (2010). Cell and Molecular Biology: Concepts and Experiments (6th ed). John Wiley & Sons. Inc. 2. Bruce Alberts and Dennis Bray (2013), Essential Cell Biology, (4th ed), Garland Science. 3. De Robertis, E.D.P. and De Robertis, E.M.F. (2010). Cell and Molecular Biology. (8th ed). Lippincott Williams and Wilkins, Philadelphia. 4. Cooper, G.M. and Hausman, R.E. (2009). The Cell: A Molecular Approach. (5th ed). Sunderland, Mass. Sinauer Associates, Inc. 5. Wayne M. Baker (2008) the World of the Cell. (7th ed). Pearson Benjamin Cummings Publishing, San Francisco. Cell Biology 6. 6. John E. Hall (2010). Guyton and Hall Textbook of Medical (12th ed), Saunders 7. Harrison's Endocrinology by J. Larry Jameson Series: Harrison's Specialty, 19th Edition Publisher: McGraw-Hill, Year: 2016.

MAPPING of COs with POs

CO-PO Mapping (Course Articulation Matrix)

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	2	2	3	2	1	2	1
CO2	2	3	3	3	1	2	1
CO3	2	3	3	3	1	2	1
CO4	3	3	3	3	2	3	2
Total Score	9	11	12	11	5	9	5

Level of Correlation between COs and POs

0 – No Correlation 1 – Low 2 – Medium 3 – High

MAPPING of COs with PSOs

CO-PSO Mapping (Course Articulation Matrix)

CO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	2	1	2	3	1	3	1
CO2	2	2	3	3	1	3	1
CO3	2	2	3	3	1	3	1
CO4	3	3	3	3	2	3	1
Total Score	9	8	11	12	5	12	5

Level of Correlation between COs and POs

0 – No Correlation 1 – Low 2 – Medium 3 – High

Course	ELECTIVE - I		
Title of the Course	MICROBIOLOGY AND IMMUNOLOGY		
Credits	3		
Hours/Week	5		
	L	P	T
	5	-	-

COURSE OUTCOMES

CO	On completion of this course, students will be able to
CO1 (K1, K2)	Indicate common pathogenic bacteria and fungi that cause toxic effects
CO2 (K3)	Apply the principles of Ag-Ab reaction to develop various techniques to support clinical and biological research
CO3 (K4)	Analyse various features and roles of different types of T-cells, B cells and Immunoglobulins
CO4 (K5, K6)	Justify the importance of certain beneficial microbes in day-to- day's food consumption, role in food decay and employ various counteracting measures

Units	
I	Taxonomical classification - bacteria, viruses (DNA, RNA), algae, fungi and protozoa. Distribution and role of microorganisms in soil, water and air. Charaka's classification of microbes, lytic cycle and lysogeny. Types of culture media, isolation of pure culture, growth curve and the measurement of microbial growth.
II	Contamination and spoilage of foods – cereals, cereal products, fruits, vegetables, meat, fish, poultry, eggs, milk and milk products. Preservation methods. Microbes involved in preparation of fermented foods - cheese, yoghurt, curd and bread. Food poisoning- bacterial food poisoning, *Salmonella*, *Clostridium botulinum* (botulism), fungal food poisoning – aflatoxin, food infection – *Clostridium, Staphylococcus* and *Salmonella*. Pathogenic microorganisms,

	E. coli, Pseudomonas, Klebsilla, Streptococcus, Haemophilus, & Mycobacterium, causes, control, prevention, cure and safety. General characteristics of antimicrobial agents.
III	Immune system- definition and properties. Cells of the immune system – neutrophils, eosinophils, basophils, mast cells, monocytes, macrophages, dendritic cells, natural killer cells, and lymphocytes (B cells and T cells). Lymphoid organs- Primary and Secondary; structure and functions. Antigens and Complement System: definition, properties- antigenicity and immunogenicity, antigenic determinants and haptens. Antigen - antibody interactions - molecular mechanism of binding. Affinity, avidity, valency, cross reactivity and multivalent binding.
IV	Immunoglobulins & Immune Response: Structure, classes and distribution of antibodies. Antibody diversity. Immune system in health & disease, Immune responses to infectious diseases-viral bacterial and protozoal. Cancer and immune system, Immunodeficiency disorders. Autoimmunity. Hypersensitivity-types. Transplantation immunology- graft rejection and HLA antigens.
V	Active and passive immunization. Vaccines-killed, attenuated-toxoids. Recombinant vector vaccines- DNA vaccines, synthetic peptide vaccines – anti idiotype vaccines production of polyclonal and monoclonal antibodies. Immuno electrophoresis, RIA, immunoblotting, avidin-biotin mediated immuno assay, fluorescent immunoassay. Immuno histochemistry - immunofluoresence, immunoferritin technique. Flow cytometry and its application. Cytokine assay - ELISA and ELISPOT.
Reading List (Print and Online)	1. https://www.ijam.co.in/index.php/ijam/article/view/1326 2. https://www.ncbi.nlm.nih.gov/books/NBK10757/ 3. https://guides.himmelfarb.gwu.edu/immunology/textbooks 4. https://microbiologynote.com/18-best-books-for-immunology/ 5. https://www.roitt.com/pdf/Online_Chapter.pdf 6. https://link.springer.com/protocol/10.1007/978-1-0716-0134-1_7
Self-Study	1. Microbial infections and gut microbiome with relevance to *tridoshas* 2. Microbial population and pH variations in different dairy products.
Recommended Texts	1. Michael J.Pelczar Jr.(2001) Microbiology (5th ed), McGraw Hill Education (India) Private Limited 2. Frazier WC , Westhoff DC, Vanitha NM (2010) Food Microbiology (5th ed), McGraw Hill Education (India) Private Limited 3. Willey J and Sherwood L (2011), Prescott's Microbiology (8th ed) McGraw Hill Education (India) 4. Ananthanarayanan , Paniker and Arti Kapil (2013) Textbook of Microbiology (9th ed) Orient BlackSwan 5. Goldsby et al. Kuby Immunology. WH Freeman & Co. 7th ed., 2013. 6. Abbas et al. Cellular and Molecular Immunology. 9th ed. Elsevier, 2018.

