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(Accredited by NAAC)

GU/Acad –PG/BoS -NEP/2024/95 Date: 15.05.2024

Ref: GU/Acad –PG/BoS -NEP/2023/102/33 dated 21.06.2023

CIRCULAR

In supersession to the above referred Circular, the Syllabus of Semester III to VIII of the **Bachelor of Science in Chemistry** Programme approved by the Standing Committee of the Academic Council in its meeting held on 06th, 07th and 21st March 2024 is enclosed. Further the Syllabus of Semester I and II approved earlier is also enclosed.

The Dean/ Vice-Deans of the School of Chemical Sciences and Principals of the Affiliated Colleges offering the **Bachelor of Science in Chemistry** Programme are requested to take note of the above and bring the contents of the Circular to the notice of all concerned.

ASHWIN VYAS LAWANDE
Digitally signed by ASHWIN VYAS LAWANDE
Date: 2024.05.15 16:31:12 +05'30'

(Ashwin Lawande)
Assistant Registrar – Academic-PG

To,

The Principals of Affiliated Colleges offering the Bachelor of Science in Chemistry Programme.

Copy to:

1. The Director, Directorate of Higher Education, Govt. of Goa
2. The Dean, School of Chemical Sciences, Goa University.
3. The Vice-Deans, School of Chemical Sciences, Goa University.
4. The Chairperson, BOS in Chemistry.
5. The Controller of Examinations, Goa University.
6. The Assistant Registrar, UG Examinations, Goa University.
7. Directorate of Internal Quality Assurance, Goa University for uploading the Syllabus on the University website.

III	CHC-200 Concepts in Inorganic and Physical Chemistry (3T+1P) CHC-201 Concepts in Organic and Analytical Chemistry (3T+1P)	CHC-211 Basic Industrial Chemistry (4)	CHC-231 Environmental Sustainability: Natural resources and community (3)		CHC- 241 Mathematical Aspects and Computers in Chemistry (1T+ 2P) OR CHC-242 Introductory skills in Green Chemistry (1T+ 2P) OR CHC-243 Drug Synthesis and Analysis (1T+ 2P)					
IV	CHC-202 Organic Chemistry-I (3T+1P) CHC-203 Inorganic Chemistry-I (3T+1P) CHC-204	CHC-221 (Minor Vocational-1) Basics of Chemical Laboratory Management (4)								CHE-261 Basic Techniques in Qualitative and Quantitative Analysis (1T+3P)

	Physical Chemistry-I (3T+1P) CHC-205 Pharmaceutical Chemistry-I (2)									
V	CHC-300 Organic Chemistry-II (3T+1P) CHC-301 Inorganic Chemistry-II (3T+1P) CHC-302 Physical Chemistry-II (3T+1P) CHC-303 Green Chemistry Techniques (2)	CHC-321 (Minor Vocational-2 Chemistry of Food and Nutrients (3T+1P)				CHC-361 Summer Internship [2]				

Semester III
Name of the Programme : B.Sc. (Chemistry)
Course Code : CHC-200
Title of the course : Concepts in Inorganic and Physical Chemistry
Number of Credits : 3T+1P
Effective from AY : 2024-25

Pre-requisites for the Course	Students should have basic knowledge of periodic table, atomic structure, solids and solvent properties	
Course Objectives:	1. To understand the origin of the periodic table and to study various periodic properties and their trends. 2. To learn the postulates of Valence Bond Theory, Molecular Orbital Theory and Valence Shell Electron Pair Repulsion Theory and to study the general characteristics of covalent and ionic compounds through theories of bonding. 3. To study the structures of cubic crystals and the laws governing them. 4. To introduce colligative properties and to study the distribution law.	
Content		**No of hours**
	1. **Periodicity of Elements** The Origin of the periodic table, Mendeleev's Periodic table, Modern/Long form of Periodic table and Periodic classification of elements into s, p, d, and f-block. Periodicity, and magic numbers. Valence Electronic configurations. Periodic properties of the elements and their trends: Atomic radii, van der Waal's radii, Ionic radii and Covalent radii, shielding or screening effect, Effective nuclear charge, Slater rules. Ionization Energy, Successive ionization energies and factors affecting ionization energy. Electron Affinity. Electronegativity: Pauling's and Allred-Rochow's scale. Calculation of electronegativity (Pauling's Method), Factors affecting electronegativity, applications of electronegativity (numericals are expected).	**08**
	2. **Chemical Bonding and Molecular Structure** Concept of electron density, Types of chemical bonds: a) Covalent bonding, Lewis theory, octet rule, the concept of Formal Charge. Valence bond theory: Interaction between two hydrogen atoms and the Potential energy diagram of the resultant system. Corrections applied to the system of two hydrogen atoms. Resonance, Rules for Resonance or Canonical Structures. Bonding in Polyatomic Species: Promotion, Hybridization, (with reference to sp^3 hybridisation in CH_4, NH_3 and H_2O) Equivalent and Non-Equivalent hybrid orbitals. Contribution of a given atomic orbital to the hybrid orbitals and series like NH_3, PH_3, AsH_3, BiH_3) Types of hybrid orbitals-sp, sp^2, sp^3, sp^3d, sp^3d^2 and sp^3d^3. b) Co-ordinate covalent bond: VSEPR Theory: Assumptions, Application of the theory to explain the geometry of molecules like H_2O, NH_3, $TiCl_4$, ClF_3, OF_2, NH_4^+ and ICl_2^-. Molecular Orbital Theory (MO) approach: Comparing Atomic Orbitals and Molecular Orbitals. Linear combination of atomic	**15**

	orbitals to give molecular orbitals, Bonding and Antibonding MOs. LCAO-MO diagrams for diatomic homonuclear molecules (O_2, N_2). Heteronuclear diatomic molecules: With reference to mixing of orbitals CO, NO and NO^+ and bond orders. Prediction of stability/reactivity and magnetic nature with special reference to O_2, O_2^+, O_2^-, O_2^{2-}. Comparison of VB and MO approaches. c) Ionic bonding**:** Energy considerations in ionic bonding; Types of Ionic Crystals, Radius Ratio Rules. Lattice energy, solvation energy and their importance in the context of stability and solubility of ionic compounds. Statement of Born-Landé equation for calculation of lattice energy; Born-Haber cycle and its applications; Polarizing power and polarizability, Fajan's rules; ionic character in covalent compounds; bond moment; dipole moment and percentage ionic character.	
	3. **Solids** Forms of solids, symmetry elements, unit cells, crystal systems, Bravais lattice. Laws of crystallography - Law of constancy of interfacial angles, Law of rational indices. Miller indices, X–Ray diffraction by crystals, Bragg's law. Determination of lattice parameters using powder method. Structures of NaCl, KCl and CsCl (qualitative treatment only). (Numerical are expected)	**07**
	4. **Phase equilibria & Colligative properties** Phases, components and degrees of freedom of a system, criteria of phase equilibrium. Phase diagrams of one-component systems (water, sulphur and CO_2), two component systems involving eutectics, congruent and incongruent melting points (Zn-Mg, Ag-Pb, NaCl- H_2O). Introduction to Raoults law. Colligative properties- Lowering of vapour pressure, depression in freezing point, elevation in boiling point. Osmosis and osmotic pressure. Experimental methods and determination of molecular weight. (Numerical are expected).	**10**
	5. **Distribution Law:** Nernst Distribution Law – Statement. Distribution constant, factors affecting distribution constant, validity of distribution law, modification of distribution law when molecules undergo a) association b) dissociation. Application of distribution law - solvent extraction, determination of association, dissociation in one solvent or both the solvent. (Numericals are expected)	**05**
Pedagogy	• Lectures and Tutorials, Seminars/ Term papers/ Assignments/ Applicative Quiz sessions/ Presentations / self-study or a combination of some of these can be used. • ICT mode will be preferred. • Sessions should be interactive in nature to enable peer group discussions and learning.	
References / Readings	1. Satya Prakash, G.D. Tuli, S.K. Basu, R.D. Madan, Advanced Inorganic Chemistry, Vol. I, 19th edn., S. Chand Publishers (2016) 2. P. L. Soni and Mohan Katyal, Textbook of Inorganic Chemistry by, Sultan Chand and Sons, 20th Edition (1997) 3. Puri, Sharma and Kalia, Principles of Inorganic Chemistry, 33rd Edition,	

	Vishal Publishing Co. (2018). 4. Krishna Mohan Srivastava, Essentials of Inorganic Chemistry, Bio-Green Books (2023). 5. L. Pauling, The Nature of The Chemical Bond, 3rd Ed.; Cornell University, Press, 1960. 6. J. D. Lee, Concise Inorganic Chemistry by, Chaman and Hall, 5th ed. (1996). 7. C. N. R. Rao edited, University General Chemistry-An Introduction to Chemical Science, 1st Edn 1973 (Reprint 2009). 8. A. Bahl and G.D. Tuli, Essentials of Physical Chemistry by S. Chand Publication (2019, New Delhi, 26th Edn. 9. Puri, Sharma and Pathania , Principles of Physical Chemistry. Vishal publishing house, (2018), New Delhi 1st Edn. 10. J.N. Gurtu, Physical Chemistry, Pragati Prakashan, (2020) Meerut, 9th Edn. 11. Gurdeep Raj , Advanced Physical Chemistry, Goel publication, (2010), 36th Edn. Meerut. 12. R. L Madan, Chemistry for degree students, S, Chand and Co. Ltd. (2017) New Delhi, 1st Edn.

Number of Credits: 01 (Practicals)		
Course Objectives:	1. To prepare standard solutions and determine strength of solutions. 2. To synthesize metal oxalates and estimate the metal ions by volumetric and gravimetric methods. 3. To introduce colligative properties and their applications. 4. To study the Nernst distribution law and its applications.	
Content		**30 hrs**
	Inorganic Chemistry experiments	**(14 hrs)**
	1. Preparation of 0.1N HCl and standardization with anhydrous Na_2CO_3/Borax.	**02**
	2. Estimation of the amount of calcium in the given calcium chloride solution (EDTA method).	**02**
	3. Determination of the strength of sodium thiosulphate using standard iodine solution.	**02**
	4. Determination of the percentage composition of the mixture of NH_4Cl and $BaSO_4$.	**02**
	5. Estimation of Fe as Fe_2O_3 from the given solution of ferrous ammonium sulphate.	**02**
	6. Preparation of Fe(III) Oxalate.	**02**
	7. Preparation of Zn(II) Oxalate.	**02**
	Physical Chemistry experiments	**(16 hrs)**
	1. Indexing and determination of lattice parameters of Simple cubic, FCC and BCC crystal systems.	**06**
	2. To determine the partition coefficient of iodine between 1,2-dichloroethane and water	**02**
	3. To determine the molecular condition of benzoic acid by distribution method	**02**
	4. To draw the phase diagram of binary system; Diphenylamine and α-Naphthol	**02**
	5. Determination of molal boiling point elevation constant of NaCl in water system	**02**

	6. Determination of molal freezing point depression constant of NaCl and water system	**02**
Pedagogy:	• Students shall be given pre-lab and post-lab assignments • Theoretical concept underlying the experiments prior to each experiment. • Each student shall perform the experiments independently.	
References / Readings	1. J. Mendham, R. C. Denney, J. D. Barnes, M. Thomas, B. Sivasankar, Vogel's Textbook of Quantitative Chemical Analysis, 6th Edn. Pearson Education. 2. G. Marr and B. W. Rockett, Practical inorganic Chemistry, Van Nostrand Reinhold Company, London. (1972) 3. S. W. Rajbhoj and T. K. Chondhekar, Systematic Experimental Physical Chemistry, Anjali Publication, Second Edition 2000. 4. Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi, 2018. 5. B. Sc. Chemistry Experiments, Talent Development Centre, IISc. 2021, Bengaluru. 6. C. Suryanarayana**,** M. Grant Norton, X-Ray Diffraction: A Practical Approach, Plenum Press (1998) New York, 1st Edn.	
Course Outcome:	At the end of the course, students will be able to: 1. explain the trend of periodic properties of elements, geometry of molecules, and stability of ionic solids. 2. construct and interpret the molecular orbital diagram of homonuclear and heteronuclear molecules. 3. predict the colligative properties of different systems. 4. calculate the distribution coefficient of binary systems. 5. prepare normal and molar solutions of a substance. 6. calculate the amount of substance in given solutions. 7. carry out volumetric and gravimetric experiments for the estimation of unknown substances. 8. deduce the lattice parameters of crystalline solids.	

Name of the Programme : **B.Sc. Chemistry**
Course Code : **CHC-201**
Title of the course : **Concepts in Organic and Analytical Chemistry**
Number of Credits : **3T+1P**
Effective from AY : **2024-25**

Prerequisites for the course	Students should have basic knowledge of functional group chemistry and methods of analysis.	
Course Objectives:	1. To understand the preparation of aromatic compounds, organic halides, alcohols, phenols and carbonyl compounds. 2. To study the reactions of aromatic compounds, organic halides, alcohols, phenols and carbonyl compounds. 3. To understand scope and importance of analytical chemistry and to interpret steps involved in chemical analysis. 4. To study concepts of data analysis for determining central tendency and dispersion. 5. To study classical methods of analysis inclusive of principles and instrumentation of UV – Visible spectrophotometry and solvent extraction.	
Content		**No. of hours**
	1. Aromatic hydrocarbons Preparation (case benzene): from phenol, from acetylene. Reactions: (case benzene): electrophilic substitution: nitration, halogenation and sulphonation. Friedel-Craft's reaction (alkylation and acylation): Preparation of toluene, ethylbenzene, isopropylbenzene, acetophenone, propiophenone, butyrophenone, *n*-propylbenzene, *n*-butylbenzene, *t*-butylbenzene, isobutylbenzene. Side chain oxidation of following alkyl benzenes to benzoic acid: Toluene, ethylbenzene, isopropylbenzene. *o*-xylene to phthalic acid, *p*-xylene to terephthalic acid.	**07**
	2. Alkyl and Aryl Halides Alkyl Halides: IUPAC Nomenclature (examples upto 5 Carbons), Preparation: from alkenes and alcohols. Reactions: hydrolysis, nitrite & nitro formation. Types of Nucleophilic Substitution (S_N1 & S_N2) reactions (mechanism without stereochemistry). Aryl Halides: Preparation: (chloro, bromo and iodobenzene): Sandmeyer reaction. Reactions (Chlorobenzene): Aromatic nucleophilic substitution S_NAr-mechanism (replacement by –OH group to give phenol and effect of nitro substituent). Benzyne Mechanism: KNH_2/NH_3 (or $NaNH_2/NH_3$).	**07**
	3. Alcohols, Phenols, Ethers and Carbonyl Compounds Alcohols: IUPAC Nomenclature (examples upto 5 Carbons), Preparation of 1°, 2° and 3° alcohols: using Grignard reagent, Ester hydrolysis, Reduction of aldehydes, ketones, Reactions: With sodium, HX (Lucas test), esterification, oxidation (with PCC, alk. $KMnO_4$). Phenols: Preparation: Cumene hydroperoxide method, from	**08**

