Savitribai Phule Pune University [SPPU]

B.Sc. (Chemistry)

(Three Years Integrated Degree Program)

Choice Based Credit System [CBCS]

From Academic Year

2019-2020

First Year (F.Y. B. Sc.)

Board of Studies (Chemistry)

Savitribai Phule Pune University [SPPU]
Pune-41107

Structure of F. Y. B. Sc. Chemistry

Semester	Course	Discipline Specific Core Course (DSCC)*
I	Theory	CH-101 : Physical Chemistry (2 credit , 36 L)
	Theory	CH-102 : Organic Chemistry (2 credit, 36 L)
	Practical	CH-103 : Chemistry Practical –I (1.5 Credit, 46.8 L)
II	Theory	CH-201 :Inorganic Chemistry (2 credit , 36 L)
	Theory	CH-202 : Analytical Chemistry (2 credit, 36 L)
	Practical	CH-203 : Chemistry Practical –II (1.5 Credit, 46.8 L)

***N.B.:**

i. **Each lecture (L) will be of 50 minutes.**
ii. **Each practical of 3h 15 min and 12 practicals per semester**
iii. **12 weeks for teaching 03 weeks for Contentious assessments**
iv. **For details refer UG rules and regulations (CBCS for Science program under science & Technology) given in Appendix**

Savitribai Phule Pune University, Pune

F.Y.B.Sc. Chemistry Syllabus

(CBCS Semester Pattern)

From Academic Year 2019-2020

Equivalence with Previous Syllabus

New Course (2019 Semester Pattern) (50 min /L)	**Old Course (2013 Annual Pattern) (48 min /L)**
CH-101 : Physical Chemistry (2 credit , 36 L) 50 Marks	Paper I : Physical and Inorganic Chemistry (72 L) 100 Marks
CH-201 :Inorganic Chemistry (2 credit , 36 L) 50 Mark	
CH-102 : Organic Chemistry (2 credit, 36 L) 50 Marks	Paper II : Organic and Inorganic Chemistry (72 L) 100 Marks
CH-202 : Analytical Chemistry (2 credit, 36 L) 50 Marks	
CH-103 : Chemistry Practical–I (1.5 Credit, 46.8 L) 50 Marks	Paper III : Chemistry Practical 100 Marks
CH-203 : Chemistry Practical-II (1.5 Credit, 46.8L) 50 Marks	

Preamble:

The syllabus of Chemistry for First year has been redesigned for Choice based Credit System (CBCS) to be implemented form 2019-2020.

In CBCS pattern semester system has been adopted for FY, SY and TY which includes Discipline Specific Core Course (DSCC) at F Y level, Ability Enhancement Compulsory Course (AECC), Discipline Specific Elective Course (DSEC) and Skill Enhancement Course (SEC). DSCC courses has been introduced at FY level and AECC courses at SY level along with DSEC. At TY level DSEC and SEC courses has been introduced.

Syllabus for Specific Core Courses of Chemistry (2 Theory and 1 Practical) subject for F. Y. B. Sc. is to be implemented from the year 2019-20. Syllabus for S. Y. and T. Y. B. Sc. will be implemented from the year 2020-21 and 2021-22 respectively as per structure approved.

Learning Objectives:

1. To understand basic concept of physical, organic and Inorganic chemistry.
2. To impart practical skills and learn basics behind experiments.
3. To prepare background for advanced and applied studies in chemistry.

SEMESTER-I

CH- 101: Physical Chemistry (2 Credits, 36 Lectures of 50 min.)

1. Chemical Energetics

Review of thermodynamics and the Laws of Thermodynamics. Important principles and definitions of thermochemistry. Concept of standard state and standard enthalpies of formations, integral and differential enthalpies of solution and dilution. Calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data. Variation of enthalpy of a reaction with temperature – Kirchhoff's equation. Statement of Third Law of thermodynamics and calculation of absolute entropies of substances, problems **[11]**

2. Chemical Equilibrium:

Introduction: Free Energy and equilibrium - Concept, Definition and significance
The reaction Gibbs Energy, Exergonic and endergonic reaction. The perfect gas equilibrium, the general case of equilibrium, the relation between equilibrium constants, Molecular interpretation of equilibrium constant. The response of equilibria to conditions- response to pressure , response to temperature, Van't Haff equation, Value of K at different temperature, Problems **[11]**

3. Ionic Equilibria

Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect. Salt hydrolysis-calculation of hydrolysis constant, degree of hydrolysis and pH for different salts. Buffer solutions. Solubility and solubility product of sparingly soluble salts– applications of solubility product principle. **[14]**

Learning Outcome

1. Chemical Energetics

1. Students will be able to apply thermodynamic principles to physical and chemical process
2. Calculations of enthalpy , Bond energy, Bond dissociation energy , resonance energy
3. Variation of enthalpy with temperature –Kirchoff's equation
4. Third law of thermodynamic and its applications

2. Chemical Equilibrium

Knowledge of Chemical equilibrium will make students to understand

1. Relation between Free energy and equilibrium and factors affecting on equilibrium constant.
2. Exergonic and endergonic reaction
3. Gas equilibrium, equilibrium constant and molecular interpretation of equilibrium constant
4. Van't Haff equation and its application

3. Ionic equilibria

Ionic equilibria chapter will lead students to understand

1. Concept to ionization process occurred in acids, bases and pH scale
2. Related concepts such as Common ion effect hydrolysis constant, ionic product, solubility product
3. Degree of hydrolysis and pH for different salts , buffer solutions

CH- 102: Organic Chemistry (2 Credits, 36 Lectures of 50 min.)

Fundamentals of Organic Chemistry

Physical Effects, Electronic Displacements: Inductive Effect, Electromeric Effect, Resonance and Hyperconjugation. Cleavage of Bonds: Homolysis and Heterolysis. Structure, shape and reactivity of organic molecules: Nucleophiles and electrophiles. Reactive Intermediates: Carbocations, Carbanions and free radicals. Strength of organic acids and bases: Comparative study with emphasis on factors affecting pK values. Aromaticity: Benzenoids and Hückel's rule. **[09]**

Stereochemistry

Introduction, classification, Interconversion of Wedge Formula, Newmann, Sawhorse and Fischer representations. Conformations with respect to ethane, butane and cyclohexane. Configuration: Geometrical - *cis – trans,* and E / Z Nomenclature (for upto two C=C systems). Optical isomerism Enantiomerism, Diastereomerism and Meso compounds). Concept of chirality (upto two carbon atoms). Threo and erythro; D and L; nomenclature; CIP Rules: R/ S (for upto 2 chiral carbon atoms) **[14]**

Aliphatic Hydrocarbons

Functional group approach for the following reactions (preparations & reactions) to be studied in context to their structure.

Alkanes: (Up to 5 Carbons) *Preparation:* Catalytic hydrogenation, Wurtz reaction, Kolbe's synthesis, from Grignard reagent. *Reactions:* Free radical Substitution: Halogenation.

Alkenes: (Up to 5 Carbons) *Preparation:* Elimination reactions: Dehydration of alkenes and dehydrohalogenation of alkyl halides (Saytzeff's rule); cis alkenes (Partial catalytic hydrogenation) and trans alkenes (Birch reduction). *Reactions:* cis-addition (alk. $KMnO_4$) and trans-addition (bromine), Addition of HX (Markownikoff's and anti-Markownikoff's addition), Hydration, Ozonolysis, oxymecuration-demercuration, Hydroboration-oxidation.

Alkynes: (Up to 5 Carbons) *Preparation:* Acetylene from CaC_2 and conversion into higher alkynes; by dehalogenation of tetra halides and dehydrohalogenation of vicinal-dihalide *Reactions:* formation of metal acetylides, addition of bromine and alkaline $KMnO_4$, ozonolysis and oxidation with hot alk. $KMnO_4$. **[13]**

Learning Outcome

1. The students are expected to understand the fundamentals, principles, and recent developments in the subject area.
2. It is expected to inspire and boost interest of the students towards chemistry as themain subject.
3. To familiarize with current and recent developments in Chemistry.
4. To create foundation for research and development in Chemistry.

Reference Books

1. Graham Solomon, T.W., Fryhle, C.B. & Dnyder, S.A. *Organic Chemistry,* John Wiley & Sons (2014).
2. McMurry, J.E. *Fundamentals of Organic Chemistry*, 7th Ed. Cengage Learning India Edition, 2013.
3. Sykes, P. *A Guidebook to Mechanism in Organic Chemistry,* Orient Longman, New Delhi (1988).
4. Eliel, E.L. *Stereochemistry of Carbon Compounds*, Tata McGraw Hill education, 2000.
5. Finar, I.L. *Organic Chemistry* (Vol. I & II), E.L.B.S.
6. Morrison, R.T. & Boyd, R.N. *Organic Chemistry*, Pearson, 2010.
7. Bahl, A. & Bahl, B.S. *Advanced Organic Chemistry,* S. Chand, 2010.
8. Samuel Glasstone, *Thermodynamics for Chemists*, Affiliated East West Private Limited.
9. B S Bahl, G D Tuli, Arun Bahl, Essentials of Physical Chemistry
10. Peter Atkins and Julio de Paula, Elements of Physical Chemistry, Sixth edition (2013), Oxford press
11. Ball D. W., Physical Chemistry, Thomson Press , India (2007)
12. Castellan, G.W. Physical Chemistry 4th Ed. Narosa (2004).
13. Atkins' Physical Chemistry –Thermodynamics and Kinetics, 11th Edition, Oxford Press
14. Thomas Engel, Philip Reid; *Physical Chemistry*, Pearson Education (2006)
15. J. N. Gurtu, A. Gurtu; *Advanced Physical Chemistry,* Pragati Edition
16. Mortimer R. G., Physical Chemistry, 3rd Edition, Elsevier, Noida (UP)
17. Samuel H. Maron and Carl F. Prutton, *Principal of physical Chemistry*, 4th Edition, Collier Macmillan Ltd.

CH- 103: Chemistry Practical Course I

(1.5 Credits, 46.8 Lectures of 50 min.)

Section A: Chemical and Lab Safety (Compulsory)

1. Toxicity of the compounds used in chemistry laboratory.
2. Safety symbol on labels of pack of chemicals and its meaning
3. What is MSDS sheets? Find out MSDS sheets of at least hazardous chemicals ($K_2Cr_2O_7$, Benzene, cadmium nitrate, sodium metal, etc.)
4. Precautions in handling of hazardous substances like Conc. acids, ammonia, organic solvents, etc.

Section B: Physical Chemistry

a. Thermochemistry (Any three)

1. Determination of heat capacity of calorimeter for different volumes.
2. Determination of enthalpy of neutralization of hydrochloric acid with sodium hydroxide.
3. Determination of enthalpy of ionization of acetic acid.
4. Determination of integral enthalpy of solution of salts (KNO_3, NH_4Cl).
5. Determination of enthalpy of hydration of copper sulphate.
6. Study of the solubility of benzoic acid in water and determination of ΔH.

b. Ionic equilibria (Two experiments)

1. Measurement of pH of different solutions like aerated drinks, fruit juices, shampoos and soaps (use dilute solutions of soaps and shampoos to prevent damage to the glass electrode) using pH-meter.

OR

1. Measurement of the pH of buffer solutions and comparison of the values with theoretical values.
2. Preparation of buffer solutions **(Any One)**
   (i) Sodium acetate-acetic acid and determine its buffer capacity
   (ii) Ammonium chloride-ammonium hydroxide and determine its buffer capacity

Section C: Organic Chemistry (Five experiments)

1. To determine type and detection of extra elements (N, S, Cl, Br, I) in organic compounds (containing up to two extra elements) **(Three)**
2. Separation of constituents of mixtures by Chromatography: Measure the R_f value in each case (**Two)**
   (a) Identify and separate the components of a given mixture of 2 amino acids (glycine, aspartic acid, glutamic acid, tyrosine or any other amino acids) / pigments from plant extract/ 2 organic compounds by paper chromatography
   (b) Identify and separate the sugars present in the given mixture by paper chromatography.

Note: Combination of two compounds/plant extract to be given

Reference Books:

1. Svehla, G. *Vogel's Qualitative Inorganic Analysis*, Pearson Education, 2012.
2. Mendham, J. *Vogel's Quantitative Chemical Analysis*, Pearson, 2009.
3. Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., *Text book of Practical Organic Chemistry*, Prentice-Hall, 5th edition, 1996.
4. Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry* Orient-Longman, 1960.
5. Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R.Chand & Co.: New Delhi (2011).
6. Prof. Robert H. Hill Jr., David C. Finster Laboratory Safety for Chemistry Students, 2nd Edition Wiley ISBN: 978-1-119-02766-9 May 2016
7. Prudent Practices in the Laboratory: Handling and Management of Chemical Hazards, Updated Version, ISBN 978-0-309-13864-2 | DOI 10.17226/12654, THE NATIONAL ACADEMIES PRESS Washington, D.C.

Learning Outcome

1. Importance of chemical safety and Lab safety while performing experiments in laboratory
2. Determination of thermochemical parameters and related concepts
3. Techniques of pH measurements
4. Preparation of buffer solutions
5. Elemental analysis of organic compounds (non instrumental)
6. Chromatographic Techniques for separation of constituents of mixtures

SEMESTER-II

CH-201: Inorganic Chemistry (2 Credits, 36 Lectures of 50 min.)

1. Atomic Structure

Origin of Quantum Mechanics: Why study quantum mechanics? Quantum mechanics arose out of interplay of experiments and Theory Energy quantization- i) Black body radiation ii) The photoelectric effect iii) Wave particle duality-a) The particle character of electromagnetic radiation b) the wave character of particle, iv) diffraction by double slit v) atomic spectra, Review of-Bohr's theory and its limitations, Heisenberg Uncertainty principle.