	7. Janeway, C. (Ed), Travers. Immunobiology 9th ed. Garland Publ., 2016. 8. Richard Coico and Sunshine. Immunology: A short course. 7th ed. Wiley-Liss, 2015. 9. Roitt et al. Roitt's Essential Immunology. 13 th ed Wiley-Blackwell Sci., 2017. 3. Thao Doan and Rover Melvold et. al., Immunology, Lippincotts Illustrated Review, 2nd edition, Williams and Wilkins, 2012.

MAPPING of COs with POs

CO-PO Mapping (Course Articulation Matrix)

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	2	2	2	2	3	1	1
CO2	2	3	3	3	2	2	1
CO3	2	3	3	2	1	2	1
CO4	3	3	3	3	3	2	2
Total Score	9	11	11	10	9	7	5

Level of Correlation between COs and POs

0 – No Correlation 1 – Low 2 – Medium 3 – High

MAPPING of COs with PSOs

CO-PSO Mapping (Course Articulation Matrix)

CO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	2	2	2	3	2	3	1
CO2	3	3	3	3	1	3	1
CO3	2	2	2	3	1	3	1
CO4	2	2	2	3	2	3	1
Total Score	9	9	9	12	6	12	4

Level of Correlation between COs and POs

0 – No Correlation 1 – Low 2 – Medium 3 – High

Course	ELECTIVE – II: PRACTICAL - I		
Title of the Course	LABORATORY COURSE ON BASIC BIOCHEMISTRY TECHNIQUES		
Credits	3		
Hours/Week	5		
	L	P	T
	-	5	-

COURSE OUTCOMES

CO	On completion of this course, students will be able to
CO1 (K1, K2)	Acquainted with the principle, instrumentation and method of performing uv absorption studies of DNA, protein and interpreting the alteration occurred during the process of denaturation
CO2 (K3)	Employ skill acquired in the isolation, purification and estimation of different biomolecules in scientific research
CO3 (K4)	Appraise the spectrophotometric principles in academic research and industries
CO4 (K5, K6)	Develop skill in analytical techniques like paper and thin layer chromatography and the group experiments will enable them to build learning skills like team work, problem solving, communication ability

Units	
I	Isolation and purification of macromolecules 1. Isolation of glycogen from liver 2. Isolation of DNA from animal tissue 3. Isolation of RNA from yeast 4. Purification of Polysaccharides –Starch and assessment of its purity

II	Biochemical studies and estimation of macromolecules 1. Estimation of glycogen from liver 2. Estimation of DNA from animal tissue 3. Estimation of RNA from yeast
III	UV absorption characteristics of macromolecules 1. Denaturation of DNA and absorption studies at 260nm. 2. Denaturation of Protein and absorption studies at 280nm.
IV	Identification of Biomolecules 1. Identification of Sugars by Paper Chromatography 2. Identification of Amino acids by Paper Chromatography
V	Group Experiments 1. Separation of identification of lipids by thin layer chromatography. 2. Two-dimensional paper chromatography of amino acids.
Reading List (Print and Online)	1. https://www.researchgate.net/publication/313745155_Practical_Biochemistry_A_Student_Companion 2. https://doi.org/10.1186/s13020-018-0177-x 3. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5368116/ 4. https://www.life.illinois.edu/biochem/455/Lab%20exercises/2Photometry/spectrophotometry.pdf 5. https://ijpsr.com/bft-article/determination-of-total-flavonoid-and-phenol-content-in-mimusops-elengi-linn/?view=fulltext 6. https://skyfox.co/wp-content/uploads/2020/12/Practical-Manual-of-Biochemistry.pdf
Self-Study	1. Laboratory Safety Rules, Requirements and Regulations. 2. Preparation of standard solutions and reagent
Recommended Texts	1. David Plummer (2001) An Introduction to Practical Biochemistry (3rd ed) McGraw Hill Education (India) Private Ltd

	2. Jayaraman, J (2011), laboratory Manual in Biochemistry, New age publishers 3. Varley H (2006) Practical Clinical Biochemistry (6th ed) , CBS Publishers 4. O. Debiyi and F. A. Sofowora, (1978) "Phytochemical screening of medical plants," Iloyidia, vol. 3, pp. 234–246, 5. Prof. Sarin A. Chavhan, Prof. Sushilkumar A. Shinde (2019) A Guide to Chromatography Techniques Edition:1 6. Analytical techniques in Biochemistry and Molecular Biology; Katoch, Rajan. Springer (2011)

MAPPING of COs with POs

CO-PO Mapping (Course Articulation Matrix)

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	2	3	3	2	1	2	1
CO2	2	3	3	3	2	1	1
CO3	2	2	2	3	1	2	1
CO4	3	3	2	3	1	2	3
Total Score	9	11	10	11	5	7	6