	diazonium salts. Reactions: Electrophilic substitution: nitration, halogenation and sulphonation. Ethers (aliphatic and aromatic): Williamson's synthesis of ethers. Cleavage of ethers with HI. Aldehydes and ketones (aliphatic and aromatic): (acetaldehyde, acetone, benzaldehyde and acetophenone) Preparation: from alcohols and acid chlorides. Reactions–with HCN, ROH, NH_3, 2,4-DNP, NH_2OH, Iodoform test. Aldol condensation-only reaction for preparation of chalcone.	
	4. Introduction to analytical techniques Chemical analysis and analytical chemistry, Scope and importance of analytical chemistry, Classification of instrumental methods, analytical process (steps involved in chemical analysis): defining the problem, sampling, separation of desired components, actual analysis, presentation and interpretation of results.	**03**
	5. Evaluation of analytical data Errors: Classification of errors - determinate and indeterminate error, constant and proportionate errors, absolute and relative error, correction and minimization of errors. Accuracy and precision, determination of accuracy in terms of relative error. Measures of central tendency and dispersion – Mean, Median, Mode, Range, Relative Deviation, Average Deviation, Relative Average Deviation (RAD), Standard deviation, Variance and Coefficient of variance. Significant figures and rounding off, Significance of zero in computation, Rules of computation. (*Numericals to be solved*)	**06**
	6. Classical methods of analysis Principles of gravimetric analysis: precipitation, coagulation, peptization, coprecipitation, post precipitation, digestion, filtration and washing of precipitate, drying and ignition. Principles of titrimetric analysis: Theories of acid-base, redox (including iodometric/iodimetric), complexometric, and precipitation titrations - choice of indicators for Acid base titrations.	**05**
	7. Solvent Extraction Basic Principle, percentage extraction (derivation not required), role of complexing agents in solvent extraction, separation factor, types of extraction (batch, continuous, counter current), (Numerical problems are to be solved)	**04**
	8. UV-Visible Spectroscopy Interaction of electromagnetic radiation with matter, Beer's and Lambert's law, derivation of Beer-Lambert's law, deviations from Beer's law, Quantitative calculations. Principles of instrumentation: Sources, monochromators, cells. Types of instruments: Photoelectric colorimeters and Spectrophotometers: Single & Double beam; comparison between colorimeter and spectrophotometer; applications: qualitative & quantitative analysis. (*Numericals to be solved*)	**05**
Pedagogy	Mainly lectures and tutorials. Seminars /term papers /assignments /	

	presentations /industry visits/ self-study or a combination of some of these can also be used. ICT mode should be preferred. Sessions should be interactive in nature to enable peer group learning.
References / Readings	1. Graham Solomons, T.W., Fryhle, C.B. and Snyder, S. A., *Organic chemistry*, 12th ed., John Wiley & Sons, UK, 2016. 2. McMurry, J., *Fundamentals of organic chemistry*, 7th ed., Cengage Learning India Edition, Noida, India, 2013. 3. Sykes, P., *A guide book to mechanism in organic chemistry*, 6th ed., Longman Scientific & Technical, England, UK,1985. 4. Finar, I. L., *Organic Chemistry* (Vol. I), 6th ed., Pearson Education, India, 1973. 5. Finar, I. L., *Organic Chemistry* (Vol. II), 3rd ed., Longmans, London, UK, 1964. 6. Morrison, R.T., Boyd, R.N. and Bhattacharjee, S. K., *Organic Chemistry*, 7th ed., Pearson, Bangalore, India, 2010. 7. Bahl, A. and Bahl, B. S., *Advanced Organic Chemistry*, S. Chand, New Delhi, India, 2012. 8. Carey, F., *Organic Chemistry*, 4th ed., McGraw Hill, New York USA, 2000. 9. Bruice, P. Y., *Organic Chemistry*, 3rd ed., Pearson Education, Asia, 2014. 10. March, J., *Advanced Organic Chemistry*, 4th ed., John Wiley, New Jersey, USA, 2007. 11. B. K. Sharma. *Instrumental Methods of Chemical Analysis,5th ed.* Goel Publishing House, Meerut. 2004. 12. K. Raghuraman, D. V. Prabhu, C. S. Prabhu and P. A. Sathe, *Basic principles in Analytical Chemistry*, 5th edition, Shet Publications Pvt. Ltd. 13. G. Chatwal and S. Anand, *Instrumental Methods of Chemical Analysis*, 5th edition Himalaya publication. 2003. 14. H.Willard,L. Meritt and J.A. Dean. *Instrumental Methods of Analysis*, 7th edition, HCBS publication. 2004. 15. D.A. Skoog and J.J. Leary, *Principles of Instrumental analysis*, 4th Edition, Saunders College Publication.1992. 16. G. D. Christian, *Analytical Chemistry*, 6th edition, Wiley publication, NewYork 2004

Number of Credits: 01 (Practicals)

Course Objectives:	1. To apply theoretical concepts to experiments. 2. To acquire hands on training in organic preparation experiments. 3. To acquire hands on training in organic qualitative analysis. 4. To evaluate data for central tendency and dispersion. 5. To apply extraction methods to separate given mixtures	
Content		**No. of hours**
	I. Organic preparations List of organic preparations to be performed. Purification by recrystallization, calculation of % yield and determination of melting point. (**Any 2)** a) Bromination of acetanilide to *p*-bromoacetanilide. b) Oxidation of Toluene to benzoic acid using $KMnO_4$. c) 2,4-dinitrophenylhydrazone of benzaldehyde/acetophenone. d) Oxime of Cyclohexanone.	**06**

	II. Organic qualitative analysis Preliminary tests, chemical nature, detection of elements, functional group determination and physical constant. (**any one from each category**). a) Water soluble compounds: succinic acid, oxalic acid, urea, thiourea. b) Water insoluble Acids/ Phenols: benzoic acid, cinnamic acid, salicylic acid, *p*-nitrobenzoic acid, *o*-chlorobenzoic acid, *α*-naphthol, *β*-naphthol. c) Water insoluble Base: m-nitroaniline, *p*-toluidine. d) Water insoluble Neutral: acetanilide, benzamide, *p*-dichlorobenzene, *m*-dinitrobenzene, e) Liquids: Acetone, ethyl acetate, ethanol, benzaldehyde, acetophenone, aniline.	**10**
	III. Evaluation of data 1. Titration of supplied calcium chloride solution with 0.01M EDTA solution. (More than 5 observations to be taken followed by statistical analysis to determine - mean, median, range, accuracy in terms of relative error) 2. Titration of given 0.1N NaOH solution using primary standard 0.1N Succinic acid solution. (5 observations to be taken followed by statistical analysis to determine - Relative Deviation, Average Deviation, Relative Average Deviation (RAD), Standard deviation, Variance and Coefficient of variance, *True Value to be provided*).	**04**
	IV. UV-Visible spectrophotometry and Colorimetry 1. Determine λ_{max} for 0.1M $K_2Cr_2O_7$ by spectrophotometry. 2. Verify Beer's law using $KMnO_4$ by colorimetric method and determine molar extinction coefficient. 3. Estimation of Cu^{2+} as $[Cu(NH_3)_4]^{2+}$ complex in the given unknown solution using Calibration curve method.	**06**
	V. Solvent Extraction 1. Separation of mixture of benzoic acid and β-naphthol using ethyl acetate by solvent extraction method. 2. Determination of partition coefficient of acetic acid in water and n-butyl alcohol. 3. Extraction of Caffeine from tea leaves decoction using dichloromethane as organic solvent.	**04**
Pedagogy:	Students should be given suitable pre- and post-lab assignments and explanation revising the theoretical aspects of laboratory experiments prior to the conduct of each experiment. Each of the experiments should be done individually by the students.	
References / Readings	1. Furniss, B. S., Hannaford, A. J., Smith P. W. G. and Tatchell, A. R., *Vogel's Textbook of Practical Organic Chemistry*, 5th ed., Pearson Education Ltd., UK, 2011. 2. Pasto, D., Johnson C. and Miller, M., *Experiments and Techniques in Organic Chemistry*, 1st ed., Prentice Hall, New Jersey, USA, 1992. 3. Fieser, L. F. and Williamson, K. L., *Organic Experiments*, 7th ed., D. C. Heath and Company, Massachusetts, USA, 1992. 4. Bansal, R. K., *Laboratory Manual of Organic Chemistry*, 5th ed., New Age	

	International Publishers, New Delhi, India, 2009. 5. Jeffery, G. H., Bassett, J., Mendham,J., Denney, R. C., *Vogel's Text Book of Quantitative Chemical Analysis*, 5th Ed., John Wiley, New York, 1989. 6. Mendham,J., Denney,R.C., Barnes, J.D., Thomas,M., *Vogel's Textbook of Quantitative Inorganic Analysis*, 6th Ed., Pearson Education Asia, 2000, 7. Elias, A.J., *Collection of Interesting chemistry experiments*, University Press(India) private limited, Hyderabad 2002
Course Outcome:	At the end of the course, students will be able to 1. Write the mechanism for substitution reactions of alkyl and aryl halides. 2. Write reactions for preparation and reactivity effects in case of alcohols, phenols, aldehydes, ketones and benzene. 3. Explain the Scope and importance of analytical chemistry and principles involved in Classical methods of analysis, UV-Visible spectrophotometric and Solvent extraction. 4. Synthesize simple organic compounds. 5. Analyse and identify organic compounds using classical qualitative analysis. 6. Solve numericals based on statistical data obtained from experimental results. 7. Compare different methods of quantitative and qualitative analysis. 8. Perform extraction and separation of chemical mixtures.

Semester IV

Name of the Programme : B.Sc. (Chemistry)
Course Code : CHC-202
Title of the course : Organic Chemistry I
Number of Credits : 3T+1P
Effective from AY : 2024-25

Prerequisites for the course	Knowledge of functional group chemistry and three-dimensional shapes of molecules	
Course Objectives:	1. To understand the preparation and reactions of carboxylic acids and amines. 2. To apply knowledge of UV-Visible spectroscopy in calculating absorption values. 3. To understand stereochemistry of organic compounds.	
Content		**No. of hours**
	1. Carboxylic acids and its derivatives Carboxylic acids (aliphatic and aromatic) IUPAC nomenclature, Preparation: Acidic and Alkaline hydrolysis of esters, Oxidation of Toluene to benzoic acid. Hydrolysis of cyanides, Grignard synthesis of carboxylic acids. Reactions: Hell - Volhard - Zelinsky Reaction. Carboxylic acid derivatives (aliphatic): (up to 5 carbons) Preparation: Acid chlorides, Anhydrides, Esters and Amides from acids and their interconversions, Reactions: Comparative study of the nucleophilicity towards acyl derivatives. Hydrolysis of acid chlorides, acid amide to carboxylic acids.	**09**
	2. Amines and Diazonium Salts Amines (aliphatic and aromatic) (upto 5 carbons) IUPAC nomenclature, Preparation: from alkyl halides, Gabriel's phthalimide synthesis, Hofmann bromamide reaction (with mechanism). Reduction of cyanides, reduction of nitroarenes. Reactions: Elimination reactions Hofmann vs. Saytzeff elimination, Carbylamine test, Hinsberg test, with HNO_2, Schotten – Baumann reaction. Electrophilic substitution of aniline: nitration, bromination, sulphonation. Diazonium salts: Preparation from aromatic amines, conversion to benzene, phenol, chlorobenzene, bromobenzene. Preparation of azo dye of aniline with *β*-naphthol.	**10**
	3. UV –Visible Spectroscopy in Organic Chemistry Introduction to spectroscopy: UV Spectroscopy: Beer-Lambert's law (statement, expression and terms involved), Types of electronic transitions, Intensity of absorption, Chromophores and Auxochromes with examples, λmax, Bathochromic and Hypsochromic shifts, hypochromic and hyperchromic effects. Visible Spectroscopy: Effect of conjugation on colour: w.r.t benzene, nitrobenzene, *p*-nitroaniline and *β*-Carotene. Application of Woodward - Fieser rules for calculation of λmax for the following systems: *α*, *β* unsaturated aldehydes, ketones. Conjugated dienes: alicyclic, homoannular and heteroannular, extended conjugated systems (aldehydes, ketones and dienes)	**14**

	(problems to be solved). Applications of UV-Visible spectroscopy.	
	4. Introduction to Stereochemistry Concept of isomerism. Types of isomerism. Stereoisomerism, conformational isomerism. Conformations with respect to ethane. Interconversion of Wedge Formula, Newmann, Sawhorse and Fischer representations. Concept of chirality (upto two carbon atoms). Configuration: Geometrical and Optical isomerism; Enantiomerism, Diastereomerism and Meso compounds. Threo and erythro; D and L; cis – trans nomenclature; Cahn Ingold Prelog Rules: R/ S (for upto 2 chiral carbon atoms) and E / Z Nomenclature (for upto two C=C systems).	**12**
Pedagogy	Mainly lectures and tutorials. Seminars / term papers /assignments / presentations /self-study or a combination of some of these can also be used. ICT mode should be preferred. Sessions should be interactive in nature to enable peer group learning.	
References / Readings	1. Kemp, W., *Organic spectroscopy*, 3rd ed., Palgrave Macmillan, New York, USA, 1991. 2. Pavia, D. L., Lampman, G. M. and Kriz, G. S., *Introduction to Spectroscopy*, 3rd ed., Thomson Learning, Fort Worth, USA, 2001. 3. Silverstein, R. M. and Webster, F., *Spectrometric Identification of Organic Compounds*, 5th ed., John Wiley & Sons, New York, USA, 1991. 4. Graham Solomons, T.W., Fryhle, C.B. and Snyder, S. A., *Organic chemistry*, 12th ed., John Wiley & Sons, New Jersey, USA, 2016. 5. Sykes, P., *A guidebook to mechanism in organic chemistry*, 6th ed., Longman Scientific & Technical, England, UK, 1985. 6. Finar, I. L., *Organic Chemistry* (Vol. I), 6th ed., Pearson Education, India, 1973. 7. Finar, I. L., *Organic Chemistry* (Vol. II), 3rd ed., Longmans, London, UK, 1964. 8. Morrison, R.T., Boyd, R.N. and Bhattacharjee, S. K., *Organic Chemistry*, 7th ed., Pearson, Bangalore, India, 2010. 9. Bahl, A. and Bahl, B.S., *Advanced Organic Chemistry*, S. Chand, New Delhi, India, 2012. 10. Carey, F., *Organic Chemistry*, 4th ed., McGraw Hill, New York, USA, 2000. 11. Bruice, P. Y., *Organic Chemistry*, 3rd ed., Pearson Education, Asia, 2014. 12. March, J., *Advanced Organic Chemistry*, 4th ed., John Wiley, New Jersey, USA, 2007. 13. Nasipuri, D., *Stereochemistry of Organic compounds - Principles and Applications*, 4th ed., New Academic Science, Kent, UK, 2013. 14. Eliel, E. L., *Stereochemistry of Carbon Compounds*, Tata McGraw-Hill, New York, USA, 1962. 15. Potapov, V. M., *Stereochemistry*, Mir Publishers, Moscow, Russia,1979. 16. Kalsi, P. S., *Spectroscopy of Organic compounds*, 6th ed., New Age International Publishers, New Delhi, India, 2004.	