Quantum mechanics: Time independent Schrodinger equation and meaning of various terms in it, Significance of ψ and ψ^2, Schrödinger equation for hydrogen atom. Radial and angular parts of the hydogenic wavefunctions (atomic orbitals) and their variations for1*s*, 2*s*, 2*p*, 3*s*, 3*p* and 3*d* orbitals (Only graphical representation). Radial and angular nodes and their significance. Radial distribution functions and the concept of the most probable distance with special reference to 1*s* and 2*s* atomic orbitals. Significance of quantum numbers, orbital angular momentum and quantum numbers *ml* and *ms*. Shapes of *s*, *p* and *d* atomic orbitals, nodal planes. Discovery of spin, spin quantum number (*s*) and magnetic spin quantum number (*ms*). **[14]**

2. Periodic table and Periodicity of Elements

Periodic table: periodic table after 150 years, review on the eve of international year of periodic table[IYPT].

Periodicity of elements: Rules for filling electrons in various orbitals, Electronic configurations of the atoms. Stability of half-filled and completely filled orbitals, concept of exchange energy. Relative energies of atomic orbitals, Anomalous electronic configurations

Long form of periodic table-s, p, d and f block elements,

Detailed discussion of following properties of elements with reference to s and p block

a) Effective nuclear charge, shielding or screening effect
b) Atomic and ionic radii
c) Crystal radii
d) Covalent radii
e) Ionization energies
f) Electronegativity, Pauling's / electronegativity scale
g) Oxidation states of elements

[10]

3. Chemical Bonding

Attainment of stable electronic configurations, Types of Chemical bonds: Ionic, covalent, coordinate and metallic bonds

Ionic Bond: General characteristics of ionic bonding, Types of ions, Energy considerations in ionic bonding, lattice energy and 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.

Covalent bond: Valence Bond Approach, Hybridization with suitable examples of linear, trigonal planar, square planar, tetrahedral, trigonal bipyramidal and octahedral arrangements. VSEPR theory, Assumptions, need of theory, application of theory to explain geometries of molecules such as i) ClF_3 ii) Cl_2O iii) BrF_5 iv) XeO_3 v) $XeOF_4$ **[12]**

Learning Outcome

1. Atomic Structure

1. Various theories and principles applied to revel atomic structure
2. Origin of quantum mechanics and its need to understand structure of hydrogen atom
3. Schrodinger equation for hydrogen atom
4. Radial and angular part of hydrogenic wave functions
5. Significance of quantum numbers
6. Shapes of orbitals

2. Periodicity of Elements

1. Explain rules for filling electrons in various orbitals- Aufbau's principle, Pauli exclusion principle, Hund's rule of maximum multiplicity
2. Discuss electronic configuration of an atom and anomalous electronic configurations.
3. Describe stability of half-filled and completely filled orbitals.
4. Discuss concept of exchange energy and relative energies of atomic orbitals
5. Design Skeleton of long form of periodic table.
6. Describe Block, group, modern periodic law and periodicity.
7. Classification of elements as main group, transition and inner transition elements
8. Write name, symbol, electronic configuration, trends and properties.
9. Explain periodicity in the following properties in details:
    a. Effective nuclear charge, shielding or screening effect; some numerical problems.
    b. Atomic and ionic size.
    c. Crystal and covalent radii
    d. Ionization energies
    e. Electronegativity- definition, trend, Pauling electronegativity scale.
    f. Oxidation state of elements

3. Chemical Bonding

1. Attainment of stable electronic configurations.
2. Define various types of chemical bonds- Ionic, covalent, coordinate and metallic bond
3. Explain characteristics of ionic bond, types of ions, energy consideration in ionic bonding, lattice and solvation energy and their importance in the context of stability and solubility of ionic compounds
4. Summarize Born-Lande equation and Born-Haber cycle,
5. Define Fajan's rule, bond moment, dipole moment and percent ionic character.

6. Describe VB approach, Hybridization with example of linear, trigonal, square planer, tetrahedral, TBP, and octahedral.
7. Discuss assumption and need of VSEPR theory.
8. Interpret concept of different types of valence shell electron pairs and their contribution in bonding.
9. Application of non-bonded lone pairs in shape of molecule
10. Basic understanding of geometry and effect of lone pairs with examples such as ClF_3, Cl_2O, BrF_5, XeO_3 and $XeOF_4$.

CH- 202: Analytical Chemistry (2 Credits, 36 Lectures of 50 min.)

1. **Introduction to Analytical Chemistry**
   What is analytical Chemistry, the analytical perspectives, Common analytical problems. **[03]**

2. **Calculations used in Analytical Chemistry**
   Some important units of measurements-SI units, distinction between mass and weight, mole, millimole and Calculations, significant figures
   Solution and their concentrations- Molar concentrations, Molar analytical Concentrations, Molar equilibrium concentration, percent Concentration, part per million, part per billion, part per thousand, Solution –dilatant volume ration, functions , density and specific gravity of solutions, problems
   Chemical Stoichiometry – Empirical and Molecular Formulas, Stoichiometric Calculations, Problems. **[10]**

3. **Qualitative Analysis of Organic Compounds**
   Types of organic compounds, characteristic tests and classifications, reactions of different functional groups, analysis of binary mixtures.
   Analysis – Detection of nitrogen, sulfur, halogen and phosphorous by Lassiagen's test.
   Purification of organic compounds- Introduction, recrystallization, distillation, sublimation **[05]**

4. **Chromatographic Techniques –Paper and Thin Layer Chromatography**
   Introduction- Introduction to chromatography, IUPAC definition of chromatography.
   History of Chromatography- paper chromatography, Thin Layer Chromatography, Ion exchange Chromatography, Gas permeation Chromatography, affinity chromatography, Gas chromatography, Supercritical fluid chromatography, High Performance Liquid Chromatography, Capillary electrophoresis, Classification of chromatographic methods – according to separation methods, according to development procedures.
   Thin Layer Chromatography: Theory and principles, outline of the method, surface adsorption and spot shape, Comparison of TLC with other forms of chromatography, adsorbents, preparation of plates, application of samples, development.
   Paper Chromatography- Origin, overview of technique, sample preparation, types of paper, solvents, equilibrium, development, sample application and detection, Identification, Quantitative methods, applications of paper chromatography **[14]**

5. pH meter

Introduction, pH meter, Glass pH electrode, combination of pH electrode-Complete Cell, Standard Buffer –reference for pH measurement, Accuracy of pH measurement, Using pH meter –How does it works? Applications of pH meter. **[04]**

Learning Outcomes

1**. Introduction to Analytical Chemistry**

i. Analytical Chemistry –branch of chemistry
ii. Perspectives of analytical Chemistry
iii. analytical problems

2. Calculations used in Analytical Chemistry

i. Calculations of mole, molar concentrations and various units of concentrations which will be helpful for preparation of solution
ii. Relation between molecular formula and empirical formula
iii. Stoichiometric calculation
iv. Define term mole, millimole, molar concentration, molar equilibrium concentration and Percent Concentration.
v. SI units, distinction between mass and weight
vi. Units such as parts per million, parts per billion, parts per thousand, solution-dilatant volume ratio, function density and specific gravity of solutions.

3 Qualitative Analysis of Organic Compounds

Basics of type determination, characteristic tests and classifications, reactions of different functional groups.

i. Separation of binary mixtures and analysis
ii. Elemental analysis -Detection of nitrogen, sulfur, halogen and phosphorous by Lassiagen's test.
iii. Purification techniques for organic compounds.

4. Chromatographic Techniques – Paper and Thin layer Chromatography

i. Basics of chromatography and types of chromatography
ii.Theoretical background for Paper and Thin Layer Chromatography

5. pH metry

i. pH meter and electrodes for pH measurement
ii. Measurement of pH
iii. Working of pH meter
iv. Applications of pH meter

Reference Books:

1. Lee, J.D. *Concise Inorganic Chemistry* ELBS, 1991.
2. Cotton, F.A., Wilkinson, G. & Gaus, P.L. *Basic Inorganic Chemistry*, 3rd ed., Wiley.
3. Douglas, B.E., McDaniel, D.H. & Alexander, J.J. *Concepts and Models in Inorganic Chemistry*, John Wiley & Sons.
4. Huheey, J.E., Keiter, E.A., Keiter, R.L. & Medhi, O.K. *Inorganic Chemistry: Principles of Structure and Reactivity*, Pearson Education India, 2006.

5. Graham Solomon, T.W., Fryhle, C.B. & Dnyder, S.A. *Organic Chemistry,* John Wiley & Sons (2014).
6. McMurry, J.E. *Fundamentals of Organic Chemistry*, 7th Ed. Cengage Learning India Edition, 2013.
7. Sykes, P. *A Guidebook to Mechanism in Organic Chemistry,* Orient Longman, New Delhi (1988).
8. Finar, I.L. *Organic Chemistry* (Vol. I & II), E.L.B.S.
9. Morrison, R.T. & Boyd, R.N. *Organic Chemistry*, Pearson, 2010.
10. Bahl, A. & Bahl, B.S. *Advanced Organic Chemistry,* S. Chand, 2010.
11. A Braithwait and F. J. Smith, *Chromatographic method*, 5th edition, Kluwer Academic publishers
12. G D Christian -Analytical Chemistry
13. Qualitative Organic Analysis 4th Edn by A I Vogel (ELBS)
14. Vogel's Quantitative Analysis
15. Douglas A Skoog, Donald M West, F James Holler ,Stainly R Crounch , *Fundamentals of Analytical Chemistry*, 9th edition
16. David Harvey, *Modern Analytical Chemistry*, McGraw Hill Higher education
17. Gurudeep R Chatwal, Sham K Anand, *Instrumental Methods of Chemical Analysis*, Himalaya Publishing House.
18. Barrow, G.M. *Physical Chemistry* Tata McGraw-Hill (2007).
19. Kotz, J.C., Treichel, P.M. & Townsend, J.R. *General Chemistry* Cengage Learning India Pvt. Ltd., New Delhi (2009).
20. Mahan, B.H. *University Chemistry* 3rd Ed. Narosa (1998).
21. Petrucci, R.H. *General Chemistry* 5th Ed. Macmillan Publishing Co.: New York (1985).
22. *Atkins' Physical Chemistry,* 10th edition (2014), Oxford University Press
23. Thomas Engel, Philip Reid; *Physical Chemistry* , Pearson Education (2006)
24. J. N. Gurtu, A. Gurtu, *Advanced Physical Chemistry,* Pragati Edition
25. McQuarrie, D. A., & Simon, J. D., *Physical Chemistry: A molecular approach*. Sausalito, CA: University Science Books (1997)
26. Atkins, P., & de Paula, J., *Physical Chemistry for the Life Sciences*. New York: W. H. Freeman and Company (2006)
27. McMahon, D. (2005). *Quantum Mechanics Demystified*. NewYork: McGraw-Hill Professional
28. Ladd, M. *Introduction to Physical Chemistry* (3rd ed). Cambridge, UK: Cambridge University Press (1998)

CH- 203: Chemistry Practical –II (1.5 Credits, 46.8 Lectures of 50 min.)

Section A: Inorganic Chemistry

Wherever required standardization of volumetric reagent must be performed.

I] Synthesis of commercially important inorganic compounds (any two)

1) Synthesis of potash alum from aluminium metal (scrap Aluminium metal)
2) Synthesis of Mohr's Salt $[(FeSO_4)\ (NH_4)_2SO_4]\bullet 6H_2O$
3) Preparation of Dark red inorganic pigment: Cu_2O
4) Synthesis of $FeSO_4\bullet 7H_2O$

Note:

i. In synthesized compound student must confirm the particular cation and anion by performing qualitative tests.
ii. Costing of product for 100 g pack can be calculated on the basis of cost of raw materials used and percent yield of the product.
iii. Synthesized compounds should be collected from all students and stored properly. They should be used in other experiments such as Mohr's salt for determination of water of crystallization. Potash alum and $FeSO_4$ can be given in IQA experiments or for estimations at SY and TY level.

II] Volumetric Analysis (Any Two)

1. Estimation of sodium carbonate and sodium hydrogen carbonate present in a mixture.
2. Determination of basicity of boric acid or oxalic acid or citric acid hence determination of their equivalent weight.
3. Estimation of water of crystallization in Mohr's salt by titrating with $KMnO_4$.

III] Analysis of Commercial products containing inorganic substances (any two)

1) Estimation of Ca from calcium supplementary tablet by complexometric titration.
2) Estimation of acid neutralizing capacity of antacids like Gelusil tablet/ Gellusil syrup etc.
3) Estimation of selectively Cu(II) from brass alloy by iodometrically (Use KIO_3 as primary standard for standardization of $Na_2S_2O_3$ and **not** $K_2Cr_2O_7$).

IV] To draw polar plots of s and p orbitals.

Section B: Organic Chemistry

I] Organic Purification Techniques

1. Purification of organic compounds by i) crystallization (from water and alcohol) ii) distillation (Two Compounds), iii) Sublimation (micro technique).

II] Organic preparations: Derivatives

2. Preparations: Mechanism of various reactions involved to be discussed. Recrystallization, determination of melting point and calculation of quantitative yields to be done. (Any Two)

a) Bromination of Cinnamic acid using sodium bromide and Sodium bromate. (Green Chemistry Approach)

OR

a) Bromination of acetanilide using KBr and Cerric ammonium nitrate in aqueous medium. (Green Chemistry Approach)
3) Semicarbazone derivatives of aldehydes and ketones
4) Oxime and 2,4-dinitrophenylhydrazone of aldehyde/ketone
Note: Presence of extra element in the synthesized compound must be tested (Br and N in respective compound)
N. B.:

1. **Use molar concentrations for volumetric /estimations/synthesis experiments.**
2. **Use optimum concentrations and volumes**
3. **Two burette method should be used for volumetric analysis (Homogeneous mixtures)**
4. **Use of microscale technique is recommended wherever possible**

Reference Books:

1. Svehla, G. *Vogel's Qualitative Inorganic Analysis*, Pearson Education, 2012.
2. Mendham, J. *Vogel's Quantitative Chemical Analysis*, Pearson, 2009.
3. Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., *Textbook of Practical Organic Chemistry*, Prentice-Hall, 5th edition, 1996.
4. Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry* Orient-Longman, 1960.
5. Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).