Level of Correlation between COs and POs

0 – No Correlation 1 – Low 2 – Medium 3 – High

MAPPING of COs with PSOs

CO-PSO Mapping (Course Articulation Matrix)

CO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	3	3	2	2	1	3	1
CO2	3	3	3	3	1	3	1
CO3	2	3	2	3	1	3	1
CO4	3	3	3	3	1	3	3
Total Score	11	12	10	11	4	12	6

Level of

Correlation between COs and POs

0 – No Correlation 1 – Low 2 – Medium 3 – High

Course	CORE - IV		
Title of the Course	ENZYMOLOGY		
Credits	5		
Hours/Week	6		
	L	P	T
	6	-	-

COURSE OUTCOMES

CO	On completion of this course, students will be able to
CO1 (K1, K2)	Describe the mechanism of enzyme action and state why enzymes work on specific substrates
CO2 (K3)	Demonstrate that enzymes functions by lowering the activation energy and apply enzymes in industries and biomedicine
CO3 (K4)	Analyze enzyme kinetic data graphically, determine the mechanism of inhibition by a drug/chemical and analyze options for applying enzymes and their inhibitors in medicine
CO4 (K5, K6)	Choose and use the appropriate methods to isolate and purify enzymes and check the purity of the enzyme for research and industrial purposes

Units	
I	Introduction to enzymes and features of catalysis: A short history of the discovery of enzymes and how they became powerful biochemical tools. Holoenzyme, apoenzyme, cofactors, coenzyme, prosthetic groups, Classification and Nomenclature, Specificity of enzyme action-group specificity, absolute specificity, substrate specificity, stereochemical specificity. Active site, Identification of amino acids at the active site - identification using chemical modification of amino acid side chains and by site-directed mutagenesis. Mechanisms of enzyme catalysis: acid-base catalysis, covalent catalysis, electrostatic catalysis, metal ion catalysis, proximity and orientation

	effects, Low barrier H-bonds, Structural flexibility Mechanism of action of chymotrypsin.
II	Enzyme techniques: Isolation and purification of enzymes - Importance of enzyme purification, methods of purification- choice of source , extraction, fractionation methods-based on size or mass (centrifugation, gel filtration); based on polarity (ion-exchange chromatography, electrophoresis, isoelectric focusing, hydrophobic interaction chromatography); based on solubility (change in pH, change in ionic strength); based on specific binding sites (affinity chromatography) ,choice of methods, Criteria of purity of enzymes. Enzyme units - Katal, IU. Isoenzymes and their applications.
III	Enzyme kinetics I: Thermodynamics of enzyme action, Activation energy, transition-state theory, steady-state kinetics & pre-steady-state kinetics. Single substrate enzyme catalyzed reactions -assumptions, Michaelis-Menten and Briggs-Haldane kinetics, derivation of Michaelis-Menten equation. Double reciprocal (Lineweaver-Burk) and single reciprocal (Eadie -Hofstee) linear plots, their advantages and limitations. Enzyme inhibition: Irreversible inhibition. Reversible inhibition-Competitive, uncompetitive, noncompetitive, mixed and substrate inhibition. Michaelis -Menten equation in the presence of competitive, uncompetitive and non-competitive inhibitors. Therapeutic use of enzyme inhibitors-Aspirin, statins (irreversible inhibitors), Methotrexate (competitive inhibitor), Etoposide (non-competitive inhibitor), camptothecin (uncompetitive inhibitor).
IV	Enzyme kinetics II: Allosteric enzymes: Cooperativity, MWC and KNF models of allosteric enzymes, Sigmoidal kinetics taking ATCase as an example. Regulation of amount and catalytic activity by - pH, temperature, substrate concentration, allosteric effectors, covalent modification. Regulation of glycogen synthase and glycogen phosphorylase. Bi - Substrate reactions: Single Displacement reactions (SDR) (Ordered and Random bi bi mechanisms), Double Displacement reactions (DDR) (Ping pong mechanism), Examples, Cleland's representation of bisubstrate reactions.
V	Enzyme technology: Immobilization of enzymes – methods - Reversible immobilization (Adsorption, Affinity binding), Irreversible immobilization (Covalent coupling, Entrapment and Microencapsulation, Crosslinking, Advantages and Disadvantages of each method, Applications of immobilized enzymes, Designer enzymes- ribozymes and

	deoxy ribozymes, abzymes, synzymes. Enzymes as therapeutic agents- therapeutic use of asparaginase and streptokinase. Application of enzymes in industry- Industrial application of rennin, lipases, lactases, invertase, pectinases, papain.
Reading List (Print and Online)	1. https://ocw.mit.edu/high-school/biology/exam-prep/chemistry-of-life/enzymes/ 2. https://onlinecourses.swayam2.ac.in/cec20_bt20/preview 3. https://mooc.es/course/enzymology/ 4. The active site of enzymes 5. https://dth.ac.in/medical/courses/biochemistry/block-1/1/index.php 6. https://www.lecturio.com/medical-courses/enzymes-and-enzyme kinetics.course#/ 7. Mechanistic enzymology in drug discovery: a fresh perspective 8. https://www.nature.com/articles/nrd.2017.219 9. Enzyme Biosensors for Biomedical Applications: Strategies for Safeguarding Analytical Performances in Biological Fluids
Self-Study	1. Mechanistic enzymology in drug discovery 2. Enzyme Biosensors for Biomedical Applications
Recommended Texts	1. Enzymes: Biochemistry, Biotechnology and Clinical chemistry, 2nd edition, 2007, Palmer T and Bonner P; Affiliated- East West press private Ltd, New Delhi 2. Fundamentals of Enzymology, 3rd edition, 2003, Price NC and Stevens L; Oxford University Press, New York 3. Voet's Biochemistry, Adapted ed, 2011, Voet,D and Voet JG; Wiley, India 4. Lehninger Principles of Biochemistry, 8th edition, 2021, Nelson DL and Cox MM; WH Freeman & Co, New York 5. Biochemistry, Berg JM, Stryer L, Gatto,G, 8th ed, 2015; WH Freeman & Co., New York. 6. Enzyme Kinetics and Mechanism; Cook PF, Cleland W, ;2007; Garland Science, London