Number of Credits: 01 (Practicals)

Course Objectives:	1. To apply theoretical concepts to experiments. 2. To acquire hands on training in organic preparation. 3. To acquire hands on training in organic qualitative analysis.	
Content		**No. of hours**
	I Preparation of organic derivatives. List of organic preparations to be performed. Purification by recrystallization, calculation of % yield and determination of melting point. (**Any 4)** a) Osazone derivative from Glucose b) Benzoyl derivative of *β*-Naphthol c) Azo dye from Aniline and *β*-Naphthol d) Acid derivative of benzamide e) Anhydride derivative of phthalic acid. f) Amino derivative of *m*-dinitrobenzene.	**10**
	II Organic qualitative analysis Preliminary tests, chemical nature, detection of elements, functional group determination and physical constant. (**any one from each category**) a) Water insoluble Acids: cinnamic acid, *p*-nitrobenzoic acid. b) Water insoluble Phenol: *o*-nitrophenol, *p*-nitrophenol. c) Water insoluble Base: *p*-nitroaniline, *o*-nitroaniline. d) Water insoluble Neutral: benzophenone, benzamide. e) Water soluble solids: succinic acid, thiourea. f) Liquids: methyl acetate, nitrobenzene, *N*-methylaniline, cyclohexanol.	**14**
	III Organic Estimation (Any 2) a) Estimation of Acetamide b) Estimation of Glucose c) Estimation of nitroaniline	**06**
Pedagogy:	Students should be given suitable pre- and post-lab assignments and explanation revising the theoretical aspects of laboratory experiments prior to the conduct of each experiment. Each of the experiments should be done individually by the students.	
References / Readings	1. Furniss, B. S., Hannaford, A. J., Smith P. W. G. and Tatchell, A. R., *Vogel's Textbook of Practical Organic Chemistry*, 5th ed., Pearson Education Ltd., London, UK, 2011. 2. Pasto, D., Johnson C. and Miller, M., *Experiments and Techniques in Organic Chemistry*, 1st ed., Prentice Hall, New Jersey, USA, 1992. 3. Fieser, L. F. and Williamson, K. L., *Organic Experiments*, 7th ed., D. C. Heath and Company, Massachusetts, USA, 1992 4. Bansal, R. K., *Laboratory Manual of Organic Chemistry*, 5th ed., New Age International Publishers, New Delhi, India 2009.	
Course Outcome:	At the end of the course, students will be able to 1. Explain the preparation and reactions of carboxylic acids and amines. 2. Identify conjugation and calculate λmax of organic compounds. 3. Draw stereoisomers of organic compounds. 4. Assign E/Z and R/S configuration to organic compounds.	

	5. Estimate the organic compounds. 6. Acquire hands on training in organic chemistry preparation methods. 7. Analyse and identify organic compounds using classical qualitative analysis. 8. Apply theoretical knowledge in understanding laboratory skills.

Name of the Programme : **B.Sc. (Chemistry)**
Course Code : **CHC-203**
Title of the course : **Inorganic Chemistry - I**
Number of Credits : **3T+1P**
Effective from AY : **2024-25**

Pre-requisites for the Course	Knowledge of periodic table and coordination chemistry is essential	
Course Objectives:	1. To understand the theoretical aspects related to inorganic qualitative analysis. 2. To study the comparative chemistry of s, p and d block elements. 3. To learn the chemistry of coordination compounds and understand their role in the biological systems. 4. To study the properties, structure and bonding in noble gases compounds.	
Content		**No of hours**
	1. Theoretical Basis for the Qualitative Inorganic Analysis Common ion effect, solubility product, complex ion formation, buffers, applications in inorganic qualitative analysis.	**03**
	2. s - block Elements Occurrence, extractions (Li and Be only), Electronic configuration, Periodic trends in Properties viz. size of atom, ion, ionization potential, flame colouration, and reactivity. Anomalous behaviour of Li & Be. Diagonal relationship between Li-Mg and Be-Al, Solubility and hydration, Biological roles.	**06**
	3. Selected topics on p-block elements **a. Chemistry of Group 13 elements:** Comparative study w.r.t. oxides, halides & hydrides. Electron deficient compounds – BH_3, BF_3, BCl_3 with respect to Lewis acidity and applications. Boranes and types of Boranes, Wade's formula. Preparations, structure and bonding in diborane and tetraborane. Introduction to carboranes. Borates: Introduction and classification. **b. Chemistry of Group 14 elements:** Comparative study w.r.t. oxides, halides & hydrides. Occurrence and extraction of Germanium. Preparation of extra pure Silicon and Germanium, applications in the semiconductor industry with special reference to Solar Panels. Silicates: Introduction, classification and structure. **c. Chemistry of Group 15 elements:** Comparative study w.r.t. oxides & oxyacids, halides & hydrides. Structures of NO, NO_2, N_2O, N_2O_4. Synthesis of ammonia by Haber-Bosch process, synthesis of HNO_3 by Ostwald's process (Physico-chemical principles not expected). Introduction to fertilizers.	**14**
	4. Chemistry of Noble Gases Introduction, electronic configuration, chemical properties and uses. Clathrates. Chemistry of xenon; preparation, structure and bonding in xenon compounds (XeF_2, XeF_4, XeO_6, XeO_4, XeO_2F_2, $[XeO_6]^{-4}$, $XeOF_4$).	**04**
	5. Comparative Chemistry of the Transition Metals	**10**

	Introduction, occurrence, electronic configuration, significance and special stability of empty, half-filled and completely filled d-orbitals. Complex formation, variable oxidation states, unusual oxidation states and their stabilities in aqueous solutions (w.r.t. vanadium and chromium), colour, magnetic and catalytic properties of transition metals and their compounds. Chemistry of titanium and vanadium w.r.t. properties of their oxides and chlorides. Qualitative tests for the ions of the first transition series.	
	6. Introduction to Coordination Compounds Molecular compounds: double salts and complex salts. Werner's theory of coordination compounds. Experimental evidences for Werner's theory: Precipitation and Molar conductivity measurements. Terminology and nomenclature of coordination compounds. Coordination numbers and geometries, Effective atomic number Rule. Structural isomerism: Ionization isomerism, Hydration isomerism, Coordination isomerism, Linkage isomerism. Stereoisomerism w.r.t. C.N. = 4 and 6 only. Role of coordination compounds in biology and medicine w.r.t. Chlorophyll, Haemoglobin and cisplatin.	**08**
Pedagogy	1. Lectures and Tutorials, Seminars/ Term papers/ Assignments/ Applicative Quiz sessions/ Presentations / self-study/ industry visit or a combination of some of these can be used. 2. ICT mode will be preferred. 3. Sessions should be interactive in nature to enable peer group discussions and learning.	
References / Readings	1. G. Svehla, Vogel's Qualitative Inorganic Analysis, Pearson Education, (2012). 2. J. Mendham, R. C. Denney, J. D. Barnes, M. Thomas, B. Sivasankar, Vogel's Textbook of Quantitative Chemical Analysis, 6th edn. Pearson Education. 3. J.C. Kotz, Paul M. Treichel, Grabriela C. Weaver, Chemistry and Chemical Reactivity, 6th edn. Thomson Books/Cole (2006). 4. P.L. Soni and Mohan Katyal, Textbook of Inorganic Chemistry by, Sultan Chand and Sons, 20th edn. (1997) 5. Puri, Sharma and Kalia, Principles of Inorganic Chemistry, 33rd edn., Vishal Publishing Co. (2018). 6. J.D. Lee, Concise Inorganic Chemistry by, Chaman, and Hall, 5th edn. (1996). 7. F. A. Cotton, G. Wilkinson, P. L. Gauss, Basic Inorganic Chemistry, 3rd edn. Wiley, (Reprint 2008). 8. N. N. Greenwood, A. Earnshaw, Chemistry of the Elements, Pergamon Press, 1st edn. (1984). 9. Glen E. Rodgers, Inorganic Chemistry, 3rd edn. Brooks/Cole (2012). 10. F. A. Cotton and G. Wilkinson, Advanced Inorganic Chemistry, 3rd edn. 11. P. W. Atkins, T. Overton, J. Rourke, M. Weller, F. Armstrong, Shriver & Atkins Inorganic Chemistry, 5th edn.; Oxford Publications, (2009). 12. Geoff Raymer and Tina Overton, Descriptive Inorganic Chemistry, 4th edn. 13. J.E. Huheey, E.A. Keiter, R.L. Keiter, U.K. Medhi, Inorganic Chemistry –	

	Principles of structure and reactivity by, 1st impression (2006) Pearson Education Publishers. 14. Neil G. Connelly, Ture Damhus, Richard M. Hartshorn, Alan T. Hutton, Nomenclature of Inorganic Chemistry. IUPAC RECOMMENDATIONS 2005, RSC Publishing. 15. Catherine E. Housecroft and Alan G. Sharpe, Inorganic chemistry 4th edn., Pearsons, 2012.

Number of Credits: 01 (Practicals)		
		30hr
Practical course objectives	1. To apply the fundamental theoretical aspects of qualitative inorganic analysis. 2. To use various titrimetric techniques to estimate the analytes. 3. To use gravimetric methods to estimate metal ions. 4. To prepare inorganic coordination compounds.	
Content		**No. of hours**
	Qualitative analysis: (4 mixtures to be analyzed) Semi-micro qualitative analysis of water soluble mixtures containing two cations and two anions. **Cations:** Ba^{2+}, Cu^{2+}, Fe^{2+}, Ni^{2+}, K^{+}, NH_4^{+} **Anions:** CO_3^{2-}, NO_3^{-}, Cl^{-}, SO_4^{2-}, S^{2-} (To precipitate metal sulphide aqueous H_2S solution can be used)	**16**
	Volumetric Analysis 1. Estimation of the amount of nickel in the given nickel sulphate solution (EDTA method). 2. Estimation of Fe (II) ions by titrating it with $K_2Cr_2O_7$ using the internal indicator.	**06**
	Gravimetric Analysis 1. Estimate the amount of Ni as bis-(dimethylglyoximato)nickel(II) in the given solution of nickel chloride using counter poise method. 2. Estimation of Mn as manganese pyrophosphate present in the given manganese sulphate solution. **Inorganic Preparations** 1. Preparation of tris-(ethylenediamine)nickel(II)chloride 2. Preparation of chrome red.	**08**
Pedagogy:	1. Students shall be given pre-lab and post-lab assignments 2. Theoretical concept underlying the experiments prior to each experiment. 3. Each student shall perform the experiments independently.	
References / Readings	1. G. Svehla, Vogel's Qualitative Inorganic analysis, 7th edn. Pearson Education Ltd. 2. V. Alexeyev. Quantitative Analysis. 2nd edn. Mir Publishers. 1969. 3. J. Derek Woollins, Inorganic experiments, WILEY-VCH, 4. George Brauer, Handbook of Preparative Inorganic Chemistry Vol. 2, 2nd edn., Academic Press (1964)	
Course outcome	At the end of this course, students will be able to: 1. explain the principles underlying inorganic qualitative analysis. 2. explain the characteristics of s, p and d-block elements and postulates of	

	Werner's theory of coordination compounds. 3. write IUPAC nomenclature and identify different types of isomers of coordination compounds. 4. describe the structure and bonding in noble gas compounds. 5. perform a qualitative analysis of inorganic mixtures. 6. prepare coordination compounds of transition elements. 7. determine unknown concentration of analytes using volumetric and gravimetric procedures.

Name of the Programme : **B.Sc. Chemistry**
Course Code : **CHC – 204**
Title of the course : **Physical Chemistry I**
Number of Credits : **3T+1P**
Effective from AY : **2024-25**

Pre-requisites for the Course	Students should have basic knowledge of thermodynamics, chemical kinetics and nuclear chemistry	
Course Objectives:	1. To study the laws of thermodynamics and various state functions 2. To understand rates of chemical reactions of zero, first and second order. 3. To introduce the composition of nucleus and study the applications of radioisotopes. 4. To know the photo-physical processes and their significance.	
Content		**No of hours**
	1. Thermodynamics-I First law of thermodynamics, definition of internal energy and enthalpy. Heat capacity: Heat capacities at constant volume and at constant pressure and their relationship, calculation of w, q, dU & dH for the expansion of ideal gases under isothermal and reversible conditions. Second law of thermodynamics: - Statements of second law of thermodynamics. Carnot cycle and its efficiency. Concept of entropy. Entropy as a state function. Entropy as a function of V & T, P & T, entropy change in physical and chemical processes. entropy change in reversible, irreversible and equilibrium conditions. Gibbs free energy and Helmholtz work function. Third law of thermodynamics and calculation of absolute entropies of substance (numericals to be solved).	**13**
	2. Chemical Kinetics-I The concept of reaction rates. Law of Mass action, effect of temperature, pressure and catalyst on reaction rates. Order and molecularity of a reaction. Derivation of integrated rate equations for zero, first and second order reactions (both for equal and unequal concentrations of reactants). Half–life of a reaction. General methods for determination of order of a reaction. Concept of activation energy and its calculation from Arrhenius equation. Introduction to theories of reaction rates (derivations is not required; numericals are expected).	**12**
	3. Nuclear Chemistry Composition of the nucleus, Mass defect and binding energy, Q – value of nuclear reactions, nuclear binding force; Nuclear models – shell model and liquid drop model, radioactive disintegration, decay constant, half life and average life, Group displacement law, units of radioactivity and radiation energy, artificial radioactivity, detection and measurement of radioactivity, ionisation chamber, GM counter and proportional counter, Scintillation counter. Nuclear Fission, discovery, Nuclear reactor – essential parts of the nuclear reactor, classification of nuclear reactors, Breeder reactor, chain reaction and its control, reprocessing of spent fuel, application of radio isotopes- in the field of medicine, agriculture,	**13**

	industry, as traces (2-3 examples of each) and in carbon dating. (numerical to be solved)	
	4. Photochemistry Introduction, Absorption and emission of light and Beer-lamberts law. Laws of photochemistry: Grothus-Draper law, Stark-Einstein law. Quantum yield or efficiency, factors affecting quantum efficiency. Primary and secondary photophysical processes and Jablonski diagram. Kinetics of photochemical reactions of H_2 & Br_2. Distinction between luminescence, fluorescence, phosphorescence and chemiluminescence. Introduction to LASER. (numericals to be solved).	**07**
Pedagogy	Mainly lectures and tutorials. Seminars / term papers /assignments / presentations/ self-study or a combination of some of these can also be used. ICT mode should be preferred. Sessions should be interactive in nature to enable peer group learning.	
References / Readings, References for practicals	1. Bahl and G.D. Tuli, Essentials of Physical Chemistry, S. Chand Publication, 2019, New Delhi, 26th Edition. 2. P. Sharma and Pathania , Principles of Physical Chemistry,Vishal Publishing Co, 2018, Jalandhar, Delhi,1st edition. 3. J.N. Gurtu, Physical Chemistry, Pragati Prakashan, 2020, Meerut, 9th edition. 4. G. Raj, Advanced Physical Chemistry, Goel publication, 36th edition, 2010, Meerut. 5. R. L. Madan, Chemistry for degree students, S Chand publications, 2017, New Delhi, 1st edition. 6. U. N. Dash, Nuclear Chemistry, S. Chand & Sons Publications, 2010, New Delhi. 7. K. K. Rohatgi-Mukherji, Fundamentals of Photochemistry, 3rd edition, New Age international Publishers, 2017, New Delhi. 8. H. J. Arnikar, Essentials of Nuclear Chemistry, New Age International Publishers, New Delhi, 2011, Reprint 2018, 4th edition.	