Learning Outcome

1. Inorganic Estimations using volumetric analysis
2. Synthesis of Inorganic compounds
3. Analysis of commercial products
4. Purification of organic compounds
5. Preparations and mechanism of reactions involved

Course Outcome

CH- 101: Physical Chemistry

After completing the course work learner will be acquired with knowledge of chemical energetics, Chemical equilibrium and ionic equilibria.

CH- 102: Organic Chemistry

Students will learn Fundamentals of organic chemistry, stereochemistry (Conformations, configurations and nomenclatures) and functional group approach for aliphatic hydrocarbons.

CH- 201: Inorganic Chemistry

Students will learn quantum mechanical approach to atomic structure, Periodicity of elements, various theories for chemical bonding.

CH-202: Analytical Chemistry

Students will know about basics of analytical chemistry, some techniques of analysis and able to do calculations essential for analysis.

Lab Course CH 103 and CH-203

1. The practical course is in relevance to the theory courses to improve the Understanding of the concepts.
2. It would help in development of practical skills of the students.
3. Use of microscale techniques wherever required

Savitribai Phule Pune University

(Formerly University of Pune)

Three Year B.Sc. Degree Program in Microbiology

(Faculty of Science & Technology)

F. Y. B. Sc. (Microbiology)

Choice Based Credit System Syllabus

To be implemented from Academic Year 2019-2020

Title of the Course: B. Sc. (Microbiology)

Preamble:

Microbiology is a broad discipline of biology which encompasses five groups of microorganisms i.e. bacteria, protozoa, algae, fungi, viruses. It studies their interaction with their environments as well as how these organisms are harnessed in human endeavour and their impact on society. The study has its extensions in various other conventional and advanced fields of biology by employing microbes as study models. Since inception of microbiology as a branch of science, it has remained an ever-expanding field of active research, broadly categorized as pure and applied science. Microorganisms were discovered over three fifty years ago and it is thought that a huge diversity yet remains to be explored.

Knowledge of different aspects of Microbiology has become crucial and indispensable to the society. Study of microbes has become an integral part of education and human progress. There is a continuous demand for microbiologists as work force – education, industry and research. Career opportunities for the graduate students are available in industry and research equally.

Introduction:

In the post globalization world higher education has to play a significant role in creation of skilled human resources for the well-being of humanity. The barriers among the academic fields seem to have dissolved. However, the disparities in the field of curriculum aspect, evaluation and mobility exist. With the changing scenario at local and global level, the syllabus restructuring should keep pace with developments in the education sector. Choice Based Credit System (CBCS) is being adopted and implemented to address the issues related to traditional system and it also aims to maintain the best of earlier curriculum. The student is at the centre of CBCS. The present curriculum focuses on students' needs, skill development, interdisciplinary approach to learning and enhancing employability.

Microbiology curricula are offered at two levels viz. undergraduate and postgraduate. The undergraduate curricula are prepared to impart basic knowledge of the respective subject from all possible angles. In addition, students are to be trained to apply this knowledge in day-to-day applications and to get a glimpse of research.

Objectives to be achieved:

- To enrich students' knowledge and train them in the pure microbial sciences
- To introduce the concepts of application and research in Microbiology
- To inculcate sense of scientific responsibilities and social and environment awareness
- To help students build-up a progressive and successful career

Course Structure:

- For First year: Student has to select 4 different subjects among the subjects offered by the College /Institute.
- For Second year: Student has to select 3 different subjects among 4 subjects chosen in first year.
- For Third year: Student has to select only 1 subject among the 3 subjects opted in second year
- CGPA will be calculated based on core 132 credits only
- Each theory credit is equivalent to 15 clock hours of teaching (12hrs classroom+3hrs of tutorials-active learning method) and each practical credit is equivalent to 30 clock hours of teaching in a semester.
- For the purpose of computation of workload, the following mechanism may be adopted as per UGC guidelines:

i) 1 Credit = 1 Theory period of one-hour duration per week
ii) 1 Credit = 1 Tutorial period of one-hour duration per week
iii) 1 Credit = 1 Practical period of two-hour duration per week

- Each theory Lecture time for FY, SY, TY is of 1 hour = 50 min
- Each practical session time for FY is of 3 hour 15 min = 195 min
- Each practical session time for SY & TY is of 4 hour 20 min = 260 min

Eligibility for Admission:

First Year B.Sc.:

a. Higher Secondary School Certificate (10+2) or its equivalent Examination with English and Biology; and two of the science subjects such as Physics, Chemistry, Mathematics, Geography, Geology, etc.

OR

b. Three Years Diploma in Pharmacy Course of Board of Technical Education conducted by Government of Maharashtra or its equivalent.

OR

c. Higher Secondary School Certificate (10+2) Examination with English and vocational subject of + 2 level (MCVC) - Medical Lab. Technician (Subject Code = P1/P2/P3)

Admissions will be given as per the selection procedure / policies adopted by the respective college keeping in accordance with conditions laid down by the University of Pune.

Reservation and relaxation will be as per the Government rules.

Medium of Instruction: English

Award of Credits:

- Each course having 4 credits shall be evaluated out of 100 marks and student should secure at least 40 marks to earn full credits of that course.

- Each course having 2 credits shall be evaluated out of 50 marks and student should secure at least 20 marks to earn full credits of that course.

- GPA shall be calculated based on the marks obtained in the respective subject provided that student should have obtained credits for that course.

Evaluation Pattern:

- Each course carrying 100 marks shall be evaluated with Continuous Assessment (CA) and University Evaluation (UE) mechanism.
- Continuous assessment shall be of 30 marks while University Evaluation shall be of 70 marks. To pass in a course, a student has to secure minimum 40 marks provided that he should secure minimum 28 marks in University Evaluation (UE).
- Each course carrying 50 marks shall be evaluated with Continuous Assessment (CA) and University Evaluation (UE) mechanism.
- Continuous assessment shall be of 15 marks while University Evaluation shall be of 35 marks.
- To pass in a course, a student has to secure minimum 20 marks provided that he/she should secure minimum14 marks in University Evaluation (UE).
- For Internal examination minimum two tests per paper of which one has to be a written test 10 marks
- Methods of assessment for Internal exams: Seminars, Viva-voce, Projects, Surveys, Field visits, Tutorials, Assignment, Group Discussion, etc (on approval of the head of the centre)

ATKT Rules:

- Minimum number of credits required to take admission to Second Year of B. Sc.: 22
- Minimum number of credits required to take admission to Third Year of B.Sc.: 44

Completion of Degree Course:

- A student who earns 140 credits, shall be considered to have completed the requirements of the B. Sc. degree program and CGPA will be calculated for such student

Titles of Papers and Scheme of Study Evaluation

F. Y. B.Sc. Microbiology

Semester	Paper Code	Paper	Paper title	credits	Lectures/Week			Evaluation		
					Th.	Tut.	Pr.	CA	UE	Total
I	MB 111	I	Introduction to Microbial World	2	2			15	35	50
	MB 112	II	Basic Techniques in Microbiology	2	2			15	35	50
	MB113	III	Practical Course based on theory paper I and II	1.5			3	15	35	50
II	MB121	I	Bacterial Cell and Biochemistry	2	2			15	35	50
	MB122	II	Microbial cultivation and growth	2	2			15	35	50
	MB123	III	Practical Course based on theory paper I and II	1.5			3	15	35	50

S. Y. B. Sc. Microbiology

Semester	Paper Code	Paper	Paper title	credits	Lectures/Week			Evaluation		
					Th	Tut	Pr.	CA	UE	Total
III	MB 211	I	Bacterial Systematics and Physiology	2	2			15	35	50
	MB 212	II	Industrial Microbiology	2	2			15	35	50
	MB213	III	Practical based on MB211 & MB 212	2			4	15	35	50
IV	MB221	I	Bacterial Genetics	2	2			15	35	50
	MB222	II	Air Water & Soil Microbiology	2	2			15	35	50
	MB223	III	Practical based on MB211 & MB 212	2			4	15	35	50

T. Y. B. Sc. Microbiology Proposed Structure

	Paper	Paper Title	Marks	Lecture
Semester V	MB 331 TC	Medical Microbiology I	50	2 Credits /per TC
	MB 332 TC	Genetics and Molecular Biology I	50	
	MB 333 TC	Enzymology	50	
	MB 334 TC	Immunology I	50	
	MB 335 TC	Fermentation technology I	50	
	MB 336 Elective Course TE	Applied Microbiology I (Elective Course)	50	2 Credits /TE
	TE 1	Dairy Microbiology		
	TE 2	Agricultural Microbiology		
	TE 3	Marine Microbiology		
	TE 4	Space Microbiology		
	MB 337 PC	Practical Course I	50	2 Credits /per PC
	MB 338 PC	Practical Course II	50	
	MB 339 PC	Practical Course III	50	
Semester VI	MB 341 TC	Medical Microbiology II	50	2 Credits /per TC
	MB 342 TC	Genetics and Molecular Biology II	50	
	MB 343 TC	Metabolism	50	
	MB 344 TC	Immunology II	50	
	MB 345 TC	Fermentation technology II	50	
	MB 346 Elective Course TE	Applied Microbiology II (Elective Course)	50	2 Credits /TE
	TE 5	Food Microbiology		
	TE 6	Geomicrobiology		
	TE 7	Nanobiotechnology		
	TE 8	Waste Management		
	MB 347 PC	Practical Course I	50	2 Credits /per PC
	MB 348 PC	Practical Course II	50	

	MB 349 PC	Practical Course III	50	

- Inadditiontothecompulsorycreditsof132, the student has to earn additional 8credits from following groups by taking/participating/conducting respective activities.

1. Courses in Group I are compulsory.

The student can earn maximum 04 credits from an individual group from Group 2 to Group-9. These extra credits will not be considered for GPA calculation; however, these are mandatory for the completion and award of B. Sc. Degree.

Group 1: Physical Education (at F. Y.B. Sc. Sem. I)-01 credit
Physical Education (at F. Y.B. Sc. Sem. II)-01credit (Note: Group I is compulsory for all the students as stated above.)

Group 2: Sport representation at Collegelevel-01 credit
Sport representation at University/Statelevel-02 credits

Group 3: National Social Service Scheme (participation in Camp): 01 credits
N.C.C. (with participation in annual camp)-01credit
N. C. C. (with B certificate/C certificate award)-02 credits
N.S.S./N.C.C. Republicdayparadeparticipation-04 credits

Group 4: Avishkar participation; Extension activity participation, Cultural activity participation– 01 credit, Avishkar selection at Universitylevel-02 credits. Avishkar winner at state level-04credits

Group 5: Research paper presentation at State/National level-01 credits. Research paper presentation at International level-02 credits

Group 6: Participation in Summer school/programme; Short term course (not less than 1-weekduration) -03 credit. Group 7: Scientific Survey, Societal survey,-02 credits.

Group 8: Field Visits; Study Tours; Industrial Visits; Participation in curricular/ cocurricular competitions-01 Credit.

Group 9: Online certificate Courses /MOOC Courses/ Career Advancement Course up to 04 credits (Minimum10 Hrs. / credit**)**

Equivalence of Previous Syllabus:F. Y. B. Sc. Microbiology

Sem	Old Course (2013 Pattern)	New Course (2019 Pattern)
I	Introduction to Microbiology	Introduction to Microbial World
	Basic Techniques in Microbiology	Basic Techniques in Microbiology
	Practical Course	Practical Course based on theory paper I and II
II	Introduction to Microbiology	Bacterial Cell and Biochemistry
	Basic Techniques in Microbiology	Microbial cultivation and growth
	Practical Course	Practical Course based on theory paper I and II

External Students

There shall be no external students.

University Terms

Dates for commencement and conclusion for the first and second terms will be declared by the University authorities. Terms can be kept by only duly admitted students. The term shall be granted only on minimum 80 percent attendance at theory and practical course and satisfactory performance during the term.

Current curriculum orientation

To accommodate more advanced topics in the syllabi, it is necessary to understand the basic science knowledge level of the students that have chosen the Microbiology discipline. Curricula of courses of state and central boards of higher secondary level were reviewed to avoid reiterations of previous syllabi.

At **first year of under-graduation**, students will be provided the basic information that includes – characteristics of microbial world. The microorganisms will be studied for morphological, structural characterization, isolations techniques from natural and extreme environments and their prominent features. The methodology to develop keen observation i.e. different microscopy techniques, staining techniques and nutritional requirements will be taught in detail; including these aspects at laboratory level as well. Introduction to biochemical characterization of components of micro-organism e.g. proteins, lipids, nucleic acids and carbohydrates and instrumental techniques to estimate these components qualitatively and quantitatively from micro-organisms or other natural sources will be the focus for second theory paper. Relevant experimentation on these topics will be included in practical course. In practical course, students will be trained in preparing laboratory manuals, standard operating practices and logbooks.

At **second year under-graduation** includes paper on principles of taxonomy and classification of major groups of microorganisms. The said paper will also include the physiological studies on these groups of micro-organisms. Second paper will deal with Air and Water Microbiology; role of micro-organisms in environment in regard to pollution and biodegradation; water and sewage treatment. Practical for the second-year students will designed to be flexible incorporating project themes on environment, agriculture and pollution aspects to acquire laboratory skills. Practical at this level will also includes application of biostatistics principles, computers for data analysis, interpretation, introduction to scientific writing and report preparation. These aspects can be better while carrying out the mini projects.