MAPPING of COs with POs

CO-PO Mapping (Course Articulation Matrix)

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	2	2	2	2	1	1	1
CO2	2	2	3	2	2	2	1
CO3	2	3	3	3	1	3	1
CO4	3	3	3	3	1	2	2
Total Score	9	10	11	10	5	8	5

Level of Correlation between COs and POs

0 – No Correlation 1 – Low 2 – Medium 3 – High

MAPPING of COs with PSOs

CO-PSO Mapping (Course Articulation Matrix)

CO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	2	1	2	3	1	2	1
CO2	2	2	2	3	1	3	1
CO3	3	3	3	3	1	3	1
CO4	3	3	3	3	2	3	2
Total Score	10	9	10	12	5	11	5

Level of Correlation between COs and POs

0 – No Correlation 1 – Low 2 – Medium 3 – High

Course	CORE - V		
Title of the Course	CELLULAR METABOLISM		
Credits	5		
Hours/Week	6		
	L	P	T
	6	-	-

COURSE OUTCOMES

CO	On completion of this course, students will be able to
CO1 (K1, K2)	Memorize the synthetic and degradative pathways in living system
CO2 (K3)	Demonstrate a conceptual theoretical knowledge of the diversity of metabolic reactions
CO3 (K4)	Correlate the disturbance of metabolic reactions to clinical manifestations with reference to carbohydrate, amino acid, fat, heme and sulphur metabolism
CO4 (K5, K6)	Justify the critical role of hormones in the control system with regard to the integration of metabolism

Units	
I	Glycolysis – aerobic and anaerobic, inhibitors, and regulation. Feeder pathway- entry of hexoses into glycolysis, Pyruvate dehydrogenase complex-mechanism and regulation. Glyoxylate cycle and its regulation. Gluconeogenesis- source, key enzymes, reaction sequence and its regulation. Pentose phosphate pathway- significance and its regulation. Metabolism of glycogen and its regulation.
II	Oxidation of fatty acids-oxidation of saturated and unsaturated fatty acids (α, β & ω oxidation) Oxidation of fatty acids with odd and even numbered carbon atoms. Regulation of β oxidation. Ketogenesis and its regulation. Biosynthesis of fatty acid–saturated and unsaturated, chain elongation, regulation. Biosynthesis of prostaglandins, thromboxanes and leukotrienes. Biosynthesis and degradation of triacylglycerol, Biosynthesis of phosphor glycero lipids - lecithin, cephalin,

	plasmalogens and phosphatidyl inositol, Cholesterol biosynthesis and its regulation. Lipoprotein metabolism-chylomicrons, VLDL, HDL and LDL.
III	Metabolism of nucleotides- *De novo* synthesis and salvage pathways of purine and pyrimidine nucleotides. Regulation and inhibitors of nucleotide biosynthesis. Role of ribonucleotide reductase and its regulation. Degradation of purine and pyrimidine nucleotides.
IV **V**	Biosynthesis of non- essential amino acids. - Role and biological significance of glutamate dehydrogenase, glutamine and asparagine synthetase, lysine, proline and phenylalanine hydroxylase. Interconversion of amino acids - proline to glutamate, methionine to cysteine, serine to glycine. Biosynthesis of spermine and spermidine. Degradation of amino acids –glucogenic and ketogenic amino acids. Formation of acetate from leucine, pyruvate from cysteine, threonine and hydroxy proline, α-keto glutarate from histidine, succinate from methionine, threonine, valine and isoleucine, Oxaloacetate from aspartate and serine. Biosynthesis and degradation of heme. Jaundice-classification, pathology. Sulpho transferases and their biological role-rhodanases, sulphatases, 3-mercapto pyruvate sulphur transferases. Mucopolysaccharidoses - Hunter syndrome, Sanfilippo syndrome and Maroteaux-Lamy syndrome.
Reading List **(Print and Online)**	1. https://www.embopress.org/doi/full/10.1038/msb.2013.19 2. https://people.wou.edu/~guralnl/450Glycogen%20metabolism.pdf 3. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3243375/ 4. https://www.researchgate.net/publication/334458898_Urea_Cycle 5. https://www.researchgate.net/publication/51233381_Heme_biosynthesis_and_its_regulation_Towards_understanding_and_improvement_of_heme_biosynthesis_in_filamentous_fungi 6. https://www.researchgate.net/publication/349746691_Microbial_Sulf ur_Metabolism_and_Environmental_Implications
Self-study	1. Cori's Cycle and Glucose- Alanine Cycle 2. Coenzymes involved in Methanogenesis
Recommended Texts	1. David L. Nelson and Michael M.Cox (2012) Lehninger Principles of Biochemistry (6th ed), W.H. Freeman