Practicals **Credits: 01**

Course Objectives:	1. To acquire knowledge on the various types of reactions and their order. 2. To understand the thermodynamic parameters used in laboratory techniques. 3. To study complex formation and determination of stability constant colorimetrically.	
Content		**No of hours**
	1. Compare the strengths of HCl and H_2SO_4 by studying kinetics of hydrolysis of methyl acetate.	**04**
	2. To determine the rate constant and order of reaction between KI and $K_2S_2O_8$.	**04**
	3. Determination of energy of activation for ethyl acetate and NaOH using equal concentration.	**04**
	4. Determination of enthalpy of ionization of Acetic acid and NaOH.	**04**

	5. Determination of enthalpy of neutralization of Acetic acid and NaOH.	**04**
	6. To study complex formation between Ni(II) and O-phenanthroline by Job's method. (Colorimetry)	**02**
	7. To study the complex formation between Fe(III) ions and Salicylic acid and to find the formula and stability constant of the complex using colorimetry.	**04**
	8. To measure the Combustion Enthalpies of Coal via Bomb Calorimetry.	**04**
Pedagogy	Students should be given suitable explanation revising the theoretical aspects prior to the conduct of each experiment and post laboratory assignments to be given. Each student performs the experiment individually.	
References / Readings, References for practicals	1. S. W. Rajbhoj and T. K. Chondhekar, Systematic Experimental Physical Chemistry, Anjali Publication, 2nd Edition, 2000, Aurangabad. 2. Khosla, B. D.; Garg, V. C. &Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co., New Delhi, 2018, 18th edition. 3. O. P. Pandey, D. N. Bajpai, S. Giri, Practical Chemistry, S. Chand Publication, 2013, New Delhi, Revised Edition. 4. B. Viswanathan, P. S. Raghavan, Practical Physical Chemistry, Viva Books Private limited, 2012, Mumbai. 5. J. N. Gurtu and A. Gurtu, Advanced Physical Chemistry Experiments, Pragati Prakashan, 2008, Meerut, Revised Edition. 6. A. M. Ranjika and P. Bopegedera, Evaluating the heats of combustion of coals using Bomb calorimetry in the general chemistry laboratory, *J. Chem. Educ.* 2023, 100, 1, 298–305	
Course Outcome:	At the end of the course, students will be able to 1. calculate and explain various thermodynamic parameters of chemical reactions. 2. differentiate between different nuclear counters. 3. estimate quantum yields of photochemical reactions. 4. compare the strength of the acids. 5. determine graphically order of reaction and estimate the energy of activation. 6. estimate the stability constant of various complexes.	

Name of the Programme : **B.Sc. (Chemistry)**
Course Code : **CHC-205**
Title of the course : **Pharmaceutical Chemistry**
Number of Credits : **2**
Effective from AY : **2024-25**

Prerequisites for the course	Students should have information about different types of diseases and illnesses	
Course Objectives:	1. To understand the terminologies in pharmaceutical chemistry 2. To study the structures of selected drugs. 3. To understand the IUPAC nomenclature of drugs. 4. To predict the mechanism of action and SAR analysis of drugs.	
Content		**No of hours**
	1. Introduction to Pharmaceutical Chemistry Why the need to study pharmaceutical chemistry? Importance of chemistry in pharmacy. Definitions of Pharmaceutical Chemistry, Pharmacophore, Pharmacognosy, Pharmacokinetics, Pharmacodynamics, Pharmacopoiea, Drug. Classifications of drugs based on their uses, definition, giving one example with structure: Anti-infective agents: Antibacterial (Sulphaacetamide), Antifungal (Clotrimazole), Antiviral (Amantadine HCl), Anthelmintics (Mebendazole), Antiamoebic (Metronidazole), Antimalarial (Chloroquine), Antitubercular (Isoniazid), Antihypertensive (Methyl Dopa), Anticoagulant (Warfarin), Diuretics (Acetazolamide), Analgesic (Paracetamol), NSAIDs (Ibuprofen), Local Anaesthetic (Benzocaine), antibiotics (Chloramphenicol), Central nervous depressant (phenobarbital), Anticonvulsant (Phenytoin).	**10**
	2. IUPAC names, Synthesis and uses of following drugs Synthesis of Aspirin, paracetamol, Ibuprofen, Sulphacetamide, Amantadine HCl, Clotrimazole, Phenobarbital, Glyceryl trinitrate, Dapsone, metronidazole.	**06**
	3. Mechanism of Action of representative drugs Analgesic and Anti-inflammatory drugs (Ibuprofen), Antilepral agent (Dapsone), Sulphonamides, antiamoebic (metronidazole), Central nervous depressant (Phenobarbital) , Antimalarial (Chloroquine).	**07**
	4. Structure Activity Relationship of representative drugs Effect of functional groups on physiological activity of drugs: hydroxy, acidic, alkyl, aldehyde, ketone, cyano, halogens, ether and ester groups with one example each Analgesic and Anti-inflammatory drugs (Ibuprofen), Antilepral agent (Dapsone), Sulphonamides (sulphacetamide), antiamoebic (metronidazole), Central nervous depressant (Phenobarbital)	**07**
Pedagogy	Mainly lectures and tutorials. Seminars / term papers /assignments / presentations /industry visits/ self-study or a combination of some of these can also be used. ICT mode should be preferred. Sessions should be interactive in nature to enable peer group learning.	
References /	1. Patrick, G. L., *Introduction to Medicinal Chemistry*, 7th edn., Oxford	

Readings	University Press, UK, 2023. 2. Singh, H. and Kapoor, V.K. *Medicinal and Pharmaceutical Chemistry*, 3rd edn., Vallabh Prakashan, Pitampura, New Delhi, 2012. 3. Foye, W.O. Lemke, T.L. William, D.A., *Principles of Medicinal Chemistry*, 7th edn., B. I. Waverly Pvt. Ltd., New Delhi, 2012. 4. Beale, J. H. and Blocks, J. H., *Wilson and Gisvold's Textbook of Organic, Medicinal and Pharmaceutical Chemistry*, 12th edn., Lippinkott Williams and Wilkins, Philadelphia, USA, 2011. 5. Lednicer, D. and Meischer, L.A., *Organic Chemistry of Drug Synthesis*. Vol. I to III. John Wiley & Sons, New Jersey, USA, 2005. 6. Sriram, D. and Yogeshwari, P., *Medicinal Chemistry*, 1st edn., Pearson Education, London, 2007. 7. Sriram, D.; and Yogeshwari, P., *Medicinal Chemistry*, 2nd edn., Pearson Education, London, 2010. 8. Wolff, M. E., *Burger's Medicinal Chemistry and Drug Discovery*, 5th edn., John Wiley & Sons, New Jersey, USA, 1997.
Course Outcome:	At the end of the course, students will be able to 1. Explain the terminologies in pharmaceutical chemistry. 2. Write the structures of selected drugs. 3. Write the mechanism of action of drugs. 4. Present structure activity relationship analysis of drugs.

ATMANIRBHAR BHARAT
SWAYAMPURNA GOA

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(Accredited by NAAC)

GU/Acad –PG/BoS -NEP/2024/100 Date: 16.05.2024

Ref: GU/Acad –PG/BoS -NEP/2023/102/8 dated 15.06.2023

CIRCULAR

In supersession to the above referred Circular, the Syllabus of Semester III to VIII of the **Bachelor of Science in Microbiology** Programme approved by the Standing Committee of the Academic Council in its meeting held on 06th, 07th and 21st March 2024 is enclosed. The syllabus of Semester I and II approved earlier is also enclosed.

The Dean/ Vice-Deans of the School of Biological Sciences and Biotechnology and Principals of the Affiliated Colleges offering the **Bachelor of Science in Microbiology** Programme are requested to take note of the above and bring the contents of the Circular to the notice of all concerned.

ASHWIN VYAS LAWANDE
Digitally signed by ASHWIN VYAS LAWANDE
Date: 2024.05.16 10:46:31 +05'30'

(Ashwin Lawande)
Assistant Registrar – Academic-PG

To,

The Principals of Affiliated Colleges offering the Bachelor of Science in Microbiology Programme.

Copy to:

1. The Director, Directorate of Higher Education, Govt. of Goa
2. The Dean, School of Biological Sciences and Biotechnology, Goa University.
3. The Vice-Deans, School of Biological Sciences and Biotechnology, Goa University.
4. The Chairperson, BOS in Microbiology.
5. The Controller of Examinations, Goa University.
6. The Assistant Registrar, UG Examinations, Goa University.
7. Directorate of Internal Quality Assurance, Goa University for uploading the Syllabus on the University website.

Programme Structure for Semester I to VIII Bachelor of Science in Microbiology										
Semester	Major -Core	Minor	MC	AEC	SEC	I	D	VAC	Total Credits	Exit
I	MIC-100 Basics of Microbiology (4) (3T+1P)	MIC-111 Microbial Ecology and Environment (4)	MIC-131 Introduction to Microbial World (3)	English	MIC-141 Techniques in Microbiology - Staining and Microscopy (3) (1T+2P)				20	--
II			MIC-132 Microbiology in Everyday Life (3)	English	MIC-142 Techniques in Microbiology: Microbial Cultivation and Enumeration (3) (1T+2P)				20	MIC-161 Laboratory Skills in Microbiology (4)
III	MIC-200 Microbial Biochemistry (4) MIC 201	MIC-211 Environmental Microbiology (4)	MIC-231 Scope of Microbiology (3)	MIL	MIC-241 Dairy Microbiology (3) (1T+2P)				20	--

	Molecular Biology (4)								
IV	MIC-202 Cell Biology (4) MIC-203 Microbial Physiology (4) MIC-204 Microbial Genetics (4) MIC-205 Basic Biostatistics (2)	MIC-221 Instrumentation in Microbiology (4)	MIL					20	MIC-261 Quality control and assurance in microbial processes and products (4)

SEMESTER III

Name of the Programme : B.Sc. Microbiology
Course Code : MIC-200
Title of the Course : MICROBIAL BIOCHEMISTRY
Number of Credits : Theory - 3, Practical - 1
Effective from AY : 2024-25

Prerequisites for the Course	Should know basics of chemistry and microbiology	
Objectives	1. To familiarize students with the structure of biomolecules (carbohydrates, lipids, and proteins), the basic building blocks of microorganisms. 2. To comprehend the structure and function of enzymes as biological catalysts, with an insight into enzyme kinetics, mechanism of enzyme action and regulation. 3. To interpret the association between structure and function of biomolecules in microorganisms. 4. To acquire hands-on experience in the detection and estimation of carbohydrates, proteins, and lipids.	
Content		**No. of Hours**
1	**Unit -1**	**(15)**
A	**Carbohydrates:** Families of monosaccharides: aldoses and ketoses, trioses, tetroses, pentoses, and hexoses. Stereo isomerism of monosaccharides, epimers, Mutarotation and anomers of glucose. Furanose and pyranose forms of glucose and fructose, Haworth projection formulae, chair, and boat form of glucose. Sugar derivatives, glucosamine, muramic acid, N- acetyl neuraminic acid, Disaccharides; concept of reducing and non-reducing sugars, occurrence and Haworth projections of maltose, lactose, and sucrose, Polysaccharides, storage polysaccharides, starch, and glycogen. Structural Polysaccharides, cellulose, peptidoglycan, and chitin.	**10**
B	**Lipids – I:** Definition and major classes of storage and structural lipids. Storage lipids; Fatty acid structure and functions. Triacyl glycerol structure, functions, and properties. Essential fatty acids. Saponification.	**5**
2	**Unit - 2**	**(15)**
A	**Lipids -II:** Structural lipids; Phosphoglycerides: Building blocks, General structure, functions, and properties. Structure of phosphatidylethanolamine and phosphatidylcholine, Sphingolipids: building blocks, structure of sphingosine, ceramide. Polyhydroxyalkanoates. Introduction of lipid micelles, monolayers, and bilayers. Overview on functions of lipids.	**5**
B	**Proteins:** Functions of proteins, Primary structures of proteins: Amino acids, the building blocks of proteins. General formula of amino acid and concept of zwitterion. biochemical structure, and notation of standard protein amino acids, Ninhydrin reaction. Secondary structure of proteins: Peptide unit. The alpha helix, the beta pleated sheet and their occurrence in proteins, tertiary, and quaternary structures of proteins. Forces holding the polypeptide together, Quaternary structures of proteins with	**10**

	examples.	
3	**Unit - 3**	**(15)**
A	**Enzymes – I:** Structure of enzyme: Apoenzyme and cofactors, prosthetic group-TPP, coenzyme - NAD, metal cofactors, Classification of enzymes, Mechanism of action of enzymes: active site, transition state complex and activation energy. Lock and key hypothesis, and Induced Fit hypothesis. Effect of pH and temperature on enzyme activity. Enzyme inhibition: competitive- sulfa drugs; non-competitive-heavy metal salts	**10**
B	**Enzymes-II:** Michaelis-Menten kinetics - Km, V_{max}. Definitions of terms – enzyme unit, specific activity, and turnover number, Multienzyme complex: pyruvate dehydrogenase; isozyme: lactate dehydrogenase.	**5**
4	**Unit - 4 Practical**	**(30)**
1.	Tests for carbohydrates, reducing sugars, non-reducing sugars. (Fehling, Benedict, Molisch, Iodine)	**4**
2.	Tests for lipids. (Determination of free fatty acids, saponification)	**4**
3.	Color reactions of proteins. (Biuret, Ninhydrin reaction)	**4**
4.	Quantitative tests for sugars (DNSA).	**4**
5.	Quantitative tests for proteins (Biuret).	**4**
6.	Study of enzyme kinetics – calculation of V_{max} and Km values	**4**
7.	Effect of pH and temperature on enzyme activity	**6**
Pedagogy:	Lectures/tutorials/assignments/Laboratory Experiments/ Demonstration	
References/ Reading	1. Berg JM, Tymoczko JL and Stryer L (2011) Biochemistry, W.H.Freeman and Company 2. Conn E and Stumpf P (2009) Outlines of biochemistry. 5th Edition. John Wiley and Sons. 3. Frobisher M (1963) Fundamentals of Microbiology, 6th Edition. W. B. Saunders Co, Philadelphia. 4. Jayaraman J (2011) Laboratory Manual in Biochemistry. 2nd edition. New Age International (P). Ltd. Publishers. 5. Nelson DL and Cox MM (2008) Lehninger Principles of Biochemistry, 5thEdition., W.H. Freeman and Company. 6. Pelczar, M.J., Chan, E.C.S. and Kreig, N.R. (2002) Microbiology. 5th Edition, Tata McGraw-Hill, New Delhi. 7. Plummer DT (2017) An Introduction to Practical Biochemistry. 3rd Edition. Tata McGraw Hill Publishers. 8. Voet D and Voet JG (2004) Biochemistry 3rd edition, John Wiley and Sons. 9. Willey JM, Sherwood LM, and Woolverton CJ (2013) Prescott's Microbiology. 9th Edition. McGraw Hill Higher Education.	
Course outcome	The student would have: 1. Identified structures of carbohydrates, proteins and lipids and explain their biological importance. 2. Explained structure and function of enzymes with reference to lock- and-key and induce-fit models. 3. Analyzed the factors affecting enzyme activity and apply the kinetics of enzymes such as Michaelis-Menten and LB plot. 4. Applied the techniques involved in biochemical methods for isolation and analysis of biomolecules.	