At **third year under-graduation**, The six theory papers will deal with broad areas of microbiology. Five such areas are – Medical microbiology, Microbial physiology, Microbial (prokaryotic and eukaryotic) genetics, Immunology and Fermentation technology. The sixth course will be Applied Microbiology that will include – Dairy Microbiology, Food Microbiology, Fermentation Technology, Agriculture Biotechnology, Fungal Biotechnology, etc. The practicals at third year will be planed more intensively, with exposure to applied fields and hands-on training.

Qualification of Teachers:

With minimum undergraduate and postgraduate degree in Microbiology (B. Sc. and M. Sc. Microbiology) and qualified as per UGC regulations.

Semester I

Paper I: Introduction to Microbial World

Sr. No.	Topic	No. of Hours
Credit One	**Amazing world of Microbiology**	**(15)**
	Development of microbiology as a discipline -Discovery of microscope and Microorganisms (Anton von Leeuwenhoek and Robert Hooke), Abiogenesis v/s biogenesis (Aristotle's notion about spontaneous generation, Francesco Redi's experiment, Louis Pasteur's & Tyndall's experiments)	**4**
	Golden Era of Microbiology Contributions of - Louis Pasteur (Fermentation, Rabies, Pasteurization and Cholera vaccine-fowl cholera experiment) Robert Koch (Koch's Postulates, Germ theory of disease, Tuberculosis and Cholera-isolation and staining techniques of causative agent) Ferdinand Cohn (Endospore discovery), Discovery of viruses (TMV and Bacteriophages), River's Postulates	**3**
	Contribution of Joseph Lister (antiseptic surgery), Paul Ehrlich (Chemotherapy), Elie Metchnikoff (Phagocytosis), Edward Jenner (Vaccination) and Alexander Fleming (Penicillin) in establishment of fields of medical microbiology and immunology, Discovery of Streptomycin by Waksman	**3**
	Contribution of Martinus W. Beijerinck (Enrichment culture technique, Rhizobium), Sergei N. Winogradsky (Nitrogen fixation and Chemo-lithotrophy) in the development of the field of soil microbiology	**2**
	Modern Era of Microbiology Carl Woese classification based on 16S rRNA Signification and Application of Human Microbiome, Nano-biotechnology and Space Microbiology	**1**
	Nobel laureates in Life Sciences of 21st Century ***(Project Based Learning: Assignments should be given to student)***	**2**
Credit Two	**Types of Microorganism and their differentiating characters**	**(15)**
	-- Prokaryotes, Eukaryotes, three domain and five domain system of classification	**1**
	--Bacteria (Eubacteria and Archaebacteria)	**1**
	--Protozoa	**1**
	--Fungi	**1**
	--Algae	**1**

	--Viruses, Viroids and Prions	**1**
	--Actinomycetes	**1**
	Beneficial and Harmful effects of microorganisms:	
	Medical Microbiology (Enlist diseases caused by various microorganisms, vaccines and antibiotics)	**1**
	Environmental Microbiology (Eutrophication, red tide, Sewage treatment, bioremediation)	**2**
	Food and Dairy Microbiology (Food spoilage, food borne diseases, Probiotics and fermented food)	**1**
	Agriculture Microbiology (Plant diseases and Biofertilizers and Bio-control agents)	**1**
	Industrial Microbiology (Production of antibiotics, enzymes, solvents and contaminants-bacteria and phages)	**2**
	Immunology (Normal flora, Three lines of defence)	**1**

Semester II

Paper I: Bacterial Cell and Biochemistry

Sr. No.	Topic	No. of Hours
Credit One	**Bacterial Cytology**	**(15)**
	- Microbial cell size, shape and arrangements	**1**
	Structure, chemical composition and functions of the following components in bacterial cell:	
	--Cell wall (Gram positive, Gram negative) Concept of Mycoplasma, Spheroplast, protoplast, L-form	**3**
	--Cell membrane	**1**
	--Endospore (spore formation and stages of sporulation)	**1**
	--Capsule	**1**
	--Flagella	**1**
	--Fimbriae and Pili	**1**
	--Ribosomes	**1**
	--Chromosomal & extra-chromosomal material	**1**
	--Cell inclusions (Gas vesicles, carboxysomes, PHB granules, metachromatic granules, glycogen bodies, starch granules, magnetosomes, sulfur granules, chlorosomes)	**4**
Credit Two	**Chemical Basis of Microbiology**	**(15)**
	Atom, Biomolecules, types of bonds (covalent, co-ordinate bond, non-covalent) and linkages (ester, phospho-diester, peptide, glycosidic)	**2**

	Chemistry of Biomolecules: Structure, organization and functions **Carbohydrates: Definition, classification** i. Monosaccharides: Classification based on aldehyde and ketone groups; structure of Ribose, Deoxyribose, Glucose, Galactose and Fructose. ii. Disaccharides: Glyosidic bond, structure of lactose and sucrose. iii. Polysaccharides: Structure and types Examples-Starch, glycogen, Peptidoglycan, chitin **Lipids: Definition, classification** i. Simple lipids – Triglycerides, Fats and oils, waxes. ii. Compound lipids – Phospholipid, Glycolipids iii. Derived lipids – Steroids, Cholesterol **Proteins: Definition, classification** i) General structure of amino acids, peptide bond. ii) Types of amino acids based on R group iii) Structural levels of proteins: primary, secondary, tertiary and quaternary iv) Study of Hemoglobin, flagellin and cytoskeletal proteins **Nucleic acids: Definition, classification** i) DNA – structure and composition ii) RNA – Types (m-RNA, t-RNA, r-RNA), structure and functions. **Classification of Bacteria -** Introduction to Bergey's Manual of Determinative and Systemic Bacteriology **Classification of Viruses: ICTV** nomenclature	**1** **1** **2** **2** **1** **1** **1** **1** **2**

Semester I
Paper II: Basic Techniques in Microbiology

Serial No.	Topic	No. of Hours
Credit One		**(08)**
	I. Units of measurement – Introduction to Modern SI units	**1**
	Microscopy:	
	1. Bright field microscopy:	**3**
	• Electromagnetic spectrum of light	
	• Structure, working of and ray diagram of a compound light microscope; concepts of magnification, numerical aperture and resolving power.	
	• Types, ray diagram and functions of – condensers (Abbe and cardioid) eyepieces and objectives	
	• Concept of aberrations in lenses - spherical, chromatic, comma and astigmatism	
	2. Principle, working and ray diagram of	
	i. Phase contrast microscope	**1**
	ii. Fluorescence Microscopy	**1**
	iii. Electron Microscopy – TEM, SEM	**2**
	II. Staining Techniques:	**(07)**
	• Definition of Stain; Types of stains (Basic and Acidic), Properties and role of Fixatives, Mordants, Decolourisers and Accentuators	**1**
	• Monochrome staining and Negative (Relief) staining	**1**
	• Differential staining - Gram staining and Acid-fast staining	**2**
	• Special staining- Capsule, Cell wall, Spore, Flagella, Lipid granules, metachromatic granules	**3**
Credit II	**Sterilization and Disinfection**	**(15)**
	1. Sterilization	
	• Physical Agents - Heat, Radiation, Filtration	**3**
	• Checking of efficiency of sterilization (Dry and Moist) – Biological and Chemical Indicators	**3**
	2. Disinfection:	
	• Chemical agents and their mode of action - Aldehydes, Halogens, Quaternary ammonium compounds, Phenol and phenolic compounds,	**4**
	• Heavy metals, Alcohol, Dyes, Detergents and Ethylene oxide.	**3**
	• Characteristics of an ideal disinfectant	**1**
	• Checking of efficiency of disinfectant - Phenol Coefficient (Rideal–Walker method)	**1**

Semester II

Paper II: Microbial cultivation and growth

Serial No.	Topic	No. of Hours
Credit One	**Cultivation of Microorganisms:**	**(15)**
	1.Nutritional requirements and nutritional classification	**2**
	2.Design and preparation of media: Common ingredients of media and types of media	**2**
	3.Methods for cultivating photosynthetic, extremophilic and chemo-lithotrophic bacteria, anaerobic bacteria, algae, fungi, actinomycetes and viruses	**4**
	4.Concept of Enrichment, Pure Culture, Isolation of culture by streak plate, pour plate, spread plate	**2**
	5. Maintenance of bacterial and fungal cultures using different techniques	
	6. Culture collection centres and their role	**3**
	7. Requirements and guidelines of National Biodiversity Authority for culture collection centres	**1** **1**
Credit Two	**Bacterial growth:**	**(15)**
	1. Kinetics of bacterial growth (Exponential growth model)	**2**
	2. Growth curve and Generation time	**2**
	3. Diauxic growth	**1**
	4. Measurement of bacterial growth- Methods of enumeration:	
	• Microscopic methods (Direct microscopic count, counting cells using improved Neubauer, Petroff-Hausser's chamber)	**3**
	• Plate counts (Total viable count)	**1**
	• Turbidometric methods (including Nephelometry)	**1**
	• Estimation of biomass (Dry mass, Packed cell volume)	**1**
	• Chemical methods (Cell carbon and nitrogen estimation)	**1**
	5. Factors affecting bacterial growth {pH, Temperature, Solute Concentration (Salt and Sugar)} and Heavy metals	**3**

F. Y. B. Sc. Microbiology Practical Course (Implemented from 2019) based on theory paper I and II

Semester I		
Expt. No.	**Topics**	**No. of Practicals**
1	i. Safety measures and Good Laboratory Practices in microbiology laboratory ii. Introduction, operation, precautions and use of common microbiology laboratory instruments: Incubator, Hot air oven, Autoclave, Colorimeter, Laminar air flow hood, Clinical centrifuge.	2
2	i. Construction (mechanical and optical), working and care of bright field microscope. ii. Permanent slide observation: Algae, Fungi and Protozoa iii. Wet mount slide preparation and its observation for: Bacteria, Algae, Fungi and Protozoa.	3
3	i. Introduction and use of common laboratory glass wares: Test tubes, culture tubes, suspension tubes, screw capped tubes, Petri plates, pipettes (Mohr and serological) micropipettes, Pasteur pipettes, Erlenmeyer flask, volumetric flask, glass spreader, Durham's tube, Cragie's tube and inoculating needles (wire loop, stab needles). ii. Learning basic techniques in Microbiology: Wrapping of glassware, cotton plugging, cleaning and washing of glassware, biological waste disposal.	2
4	**Basic staining techniques:** **i. Monochrome staining** **ii. Negative staining** **iii. Gram staining of bacteria**	3
5	Observation of motility in bacteria using: Hanging drop method and swarming growth method.	2
6.	Checking of efficacy of chemical disinfectant: Phenol Coefficient by Rideal–Walker method.	2
	TOTAL	**14**

Semester II		
Expt. No.	**Topics**	**No. of Practicals**
1	i. Preparation of simple laboratory nutrient media (Nutrient agar/broth, MacConkey's agar). ii. Checking sterilization efficiency of autoclave using a biological indicator (*B. stearothermophilus*) iii. Preparation of Winogradsky's column and observation of different types of microorganisms using bright field microscope	3
2	**Special staining techniques:** i. Endospore staining ii. Capsule staining	2
3	Isolation of bacteria by streak plate technique (Colony and cultural characteristics)	1
4	Enumeration of bacteria from fermented food / soil / water by: i. Spread plate method ii. Pour plate method	2
5	**Study of normal flora of skin:** i. Cultivating and observing different morphoforms of bacteria from skin. ii. Study of effect of washing on skin with soap and disinfectant on it's microflora	2
6	i. To study the effect of different parameters on growth of *E. coli*: pH, temperature, sodium chloride concentration ii. Study of oligodynamic action of heavy metal	3
7	Preservation of cultures on slants, soil and on grain surfaces; revival of these cultures and lyophilized cultures.	1
	TOTAL	**14**

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Savitribai Phule Pune University

(Formerly University of Pune)

Three Year B.Sc. Degree Program in Botany

(Faculty of Science & Technology)

F.Y.B.Sc. Botany

Choice Based Credit System Syllabus

To be implemented from Academic Year 2019-2020

Title of the Course: B. Sc Botany

1. Structure of Course:

Structure B.Sc. Botany syllabus					
Year	Semester	Course Type	Course code	Course Name	Credits
1	1	Compulsory Course	BO 111	Plant life and utilization I	2
			BO 112	Plant morphology and Anatomy	2
			BO 113	Practical based on BO 111 & BO 112	1.5
	2	Compulsory Course	BO 121	Plant life and utilization II	2
			BO 122	Principles of plant science	2
			BO 123	Practical based on BO 121 & BO 122	1.5
2	3	Compulsory Course	BO 231	Botany Theory Paper 1	2
			BO 232	Botany Theory Paper 2	2
			BO 233	Botany Practical Paper	2
	4	Compulsory Course	BO 241	Botany Theory Paper 1	2
			BO 242	Botany Theory Paper 2	2
			BO 243	Botany Practical Paper	2
3	5	Discipline Specific Elective Course	BO 351	Botany Theory Paper 1	2
			BO 352	Botany Theory Paper 2	2
			BO 353	Botany Theory Paper 3	2
			BO 354	Botany Theory Paper 4	2
			BO 355	Botany Theory Paper 5	2
			BO 356	Botany Theory Paper 6	2
			BO 357	Botany Practical Paper 1	2
			BO 358	Botany Practical Paper 2	2
			BO 359	Botany Practical Paper 3	2
		Skill Enhancement course	BO 3510	Botany Theory Paper 7	2
			BO 3511	Botany Theory Paper 8	2
3	6	Discipline Specific Elective Course	BO 361	Botany Theory Paper 1	2
			BO 361	Botany Theory Paper 2	2
			BO 362	Botany Theory Paper 3	2
			BO 363	Botany Theory Paper 4	2
			BO 364	Botany Theory Paper 5	2
			BO 365	Botany Theory Paper 6	2
			BO 366	Botany Practical Paper 1	2
			BO 367	Botany Practical Paper 2	2
			BO 368	Botany Practical Paper 3	2
		Skill Enhancement course	BO 3610	Botany Theory Paper 7	2
			BO 3611	Botany Theory Paper 8	2

2. Equivalence of Previous Syllabus:

Old Course (2013 Pattern)	New Course (2019 CBCS Pattern)
Fundamentals of Botany: PAPER – I Term- I: Plant Diversity	BO 111 Plant life and utilization I
Botany Theory Paper II Term I – Industrial Botany	BO 112 Plant morphology and Anatomy
Fundamentals of Botany: PAPER - I Term- II: Morphology and Anatomy	BO 121 Plant life and utilization II
Botany Theory Paper II Term- II – Industrial Botany	BO 122 Principles of plant science
F. Y. B. Sc. Botany Practical Paper - III based on Theory Paper I and Paper II	BO 113 Practical based on BO 111 & BO 112 and BO 123 Practical based on BO 121 & BO 122

SEMESTER-I: PAPER-I

BO-111: PLANT LIFE AND UTILIZATION I (30 Lectures)

CREDIT-I **15 Lectures (15 Hours)**

1. INTRODUCTION **3 L**

General outline of plant kingdom (**Lower Cryptogams**: Thallophytes- Algae, Fungi & Lichens; **Higher Cryptogams**: Bryophytes and Pteridophytes; **Phanerogams**: Gymnosperms and Angiosperms- Dicotyledons and Monocotyledons). Distinguishing characters of these groups and mention few common examples from each.