	2. Voet. D and Voet. J.G (2010) Biochemistry, (4th ed), John Wiley & Sons, Inc. 3. Metzler D.E (2003). The chemical reactions of living cells (2nd ed), Academic Press. 4. Zubay G.L (1999) Biochemistry, (4th ed), Mc Grew-Hill. 5. Textbook of Biochemistry with Clinical Correlations, 7th Edition, Thomas M. Devlin (Editor), Wiley 6. Human Biochemistry – James M. Orten & Otto. W. Neuhan- 10th edn- The C.V. Mosby Company

MAPPING of COs with POs

CO-PO Mapping (Course Articulation Matrix)

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	2	2	2	2	1	1	1
CO2	2	2	3	2	2	2	1
CO3	2	3	3	3	1	3	1
CO4	3	3	3	3	1	2	2
Total Score	9	10	11	10	5	8	5

Level of Correlation between COs and POs

0 – No Correlation 1 – Low 2 – Medium 3 – High

MAPPING of COs with PSOs

CO-PSO Mapping (Course Articulation Matrix)

CO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	2	1	2	3	1	2	1
CO2	2	1	2	3	1	2	1
CO3	3	3	3	3	2	3	1
CO4	3	2	3	3	1	3	1
Total Score	10	7	10	12	5	10	4

Level of Correlation between COs and POs

0 – No Correlation 1 – Low 2 – Medium 3 – High

Course	CORE - VI		
Title of the Course	CLINICAL BIOCHEMISTRY		
Credits	4		
Hours/Week	6		
	L	P	T
	6	-	-

COURSE OUTCOMES

CO	On completion of this course, students will be able to
CO1 (K1, K2)	Classify diagnostic/screening tests to detect common non-communicable diseases adopting good laboratory practice
CO2 (K3)	Schedule protocols to identify lifestyle metabolic disorders and for pre and post-natal diagnosis leading to healthy progeny
CO3 (K4)	Compare serum/plasma enzymes levels with the organ pathologies associated with specific diseases
CO4 (K5, K6)	Evaluate the serum hormone levels and clinical symptoms with underlying hormonal disturbances

Units	
I	Biochemical investigations in diagnosis, prognosis, monitoring, screening: Collection and Preservation of biological specimens -blood, urine, CSF and amniotic fluid. Biological reference ranges. Disorders of blood cells: Disorders of blood cells: Red blood cell disorders, White blood cell disorders, Porphyrias, Disorders of blood clotting mechanism, Diagnostic test for clotting disorders.
II	Diabetes mellitus: pathology and complications: Acute changes; Chronic complications- Diabetic nephropathy, neuropathy, retinopathy and Diabetic foot ulcers, Random/Fasting/PP glucose testing, Glucose tolerance tests – types and HbA1c, Diagnosis and monitoring of diabetes, Hypoglycemia and critical alert value for glucose. Markers of complications of Diabetes

	mellitus: Metabolic syndrome. Disorders of lipid metabolism- Lipid profile, lipoproteinemia, Atherosclerosis, Lipid storage diseases. Diet and life style modifications, Antidiabetic drugs.
III	Diagnostic Enzymology: Clinically Important Enzymes and Isoenzyme as diagnostic markers: Clinical significance of AST, ALT, ALP, ACP, CK, γ-GT, amylase, pseudocholinesterase. Enzyme patterns in diagnosis of myocardial infarction, hepatobiliary disease, muscle dystrophy and bone disorders. Pre- and post-natal testing: Amniocentesis, Pre- and post-natal testing for inborn errors of metabolism - Autosomal recessive mode of inheritance-cystic fibrosis, X linked recessive inheritance-Duchenne muscular dystrophy. New born screening (NBS), Tandem mass spectrometry application in NBS.
IV	Liver function tests: Liver function test panel, Fatty liver. Plasma protein changes in liver diseases. Hepatitis A, B and C. Cirrhosis, fibrosis and Portal hypertension. Acute phase proteins - CRP, Haptoglobins, α-fetoprotein, ferritin and transferrin and their clinical significance. Serum protein electrophoresis. Inflammatory markers (cytokines such as TNF-alpha IL6 and others).
V	Renal function tests - tests for glomerular and tubular function- Acute and chronic renal failure-Glomerulonephritis, Nephrotic syndrome, urinary calculi-Nephrocalcinosis and Nephrolithiasis-causes, pathology and symptoms. Dialysis-Hemodialysis and peritoneal dialysis. Electrolyte disorder: hypercalcemia and hypocalcemia; Calcium homoestasis in Blood; phosphate- hyperphosphatemia and hypophosphatemia; Potassium- hyperkalaemia and hypokalaemia, Sodium-hypernatremia and hyponatremia; Chloride- hyperchloremia, hyporchloremia. Hormonal disorders and diagnostics: T3, T4 and TSH in the diagnosis of thyroid disorders; Diagnostic methods for disorders associated with adrenal, pituitary and sex hormones - Addison's disease, Cushing's syndrome, pituitary tumour, Hypopituitarism, Hypogonadism.
Reading List (Print and Online)	Utility of HIL in Clinical Chemistry: 1. https://www.aacc.org/science-and-research/clinical-chemistry-trainee-council/trainee-council-in-english/pearls-of-laboratory-medicine/2018/utility-of-hil-in-clinical-chemistry Pre, Post and Analytical Errors in Clinical Chemistry laboratory 1. DOI: 10.7860/NJLM/2016/22587:2173 2. https://doi.org/10.2147/JMDH.S286679