Name of the Programme : **B.Sc. Microbiology**
Course Code : **MIC-201**
Title of the Course : **MOLECULAR BIOLOGY**
Number of Credits : **Theory - 3, Practical - 1**
Effective from AY : **2024-25**

Prerequisites for the Course	Should know basics of microbiology	
Objectives	1. To understand the structure of nucleic acids and the processes of replication, transcription, and translation in prokaryotes and eukaryotes. 2. To illustrate and interpret the role of DNA, RNA, and proteins in life processes in microorganisms at molecular level. 3. To appraise and distinguish the significance of replication, transcription, and translation in bacteria 4. To measure nucleic acids and proteins, integrate their importance in bacteria, and create experiments to demonstrate the impact of inhibitors on the same.	
Content		**No. of Hours**
1	**Unit – 1**	**(15)**
A	**Nucleic acids:** Nucleosides and nucleotides as building blocks of nucleic acids. **DNA:** Watson – Crick model of DNA; Prokaryotic DNA (Circular DNA, Supercoiled, Palindromic), Plasmids; Eukaryotic DNA (Repetitive sequences, split genes, nucleosomes), mitochondrial and chloroplast DNA; Guanine quadruplex (G4) DNA. **RNA:** mRNA, rRNA, tRNA, non-coding RNA, microRNA and Si RNA.	**8**
B	**Replication of DNA - I :** Modes of replication - Conservative, semi conservative (Meselson - Stahl experiment) and dispersive; Processes and enzymes involved in replication; Inhibitors of replication;	**7**
2	**Unit – 2**	**(15)**
A	**Replication of DNA – II:** Models of replication in prokaryotes and eukaryotes - Rolling circle model/sigma, theta and linear. Differences between prokaryotic and eukaryotic replication process.	**3**
B	**Transcription:** Initiation, Elongation, Termination; post transcriptional modification - RNA splicing (Ribozyme), Reverse transcriptase and its implication, Inhibitors of transcription. Concept of operon. Differences between prokaryotic and eukaryotic transcription process.	**12**
3	**Unit – 3**	**(15)**
A	**Translation I:** Concept of genetic code, Properties: codon/ anticodon, Wobble hypothesis, start and stop codons; Ribosomes as sites of protein biosynthesis; amino acid activation and specificity; Initiation, Elongation, Termination.	**10**
B	**Translation II:** Post translational processing and modification; Inhibitors of protein synthesis. Differences between prokaryotic and eukaryotic translation process.	**5**
4	**Unit - 4 Practical**	**(30)**
1.	Study of different types of DNA and RNA using micrographs.	**2**
2.	Extraction of genomic DNA, quantitative estimation (A_{260}) and estimation of purity ($A_{260/280}$).	**2**
3.	Agarose gel electrophoresis for genomic DNA	**4**
4.	Estimation of DNA by Diphenylamine method;	**2**

5.	Estimation of RNA by Orcinol method;	**2**
6.	Estimation of Protein by Folin-Lowry method	**2**
7.	Effect of replication inhibitor on bacterial growth	**4**
8.	Effect of transcription inhibitor on bacterial growth	**4**
9.	Effect of protein synthesis inhibitor on bacterial growth	**4**
10.	Demonstration of lac operon using growth of *E. coli* by diauxic growth curve.	**4**
Pedagogy:	Lectures/tutorials/assignments/Laboratory Experiments/Demonstration	
References/ Reading	1. Frobisher M, (1974) Fundamentals of Microbiology, 9th edition, W. B. Saunders Co, Philadelphia. 2. Gardner EJ, Simmons MJ, Snustad DP (2006). Principles of Genetics, 8th eidition. Wiley-India. 3. Goodenough U, (1974) Genetics, Holt, Rinehart & Winston of Canada Ltd. 4. Krebs JE, Goldstein ES, Kilpatrick ST (2017) Lewin's Genes XII, Jones and Bartlett Publishers. 5. Maloy SR, Cronan JE and Friefelder D. (2004) Microbial Genetics 2nd edition, Jones and Barlett Publishers. 6. Nelson DL and Cox MM (2008). Lehninger Principles of Biochemistry, W.H. Freeman and Company. 7. Pelczar MJ, Chan ECS and Krieg NR (2002). Microbiology. McGraw Hill Book Company. 8. Stanier RY, Ingraham JI, Wheelis ML and Painter PR (1986). General Microbiology, 5th edition. McMillan Press. 9. Strickberger M (1995), Microbial Genetics, 3rd edition, Prentice Hall India Learning Private Limited 10. Tymoczko JL, Berg JM and Stryer L. (2002) Biochemistry, 5th edition, W.H. Freeman and Company 11. Willey JM, Sherwood LM, and Woolverton CJ (2013) Prescott's Microbiology. 9th Edition. McGraw Hill Higher Education. E-books / Journals.	
Course outcome	1. Understood the structure of nucleic acids and the processes of replication, transcription, and translation in prokaryotes and eukaryotes. 2. Explained the role of DNA, RNA, and proteins in life processes in microorganisms at molecular level. 3. Applied the techniques of molecular biology in replication, transcription, and translation in bacteria. 4. Designed the experiments to demonstrate effect of biomolecules on molecular processes in bacteria.	

SEMESTER IV

Name of the Programme : B.Sc. Microbiology
Course Code : MIC-202
Title of the Course : CELL BIOLOGY
Number of Credits : Theory - 3, Practical - 1
Effective from AY : 2024-25

Prerequisites for the Course	Foundational knowledge in general biology, chemistry, biochemistry, genetics, and basic mathematics and statistics.	
Objectives	1. To study the types and functioning of different cellular structures of prokaryotic cells & organelles in eukaryotic cells 2. Explore the molecular mechanisms underlying cellular processes such as cell signaling and protein transport 3. Develop critical thinking, analytical skills, and the ability to apply knowledge to solve problems in cell biology research and applications. 4. To gain understanding of Cancer types, Cell cycle and Cell death.	
Content		**No. of Hours**
1	**Unit - 1**	**(15)**
A	**Introduction to cell biology & Ultrastructure:** Overview of cell theory, Prokaryotic cell structure & function - cell wall, cell membrane, ribosomes & nucleoid, Eukaryotic cell structure & function - Cell membrane, cellular organelles - Nucleus, ER, Golgi apparatus, cytoskeleton, cellular junctions - adhesion junctions, tight junctions, gap junctions, and plasmodesmata.	**7**
B	**Cell Signaling:** Types of cell signaling, Pathways: Bacterial Chemotaxis, Quorum sensing in bacteria, Cyclic GMP and MAP kinase pathway, CFTR, Calmodulin.	**8**
2	**Unit - 2**	**(15)**
A	**Eukaryotic Cell Cycle:** Regulation of eukaryotic cell cycle, mitosis and meiosis. Cell death and apoptosis (Intrinsic and Extrinsic pathways)	**5**
B	**Protein Sorting and Transport:** Targeting and insertion of proteins in the ER, protein folding, processing and quality control in ER, export of proteins and lipids. Protein organization, glycosylation, protein sorting and export from Golgi Apparatus.	**10**
3	**Unit - 3**	**(15)**
A	**Cancer and abnormal cell division:** Introduction to cancer, Oncogenes, Tumor suppressor genes, Properties of cancer cells, Introduction to stem cells	**5**
B	**Development of Cancer, causes and types:** Development of cancer cells (activation of cell division), Symptoms, Causes, Risk factors, Classification (benign and malignant), Different types (Carcinoma, Sarcoma, Leukemia, Lymphoma and Myeloma), Stages of cancer (Histological classification).	**10**
4	**Unit - 4 Practical**	**(30)**
1.	Study of stages of mitosis.	**2**
2.	Study of stages of meiosis.	**2**
3.	Study of gap junctions through electron micrographs.	**2**
4.	Identification and study of cancer cells by photomicrographs.	**4**
5.	Demonstration of quorum sensing (Swarming by *Proteus*).	**8**
6.	Demonstration of positive and negative chemotaxis (Effect of attractants and repellents on *E.coli*).	**8**

7.	Study of apoptosis and necrosis using electron micrographs	**4**
Pedagogy:	Lectures/tutorials/assignments/Laboratory Experiments/Demonstration	
References/ Reading	1. Adler J. (1975) Chemotaxis in Bacteria. Annual Reviews of Biochemistry. 44:341-356. 2. Alberts B, Johnson A, Lewis J, Raff M, Roberts K, Walter P, (2002) Molecular Biology of The Cell, 4th Edition, Garland science, Taylor and Francis group 3. Cooper GM, Hausman RE, (2013), The Cell: A Molecular Approach, 6th Edition, ASM Press & Sunderland, Washington, D.C.; Sinauer Associates, MA, 4. De Robertis EDP, De Robertis EMF, (2017) Cell and Molecular Biology, 8th Edition, Lipincott Williams and Wilkins, Philadelphia 5. Hardin J, Bertoni G, Kleinsmith LJ, (2021) Becker's World of the Cell. 10th Edition, Pearson. 6. Karp G. (2013) Cell and Molecular Biology: Concepts and Experiments, 7th Edition, John Wiley & Sons. Inc. 7. Lodish H, Berk A, Kaiser C, Krieger M, Scott M, Bretscher A, Ploegh H, Matsudaira P, (2016) Molecular cell biology, 8th Edition W H Francis and company, NewYork,	
Course outcome	The students shall be able to 1. Demonstrate a comprehensive understanding of the fundamental concepts, structures, and functions of cells and their organelles. 2. Utilize laboratory techniques and methodologies effectively to conduct experiments, analyze results, and draw evidence-based conclusions. 3. Gain in depth knowledge of different types of cancers and their occurrence 4. Understand the concept of protein sorting and transport in eukaryotic cells	

Name of the Programme : **B.Sc. Microbiology**
Course Code : **MIC 203**
Title of the Course : **MICROBIAL PHYSIOLOGY**
Number of Credits : **Theory - 3, Practical - 1**
Effective from AY : **2024-25**

Prerequisites for the Course	Should have knowledge of basic principles of chemistry and structures of biomolecules.	
Objectives	1. To understand the energetics and biochemistry of metabolic pathways 2. To acquire a comprehensive understanding of chemoheterotrophic carbohydrate, protein and lipid metabolism. 3. To comprehend the phototrophic metabolism and appreciate the differences between anoxygenic and oxygenic photosynthesis. 4. To demonstrate various metabolic processes in bacteria.	
Content		**No. of Hours**
1	**Unit - 1**	**(15)**
A	**Bioenergetics and Electron transport chain:** Definitions of Gibb's Free Energy, Standard free energy change and equilibrium constant, Coupled reactions and additive nature of standard free energy change, ATP as an Energy-rich compounds, Substrate level phosphorylation	**5**
B	**Electron transport chain:** Chemiosmotic theory, ETC and oxidative phosphorylation, ATP Synthase, Binding change mechanism of ATP synthesis, Inhibitors of ATP synthesis	**5**
C	**Chemoheterotrophic Carbohydrate Anabolism:** Gluconeogenesis, Biosynthesis of Glycogen and peptidoglycan	**5**
2	**Unit - 2**	**(15)**
A	**Chemoheterotrophic Carbohydrate Catabolism:** Glycolysis, Fermentation, Pasteur effect, TCA Cycle, Glyoxylate cycle (Amphibolic pathway, Anaplerotic reactions), HMP pathway, ED pathway, Glycogenolysis.	**10**
B	**Chemoheterotrophic Lipid Metabolism: Catabolism:** Beta oxidation, Omega-oxidation. **Anabolism:** Biosynthesis of saturated fatty acids and poly beta-hydroxybutyric acid	**5**
3	**Unit - 3**	**(15)**
A	**Chemoheterotrophic Protein Metabolism Catabolism:** Digestion Deamination, Decarboxylation, Stickland reaction.	**5**
B	**Phototrophic Metabolism:** Introduction to phototrophic metabolism, Characteristics of major groups of phototrophic microorganisms: Photoautotrophy and Photoheterotrophy, Oxygenic photosynthesis vs Anoxygenic photosynthesis, Electron flow and ATP synthesis in Oxygenic photosynthesis (cyanobacteria) and Anoxygenic photosynthesis (Green sulfur bacteria), Autotrophy: Calvin cycle and Reverse citric acid cycle	**10**
	PRACTICALS	**(30)**
1.	Numerical problems on calculations of Standard Free Energy Change and Equilibrium constant	**2**
2.	Detection of mixed acid fermentation and butanediol fermentation in bacteria	**2**
3.	Detection of citrate and tryptophan utilization by bacteria	**2**
4.	Fermentation - Sugars, HL test	**2**

5.	Estimation of lactic acid/acetic acid	**4**
6.	Standard curve for starch	**2**
7.	Staining of PHB granules	**2**
8.	Chromatographic separation of amino acids by paper chromatography	**2**
9.	Cultivation of and staining of photosynthetic bacteria from pond water	**4**
10.	Detection of bacterial enzyme activity: amylase, caseinase, catalase, nitratase, urease, lipase, pectinase, cellulase	**8**
Pedagogy:	Lectures/tutorials/assignments/Laboratory Experiments/Demonstration	
References/ Reading	1. Berg JM, Tymoczko JL and Stryer L. (2002) Biochemistry, W.H. Freeman and Company. 2. Conn E and Stumpf P. (2009) Outlines of biochemistry, 5th edition. John Wiley and Sons 3. Jayaraman J. (2011) Laboratory Manual in Biochemistry. New Age International (P). Ltd. Publishers 4. Moat AG, Foster JW, Spector MP (2009) Microbial Physiology, 4ed. John Wiley & Sons 5. Murray RK et al. (2016) Harper's Illustrated Biochemistry 28th Edition. The McGraw-Hill Companies, Inc 6. Nelson DL and Cox MM. (2021) Lehninger Principles of Biochemistry. Macmillan Learning 7. Pawar, CB and Daginawala HF (2010) General Microbiology Volume I. Himalaya Publishing House 8. Plummer DT. (2017) An Introduction to Practical Biochemistry. Tata McGraw Hill Publishers 9. Stanier RY, Ingraham JL, Wheelis ML, and Painter PR. (2005). General Microbiology. 5th edition. McMillan. 10. Voet, D. and Voet J.G. (2010) Biochemistry. 4th edition. John Wiley and Sons.H. Freeman and Company. 11. Wiley JM, Sherwood LM, Woolverton CJ. (2013) Prescott's Microbiology. 9th Edition. McGraw Hill International.	
Course outcome	Student will be able to: 1. Gain knowledge of energy transfers and biomolecular transformations. 2. Comprehend metabolic pathways of carbohydrate, protein and lipid metabolism. 3. Understand the distinct groups of phototrophic microorganisms and the differences between anoxygenic and oxygenic photosynthesis. 4. Apply the techniques to understand the physiology of microorganisms.	