2. ALGAE **9 L**

2.1: Introduction
2.2: General Characters
2.3: Classification (Bold and Wynne 1978) up to classes with reasons
2.4: Life Cycle of *Spirogyra* w.r.t. Habit, Habitat, Structure of thallus, structure of typical cell, Reproduction- Vegetative, Asexual and Sexual, systematic position with reasons
2.5: Utilization of Algae in Biofuel Industry, Agriculture, Pharmaceuticals, Food and Fodder

3. LICHENS **3 L**

3.1: Introduction
3.2: General Characters
3.3: Nature of Association, forms- Crustose, Foliose and Fruticose.
3.4: Utilization of lichens.

CREDIT-II **15 Lectures (15 Hours)**

4. FUNGI **9 L**

4.1: Introduction
4.2: General Characters
4.3: Classification (Ainsworth, 1973)
4.4: Life Cycle of Mushroom- *Agaricus bisporus* w.r.t. Habit, Habitat, Structure of thallus, Structure of Sporocarp, Structure of Gill, Reproduction- Asexual and sexual, Systematic position.
4.5: Utilization of Fungi in Industry, Agriculture, Food and Pharmaceuticals.

5. BRYOPHYTES **6 L**

5.1: Introduction
5.2: General Characters
5.3: Classification (G.M. Smith 1955)
5.4: Life Cycle of *Riccia* w.r.t. Habit, habitat, external and internal structure of thallus, Reproduction- vegetative, asexual and sexual- Structure of sex organs, fertilization, structure of mature sporophyte, structure of spore, systematic position with reasons.
5.5: Utilization: Bryophytes as ecological indicators, agriculture, fuel, industry and medicine.

(Development of sex organs not expected for all the above mentioned life cycles).

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SEMESTER-I: PAPER-II

BO-112: PLANT MORPHOLOGY AND ANATOMY (30 Lectures)

CREDIT-I **15 Lectures (15 hours)**

1. MORPHOLOGY: 2 L

1.1: Introduction, definition, descriptive and interpretative morphology.
1.2: Importance in identification, nomenclature, classification, phylogeny and Plant breeding.

2. MORPHOLOGY OF REPRODUCTIVE PARTS:

2.1: INFLORESCENCE: 3 L

2.1.1 Introduction and definition
2.1.2 Types:
a) Racemose -Raceme, Spike, Spadix, Corymb, Umbel, Catkin and Capitulum.
b) Cymose -Solitary, Monochasial- Helicoid and scorpiod; Dichasial and Polychasial.
c) Special types -Verticillaster, Cyathium and Hypanthodium.
2.1.3 Significance

2.2: FLOWER: 7 L

2.2.1 Introduction and definition
2.2.2 Parts of a typical flower: Bract, Pedicel, Thalamus- forms, Perianth- Calyx and Corolla, Androecium and Gynoecium.
2.2.3 Symmetry: Actinomorphic and zygomorphic, Sexuality- Unisexual ands bisexual, Insertion of floral whorls on thalamus- Hypogyny, Epigyny and perigyny, Merous condition-Trimerous, tetrmerous and pentamerous.
2.2.4 Floral whorls:
a) **Calyx:** Nature- Polysepalous, Gamosepalous; Aestivation- types, Modifications of Calyx- Pappus, Petaloid and Spurred.
b) **Corolla:** Forms of Corolla-
i) Polypetalous- Cruciform and Papilionaceous.
ii) Gamopetalous- Infundibuliform, Bilabiate, Tubular and Campanulate.
iii) Aestivation- types and significance.
c) **Perianth:** Nature- Polytepalous, Gamotepalous.
d) **Androecium:** Structure of typical stamen, Variations- cohesion and adhesion.
e) **Gynoecium:** Structure of typical carpel, number, position, cohesion and adhesion; placentation- types and significance.

2.3: FRUITS: 3 L

2.3.1 Introduction and definition
2.3.2 Types of fruits:
a) **Simple:** Indehiscent - Achene, Cypsela, Nut and Caryopsis.
Dehiscent - Legume, Follicle and Capsule,
b) **Fleshy:** Drupe, Berry, Hespiridium and Pepo.
c) **Aggregate:** Etaerio of Berries and Etaerio of Follicles.
d) **Multiple fruits:** Syconus and Sorosis.

CREDIT- II **15 Lectures (15 Hours)**

3. ANATOMY: **2 L**

3.1 Introduction and definition

3.2 Importance in Taxonomy, Physiology, Ecological interpretations, Pharmacongnosy and Wood identification.

4. TYPES OF TISSUES: **8 L**

Outline with brief description, simple and complex tissues.

4.1: **Meristmatic tissues:** Meristem, characters and types based on origin, position and plane of division, functions.

4.2: **Permanent tissues:** Simple tissues - parenchyma, collenchymas, chlorenchyma and sclerenchyma.

4.3: **Complex/Vascular tissues:** Components of xylem and phloem, types of vascular bundles and functions.

4.4: **Epidermal tissues:** Epidermis, structure of typical stomata, trichomes, motor cells; functions.

5. INTERNAL ORGANIZATION OF PRIMARY PLANT BODY: **5 L**

5.1: Internal structure of dicotyledon and monocotyledon root.

5.2: Internal structure of dicotyledon and monocotyledon stem.

5.3: Internal structure of dicotyledon and monocotyledon leaf.

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10. Pandey, B.P. (2007). Plant Anatomy. S. Chand and Co. Ltd. New Delhi.
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14. Sharma, O.P. (1993). Plant Taxonomy. 2nd Edition, McGraw Hill Education, New Delhi.
15. Singh, Gurucharan (2005). Systematics- Theory and Practice. Oxford IBH.
16. Sutaria, R.N.A. Text Book of Systematic Botany.
17. Tayal, M.S. (2012). Plant Anatomy. Rastogi Publications.

BO 113: PRACTICALS BASED ON BO 111 & BO 112 (1.5 CREDITS)

1. Study of Life Cycle of *Spirogyra.* 1 P
2. Study of Life Cycle of *Agaricus.* 1 P
3. Study of Life Cycle of *Riccia* 1 P.
4. Study of forms of Lichens- Crustose, Foliose and fruticose. 1 P
5. Study of Mushroom Cultivation. 1 P
6. One day visit to study Algae, Fungi, Bryophytes and Lichens. 1 P
7. Study of Inflorescence. 2 P
   a. Racemose: Raceme, Spike, Spadix, Catkin, Corymb, Umbel and Capitulum
   b. Cymose: Solitary cyme, Uniparous cyme: helicoid and scorpiod, Biparous cyme and Multiparous cyme.
   c. Special type: Verticillaster, Hypanthodium and Cyathium.
8. Study of flower with respect to Calyx, Corolla and Perianth, Androecium and Gynoecium. 2 P
9. Study of fruits with suitable examples. 2 P
   a) Simple fruit: Dry: Achene, Cypsella and Legume; Fleshy: Berry and Drupe.
   b) Aggregate fruit: Etaerio of follicles and Etaerio of Berries.
   c) Multiple fruit: Syconus and Sorosis.
10. Study of internal primary structure of dicotyledonous root and stem e.g. Sunflower. 1 P
11. Study of internal primary structure of monocotyledonous root and stem e.g. Maize. 1 P
12. Study of internal primary structure of dicotyledonous and monocotyledonous leaf e.g. Sunflower and Maize. 1 P

SEMESTER-II: PAPER-I

BO-121: PLANT LIFE AND UTILIZATION-II (30 Lectures)

CREDIT-I **15 Lectures (15 hours)**

1. **INTRODUCTION:** Introduction to plant diversity- Pteridophytes, Gymnosperms and Angiosperms with reference to vascular plants. 3 L
2. **PTERIDOPHYTES:** General characters, Outline classification according to Sporne (1976) up to classes with reasons. Life cycle of *Nephrolepis* w.r.t. Habit, habitat, distribution, morphology, anatomy of stem and leaf, Reproduction – vegetative and sexual. 10 L
3. Utilization and economic importance of Pteridophytes. 2 L

CREDIT-II **15 Lectures (15 hours)**

1. **GYMNOSPERMS:** General characters, Outline classification according to Sporne (1977) up to classes with reasons. Life cycle of *Cycas* w.r.t. Habit, Habitat, Distribution, Morphology and Anatomy of Stem, leaf and reproductive organs- Male cone, Microsporophyll, microspores and megasporophyll, megaspore; structure of seed; Utilization and economic importance of gymnosperms. 8 L
2. **ANGIOSPERMS:** General characters, Outline of classification of Bentham and Hooker's system up to series, comparative account of monocotyledons and dicotyledons. 4L
3. Utilization and economic importance of Angiosperms: In food, fodder, fibers, horticulture and medicines. 3L

REFERENCES:

1. Bendre, Ashok and Kumar, Ashok (1993). A Text Book of Practical Botany, Rastogy Publications, Meerut.
2. Chamberlain, C.J. (1934). Gymnosperms- Structure and Evolution. Chicago.
3. Coulter, J.M. and Chamberlain, C.J. (1917). Morphology of Gymnosperms. Chicago.
4. Davis, P.H. and Heywood, V.H. (1963). Principles of Angiosperms taxonomy. Oliver and Boyd Publ. London.
5. Dutta, S.C. (1988). Systematic Botany. Wiley Eastern Ltd., New Delhi.
6. Eames, E.J. (1983). Morphology of Vascular Plants. Standard University Press.
7. Gangulee and Kar (2006). College Botany. New Central Book Agency (P.) Ltd. Kolkata.
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11. Sharma, O.P. (1990). Text Book of Pteridophyta. McMillan India Ltd. Delhi.
12. Singh, V. and Jain, D.K. (2010). Taxonomy of Angiosperms. Rastogy Publications, Meerut.

13. Singh, V., Pande, P.C., and Jain, D.K. (2011). A Text Book of Botany: Angiosperms. Rastogy Publications, Meerut.
14. Smith, G.M. (1955). Cryptogamic Botany Vol. II. McGraw Hill.
15. Sporne, K.R. (1986). The Morphology of Pteridophytes. Hutchinson University Library, London.
16. Sundar Rajan, S. (1999). Introduction to Pteridophyta. New Age International Publishers, New Delhi.
17. Vashishta, P.C., Sinha, A.R. and Kumar, Anil (2006). Gymnosperms. S. Chand and Comp. Ltd. New Delhi.
18. Vashista, B.R., Sinha A.K. and Kumar, A. (2008). Botany for degree students-Pteridophyta, S. Chand and Comp. Ltd. New Delhi.

SEMESTER-II: PAPER-II

BO-122: PRINCIPLES OF PLANT SCIENCE (30 Lectures)

CREDIT-1: PLANT PHYSIOLOGY AND CELL BIOLOGY

15 Lectures (15 Hours)

1. Introduction, definition and scope of plant physiology. 1 L
2. Diffusion – definition, importance of diffusion in plants, imbibition as a special type of diffusion. 1 L
3. Osmosis – definition, types of solutions (hypotonic, isotonic, hypertonic), endosmosis, exo-osmosis, osmotic pressure, turgor pressure, wall pressure, importance of osmosis in plants. 2 L
4. Plasmolysis – definition, mechanism and significance. 1 L
5. Plant growth - introduction, phases of growth, factors affecting growth, 2 L
6. Structure of plant cell, differences between prokaryotic and eukaryotic cell. 2 L
7. Plant cell wall – components of primary cell wall, structure and functions. 1 L
8. Ultrastructure and functions of chloroplast 2 L
9. Cell cycle in plants- importance of cell cycle in plants, divisional stages of mitosis and meiosis. 3 L

CREDIT-II: MOLECULAR BIOLOGY (15 Lectures) 15 Hours

1. Introduction and scope of molecular biology, central dogma of molecular biology. 2 L
2. Structure of DNA, nucleoside and nucleotide 2 L
3. Watson Crick model of DNA and its characteristic features, types of DNA (A, B and Z DNA). 3 L
4. Types of chromosomes. 2 L
5. Structure and types of RNA. 3 L
6. DNA replication- Types of replication (conservative, semi-conservative and dispersive), enzymes involved, leading and lagging strands, Okazaki fragments. 3 L

REFERENCES:

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2. Cooper, G.M. and Hausman, R.E. (2007). The Cell: Molecular Approach 4th Edition, Sinauer Associates, USA.
3. David, Nelson and Cox, Michael (2007). Lehninger Principles of Biochemistry. W.H. Freeman and Company. New York.
4. Devlin, R.M. (1983). Fundamentals of Plant Physiology. Mc. Millan, New York.
5. Dutta, A.C. (2000). A Class Book of Botany. Oxford University Press, UK.
6. Hopkins, William G. (1995). Introduction to Plant Physiology. Publ. John Wiley and Sons, Inc.