	Standards of Medical Care in Diabetes—2022 Abridged for Primary Care Providers 1. https://diabetesjournals.org/clinical/article/40/1/10/139035/Standards-of-Medical-Care-in-Diabetes-2022 2. https://doi.org/10.2337/diaspect.16.1.32 3. http://www.ngsp.org/ Quality control in clinical laboratory 1. https://www.researchgate.net/publication/335830829_Quality_Control_in_a_Clinical_Laboratory 2. https://labpedia.net/quality-control-of-the-clinical-laboratory/ 3. https://journals.sagepub.com/doi/full/10.1016/j.jala.2008.12.001 4. https://www.labroots.com/webinar/bio-rad-unity-solution-molecular-quality-control-data-management
Self-Study	Potential sources of variability in the estimation of the analytes: 1. Pre-analytical phase: acceptance rejection criteria in terms of haemolysis/icteric/lipemia (HIL) interferences 2. Analytical phase: Linearity, detection limits precision, accuracy, specificity, sensitivity; Total Allowable Error. (Definitions and examples). 3. Post-analytical phase: Units of reporting of clinical chemistry parameters- Interpretation of results in clinical chemistry based on laboratory investigations and quality control: 1. critical / alert values 2. American Diabetes Association (ADA) Standards of Medical Care in Diabetes (yearly update); HBA1C testing: NGSP
Recommended Texts	1. Thomas M. Devlin (2014) Textbook of Biochemistry with Clinical Correlations (7th ed). John Wiley & Sons 2. Montgomery R, Conway TW, Spector AA (1996), Biochemistry: A Case-Oriented Approach (6th ed), Mosby Publishers, USA. 3. Tietz Fundamentals of Clinical Chemistry and Molecular Diagnostics (2018) (8th ed), Saunders 4. Dinesh Puri, (2020) Text book of Biochemistry: A clinically oriented approach – 4th Edition, Elsevier. 5. M.N. Chatterjee and Rana Shinde (2012). Textbook of Medical Biochemistry (8th ed), Jaypee Brothers Medical Publishers. 6. Clinical Case Discussion in Biochemistry A Book On Early Clinical Exposure (ECE), Poonam Agrawal, 2021, CBS Publishers & distributors pvt. Ltd

MAPPING of COs with POs

CO-PO Mapping (Course Articulation Matrix)

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	2	1	2	3	1	2
CO2	2	3	3	2	3	2	1
CO3	2	3	2	1	0	1	0
CO4	3	3	2	2	1	1	0
Total Score	10	11	8	7	7	5	3

Level of Correlation between COs and POs

0 – No Correlation 1 – Low 2 – Medium 3 – High

MAPPING of COs with PSOs

CO-PSO Mapping (Course Articulation Matrix)

CO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	2	3	2	3	2	3	1
CO2	3	3	3	3	3	3	1
CO3	2	3	3	3	1	3	1
CO4	2	3	3	3	1	3	1
Total Score	9	12	11	12	7	12	4

Level of Correlation between COs and POs

0 – No Correlation 1 – Low 2 – Medium 3 – High

Course	ELECTIVE - III		
Title of the Course	ENERGY AND DRUG METABOLISM		
Credits	3		
Hours/Week	4		
	L	P	T
	4	-	-

COURSE OUTCOMES

CO	On completion of this course, students will be able to
CO1 (K1, K2)	Match the role of mitochondria and chloroplasts in the production of energy currency
CO2 (K3)	Sketch the interrelationship of carbohydrate, protein, and fat metabolism in human body
CO3 (K4)	Analyze the diverse role of TCA cycle as the central metabolic pathway and role of liver to metabolize the xenobiotics
CO4 (K5, K6)	Justify the role of biological oxidation and energy rich compounds in maintaining the energy level of the system

Units	
I	Thermodynamic- principles in biology- Concept of entropy, enthalpy and free energy change. Redox systems. Redox potential and calculation of free energy. Biological oxidation – Oxidases, dehydrogenases, hydroperoxidases, oxygenases. Energy rich compounds – phosphorylated and non-phosphorylated. High energy linkages.
II	Electron transport chain-various complexes of ETC, Q-cycle. Inhibitors of ETC. Oxidative phosphorylation-P/O ratio, chemiosmotic theory. Mechanism of ATP synthesis - role of F0-F1 ATPase, ATP-ADP cycle. Inhibitors of oxidative phosphorylation ionophores, protonophores. Regulation of oxidative phosphorylation

III	Light reaction-Hills reaction, absorption of light, photochemical event. Photo ETC-cyclic and non-cyclic electron flow. Photophosphorylation-role of CF0-CF1 ATPase. Dark reaction- Calvin cycle, control of C3 pathway, and Hatch-Slack pathway (C4 pathway), Photorespiration. Synthesis and degradation of starch
IV	Interconversion of major food stuffs. Energy sources of brain, muscle, liver, kidney and adipose tissue. Amphibolic nature of Citric acid cycle. Anaplerotic reaction. Krebs cycle, Inhibitors and regulation of TCA cycle. Transport of extra mitochondrial NADH – Glycerophosphate shuttle, malate aspartate shuttle. Energetics of metabolic pathways – glycolysis, (aerobic and anaerobic), citric acid cycle and beta oxidation.
V	Activation of sulphate ions – PAPS, APS, SAM and their biological role. Metabolism of xenobiotics – Phase I reactions – hydroxylation, oxidation and reduction. Phase II reactions – glucuronidation, sulphation, glutathione conjugation, acetylation and methylation. Mode of action and factors affecting the activities of xenobiotic enzymes.
Reading List (Print and Online)	1. https://chemed.chem.purdue.edu/genchem/topicreview/bp/ch21/gibbs.php 2. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7767752/#:~:text=The%20mitochondrial%20electron%20transport%20chain,cellular%20ATP%20through%20oxidative%20phosphorylation. 3. https://www.researchgate.net/figure/Oxidative-phosphorylation-in-mitochondrial-electron-transport-chain-ETC-and-proton_fig1_230798915 4. https://bajan.files.wordpress.com/2010/05/amphibolic-nature-of-krebs-cycle.pdf 5. https://www.sciencedirect.com/topics/medicine-and-dentistry/xenobiotic-metabolism#:~:text=Xenobiotic%20metabolism%20can%20be%20defined,more%20readily%20excreted%20hydrophilic%20metabolites
Self-Study	1. Calculation of Keq and $\triangle$ G 2. Interrelationship of carbohydrate, protein, and fat metabolism-role of acetyl CoA
Recommended Texts	1. David L. Nelson and Michael M. Cox (2012) Lehninger Principles of Biochemistry (6th ed), W.H. Freeman 2. Robert K. Murray, Darryl K. Granner, Peter A. Mayes, and Victor W. Rodwell (2012), Harper's Illustrated Biochemistry, (29th ed), McGraw-Hill Medical