Name of the Programme : **B.Sc. Microbiology**
Course Code : **MIC-204**
Title of the Course : **MICROBIAL GENETICS**
Number of Credits : **Theory - 3, Practical - 1**
Effective from AY : **2024-25**

Prerequisites for the Course	Basic knowledge of cell biology, nucleic acids and their functions.	
Objectives	1. To comprehend gene expression and regulation. 2. To explore the various types of gene transfer mechanisms in bacteria. 3. To understand the molecular processes in genetic recombination 4. To investigate the causes of mutations, study the types and carry out procedures for detection of mutants.	
Content		**No. of Hours**
1	**Unit – 1**	**(15)**
A	**Gene expression and regulation** General Structure of Operon: Structural and regulatory genes, Induction and repression; catabolite repression. Positive and negative regulation of lac operon. Trp operon, structure and regulation.	**5**
B	**Gene transfer mechanisms I: Transformation:** Griffith's experiment; Avery MacLeod and McCarty's experiment. Factors affecting transformation Competence factor. Steps in transformation.	**5**
C	**Gene transfer mechanisms II: Transduction:** Davis' U-Tube experiment. Lyti and lysogenic cycles. Generalized, Specialized, Complete and Abortive Transduction	**5**
2	**Unit – 2**	**(15)**
A	**Gene transfer mechanisms III: Conjugation:** Gene transfer by F+ strains, Hfr donor, F-prime state. Chromosome mapping.	**5**
B	**Molecular Recombination:** General features of recombination, types of recombination. Models for reciprocal and non-reciprocal recombination – Holliday's model	**5**
C	Fox Model, evidence for Fox and Holliday's model, Rec A and Rec BCD complex.	**5**
3	**Unit – 3**	**(15)**
A	**Mutations:** Spontaneous Mutations, Concept of spontaneous mutations and mechanisms. Principle, methodology and significance of replica plating, fluctuation test and Gradient plate method. Auxotrophs	**5**
B	**Types of mutations:** Point mutations: base pair substitution, tautomerism (transitions, transversions). Frame shift (slippage). Missense, nonsense, silent, conditional, suppressor (intragenic, extragenic). Large deletions.	**5**
C	**Induced Mutations:** Physical /chemical mutagens. Teratogenicity testing – Ames test. **Site directed mutagenesis.** **DNA damage and repair Mechanisms** (light/dark repair).	**5**
	Unit - 4 Practical	**(30)**
1.	Preparation of competent cells for transformation.	**5**
2.	Bacterial transformation.	**5**
3.	Bacterial conjugation.	**5**
4.	Replica plate technique.	**5**
5.	Gradient Plate Technique	**5**

6.	UV Survival curve with effect of dark repair mechanism	**5**
Pedagogy	Lectures/Tutorials/Assignments/Demonstrations/Group Discussions/Laboratory Experiments	
References/ Reading	1. Berg JM, Tymoczko JL and Stryer L. (2002) Biochemistry, W.H. Freeman and Company. 2. Gardner, E.J., Simmons, M.J. and Snustad, D.P. (2006) Principles of Genetics, 8th eition. Wiley-India. 3. Nelson DL and Cox MM. (2021) Lehninger Principles of Biochemistry. Macmillan Learning 4. Pelczar MJ, Chan ECS and Krieg NR. (1993). Microbiology. 5th edition. McGraw Hill Book Company 5. Primrose, S.B., Twyman, R.M. (2006) Principles of Gene Manipulation. Wiley-Blackwell. 6. Sambrook, J. and Russell, D. (2012) Molecular Cloning: A Laboratory Manual. Cold Spring Harbor Laboratory Press 7. Stanier RY, Ingraham JL, Wheelis ML, and Painter PR. (2005). General Microbiology. 5th edition. McMillan. 8. Wiley JM, Sherwood LM, Woolverton CJ. (2013) Prescott's Microbiology. 9th Edition. McGraw Hill International.	
Course Outcomes	Students would have: 1. Understood the mechanism of gene expression and regulation in prokaryotes. 2. Learned of the discovery of the various mechanisms of gene transfer and understood the mechanisms and applications of horizontal gene transfer. 3. Comprehended the molecular mechanisms of genetic recombination. 4. Described various types of mutations, determined their in microbial genetics and detect mutants in a population.	

Name of the Programme : **B.Sc. Microbiology**
Course Code : **MIC-205**
Title of the Course : **BASIC BIOSTATISTICS**
Number of Credits : **Theory - 2**
Effective from AY : **2024-25**

Prerequisites for the Course	Mathematics fundamentals, computer knowledge	
Objective:	The students will be able to 1. Understand the different tools for data analysis 2. Apply the appropriate tool for data processing of biological data 3. Interpret statistical information 4. Use appropriate tools for data representation	
Content:		**No. of Hours**
1	**Unit – 1**	**(15)**
A	**Biological data and its processing:** Types of Data (qualitative and quantitative, Primary & Secondary data), Characteristics of biological data (Variables and constants, discrete and continuous variables, relationship and prediction); Types of measurements of biological data (interval scale, ratio scale, ordinal scale, nominal scale, discrete and continuous data).	**5**
B	Population and samples, random samples, parameter and statistics, Tabulation and frequency distribution, relative frequency distribution, cumulative frequency distribution. Graphical representation: types of graphs, and their applications	**5**
C	Meaning, computation, scope, limitations of Measures of central tendency (simple Mean, Mode and Median of grouped and ungrouped data), Measures of Dispersion (standard deviation) and Measure of Asymmetry (Skewness). Relationship between mean, median, mode	**5**
2	**Unit – 2**	**(15)**
A	**Statistical concepts:** Sampling Distributions: Concept with example of sampling distribution of mean; Normal distributions and its characteristics; source and classification of errors	**5**
B	Basic concepts concerning testing of hypotheses: Meaning of hypothesis, meaning and construction of Null hypothesis and alternative hypothesis, steps in hypothesis testing, confidence limits and the level of significance, critical region	**5**
C	Large Sample Test based on Normal Distribution (Z test) and Small sample test: t-test	**5**
Pedagogy:	Lectures, seminars, assignments and problem solving.	
References/ Readings	1. Banerjee P. K. (2007) Introduction to Biostatistics. Chand S. & COmpany 2. Bonamente M. (2017) Statistics and Analysis of Scientic Data. 3. Springer Heumann C, Shalabh MS. (2016) Introduction to Statistics and Data Analysis With Exercises, Solutions and Applications in R. Springer 4. Kothari CR (2004) Research Methodology – methods and techniques. New Age International (P) Limited, Publishers New Delhi 5. Medhi J. (2005) Statistical Methods. New age International Publishers. 6. Rastogi V. B. (2009) Fundamentals of Biostatistics. Ane Books Pvt. Ltd. New Delhi	
Course Outcomes	The students will 1. Have understood the meaning of data and its types	

	2. Have understood the different tools for data analysis 3. Apply and use appropriate tool for data processing 4. Interpret statistical information

ATMANIRBHAR BHARAT
SWAYAMPURNA GOA

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(Accredited by NAAC)

GU/Acad –PG/BoS -NEP/2024/97 Date: 15.05.2024

Ref: GU/Acad –PG/BoS -NEP/2023/102/7 dated 16.06.2023

CIRCULAR

In supersession to the above referred Circular, the updated approved Syllabus of the **Bachelor of Science in Botany** Programme approved by the Standing Committee of the Academic Council in its meeting held on 06th, 07th and 21st March 2024 is enclosed.

The Dean/ Vice-Deans of the School of Biological Sciences and Biotechnology and Principals of the Affiliated Colleges offering the **Bachelor of Science in Botany** Programme are requested to take note of the above and bring the contents of the Circular to the notice of all concerned.

ASHWIN VYAS LAWANDE
Digitally signed by ASHWIN VYAS LAWANDE
Date: 2024.05.15 14:30:46 +05'30'

(Ashwin Lawande)
Assistant Registrar – Academic-PG

To,

The Principals of Affiliated Colleges offering the Bachelor of Science in Botany Programme.

Copy to:

1. The Director, Directorate of Higher Education, Govt. of Goa
2. The Dean, School of Biological Sciences and Biotechnology, Goa University.
3. The Vice-Deans, School of Biological Sciences and Biotechnology, Goa University.
4. The Chairperson, BOS in Botany.
5. The Controller of Examinations, Goa University.
6. The Assistant Registrar, UG Examinations, Goa University.
7. Directorate of Internal Quality Assurance, Goa University for uploading the Syllabus on the University website.

GOA UNIVERSITY

Programme Structure for Semester I to VIII Bachelor of Science in Botany

Semester	Major -Core	Minor	MC	AEC	SEC	I	D	VAC	Total Credits	Exit
I	BOT-100 #@$%&* Fundamentals of Botany (3T+1P)	BOT-111 Plants in Everyday Life (4T)	BOT-131 Kitchen Gardening (3) OR BOT-132 Ecosystem Diversity (3)	(2)	BOT-141 Nursery and Gardening (1T+2P)					
II				(2)						BOT-161 Floriculture (1+3)
III	BOT-200 @%* Diversity of Microbes and Non-flowering plants (3T+1P) BOT-201 #$& Plant Physiology (3T+1P)	BOT-211 Algal Plant-Animal Interactions (3T+1P) OR BOT-212 Soil and Water Analysis (3T+1P)	BOT-231 Plant Propagation Methods (3T)	(2)	BOT-241 Herbal Technology (1T+2P)					

IV	BOT-202 #$& Anatomy and Reproductive Biology of Flowering Plants (3T+1P) BOT-203 #$& Cell Biology and Plant Biochemistry (3T+1P) BOT-204 @%* Biofertilizers (3T+1P) BOT-205 #$& Palynology (1T+1P)	BOT-221 Techniques in Floral Arrangement (2T+2P) [VET] OR BOT-222 Ecotourism (2T+2P) [VET]								BOT-261 Organic farming (1+3)
V	BOT-300 #$& Plant Taxonomy and Phylogeny (3T+1P) BOT-301 #$& Cytogenetics and Plant Breeding (3T+1P)	BOT-321 Mushroom Cultivation Technology (3T+1P) [VET]				BOT-361 Internship- (2)				

Disciplinary/Interdisciplinary Minor

Name of the Programme : B. Sc. (Botany)
Course Code : BOT-212
Title of the Course : Soil and Water Analysis
Number of Credits : 4 (3 Theory + 1 Practical)
Effective from AY : 2024-25

Prerequisites for the course:	Basic knowledge of soil, water and biology.	
Course Objectives:	This course is aims to: 1. Enhance students' understanding of the properties of soil and water. 2. Impart skills in soil and water sampling and analysis techniques. 3. Foster the ability to interpret experimental results of soil and water quality. 4. Raise awareness on the significance of soil and water quality on plants and ecosystems.	
Content:	**Theory:**	**45 hours**
	Module 1: Fundamentals of soil and water analysis **Introduction to soil and water quality maintenance:** Importance and scope; significance in agriculture, natural vegetation, and ecosystem management; relationship between soil and water quality. **Properties of soil**: Soil types, composition, soil profile; soil structure and permeability; soil temperature, pH, electrical conductivity and moisture content. **Physico-chemical properties of water:** pH, electrical conductivity, temperature, turbidity; Total Dissolved Solids (TDS), dissolved CO_2, dissolved oxygen; Chemical Oxygen Demand (COD), Biological Oxygen Demand (BOD), Total Organic Carbon (TOC); nutrient levels (nitrogen and phosphorus) and heavy metals. **Environmental impact assessment:** Soil degradation and water pollution (causes and effects); mitigation measures for sustainable plant growth.	**15 hours**
	Module 2: Soil analysis and evaluation **Soil sampling and analysis**: Soil sampling tools (soil auger, shovel/spade, hand trowel); soil sampling methods (simple random sampling, composite sampling); preparation of soil samples for analysis (air and oven drying). Methods of physico-chemical analysis - soil colour, texture, water holding capacity, moisture content, electrical conductivity, pH, organic matter, water-soluble salts and levels of nitrogen and ammonia. **Microbial flora of soil**: Soil microorganisms (bacteria, fungi, algae, protozoa, viruses); factors affecting soil microbial population; microbiological tests for soil fertility (phosphate solubilization, denitrification). **Soil factors affecting plant growth**: Soil fertility, productivity, and nutrient toxicity; symptoms of nutrient toxicity in plants;	**15 hours**

	presence of heavy metals, pesticides and herbicides.	
	Module 3: Water analysis and quality assessment **Water sampling and analysis**: Methods of water sampling (grab sampling, integrated sampling); sample handling and preparation for analysis. Methods of physico-chemical analysis - turbidity, transparency, colour, odour, temperature, pH, electrical conductivity, total dissolved solids (TDS), hardness, alkalinity, dissolved oxygen, water-soluble salts, biological oxygen demand (BOD), chemical oxygen demand (COD), total organic carbon (TOC) and heavy metals (Pb, Hg). **Irrigation water quality assessment**: Parameters for assessing water quality for irrigation; phytoplankton and its impact on water quality. **Microbial analysis of water**: Detection of pathogens in water (indicator organisms); waterborne diseases and prevention; drinking water quality standards for India (BIS standards) and Water Quality Index (WQI).	**15 hours**
	Practical:	**30 hours**
	1. Study of instruments used for soil and water analysis - soil thermometer, pH meter, conductivity meter, Secchi disk.	**2 hours**
	2. Determination of soil texture.	**2 hours**
	3. Determination of water holding capacity of different soil samples (sand, loam and clay).	**2 hours**
	4. Analysis of carbonates, chlorides, nitrates, sulphates, organic matter and base deficiency of any two soil samples by rapid field tests.	**4 hours**
	5. Determination of organic matter of soil sample by Walkley & Black's rapid titration method.	**2 hours**
	6. Determination of electrical conductivity of any two soil and water samples.	**4 hours**
	7. Determination of pH of any two soil and water samples using universal indicator and pH meter.	**2 hours**
	8. Determination of Total Solids (TS), Total Suspended Solids (TSS) and Total Dissolved Solids (TDS) in water sample.	**4 hours**
	9. Determination of total hardness of water sample.	**2 hours**
	10. Determination of total alkalinity of water sample.	**2 hours**
	11. Estimation of dissolved oxygen of water sample.	**2 hours**
	12. Determination of phytoplankton count of water sample.	**2 hours**
Pedagogy:	Lectures, use of multimedia, tutorials, assignments, presentations, hands-on experiments and demonstrations.	
References/ Readings:	1. **Gupta**, **PK** (1999). Hand Book of Soil, Fertilizer and Manure. Agro Botanica, Bikaner. 2. **Gupta**, **PK** (2001). Methods in Environmental Analysis: Water, Soil and Air. Agrobios, India. 3. **Pande**, **SP** and **Deshpande**, **LS** (2021). A Technical Manual for Water and Wastewater Analysis. Himalaya Publishing House, Mumbai.	

	4. **Piper**, **CS** (2010). Soil and Plant Analysis. Srishti Book Distributors, New Delhi. 5. **Sharma**, **PD** (2010). Ecology and Environment. 8th edition. Rastogi Publication, Meerut. 6. **Shukla**, **RS** and **Chandel**, **PS** (2018). A Textbook of Plant Ecology. S. Chand and Company Limited, New Delhi. 7. **Singh**, **D**, **Chhonkar**, **BS** and **Dwivedi**, **BS** (2013). Manual on Soil, Plant and Water Analysis. Westville Publishing House, New Delhi.
Course Outcomes:	On completion of this course, students will be able to: 1. Recall the tools and techniques employed in sampling of soil and water. 2. Understand the properties of soil and water and methods of their analysis. 3. Analyze the parameters influencing soil and water quality and its effect on plant growth and human welfare. 4. Develop skills in testing of soil and water and interpretation of results.