7. Lewin, Benjamin (2011). Genes. X Jones and Bartlett.
8. Lincolin, Taiz and Eduardo, Zeiger (2010). Plant Physiology. 5th Edition. Sinauer Associates, Inc. Publishers. Sunder land, USA.
9. Opik, Helgi, Rolfe, Stephen A. and Willis, Arthur J. (2005). The Physiology of Flowering Plants. Cambridge University Press, UK.
10. Pal, J.K. and Ghaskadbi, Saroj (2009). Fundamentals of Molecular Biology. Oxford University Press. India.
11. Pandey, S.N. and Sinha, B.K. (2014). Plant Physiology. Vikas Publishing House Pvt. Ltd., India.
12. Salisbury, F.B. and Ross, C.B. (2005). Plant Physiology. 5th Edition. Wadsworth Publishing Co. Belmont California, USA.
13. Watson, James D., Baker, Tania; Bell, Stephen P.; Alexander Gann; Levine, Michael and Lodwick, Richard (2008). Molecular Biology of the Gene. 6th Edition, Pearson Education, Inc. and Dorling Kindersley Publishing, Inc. USA.
14. Weaver, R. (2011). Molecular Biology. 5th Edition, Publisher- McGrew Hill Science. USA.

BO 123: PRACTICALS BASED ON BO 121 & BO 122 (1.5 CREDITS)

1. Study of life cycle of *Nephrolepis*. 1 P
2. Study of life cycle of *Cycas*. 1 P
3. Study of Bentham and Hooker's system of classification outline up to series with example 1 P
4. Study of comparative account of Dicotyledonous and Monocotyledonous plants w.r.t to external morphological characters. 1 P
5. Study of utilization and economic importance of Angiosperms- food, fodder, fibers, horticulture and medicines. 1 P
6. One day visit to study diversity of vegetation. 2 P
7. To observe characteristic features of prokaryotic and eukaryotic plant cell. 1 P
8. Staining of suitable nuclear material by Basic Fuchsin 1 P
9. Study of mitosis- preparation of slides using onion root tips to observe divisional stages. 1 P
10. Study of meiosis- preparation of slides using *Tradescantia/ Rhoeo/* Maize / Onion flower buds to observe divisional stages. 2 P
11. Estimation of chlorophyll-a and chlorophyll-b by using suitable plant material. 1 P
12. Plasmolysis- endosmosis, exosmosis, incipient plasmolysis using *Rhoeo* leaf peeling and Demonstration of Osmosis- curling experiment. 1 P
13. Study of DPD by using suitable plant sample 1 P

Savitribai Phule Pune University

(Formerly University of Pune)

Three Year B.Sc. Degree Program in Statistics

(Faculty of Science & Technology)

F.Y.B.Sc. Statistics

Choice Based Credit System Syllabus

To be implemented from Academic Year 2019-2020

Title of the program: F.Y.B.Sc. Statistics/ Statistical Techniques

Preamble of the syllabus:

The word ***Statistics*** is used in different ways in different contexts. To a cricket fan, Statistics is the information about runs scored or wickets taken by a player. To the manager of a manufacturing unit, Statistics may be the information about the process control. To a medical researcher investigating the effects of a new drug, Statistics are evidence of research efforts. To a college student, Statistics are the grades or marks scored in a course. Thus, in all these illustrations Statistics word refers to quantitative data in the area under study. Statistics as a subject is an important branch of knowledge and is devoted to various techniques of collection, presentation, analysis and interpretation of data. It is a science of learning fromdata.

Statistics provides tools for making decisions when conditions of uncertainty prevail. Hence these tools and techniques are used in almost all fields. Statistics is indispensable for people working in fields like agriculture, business, management, economics, finance, insurance, education, biotechnology and medical science etc. Since last two decade, with the help of computers large amount of data can be handled and more sophisticated statistical techniques can be used in an effective manner. Knowledge of different aspects of Statistics has become crucial. There is a continuous demand for statisticians in every field – education, industry, software, insurance, clinical trials data and research. The syllabus of the three Year B. Sc. degree course in Statistics is framed in such a way that the students at the end of the course can apply judiciously the statistical tools to a variety of data sets to arrive at someconclusions.

Statistics can be divided into two broad categories, (1) exploratory statistics or descriptive statistics, which is concerned with summarizing data and describing these data, and (2) confirmatory statistics or inferential statistics, which is concerned with making decisions about the population based on thesample.

Up to higher secondary school, students are mostly exposed to descriptive statistics. These techniques are briefly reviewed but the emphasis in degree course is on inferential statistics. At the end of the degree course a student is expected to apply the statistical tools to real life data and analyzeit.

Introduction: Choice based credit (semester) system:
B. Sc. in Statistics program is of three years duration, with semester pattern for all the three years. A student of three-year B.Sc. degree program will not be allowed to offer Statistics and Statistical Techniques simultaneously in any of the three years of the course. Students offering **Statistics** at the First year of the three-year B.Sc. course may be allowed to offer **Statistical Techniques** as one of their subjects in the second year of the three-year B.Sc. in place of Statistics. Students offering Statistical Techniques at the first year of the three-year B.Sc. course may be allowed to offer Statistics as one of their subjects in the second year of the three-year B.Sc. course in place of Statistical Techniques provided they satisfy other requirements regarding subject combinations, ifany.

At **first year of under-graduation**, students will be given the basic information that includes – methods of data representation and summarization. Correlation and regression are the forecasting tools that are frequently used in statistical analysis. These topics are studied in one of the papers in each semester. Further they are introduced to probability and different discrete probability distributions along with applications in the other paper. Relevant experiments on these topics will be included in practicalcourse. Further the students are expected start using some statistical software and verify the computations during practicals. It is a skill oriented part of the course.

At **second year of under-graduation,** students are expected to study various probability distributions and its applications to real life situations. It is a foundation for further theory. An important branch of Statistics, viz. testing of hypotheses related to mean, variance, proportion, correlation etc. will be introduced. Some topics related to applications of Statistics will be also introduced. Further the students are expected start using some statistical software and verify the computations during practicals. It is a skill oriented part of the course.

At **third year of under-graduation**, six theory papers deal with theoretical as well as applied aspect of statistics. Some papers papers such as distribution theory and parametric inference are core and and mathematical in nature. Some papers such as sampling methods and Design of Experiments are core and applied but less mathematical. In Design of Experiments paper, various designs used in agriculture and industry are studied agriculture, clinical trials. Papers of applied nature, like medical statistics, actuarial statistics, time series, and optimization techniques (operations research), statistical quality control. There are some skill oriented courses C programming and R software. There are three practical courses based on core courses. In one of the practical courses, project component will be introduced to get hands on training or experiential learning.

Structure of the Course

Structure of the course for three years and the pattern of examination and question papers are as specified below

Structure of F. Y. B. Sc. Statistics/ Statistical Techniques

Semester	Paper code	Paper	Paper title	credits	Marks CIA	ESE	Total
1	ST 111	I	Descriptive Statistics I	2	15	35	50
	ST 112	II	Discrete Probability	2	15	35	50
	ST113	III	Statistics Practical PaperI	1.5	15	35	50
2	ST121	I	Descriptive Statistics II	2	15	35	50
	ST122	II	Discrete Probability Distributions	2	15	35	50
	ST123	III	Statistics Practical Paper II	1.5	15	35	50

Structure of S. Y. B. Sc. Statistics

Semester	Paper code	Paper	Paper title	credits	Marks CIA	ESE	Total
3	ST 231	I	Statistics theory paper 1	2	15	35	50
	ST 232	II	Statistics theory paper 2	2	15	35	50
	ST233	III	Statistics Practical Paper	2	15	35	50
4	ST241	I	Statistics theory paper 1	2	15	35	50
	ST242	II	Statistics theory paper 2	2	15	35	50
	ST243	III	Statistics Practical Paper	2	15	35	50

Structure of T. Y. B. Sc. Statistics

Semester	Paper code	Paper	Paper title	credits	Marks CIA	ESE	Total
5	ST 351	I	Statistics theory paper 1	2	15	35	50
	ST 352	II	Statistics theory paper 2	2	15	35	50
	ST 353	III	Statistics theory paper 3	2	15	35	50
	ST 354	IV	Statistics theory paper 4	2	15	35	50
	ST 355	V	Statistics theory paper 5	2	15	35	50
	ST 356	VI	Statistics theory paper 6	2	15	35	50
	ST 357	VII	Statistics Practical Paper 1	2	15	35	50
	ST 358	VIII	Statistics Practical Paper 2	2	15	35	50
	ST 358	IX	Statistics Practical Paper 3	2	15	35	50
	ST 359	X	Skill enhancement course 1	2	15	35	50
	ST 3510	XI	Skill enhancement course 2	2	15	35	50
6	ST 361	I	Statistics theory paper 1	2	15	35	50
	ST 362	II	Statistics theory paper 2	2	15	35	50
	ST 363	III	Statistics theory paper 3	2	15	35	50
	ST 364	IV	Statistics theory paper 4	2	15	35	50
	ST 365	V	Statistics theory paper 5	2	15	35	50
	ST 366	VI	Statistics theory paper 6	2	15	35	50
	ST 367	VII	Statistics Practical Paper 1	2	15	35	50
	ST 368	VIII	Statistics Practical Paper 2	2	15	35	50
	ST 369	IX	Statistics Practical Paper 3	2	15	35	50
	ST 3610	X	Skill enhancement course 1	2	15	35	50
	ST 3511	XI	Skill enhancement course 2	2	15	35	50

SEMESTER – I

PAPER – I

ST – 111: Descriptive Statistics I

Objectives: The main objective of this course is to acquaint students with some basic concepts in Statistics. They will be introduced to some elementary statistical methods of analysis of data. At the end of this course students are expected to be able,

(i) to compute various measures of central tendency, dispersion, skewness and kurtosis.
(ii) to analyze data pertaining to attributes and to interpret theresults.

Unit 1. Introduction to Statistics(2L)**2H**

1.1 Meaning of Statistics as aScience.
1.2 Importance ofStatistics.
1.3 Scope of Statistics: In the field of Industry, Biological sciences, Medical sciences, Economics, Social Sciences, Management sciences, Agriculture, Insurance, Information technology, Education andPsychology.
1.4 Statistical organizations in India and their functions: CSO, ISI, NSSO,IIPS (Devnar, Mumbai), Bureau of Economics andstatistics.
1.5 Statistical Heritage (Indian Perspective: i)Dr. V. S. Huzurbazar, Dr. P.C. Mahalnobis, Dr. P. V. Sukhatme, Dr. C. R. Rao).

Unit 2. PopulationandSample (4L)**3H**

2.1 Types ofcharacteristics:
Attributes: Nominal scale, ordinal scale,
Variables: Interval scale, ratio scale, discrete and continuous variables,
difference between linear scale and circular scale
2.2 Types ofdata:
(a) Primary data, Secondarydata
(b) Cross-sectional data, time series data, directionaldata.

2.3 Notion of a statistical population:

Finite population, infinite population, homogeneous population and heterogeneous population. Notion of a sample and a random sampleMethods of sampling (Description only): Simple random sampling with and without replacement (SRSWR and SRSWOR) stratified random sampling, systematic sampling, cluster sampling and two-stage sampling.

Unit 3. SummaryStatistics: **(**14 L) **12H**

3.1 Review/Revision of Presentation of Data.
Interpretation of Data from table and graph.
datavalidation

3.2 Frequency Classification: Raw data and its classification, ungrouped frequency distribution,Sturges' rule, grouped frequency distribution, cumulative frequency distribution,inclusive and exclusive methods of classification, Open end classes, and relativefrequencydistribution.

3.3 Measures of CentralTendency:
Concept of central tendency of statistical data, Statistical averages, characteristics of a

good statistical average.
Arithmetic Mean (A.M.): Definition, effect of change of origin and scale, combined mean of a number of groups, merits and demerits, trimmed arithmeticmean.
Mode and Median: Definition, formulae (for ungrouped and grouped data), merits and demerits. Empirical relation between mean, median and mode.
Partition Values: Quartiles, Deciles and Percentiles (for ungrouped and grouped data), Box Plot.
Geometric Mean (G.M.): Definition, formula, merits and demerits.
Harmonic Mean (H.M.): Definition. Formula, merits and demerits.
Order relation between arithmetic mean, geometric mean, harmonic mean
Weighted Mean: weighted A.M., G.M. and H.M.
Situations where one kind of average is preferable to others.

3.4 Measures ofDispersion:
Concept of dispersion, characteristics of good measure of dispersion.
Range, Semi-interquartile range (Quartile deviation): Definition, merits and demerits, Mean deviation: Definition, merits and demerits, minimality property (without proof), Variance and standard deviation: Definition, merits and demerits, effect of change of origin and scale, combined variance for n groups (derivation for twogroups).
Mean squared deviation: Definition, minimality property of mean squared deviation (with proof), Measures of dispersion for comparison: coefficient of range, coefficient of quartile deviation and coefficient of mean deviation, coefficient of variation(C.V.)

2. **Moments, SkewnessandKurtosis:**(8 L)**7H**

4.1 Raw moments (m'_r) for ungrouped and groupeddata.

Central moments (m_r) for ungrouped and grouped data, Effect of change of origin and scale.Relations between central moments and raw moments, upto 4-th order (without proof).