	3. Metzler D.E (2003). The chemical reactions of living cells (2nd ed), Academic Press. 4. Zubay G.L (1999) Biochemistry, (4th ed), Mc Grew-Hill. 5. Devlin RM (1983) Plant Physiology (4th ed), PWS publishers 6. Taiz L, Zeiger E (2010), Plant Physiology (5th ed), Sinauer Associates, Inc

MAPPING of COs with POs

CO-PO Mapping (Course Articulation Matrix)

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	1	0	2	0	1	0
CO2	2	3	2	1	1	2	1
CO3	2	3	3	2	1	1	1
CO4	3	2	2	2	1	1	0
Total Score	10	9	7	7	3	5	2

Level of Correlation between COs and POs

0 – No Correlation 1 – Low 2 – Medium 3 – High

MAPPING of COs with PSOs

CO-PSO Mapping (Course Articulation Matrix)

CO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	2	1	2	3	1	2	1
CO2	3	1	3	3	1	2	1
CO3	3	2	3	3	2	3	1
CO4	2	1	2	3	1	2	1
Total Score	10	5	10	12	5	9	4

Level of Correlation between COs and POs

0 – No Correlation 1 – Low 2 – Medium 3 – High

Course	ELECTIVE - IV		
Title of the Course	NUTRITIONAL BIOCHEMISTRY		
Credits	3		
Hours/Week	4		
	L	P	T
	4	-	-

COURSE OUTCOMES

CO	On completion of this course, students will be able to
CO1 (K1, K2)	Understand the role played by antinutritional factors, inter-relationship of nutrition, infection, immunity and poverty
CO2 (K3)	Describe the biochemical, physiological and nutritional functions of macronutrients and their integrated role.
CO3 (K4)	Evaluate the functions of vitamins, minerals, fluids and electrolyte balance in different physiological states and in sports persons
CO4 (K5, K6)	Plan a balanced diet based on an individual's energy requirement during states of health and disease

Units	
I	Basic concepts - Nutrition - Food groups and balanced diet. Novel Foods. Calorific value of foods: Direct and indirect calorimetry. Empty calories. Basal metabolic rate: Factors affecting BMR. SDA and physical activity. Calculation of day's energy requirement. Assessment of nutritional status. Lactose intolerance. Nutritional requirement and biochemical changes in different physiological states -infancy, childhood, pregnancy, lactation, and ageing. Sports nutrition.
II	Elements of nutrition - Plant and animal sources of simple and complex carbohydrates, fats and proteins and their requirement. Biological significance, deficiency and toxicity of macronutrients and micronutrients. Role of dietary fibre. Protein sparing action of carbohydrates and fats. Essential amino acids. Essential fatty acids.

	Effects of naturally occurring food toxins, preservatives, additives, alcohol and tobacco on health.
III	Vitamins and Minerals- Dietary sources, classification, biochemical functions, requirements, absorption, metabolism and excretion. Vitamin B complex as coenzyme. Nutritional significance of dietary calcium, phosphorus, magnesium, iron, iodine, zinc and copper.
IV	Malnutrition - Diseases arising due to Protein - Calorie Malnutrition and undernutrition (Kwashiorkor and Marasmus), Prevention of malnutrition. Deficiency diseases associated with vitamin B complex, vitamin C and A, D, E & K vitamins - Mineral deficiency diseases - aetiology, sign and symptoms and dietary supplementation. Enrichment and fortification (vitamins and minerals)
V	Nutrition in diseases - Aetiology, signs and symptoms, treatment and dietary management during fever (Typhoid and Malaria) and infectious diseases (COVID-19), Jaundice, hyper acidity (Ulcer), Atherosclerosis, Hypertension, kidney diseases and diabetes in adults. Starvation and Obesity. Inter-relationship of nutrition, infection, immunity and poverty
Reading List (Print and Online)	1. https://www.jmedscindmc.com/article.asp?issn=1011-4564;year=2014;volume=34;issue=5;spage=211;epage=213;aulast=Shrivastava 2. https://www.researchgate.net/figure/Relationship-between-malnutrition-infection-and-immunity-Malnutrition-is-considered-the_fig1_280722727 3. https://en.wikipedia.org/wiki/Novel_food 4. https://www.chemicalsafetyfacts.org/preservatives/ 5. https://www.sciencedirect.com/topics/agricultural-and-biological-sciences/food-enrichment
Self-Study	1. Antabuse drugs and food 2. Selection of foods and market visit, reading and understanding the food labels
Recommended Texts	1. Srilakshmi. E .(2016) Nutrition Science, New Age International Publishers. 2. Mahan, Kathleen L. (2004) Krause's Food, Nutrition and Diet Therapy, W.B. Saunder's 11th Edition 3. Andreas M. Papas (1998). Antioxidant Status, Diet, Nutrition, and