Skills Enhancement Course (SEC)

Name of the Programme : B. Sc. (Botany)
Course Code : BOT-241
Title of the Course : Herbal Technology
Number of Credits : 3 (1 Theory + 2 Practical)
Effective from AY : 2024-25

Prerequisites for the course:	Basic knowledge of plants.	
Course Objectives:	This course aims to: 1. Impart knowledge on the use of medicinal and aromatic plants in the manufacture of herbal drugs, cosmeceuticals and nutraceuticals. 2. Focus on developing entrepreneurial skills by imparting hands-on training in the preparation of herbal products.	
Content:	**Theory:**	**15 hours**
	Module 1: Herbal technology for industrially important products and formulations **Introduction:** Importance of herbal medicines, brief account of methods of collection and processing (drying, garbling, packing and storage) of herbal raw materials. **Methods of preparation of crude herbal extracts and drug evaluation:** Brief account of decoction, maceration, infusion, hot continuous extraction, distillation and supercritical fluid extraction. Brief account of drug evaluation using morphological, microscopic, chemical, physical and biological methods; quality control of herbal drugs. Drug adulteration - deliberate and indeliberate adulteration; types of adulterants. **Herbal cosmeceuticals and nutraceuticals:** Herbal plants used in cosmetic formulations for skin care - cream, lotion and sunscreen; hair care - oil, shampoo, conditioner and dye; oral care - toothpaste and mouthwash (any two plants for each product and its formulation). Herbal excipients - significance of substances of natural origin as excipients (binding agents, colourants, diluents, emulsifying agents, flavours and sweetening agents) - any two examples for each type. Aromatherapy - study of various oils used in aromatherapy with special reference to its applications in inhalation, local application and bath. Herbal nutraceuticals and their health benefits; culinary uses of any five herbs. **Herbal product-based industries and institutions:** Contribution of Dabur Ltd., Himalaya Wellness Company and Vicco Labs; Central Institute of Medicinal and Aromatic Plants (CIMAP) and National Medicinal Plants Board (NMPB); role of Traditional Knowledge Digital Library (TKDL).	**15 hours**
	Practical:	**60 hours**
	1. Study of biological source, organoleptic characters, chemical	**10 hours**

	constituents and medicinal uses of the following plants: *Allium sativum*, *Andrographis paniculata*, *Bixa orellana*, *Boerhavia diffusa*, *Catharanthus roseus*, *Centella asiatica, Garcinia indica*, *Hemidesmus indicus*, *Justicia adhatoda*, *Ocimum sanctum*, *Phyllanthus emblica*, *Piper longum*, *Rauwolfia serpentina, Saraca indica* and *Tinospora cordifolia* (fresh specimens or photographs).	
	2. Study of organoleptic and microscopic characters, chemical constituents and medicinal uses of the following herbs: *Aloe vera* - leaf, *Coriandrum sativum* - fruit, *Curcuma longa* - rhizome, *Cymbopogon citratus* - leaf, *Drimia indica* - bulb scale and *Zingiber officinale* - rhizome (fresh specimens).	**6 hours**
	3. Preparation of herbal decoction for common cold (demonstration).	**2 hours**
	4. Preparation of lemon grass or mint tea/infusion (demonstration).	**2 hours**
	5. Microscopic evaluation and chemical tests (Metanil yellow test and chalk powder test) to detect adulteration of turmeric powder.	**2 hours**
	6. Preparation of herbal cream (demonstration).	**2 hours**
	7. Preparation of herbal lotion (demonstration).	**2 hours**
	8. Preparation of herbal soap (demonstration).	**4 hours**
	9. Preparation of herbal lip balm (demonstration).	**2 hours**
	10. Preparation of rose water (demonstration).	**2 hours**
	11. Preparation of herbal hair oil (demonstration).	**2 hours**
	12. Preparation of herbal shampoo (demonstration).	**2 hours**
	13. Preparation of herbal hair dye (demonstration).	**2 hours**
	14. Preparation of herbal mouthwash (demonstration).	**2 hours**
	15. Identification of chemical characters of herbal excipients: Acacia, agar, starch and tragacanth.	**4 hours**
	16. Preparation of herbal infused oils for inhalation, massage oil for local application and bath salts (demonstration).	**2 hours**
	17. Preparation of coriander chutney or any other herbal dish (demonstration).	**2 hours**
	18. Oral presentation and submission of a herbal plant grown by the student.	**6 hours**
	19. Field visit to herbal industry / medicinal plant garden.	**4 hours**
Pedagogy:	Lectures, use of multimedia, tutorials, assignments, presentations, hands-on experiments, demonstrations, field visit and team-based learning.	
References/ Readings:	1. **Agarwal**, **SS** and **Paridhavi**, **M** (2012). Herbal Drug Technology. 2nd edition. Universities Press (India) Private Limited, Hyderabad. 2. **Gokhale**, **SB** and **Kokate**, **CK** (2017). Practical Pharmacognosy. 18th edition. Nirali Prakashan, Pune. 3. **Handa**, **P** (1982). Herbal Beauty Care. Orient Paperbacks, Delhi. 4. **Kalia**, **AN** (2005). Textbook of Industrial Pharmacognosy. CBS Publishers & Distributors Pvt. Ltd., New Delhi.	

	5. **Kapoor**, **S** (2000). Khana Khazana. Popular Prakashan Pvt. Ltd., Mumbai. 6. **Kar**, **A** (2003). Pharmacognosy and Pharmacobiotechnology. 2nd edition. New Age International (P.) Limited, New Delhi. 7. **Khandelwal**, **KR** (2002). Practical Pharmacognosy: Techniques and Experiments. 9th edition. Nirali Prakashan, Pune. 8. **Kokate**, **CK**, **Purohit**, **AP** and **Gokhale**, **SB** (2015). Pharmacognosy. 51st edition. Nirali Prakashan, Pune. 9. **Kumar**, **NC** (1993). An Introduction to Medical Botany and Pharmacognosy. Emkay Publications, Delhi. 10. **Kumaresan**, **V** (2015). Herbal Biotechnology and Pharmacognosy. Saras Publication, Tamil Nadu. 11. **Mendonsa**, **G** (2007). The Best of Goan Cooking. UBS Publishers Distributors Pvt. Ltd., New Delhi. 12. **Miller**, **L** and **Miller**, **B** (1998). Ayurveda and Aromatherapy: The Earth Essential Guide to Ancient Wisdom and Modern Healing. Lotus Press, United States. 13. **Prasad**, **N** (2020). Biodiversity: Herbal Medicine. Random Publications, New Delhi. 14. **Qadry**, **JS** (2014). A Textbook of Pharmacognosy. 17th edition. CBS Publishers & Distributors Pvt. Ltd., New Delhi. 15. **Rosaline**, **A** (2011). Pharmacognosy. MJP Publishers, Chennai. 16. **Shah**, **B** and **Seth**, **AK** (2010). Textbook of Pharmacognosy and Phytochemistry. Elsevier India Private Limited, New Delhi. 17. **Shirsat**, **MK**, **Dwivedi**, **J**, **Khathuriya**, **R** and **Wadhave**, **AA** (2017). Handbook of Pharmacognosy. Success Publications, Pune. 18. **Trease**, **EC** and **Evans**, **WC** (2009). Pharmacognosy. 16th edition. W.B. Saunders Co. Ltd., London. 19. **Unnisa**, **A** and **Sahoo**, **SK** (2015). A Textbook of Industrial Pharmacognosy. Professional Publications, Hyderabad. 20. **Vimaladevi**, **M** (2015). Textbook of Herbal Cosmetics. CBS Publishers & Distributors Pvt. Ltd., New Delhi.
Course Outcomes:	On completion of this course, students will be able to: 1. Recall the importance of medicinal and aromatic plants for preparation of herbal medicines. 2. Describe the methods for preparation of crude herbal extracts and drug evaluation. 3. Apply the acquired knowledge and skills to prepare herbal products. 4. Analyse the use of herbal plants for preparation of cosmeceuticals and nutraceuticals.

Disciplinary/Interdisciplinary Minor (VET)

Name of the Programme : B. Sc. (Botany)
Course Code : BOT-222
Title of the Course : Ecotourism
Number of Credits : 4 (2 Theory + 2 Practical)
Effective from AY : 2024-25

Prerequisites fo the course:	Basic knowledge of environment, travel and tourism.	
Course Objective(s):	This course aims to: 1. Introduce the concept of ecotourism enabling students to grasp the theories and practices associated with it. 2. Familiarize the students with ecotourism projects. 3. Empower students to explore entrepreneurial opportunities and effectively manage ecotourism resources. 4. Provide an exposure to entrepreneurial opportunities in the field of ecotourism.	
Content	**Theory:**	**30 Hours**
	Module 1: Concept of ecotourism, its characteristics and components **Concept of ecotourism:** Definition, introduction, history, relevance and scope; an overview of ecotourism in the world; adventure and cultural ecotourism, canopy walkway, conservation enterprises, commercialization chain, ecotourism activities, products, resources, services, endemism, eco-labelling, sustainable tourism and certification. **Characteristics of ecotourism:** Nature area focus, contribution to conservation, benefiting local communities, cultural aspects, customer satisfaction and responsible marketing. **Components of ecotourism:** Travel, tourism industry, biodiversity, local people, cultural diversity, environmental awareness, interpretation, stake holders, capacity building in ecotourism.	**15 hours**
	Module 2: Ecotourism - planning and resources **Planning:** Background, objectives, strategy, design of activities, target groups, opportunities, threats, positive and negative impacts, ecotourism auditing; ecotourism facilities – Green report card. Ecotourism management – issues and challenges. **Resources in Goa**- Western Ghats, water falls, rivers, bird watching sites, agricultural sites (spice farms, *kulagar*, *Khazan* lands); festivals and events related to ecotourism; national parks and wildlife sanctuaries, sacred groves, hills; tribal art, rural handicrafts (brief discussion on any two examples in each of the above categories with respect to scope in ecotourism). **Potential of ecotourism in Goa:** Community-based ecotourism - homestays, local cuisines. **Ecotourism development agencies:** International (UNWTO, UNDP, WWF, The International Ecotourism society-TIES);	**15 hours**

	National (ATREE, FRI, Department of Forest and Environment Government of Goa).	
	Practical:	**60 hours**
	1. Showcase any two documentaries on ecotourism.	**4 hours**
	2. Schematic layout of a website structure on ecotourism theme (spice farm with bird watching).	**4 hours**
	3. Thematic photographic portfolio on ecotourism comprising students original work pertaining to Goa. (*Kulagar*/farm stays).	**4 hours**
	4. Design an artistic publicity brochure on ecotourism theme.	**6 hours**
	5. Prepare and submit a short film on ecotourism.	**6 hours**
	6. Prepare a brief report on Agro ecotourism (spice farm, *kulagar*, pineapple, cashew plantation) and Cultural ecotourism (*Tavshayche fest*, *Kansache fest*, *Patolyanche fest*, *Bonderam, Sao Joao*). (Any one example from agro and cultural tourism to be taken).	**6 hours**
	7. Prepare map of Goa showing ecotourism places.	**2 hours**
	8. Documentation of two Eco products of Goa and report submission.	**4 hours**
	9. Study of content of any two ecotourism websites of Goa.	**4 hours**
	10. Submission of a short ecotourism project proposal by students.	**6 hours**
	11. Field visit to any one ecotourism site in Goa and report submission.	**6 hours**
	12. Digital marketing strategy to promote responsible ecotourism.	**4 hours**
	13. Documentation of tradable eco resources of Goa.	**2 hours**
	14. Writing a narrative explaining about spice farm / sacred grove / *khazan* land / wildlife sanctuaries of Goa.	**2 hours**
Pedagogy:	Lectures, tutorials, assignments, presentations, demonstrations, field visit and team-based learning.	
References/ Readings:	1. **Batta**, **A** (2000). Tourism and Environment. Indus Publishing Co., New Delhi. 2. **Bhattacharya**, **AK** (2005). Ecotourism and Livelihoods. Concept Publishing Company, New Delhi. 3. **Cater**, **E** (1994). Ecotourism in the Third World: Problems and Prospects for Sustainability. In: E. Cater and G. Lowman (Ed.) Ecotourism: A Sustainable Option, Wiley, Chichester, U.K. 4. **Cardoso**, **AS**, **Sousa**, **BB** and **da Cunha**, **AG** (2022). Mobile Applications in Urban Ecotourism: Promoting Digitization and Competitive Differentiation. In: Integrated Business Models in the Digital Age (pp. 349-369). Palgrave Macmillan, New York. 5. **Croall**, **J** (1995). Preserve or Destroy: Tourism and Environment. Calouste Gulbenkian Foundation, London. 6. **Lindberg**, **K** and **Hawkins**, **DE** (1999). Ecotourism: A Guide for Planners	

	and Managers. Natraj Publishers, Dehradun. 7. **Nekhvyadovich**, **LI**, **Kuttubaeva**, **TA** and **Petrenko**, **NE** (2022). Ecotourism as a Basis for Sustainable Regional Development. In: Geo-Economy of the Future (pp. 307-314). Springer, Switzerland. 8. **Varghese**, **A**, **Ommen**, **MA**, **Paul**, **MM** and **Nath**, **S** (Eds.) (2022). Conservation through Sustainable Use: Lessons from India. Taylor & Francis, London.
Course Outcomes:	On completion of this course, students will be able to: 1. Understand the concepts and principles of ecotourism. 2. Identify the potential areas to be utilized for recreational activities in ecotourism generating entrepreneurial opportunities. 3. Analyze the problems associated with ecotourism and design a sustainable solution. 4. Create opportunities for locals to develop ecotourism areas and conservation of natural resources.

Note: Colleges can take assistance of Goa Tourism, Forest Dept. Nature Club etc. for running the course.

Some examples of Eco-products of Goa - *Coconut oil, Spices, Recheado Masala, Aam papad, Jackfruit papad (sweet, salty), Doddol, Bebinca, Kunbi shawl, Kunbi saree, Cashew feni, Methi pez, Ragi ambil, Methi ladu, Kokum sola, Votachi sola, Khola chili, Harmal chili, Halsande, Sat shirache bhende, Agshechi vayngi, Sur, Artisan bread, Mandoli keli, Parra watermelon, Sanna, Doce, Bolina, Khaje.*

ATMANIRBHAR BHARAT
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(Accredited by NAAC)

GU/Acad –PG/BoS -NEP/2024/111 Date: 17.05.2024

Ref: GU/Acad –PG/BoS -NEP/2023/102/36 dated 15.06.2023

CIRCULAR

In supersession to the above referred Circular, the Syllabus of Semester III to VIII of the **Bachelor of Science in Mathematics** Programme approved by the Standing Committee of the Academic Council in its meeting held on 06th, 07th and 21st March 2024 is enclosed. The syllabus of Semester I and II approved earlier is also attached.

The Dean/ Vice-Deans of the School of Physical and Applied Sciences and Principals of the Affiliated Colleges offering the **Bachelor of Science in Mathematics** programme are requested to take note of the above and bring the contents of the Circular to the notice of all concerned.

ASHWIN VYAS LAWANDE
Digitally signed by ASHWIN VYAS LAWANDE
Date: 2024.05.17 11:07:58 +05'30'

(Ashwin Lawande)
Assistant Registrar – Academic-PG

To,

The Principals of Affiliated Colleges offering the Bachelor of Science in Mathematics Programme.

Copy to:

1. The Director, Directorate of Higher Education, Govt. of Goa
2. The Dean, School of Physical and Applied Sciences, Goa University.
3. The Vice-Deans, School of Physical and Applied Sciences, Goa University.
4. The Chairperson, BOS in Mathematics.
5. The Controller of Examinations, Goa University.
6. The Assistant Registrar, UG Examinations, Goa University.
7. Directorate of Internal Quality Assurance, Goa University for uploading the Syllabus on the University website.