4.2 Concept of skewness of frequency distribution, positive skewness, negative skewness, symmetric frequencydistribution.
Bowley'scoefficientofskewness:Bowley'scoefficientofskewnessliesbetween −1 to 1 (with proof), interpretation using Box plot.
Karl Pearson's coefficient ofskewness.
Measures of skewness based on moments($\widehat{\beta_1}$,$\widehat{\gamma_1}$).

4.3 Concepts of kurtosis, leptokurtic, mesokurtiand platykurticfrequency distributions.
Measures of kurtosis based on moments ($\widehat{\beta_2}$,$\widehat{\gamma_2}$).

5 Theory of Attributes: (8 L) **6H**

5.1 Attributes: Concept of a Likert scale, classification, notion of manifold classification, dichotomy, class- frequency, order of a class, positive class-frequency, negative class frequency, ultimate class frequency, relationship among different class frequencies (up to three attributes), and dot operator to find the relation between frequencies, fundamental set of class frequencies.

5.2 Consistency of data up to 2attributes.

5.3 Concepts of independence and association of two attributes.
Yule's coefficient of association (Q), $-1 \leq Q \leq 1$,interpretation.

Recommended Books:

1. Agarwal, B. L. (2003). Programmed Statistics, Second Edition, New Age International Publishers, NewDelhi.
2. Ghosh, J. K. and Mitra, S. K., Parthsarthi, K. R. (1993). Glimpses of India's Statistics Heritage, Wiley publishing Co.
3. Goon, A. M., Gupta, M. K. and Dasgupta, B. (1983). Fundamentals of Statistics, Vol. 1, Sixth Revised Edition,The World Press Pvt. Ltd.,Calcutta.
4. Gupta, S. C. and Kapoor, V. K. (1983). Fundamentals of Mathematical Statistics, Eighth Edition, Sultan Chand and Sons Publishers, NewDelhi.
5. Gupta, S. C. and Kapoor, V. K. (1997). Fundamentals of Applied Statistics, Third Edition, Sultan Chand and Sons Publishers, NewDelhi.
6. Neil A. Weiss, (2016). Introductory Statistics, Tenth Edition, Pearson.
7. Purohit, S. G., Gore S. D., Deshmukh S. R. (2008). Statistics Using R, Narosa Publishing House, NewDelhi.
8. Sarma, K. V. S. (2001). Statistics Made it Simple: Do it yourself on PC. Prentce Hall of India, NewDelhi.
9. Snedecor G. W. and Cochran W. G.(1989). Statistical Methods, Eighth Ed. East-WestPress.

SEMESTER – I

PAPER – II

ST – 112: Discrete Probability and Probability DistributionsI

Objectives

The main objective of this course is to introduce to the students the basic concepts of probability, axiomatic theory of probability, concept of random variable, probability distribution (univariate and bivariate) discrete random variables, expectation and moments of probability distribution. By the end of the course students are expected to be able

(i) to distinguish between random and non-randomexperiments.
(ii) to find the probabilities ofevents.
(iii) to obtain a probability distribution of random variable (one or two dimensional) in the given situation.

1. Basics of Probability:(6L)**4H**

1.1 Experiments/Models, Ideas of deterministic and non-deterministic models. Random Experiment, concept of statisticalregularity.

1.2 Definitions of - (i) Sample space, (ii) Discrete sample space: finite and countably infinite, (iii) Event, (iv) Elementary event, (v) Complement of an event. (vi) Certain event (vii) Impossibleevent

Concept of occurrence of anevent.

Algebra of events and its representation in set theory notation. Occurrence of followingevents.

(i) at least one of the givenevents,
(ii) none of the givenevents,
(iii) all of the givenevents,
(iv) mutually exclusiveevents,
(v) mutually exhaustiveevents,
(vi) exactly one event out of the givenevents.

1.3 Classical definition of probability and itslimitations.

Probability model, probability of an event, equiprobable and non-equiprobable sample space,

1.4 Axiomatic definition ofprobability. Theorems and results on probability with proofs based on axiomatic definition such as $P(AUB)=P(A)+P(B)-P(A \cap B)$. Generalization $P(AUBUC)$,$0 \leq P(A) \leq 1$, $P(A) + P(A') = 1$, $P(\Phi) = 0$,$P(A) \leq P(B)$ when $A \subset B$

Boole's inequality.

2. Conditional Probability and Bayes'Theorem:(5L)**4H**

2.1 Definition of conditional probability of an event. Results on conditional probability.

Definition of independence of two events $P(A \cap B) = P(A) \cdot P(B)$

Pairwise independence and mutual independence for three events

Multiplication theorem

$P(A \cap B) = P(A) \cdot P(B|A)$. Generalization to

$P(A \cap B \cap C)$.

2.2 Partition of the samplespace, prior and posterior probabilities.Proof of Bayes' theorem. Applications of Bayes' theorem in reallife. True positive , false positive and sensitivity of test as application of Bayes' theorem.

3. Univariate Probability Distributions (Defined on Discrete Sample Space): (3L) 2**H**

Concept and definition of a discrete randomvariable.
Probability mass function (p.m.f.) and cumulative distribution function (c.d.f.), F(·) of discrete random variable, properties ofc.d.f..
Mode and median of a univariate discrete probabilitydistribution.

4. Mathematical Expectation (Univariate Random Variable):(8L)**7H**

4.1 Definition of expectation (Mean) of a random variable, expectation of a function of a random variable, m.g.f. and c.g.f. Properties of m.g.fandc.g.f.
4.2 Definitions of variance, standard deviation (s.d.) and Coefficient of variation (c.v.) of univariate probability distribution, effect of change of origin and scale on mean, variance ands.d.
4.3 Definition of raw, central and factorial raw moments of univariate probability Distributions and their interrelations **(**withoutproof).
4.4 Coefficients of skewness and kurtosis based onmoments.

5 Some Standard Discrete Probability Distributions: (15L) 13H

5.1 Degenerate distribution (one point distribution):
P(X=c) =1, mean and variance.

5. 2 Uniform discrete distribution on integers 1 to n:
p.m.f., c.d.f., mean, variance, real life situations, comments on mode and median.
5.3 Bernoulli Distribution:p.m.f., mean, variance.

5.4 Binomial Distribution : p.m.f.

$$P(x) = \binom{n}{x} p^x q^{n-x}, x = 0,1,2,\dots,n; 0 < p < 1, q = 1-p$$
$$= 0, \text{ otherwise}$$

Notation: X ~ B(n, p).
Recurrence relation for successive probabilities, computation of probabilities of different events, mode of the distribution, mean, variance, m.g.f. and c.g.f. moments, skewness (comments when p = 0.5, p > 0.5, p < 0.5). Situations where this distribution is applicable.
Additive property for binomial distribution.
Conditional distribution of X given (X+Y) for binomial distribution.

.

5.5 Hypergeometric Distribution: Necessity and importance of Hypergeometric distribution, capture-recapture method.
p.m.f. of the distribution,

$$p(x) = \frac{\binom{M}{x}\binom{N-M}{n-x}}{\binom{N}{n}}, \qquad x = 0,1,\dots,\min(M,n)$$
$$= 0, \quad \text{otherwise}$$

Notation : X ~ H(N,M,n).
Computation of probability, situations where this distribution is applicable, binomial approximation to hypergeometric probabilities, statement of mean and variance of the distribution (Derivation is not expected).

Recommended Books:

1. Agarwal B. L. (2003). Programmed Statistics, second edition, New Age International Publishers, NewDelhi.
2. Gupta, S.C. and Kapoor, V. K. (1983). Fundamentals of Mathematical Statistics, Eighth Edition, Sultan Chand and Sons Publishers, NewDelhi.
3. Hoel P. G. (1971). Introduction to Mathematical Statistics, John Wiley and Sons, New York.
4. Hogg,R.V.andCraigR.G.(1989).IntroductiontoMathematicalStatistics,Ed. MacMillan Publishing Co., NewYork.
5. Mayer, P. (1972). Introductory Probability and Statistical Applications, Addison Wesley Publishing Co.,London.
6. Mood, A. M. and Graybill, F. A. and Boes D.C. (1974). Introduction to the Theory of Statistics, Ed. 3, McGraw Hill BookCompany.
7. Rao, VLS Prakash (2008). First Course in Probability and Statistics, New Age International Publishers, NewDelhi.
8. Ross S. (2002). A First Course in Probability, Sixth Edition, Pearson Education, Inc. & Dorling Kindersley Publishing,Inc.

SEMESTER I

Statistics Practical Paper III

ST – 113 : PRACTICALS

Pre-requisites: Knowledge of the topics in theory papers I and II.
Objectives: At the end of this course students are expected to be able

(i) to use various graphical and diagrammatic techniques and interpretation.
(ii) to analyse data pertaining to discrete and continuous variables and to interpret the results,
(iii) to compute various measures of central tendency, dispersion, skewness and kurtosis.
(iv) to interpret summary statistics of computer output.
(v) to summarize and analyze the data using computer.

S. No.	Title of the experiment	No. of Practicals
1	Diagrammatic representation of statistical data: simple and subdivided bar diagrams, multiple bar diagram, percentage bar diagram, pie diagram. Also using Ms-Excel/Any statistical software	2
2	Graphical representation of statistical data: Histogram, frequency curve and ogive curves. Determination of mode and median graphically. Also using Ms-Excel/Any statistical software	2
3	Tabulation	1
4	Data Interpretation form various graphs and diagrammes.	1
5	Use of random number tables to draw SRSWOR, SRSWR, stratified sample and systematic sample. Also using Ms-Excel/ Any statistical software	2
6	Computation of measures of central tendency and dispersion (ungrouped data). Use of an appropriate measure and interpretation of results and computation of partition values.	1
7	Computation of measures of central tendency and dispersion (grouped data). Use of an appropriate measure and interpretation of results and computation of partition values.	1
8	Measures of skewness and kurtosis, Box plot.	1
9	Computation of summary statistics using Ms-Excel/ Any statistical software	1
10	Project	3

SEMESTER – II

PAPER – I

Objectives: The main objective of this course is to acquaint students with bivariate data. They will be introduced to some methods of analysis of bivariate data. At the end of this course students are expected to be able,

(i) to compute the correlation coefficient for bivariate data and interpret it.
(ii) to fit linear, quadratic and exponential curves to the bivariate data to investigate relation between two variables.
(iii) to compute and interpret various index numbers.

ST - 121: Descriptive Statistics II

1 Correlation: (10L) **9H**

1.1 Bivariate data, Scatter diagram and interpretation.
Concept of correlation between two variables, positive correlation, negative correlation, no correlation.
Covariance between two variables (m_{11}): Definition, computation, effect of change of origin and scale.
1.2 Karl Pearson's coefficient of correlation (r): Definition, computation for ungrouped data and interpretation. Properties: (i) $-1 \leq r \leq 1$(with proof), (ii) Effect of change of origin and scale (with proof).
1.3 Spearman's rank correlation coefficient: Definition, derivation of formula, computation and interpretation (without ties). In case of ties, compute Karl Pearson's correlation coefficient between ranks. (Spearman's rank correlation coefficient formula with correction for ties not expected.)

2**Fitting of Line (Regression Line):** (8L) **6H**

2.1 Concept of dependent and independent variables.
2.2 Identification of response and predictor variables and relation between them.
2.3 Meaning of regression, difference between correlation andregression, Connection between correlation and regression. Fitting of line Y= a + bX. a and b are estimated using least square method.Regression coefficient. Explained and unexplained variation, coefficient of determination, standard error of an estimate of line of regression. Interchanging the role of X and Y we can study some more properties.

3. **Curve Fitting:** (10L) **9H**

3.1 Necessity and importance of drawing second degree curve.
3.2 Fitting of second degree curve ($Y = a + b X + cX^2$),
3.3 Fitting of exponential curves of the type $Y = a\, b^X$ and $Y = aX^b$.
In all these curves constants a, b, c are found out by the method of least squares.
(Justification via determinant of matrix of second derivative/second derivative test).

4. **Index Numbers:**(8L) **6H**

4.1 Introduction and scope of Index Numbers. Various types of Index Numbers like Human Development Index, Happiness Index BSE sensitivity Index.
4.2 Definition and Meaning.

4.3 Problems/considerations in the construction of index numbers.
4.4 Simple and weighted price index numbers based on price relatives.
4.5 Simple and weighted price index numbers based on aggregates.
4.6 Laspeyre's, Paasche's and Fisher's Index numbers.
4.7 Consumer price index number: Considerations in its construction. Methods of construction of consumer price index number - (i) family budgetmethod
(ii) aggregate expenditure method
4.8 Shifting of base, splicing, deflating, purchasingpower.

Recommended Books:

1. Agarwal, B. L. (2003). Programmed Statistics, Second Edition, New Age International Publishers, New Delhi.
2. Goon, A. M., Gupta, M. K. and Dasgupta, B. (1983). Fundamentals of Statistics, Vol. 1, Sixth Revised Edition,The World Press Pvt. Ltd.,Calcutta.
3. Gupta, S. C. and Kapoor, V. K. (1983). Fundamentals of Mathematical Statistics, Eighth Edition, Sultan Chand and Sons Publishers, NewDelhi.
4. Gupta, S. C. and Kapoor, V. K. (1997). Fundamentals of Applied Statistics, Third Edition, Sultan Chand and Sons Publishers, NewDelhi.
5. Montgomery, D. C; Peck, E. A.; Vining, G. G.(2006). Introduction to Linear Regression Analysis, John Wiley and Sons
6. Purohit, S. G., Gore S. D., Deshmukh S. R. (2008). Statistics Using R, Narosa Publishing House, New Delhi.
7. Sarma, K. V. S. (2001). Statistics Made it Simple: Do it yourself on PC. Prentce Hall of India, New Delhi.
8. Snedecor G. W. and Cochran W. G.(1989). Statistical Methods, Eighth Ed. East- West Press.