	Health (1st ed) CRC Press. 4. M. Swaminathan (1995) Principles of Nutrition and Dietetics. Bappco 5. Margaret Mc Williams (2012). Food Fundamentals (10th ed) Prentice Hall 6. Tom Brody (1998) Nutritional Biochemistry (2nd ed). Academic Press, USA

MAPPING of COs with POs

CO-PO Mapping (Course Articulation Matrix)

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	2	2	2	3	0	1
CO2	3	2	1	2	0	0	0
CO3	2	3	3	2	1	2	0
CO4	3	3	3	3	2	2	1
Total Score	11	10	9	9	6	4	2

Level of Correlation between COs and POs

0 – No Correlation 1 – Low 2 – Medium 3 – High

MAPPING of COs with PSOs

CO-PSO Mapping (Course Articulation Matrix)

CO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	2	1	3	3	3	3	1
CO2	2	1	2	3	1	2	1
CO3	3	2	3	3	2	3	1
CO4	3	2	3	3	3	3	2
Total Score	10	6	11	12	9	11	5

Level of Correlation between COs and POs

0 – No Correlation 1 – Low 2 – Medium 3 – High

Course	SKILL ENHANCEMENT I: PRACTICAL - II		
Title of the Course	LABORATORY COURSE ON BIOMOLECULES AND BIOCHEMICAL TECHNIQUES		
Credits	2		
Hours/Week	4		
	L	P	T
	-	4	-

COURSE OUTCOMES

CO	On completion of this course, students will be able to
CO1 (K1, K2)	Familiarize with the principle, instrumentation and method of quantifying important metabolites
CO2 (K3)	Employ skill acquired in fine handling of instruments like colorimeter, spectrophotometer to estimate the biomolecules and minerals from various biological sources
CO3 (K4)	Identify the presence of phytochemicals and quantify them in the plant samples
CO4 (K5, K6)	Develop skills in subcellular fractionation, cell sorting etc in groups which enable them to build learning skills like team work, problem solving, communication ability

Units	
I	Colorimetric estimations 1. Estimation of Pyruvate 2. Estimation of tryptophan 3. Estimation of protein
II	Estimation of minerals from rich source 1. Estimation of calcium

	2. Estimation of iron 3. Estimation of phosphorous
III	Estimation of nutrients from plants 1. Estimation of fructose content in grape fruit 2. Estimation of ascorbic acid from citrus fruit
IV	Plant Biochemistry 1. Qualitative analysis Phytochemical screening 2. Estimation of Flavonoids - Quantitative analysis
V	Group Experiments 1. Fractionation of sub-cellular organelles by differential centrifugation-Mitochondria and nucleus 2. Identification of the separated sub-cellular fractions using marker enzymes (any one) 3. Separation of plant pigments from leaves by column chromatography
Reading List (Print and Online)	1. https://www.researchgate.net/publication/313745155_Practical_Biochemistry_A_Student_Companion 2. https://doi.org/10.1186/s13020-018-0177-x 3. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5368116/ 4. https://www.life.illinois.edu/biochem/455/Lab%20exercises/2Photometry/spectrophotometry.pdf 5. https://ijpsr.com/bft-article/determination-of-total-flavonoid-and-phenol-content-in-mimusops-elengi-linn/?view=fulltext 6. https://skyfox.co/wp-content/uploads/2020/12/Practical-Manual-of-Biochemistry.pdf
Self-Study	1. Laboratory Safety Rules, Requirements and Regulations. 2. Preparation of standard solutions and reagent
Recommended Texts	1. David Plummer (2001) An Introduction to Practical Biochemistry (3rd ed) McGraw Hill Education (India) Private Ltd 2. Jayaraman, J (2011), laboratory Manual in Biochemistry, New age publishers

	3. Varley H (2006) Practical Clinical Biochemistry (6th ed) , CBS Publishers 4. O. Debiyi and F. A. Sofowora, (1978) "Phytochemical screening of medical plants," Iloyidia, vol. 3, pp. 234–246. 5. Prof. Sarin A. Chavhan, Prof. Sushilkumar A. Shinde (2019) A Guide to Chromatography Techniques Edition:1 6. Analytical techniques in Biochemistry and Molecular Biology; Katoch, Rajan. Springer (2011).

MAPPING of COs with POs

CO-PO Mapping (Course Articulation Matrix)

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	2	1	2	0	2	0
CO2	2	2	3	2	1	3	1
CO3	2	3	2	1	1	2	0
CO4	3	2	2	2	0	2	3
Total Score	10	9	8	7	2	9	4

Level of Correlation between COs and POs

0 – No Correlation 1 – Low 2 – Medium 3 – High

MAPPING of COs with PSOs

CO-PSO Mapping (Course Articulation Matrix)

CO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	3	3	2	3	1	3	1
CO2	3	3	2	3	1	3	1
CO3	3	3	3	3	2	3	1
CO4	3	3	3	2	1	3	3
Total Score	12	12	10	11	5	12	6

Level of Correlation between COs and POs

0 – No Correlation 1 – Low 2 – Medium 3 – High