Programme Structure for Semester I to VIII Under Graduate Programme - Mathematics										
Semester	Major -Core	Minor	MC	AEC	SEC	I	D	VAC	Total Credits	Exit
I	MAT-100* Foundational Mathematics (3L+1P)	MAT-111 Elementary Mathematics (3L+1T) OR MAT-112 Elementary Statistics (3L+1T)	MAT-131 Mathematical Techniques in Competitive Exams (3L)		MAT-141 Numerical Analysis using Python/SageMath (1L+2P)				20	
II			MAT-132 Discreptive Statistics (3L)		MAT-142 (Statistical Methods Using R/SPSS/PSPP (1L+2P)				20	MAT-161 (4)*
III	MAT-200 #$* Calculus of One Variable (3L+1T) MAT-201 Ordinary Differential Equations (3L+1T)	MAT-211 Matrix Algebra (3L+1P) OR MAT-212 Enumerative Combinatorics (3L+1P)	MAT-231 Basic Financial Mathematics (3L)		MAT-241 Technical Typesetting Using LaTeX (1L + 2P)				20	

		OR MAT-213 Transformation Techniques (3L+1P)								
IV	MAT-202* Analysis (3L+1T) MAT-203#$* Linear Algebra (3L+1T) MAT-204 Basic Number Theory (3L+1T) MAT-205#* Analytical 2D Geometry (2L)	MAT-221 Probability Theory VET (3T+1P) OR MAT-222 Theory of Equations (3L+1P) OR MAT-223 Graph Theory (3L+1P)							20	MAT-162 (4)@
V	MAT-300* Riemann Integration and	MAT-321 Linear Programming				Internship (2)			20	

Name of the Programme : **B.Sc. Mathematics**
Course Code : **MAT-241**
Title of the Course : **Technical Typesetting Using LaTeX**
Number of Credits : **1L+2P**
Effective from AY : **2024-2025**

Pre-requisites for the Course:	Basic 12th standard mathematics.	
Course Objectives:	To make students competent in using LaTeX for typesetting any technical document and making impressive presentations.	
Content		**No. of Hours**
Unit I	**Basics of LaTeX:** Introduction to TeX and LaTeX; Document classes; Typesetting a simple document; Adding basic information to a document; Adding watermark to a document; Fonts and Sizes; Sectioning command and alignment; list and Enumeration; Quotations; Environments; Footnotes; Typesetting tables with multiple columns and tabular environment ; boxed text,Minipage. **(DEMONSTRATIONS TO BE DONE DURING PRACTICAL)**	**4**
Unit II	**Mathematical Typesetting with LaTeX:** Accents and symbols; Mathematical formula typesetting (elementary and advanced): Subscript/Superscript, Fractions, Roots,Ellipsis,greek letters, Mathematical Symbols, Special characters, Arrays, Delimiters, Multiline formulas, Matrices, Spacing and changing style in math mode; Boxed equations; Creating mathematical environments, \newtheorem command. **Cross Referencing, Index and Bibliography:** Cross referencing figures, tables, sections, equations, etc; Table of contents; Bibliography using NATBIB; Bibliographic styles; BIBTeX and Database creation. **(DEMONSTRATIONS TO BE DONE DURING PRACTICAL)**	**8**
Unit III	**Graphics and Beamer Presentation in LaTeX:** Graphics in LaTeX; Simple pictures using PSTricks; Beamer presentation. **(DEMONSTRATIONS TO BE DONE DURING PRACTICAL)**	**3**
Practical	**60 hours (4 hours each) of practical should be dedicated for the following:** 1. Typing a basic document in LaTeX – trying out the effect of spaces, line breaks, empty lines, writing special characters in text, adjusting fonts, shapes and styles, adding watermark, sectioning and paragraphs.	**60**

	2. Exploring simple documents – customizing margins, page numbers, quotations, horizontal lines, using vspace and hspace and flushleft/flushright commands, enumeration and itemize environments. 3. Understanding the various document classes such as article/report/thesis/book and experimenting with each class to understand the output. 4. Customizing tables, minipage environment. 5. Typesetting accents and Greek symbols, Basic mathematical typesetting. 6. Working with Subscript/Superscript, Fractions, Roots, Ellipsis, Mathematical operators, Special characters, Arrays, Delimiters. 7. Using equation environment, breaking/appropriately writing long equations, typing equations with cases, spaces in math mode, text in math mode. 8. Typing of matrices, infinite series, continued fractions, and boxed equations, and the like. 9. Using the theorem environment to typeset definitions, remarks, lemmas, theorems, corollaries, etc. 10. Cross referencing – using tag commands, hyperref environment, adding hyperlinks to text. 11. Graphics in LaTeX(Inserting images) using additional apps like geogebra, latexdraw etc . 12. Creating bibliographic database and exploring various bibliographic environments to create bibliography. Generating the Table of Contents. 13. Drawing simple pictures using PSTricks. 14. Making presentations using Beamer in LaTeX. 15. Making use of the exam class to prepare question papers in LaTeX.	
Pedagogy:	Lectures/Practical/Self study. Theory to be kept for explaining what exactly will be done and answering common queries/errors. Practical to focus on how exactly it will be done.	
Reference Reading:	**PRINCIPAL TEXT:** L. Lamport : *A Documentation Preparation System LATEX User's Guide and Reference Manual*, Second Edition, Pearson, 2006. **REFERENCES:** 1) E. Krishnan : *LaTeX Tutorials – A Primer,* Indian TeX Users Group, 2003. 2) G. Gratzer: *More Math Into LaTeX,* Springer, 2016. 3) Karl Berry, Stephen Gilmore and Torsten Martinsen LATEX2e: An unofficial reference manual, January 2023 4) S. Kottwitz: *LaTeX – Beginner's Guide,* Packt Publishing, 2011.	

	5) Van M. R. C. Dongen: *LaTeX and Friends*, Springer – Verlag, 2012.
Course Outcomes:	1.To Create and typeset a LaTeX document. 2.To Build documents containing Mathematics. 3.To experiment with pictures and graphics in LaTeX. 4.To Prepare impressive beamer presentations and typeset question papers using the exam class.

ATMANIRBHAR BHARAT
SWAYAMPURNA GOA

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(Accredited by NAAC)

GU/Acad –PG/BoS -NEP/2024/256 Date: 29.06.2024

Ref: GU/Acad –PG/BoS -NEP/2023/102/1 dated 16.06.2023

CIRCULAR

With reference to the above referred Circular, the Syllabus of Semester III of the **Bachelor of Arts in Konkani** Programme approved by the Standing Committee of the Academic Council in its meeting held on 10th and 11th May 2024 is enclosed.

The Dean/ Vice-Deans of the Shenoi Goembab School, of Languages and Literature and Principals of the Affiliated Colleges offering the **Bachelor of Arts in Konkani** Programme are requested to take note of the above and bring the contents of the Circular to the notice of all concerned.

ASHWIN VYAS LAWANDE
Digitally signed by ASHWIN VYAS LAWANDE
Date: 2024.06.29 16:26:00 +05'30'

(Ashwin Lawande)
Deputy Registrar – Academic

To,

The Principals of Affiliated Colleges offering the Bachelor of Arts in Konkani Programme.

Copy to:

1. The Director, Directorate of Higher Education, Govt. of Goa
2. The Dean, Shenoi Goembab School of Languages and Literature, Goa University.
3. The Vice-Deans, Shenoi Goembab School of Languages and Literature, Goa University.
4. The Chairperson, BOS in Konkani.
5. The Controller of Examinations, Goa University.
6. The Assistant Registrar, UG Examinations, Goa University.
7. Directorate of Internal Quality Assurance, Goa University for uploading the Syllabus on the University website.

III	KON- 200 नाटक: सिध्दांत आनी उपयोजन (Drama: Theory and Application) (4) KON- 201 प्रसार माध्यमां खातीर लेखन (Writing for Media) (4)	KON- 211 (गॉयचे पारंपारीक वेवसाय) Traditional Occupations of Goa (4)	KON- 231 फिल्म आस्वादन (Film Appreciation) (3)	KON- 251 संभाशण कौशल्य (Communication Skills) (2)	KON- 241 कार्यावळ वेवस्थापन कौशल्य (Event Management Skills) (3)					
IV	KON- 202 कविता: सिध्दांत आनी उपयोजन (Poetry: Theory & Application) (4) KON- 203 कॉकणींतलें बाल साहित्य (Children Literature in Konkani) (4)	KON- 221 कॉकणीचो संगणकी वापर (Usage of Konkani in Computers) (3L+1P) (VET)		KON- 252 कॉकणी भाशेचें मुळावें गिन्यान (Basic Knowledge of Konkani) (2)						KON-261 सुत्रसंचालन आनी मुलाखत कौशल्यां (Anchoring & interviewing Skills) (4)

Name of the Programme : **B. A.**
Course code : **KON 251**
Title of the Course : **संभाशण कौशल्य (Communication Skills)**
Number of Credits : **02**
Effective from AY : **2024 - 25**

Pre-requisites for the Course:	1. विद्‌याथ्यांक संभाशण करपाची आवड आसची. 2. विद्‌याथ्यांक कोंकणी भाशेचें गिन्यान आसचें.	
Course Objectives:	1. विद्‌याथ्यांक संभाशण कौशल्यांचो सिध्दांतीक परिचय करून दिवप. 2. विद्‌याथ्यां भितरलीं संभाशण कौशल्यां विकसीत करप. 3. भौशीक सुवातेर उलोवपा खातीर विद्‌याथ्यां भितरलो आत्मविश्वास वाडोवप. 4. परिणामकारण संभाशण करपाक विद्‌याथ्यांक तयार करप.	
	1 credit theory and 1 credit practical	**वरां**
Content:	**अ. संभाशण कौशल्य : अर्थ, व्याख्या, स्वरूप**	**03**
	आ. संभाशण कौशल्याचें म्हत्व आनी गरज	**03**
	इ. संभाशाणाचे प्रकार : 1. शाब्दीक संभाशण (verbal communication) 2. अशाब्दीक (non – verbal communication) 3. लिखीत संभाशण (written communication), 4. प्रत्यक्ष (एकामेका मुखार उलोवपाक) 5. अप्रत्यक्ष (फोन, इमेल, आदी) 6. उपचारीक (अनवळखी मनशा कडेन) 7. अनुपचारीक (वळखीच्या मनशा कडेन)	**03**
	ई. संभाशण कौशल्य जोडपाचीं साधनां : वाचन, भाशेचर प्रभुत्व, प्रसार माध्यामांतल्यान माहिती मेळोवप, अणभव लागीं करप, एकाग्रता, पुर्वतयारी, केन्ना कितें उलोवप हाची जाणीव, आदी..	**03**
	उ. प्रभावी आनी परिणामकारक संभाशणा खातीर ह्यो गजाली गरजेच्यो: शब्दभंडार, शब्दांचें सामर्थ्य कळप, वाचन, भाशेचेर प्रभुत्व, विचार स्पश्टपणान मांडप, केन्ना, कितें, कशें उलोवप हाची जाणीव, पुर्वतयारी, व्यक्तीमत्व, एकाग्रता, न्युनगंड काडून उडोवप, बऱ्या सुरांत उलोवप, आदी.	**03**
	ऊ. हे उपक्रम विद्‌यार्थां कडच्यान वर्गांत करून घेवचे: 1. वक्तृत्व / पब्लीक स्पिकींग – विशय दिवन उलोवंक लावन संभाशणांत येवपी आडखळी पयस करून आत्मविश्वास वाडोवप.	**15**

	2. एकपात्री – प्रसंग दिवन नाट्यात्मक रितीन सादरीकरण करुंक लावचें. 3. लेखनाचो सराव – प्रभावी लेख /प्रसंग/ खबर बरोवन घेवची.	
	वट्ट	**30**
	टीप: हो पेपर पुरायपणान प्रत्यक्षीक स्वरुपाचो आशिल्ल्यान चार वरां दिवचीं.	
Pedagogy:	व्याख्यान, अभ्यासिका, गट चर्चा, स्वाध्याय.	
References/ Readings:	1. आर्य्या, मानवती. आर्य कृष्ण चंद्र. *"प्रभावी बोलण्याची 40 सूत्रे"*. गांधीनगर, औरंगाबाद: साकेत प्रकाशन. 2. ताटके, नीलम. *"कला संभाषणाची"*. पुणे: डायमंड पब्लिकेशन. 3. मोघाशी, मधुकर. *"व्यक्तिमत्व विकास आनी भाषा"*. स्नेहवर्धन प्रकाशन. 4. शुक्ला आभा. सिंह जया. *"संकल्प संप्रेशण कौशल्य"*. रुद्र प्रकाशन आणि वितरक. 2022. 5. Carnegie, Dale. *"How to Win Friends and Influence People"*. Shahpur Jat, New Delhi: Shrishti publishers & distributors. 2020. 6. Giblin, Les. *"The Art of Dealing With People"*. Madhya Pradesh: Manjel publishing house. 2017. 7. Lowndes, Leil. *"How to Talk to Anyone"*. McGraw Hill LLC. 2003.	
Course Outcomes:	1. विद्यार्थ्यांक शब्दीक, अशब्दीक आनी लिखीत संभाशणाचें म्हत्व कळटलें. 2. विद्यार्थी संभाशणाचीं साबार कौशल्यां शिकतले. 3. संभाशण कौशल्य एक कला म्हण आपणावन त्या मळार काम करपाक शकतले. 4. परिणामकारक संभाशण करपाक विद्यार्थी तयार जातले.	

Name of the Programme : **B.A. Konkani**
Course Code : **KON-252**
Title of the Course : **कोंकणी भाशेचें मुळावें गिन्यान (Basic Knowledge of Konkani)**
Number of Credits : **02**
Effective From AY : **2024-25**

Pre- requisites for the Course:	कोंकणी भाशेची वळख आसची.	
Course Objectives:	1. विद्यार्थ्याक कोंकणी भाशेचें मुळावें गिन्यान मेळप. 2. कोंकणी भाशेची मौखीक आनी लिखीत कौशल्यां आत्मसात जावचीं. 3. दिसपट्टे जिणेंत कोंकणी भाशेचो प्रभावी वापर करपाक कळचो. 4. कोंकणी भाशेच्या व्याकरणा विशीं म्हायती मेळची.	
		वरां
Content:	**1. कोंकणी भाशेची वळख** अ. भासः संकल्पना आनी म्हत्व आ. आवयभास आनी तिचें म्हत्व इ. कोंकणी भाशेचीं खाशेलपणां	**06**
	2. कोंकणी भाशेच्या मौखीक कौशल्यांचो अभ्यास अ. भाशेच्या मौखीक कौशल्यांची गरज आ. उलोवपां, व्याख्यानां, मतां आयकून भाश्य करप. इ. विशय दिवन कोंकणी उलोवपाचो सराव. ई. कोंकणी मजकुराचें वाचन.	**10**
	3. कोंकणी भाशेच्या लिखीत कौशल्यांचो अभ्यास अ. लिखीत कौशल्यांचें म्हत्व आनी गरज सांगून : ल्हान मजकूर बरोवंक लावचे. आ. कोंकणी शुध्दलेखनाचे नेम (कांय म्हत्वाचे नेम शिकोवचे) इ. कोंकणी व्याकरण (विकारी आनी अविकारी उतरांची वळख, काळ, लिंग, वचन)	**14**
	वट्ट	**30**
Pedagogy	व्याख्यान, अभ्यासिका, गटचर्चा, स्वाध्याय.	
References/Readings	1. *कोंकणी शुध्दलेखनाचे नेम* (आवृत्ती 2015), गोवा कोंकणी अकादेमी, पणजी, 2015. 2. धुंगट पै, मनोहर. *कोंकणी म्हणीसागर,* गोवा कोंकणी अकादेमी, बोरी फोंडें गोंय, 2003. 3. बोरकार, सुरेश. *कोंकणी व्याकरण,* कोंकणी भाशा मंडळ, गोंय, तिसरी आवृत्ती 2012. 4. भावे, भूषण. वजरीकार, प्रकाश. पर्येंकार, प्रकाश. *कारबारी कोंकणी.* राजहंस वितरण पणजी गोंय, 1999.	

	5. भावे, भूषण. *साहित्य विमर्श,* सत्तरी गोंय:शाल्मली क्रिएशन्स, 2016. 6. *भावे, भूषण.अनु. कोंकणी भाशा : प्रकृती आनी परंपरा* पणजी गोंय: गोवा कोंकणी अकादेमी. 2013. 7. लवंदे वसंत. कोंकणी भाशेचें अध्यापन, पणजी, गोंय: गोवा कोंकणी अकादेमी, 1995. 8. *वेरेंकार, श्याम. (संपा.) कोंकणी भास, साहित्य आनी संस्कृताय,* मडगांव गोंय: कोंकणी भाशा मंडळ, 2003.
Course Outcomes	1. विद्यार्थ्यांक कोंकणी भाशेचें मुळावें गिन्यान मेळटा. 2. कोंकणी भाशेची मौखीक आनी लिखीत कौशल्यां आत्मसात जाता. 3. दिसपट्टे जिणेंत कोंकणी भाशेचो प्रभावी वापर करपाक कळटा. 4. कोंकणी भाशेच्या व्याकरणा विशीं म्हायती मेळटा.