SEMESTER – II

PAPER – II

ST – 112: Discrete Probability and Probability Distributions II

Objectives: The main objective of this course is to introduce to the students some discrete Distributions and its application in real life.

(i) to apply standard discrete probability distribution to differentsituations.

(ii)tostudy properties of these distributions as well as interrelation between them.

1. Some Standard Discrete Probability Distributions: **(1 6 L) 1 3 H**

1.1Poisson distribution:

p.m.f. of the distribution

$$p(x) = \frac{e^{-m}m^{x}}{x!}, \quad x = 0,1,2,\ldots, \quad m > 0$$

= 0, otherwise

Notation: X ~P(m).
m.g.f. and c.g.f. Moments, mean,————variance, skewness and kurtosis.
Situations where this distribution is applicable.
Additive property for Poissondistribution.
Conditional distribution of X given (X+Y) for Poissondistribution.

1.2Geometric distribution:

Notation: X ~G(p),
Geometric distribution on support (0, 1, 2, ...,) with p.m.f. $p(x) = pq^{x}$.
Geometric distribution on support (1, 2, ...) with p.m.f. $p(x) = pq^{x-1}$. $0 < p < 1$, $q = 1 - p$.
Mean, variance, m.g.f. and c.g.f.
Situations where this distribution is applicable.
Lack of memory property.

2. Bivariate DiscreteProbabilityDistribution: (6L) 5H

2.1 Definition of two-dimensional discrete random variable, its joint p.m.f. and its distribution function and their properties.

2.2 Concept of identically distributedr.vs.

2.3 Computation of probabilities of events in bivariate probabilitydistribution.

2.4 Concepts of marginal and conditional probabilitydistributions.

2.5 Independence of two discrete random variables based on joint and marginal p.m.f.s

3 Mathematical Expectation (BivariateRandomVariable) (14L) 12H

3.2 Definition of raw and central moments, m.g.f,c.g.f.

3.3 Theorems on expectations of sum and product of two jointly distributed random variables.

3.4 Conditionalexpectation.

3.5 Definitions of conditional mean and conditionalvariance.

3.6 Definition of covariance, coefficient of correlation, independence anduncorrelatedness of twovariables.

3.7 Variance of linear combination of variables Var(aX +bY).

Recommended Books:

1. Agarwal B. L. (2003). Programmed Statistics, second edition, New Age International Publishers, NewDelhi.
2. Gupta, S.C. and Kapoor, V. K. (1983). Fundamentals ofMathematical Statistics, Eighth Edition, Sultan Chand and Sons Publishers, NewDelhi.
3. Hoel P. G. (1971). Introduction to Mathematical Statistics, John Wiley and Sons, New York.
4. Hogg,R.V.andCraigR.G.(1989).IntroductiontoMathematicalStatistics,Ed. MacMillan Publishing Co., NewYork.
5. Mayer, P. (1972). Introductory Probability and Statistical Applications, Addison Wesley Publishing Co.,London.
6. Mood, A. M. and Graybill, F. A. and Boes D.C. (1974). Introduction to the Theory of Statistics, Ed. 3, McGraw Hill BookCompany.
7. Ross S. (2002). A First Course in Probability, Sixth Edition, Pearson Education, Inc. & Dorling Kindersley Publishing,Inc.

Reference Websites for Paper I and Paper II:

1. www.stats.unipune.ac.in (100 Data sets for Statistics Educationby Dr. Anil P. Gore, Dr. Mrs. S. A. Paranjpe and Madhav B. Kulkarni available in ISPSfolder).
2. www.freestatistics.tk(National StatisticalAgencies)
3. www.psychstat.smsu.edu/sbk00.htm(Onlinebook)
4. www.bmj.bmjournals.com/collections/statsbk/index.shtml
5. www.statweb.calpoly.edu/bchance/stat-stuff.html
6. www.amstat.org/publications/jse/jse-data-archive.html(International journal on teaching and learning ofstatistics)
7. www.amstat.org/publications/chance(Chancemagazine)
8. www.statsci.org/datasets.html(Datasets)
9. www.math.uah.edu/stat(Virtual laboratories inStatistics)
10. www.amstat.org/publications/stats(STATS : the magazine for students of Statistics)
11. www.stat.ucla.edu/cases(Case studies inStatistics).
12. www.statsoft.com
13. www.statistics.com
14. www.indiastat.com
15. www.unstat.un.org
16. www.stat.stanford.edu
17. www.statpages.net
18. www.wto.org
19. www.censusindia.gov.in
20. www.mospi.nic.in
21. www.statisticsofindia.in

SEMESTER II

Paper III

ST – 123 : PRACTICALS

Pre-requisites: Knowledge of the topics in theory papers I and II.
Objectives: At the end of this course students are expected to be able

(i) to compute correlation coefficient, regressioncoefficients,
(ii) to compute probabilities of bivariatedistributions,
(iii) to fit binomial and Poissondistributions
(iv) to compute probabilities of bivariatedistributions.
(v) to draw random samples from Poisson and binomial distributions.

S. No.	Title of the experiment	No. of Practicals
1	Scatter diagram, correlation coefficient (ungrouped data). Fitting of line of regression.	2
2	Fitting of second degree curve, exponential curve of type $Y = ab^x$, $Y = ax^b$	2
3	Fitting of Binomial distribution and computation of expected frequencies.	1
4	Fitting of Poisson distribution and computation of expected frequencies.	1
5	Applications of Binomial &hypergeometric distributions.	1
6	Applications of Poisson & geometric distributions.	1
7	Model sampling from Poisson and Binomial distributions.	1
8	Index numbers.	1
9	Scatter diagram, correlation coefficient, fitting of a line of regression, fitting of second degree curve **using**Ms-excel/ Any statistical software& interpretation.	2
10	Project	3

Notes:

1. For project, a group of maximum 8 students bemade.
2. All the students in a group be given equal marks forproject.
3. Different data sets from newspapers, internet, magazines may be collected and students will be asked to use Statistical techniques/tools which they havelearnt.
4. Students must complete all the practicals to the satisfaction of the teacher concerned.
5. Students must produce at the time of practical examination, the laboratory journal along with the completion certificate signed by the Head of the Department.

Savitribai Phule Pune University [SPPU]

B.Sc. (Chemistry)

(Three Years Integrated Degree Program)

Choice Based Credit System [CBCS]

2019 Pattern

Second Year Bachelors of Science

(S. Y. B. Sc.)

From Academic Year

2020-21

Board of Studies in Chemistry

Savitribai Phule Pune University [SPPU]

Pune-411007

Structure of S. Y. B. Sc. Chemistry

(According to CBCS – 2019 Pattern of SPPU)

Semester	Course	Discipline Specific Core (DSCC)*
III	Theory	**CH-301** : Physical and Analytical Chemistry (2 credit, 36 L)
	Theory	**CH-302** : Inorganic and Organic Chemistry (2 credit, 36 L)
	Practical	**CH-303** : Chemistry Practical - III (2 credit, 72 L)
IV	Theory	**CH-401** : Physical and Analytical Chemistry (2 credit, 36 L)
	Theory	**CH-402** : Inorganic and Organic Chemistry (2 credit, 36 L)
	Practical	**CH-403** : Chemistry Practical - IV (2 credit, 72 L)

***Important Notice:**

i. Each lecture (L) will be of 50 minutes.

ii. Each practical of 4 hours and 12 practical sessions per semester

iii. 12 weeks for teaching 03 weeks for evaluation of students (theory as well as practical).

iv. For details refer UG rules and regulations (CBCS for Science program under Science & Technology) published on SPPU website.

Evaluation Pattern (As per CBCS rules, SPPU 2019 Pattern)

1. Each theory and practical course carry 50 marks equivalent to 2 credits.
2. Each course will be evaluated with Continuous Assessment (CA) and University Assessment (UA) mechanism.
3. Continuous assessment shall be of 15 marks (30%) while university Evaluation shall be of 35 marks (70%).
4. To pass each course, a student has to secure 40% mark in continuous assessment as well as university assessment i.e. 6 marks in continuous assessment and 14 marks in university assessment for the respective course.
5. For Continuous Assessment (internal assessment) minimum two tests per paper must be organized, of which one must be written test of 10 marks.
6. Method of assessment for internal exams: Viva-Voce, Project, survey, field visits, tutorials, assignments, group discussion, etc. (on approval of the head of centre).

Theory - University Assessment Question Paper Pattern

(According to CBCS - 2019 Pattern of SPPU)

Note that in theory question paper weightage will be given to each topics equivalent to number of lectures assigned in the syllabus.

<table>
<tr><td colspan="3">Total Marks: 35</td><td colspan="2">Duration: 2 Hours</td></tr>
<tr><td colspan="5">Note: i) Question -1 will be compulsory (5 marks).
ii) Solve any three questions from question 2- 5.
iii) Questions 2 to 5 carry equal marks (10 each).</td></tr>
<tr><td>Q-1</td><td></td><td>Solve any five of the following
(a)
(b)
(c)
(d)
(e)
(f)</td><td>a) four tricky questions and b)two question on problem type (if applicable).</td><td>5 marks</td></tr>
<tr><td>Q-2</td><td>(A)

(B)</td><td colspan="2">Describe type of question(s)
i)
ii)
Short question, but tricky</td><td>6 mark

4 mark</td></tr>
<tr><td>Q-3</td><td>(A)

(B)</td><td colspan="2">Explain type of question(s)
i)
ii)
Problem based question if applicable. Justification type of question</td><td>6 mark

4 mark</td></tr>
<tr><td>Q-4</td><td>(A)

(B)</td><td colspan="2">Discuss type of question(s)
i)
ii)
Problem based question if applicable. Justification type of question</td><td>6 mark

4 mark</td></tr>
<tr><td>Q-5</td><td>
(A)
(B)
(C)</td><td colspan="2">Attempt any two of the following
Questions A, B, C, - will be Explain, Derivation, Discuss, Notes, etc. type of long questions</td><td>10 mark</td></tr>
</table>

S. Y. B. Sc. Chemistry Syllabus

(CBCS - 2019 Semester Pattern)

From Academic Year 2020-21

Equivalence with Previous Syllabus (2013 Pattern)

New Course (2019 Pattern)	Old Course (2013 Pattern)
CH-301 : Physical and Analytical Chemistry	**CH-211** : Physical and Analytical Chemistry
CH-302 : Inorganic and Organic Chemistry	**CH-212** : Organic and Inorganic Chemistry
CH-303 : Chemistry Practical - III	**CH-223** : Chemistry Practical
CH-401 : Physical and Analytical Chemistry	**CH-221** : Physical and Analytical Chemistry
CH-402 : Inorganic and Organic Chemistry	**CH-222** : Organic and Inorganic Chemistry
CH-403 : Chemistry Practical - IV	**CH-223** : Chemistry Practical

Preamble:

The syllabus of Chemistry for second year has been redesigned for Choice based Credit System (CBCS: 2019 pattern) to be implemented form 2020-21.

In CBCS pattern semester system has been adopted for FY, SY and TY which includes Discipline Specific Core Course (DSCC) at F Y level, Ability Enhancement Compulsory Course (AECC), Discipline Specific Elective Course (DSEC) and Skill Enhancement Course (SEC). A DSCC course has been introduced at FY level and AECC courses at SY level along with DSEC. At TY level DSEC and SEC courses has been introduced.

Syllabus for Specific Core Courses of Chemistry (2 Theory and 1 Practical) subject for F. Y. B. Sc. is to be implemented from the year 2019-20. Syllabus for S. Y. and T. Y. B. Sc. will be implemented from the year 2020-21 and 2021-22 respectively as per structure approved.

Learning Outcome:

1. To understand basic concept/principles of Physical, Analytical, Organic and Inorganic chemistry.
2. To impart practical skills and learn basics behind experiments.
3. To prepare background for advanced and applied studies in chemistry.

Overall Syllabus

SEMESTER-III			
Sr. No.	**Course Code**	**Course Name**	**Credits and No of Lect.**
1	CH-301	Physical and Analytical Chemistry	Credit -2, 36 L
2	CH-302	Inorganic and organic Chemistry	Credit -2, 36 L
3	CH-303	Practical Chemistry-III	Credit -2, 72 L
SEMESTER-IV			
4	CH-401	Physical and Analytical Chemistry	Credit -2, 36 L
5	CH-402	Inorganic and organic Chemistry	Credit -2, 36 L
6	CH-403	Practical Chemistry-IV	Credit -2, 72 L

The detailed Semester and Course wise of Syllabus is as follows:

SEMESTER-III

CH-301: Physical and Analytical Chemistry [Credit -2, 36 L]

Chapter No.	Chapter	No of Lectures
1	Chemical Kinetics	12
2	Surface Chemistry	06
3	Errors in Quantitative Analysis	05
4	Volumetric analysis	13

1. Chemical Kinetics: [12 L]

Introduction to kinetics, the rates of chemical reactions – definition of rates, rate laws and rate constants, reaction order and molecularity, determination of rate law, factors affecting reaction rates, integrated rate laws – zeroth-order reactions, first-order reactions, second-order reactions (with equal and unequal initial concentration of reactants), half-life period, methods for determination order of a reactions, Arrhenius equation- temperature dependence of reaction rates, interpretation of Arrhenius parameters, reaction dynamics - collision theory and transition-state theory of bimolecular reactions, comparison of the two theories, Problems.

*(**Ref. No: 1**- 725-728, 731-733, 741-742, 780-784, 792-794, **Ref. No: 2**- 1033- 1067)*

Learning Outcome:

After studying the Chemical Kinetics student will able to-

1. Define / Explain concept of kinetics, terms used, rate laws, molecularity, order.
2. Explain factors affecting rate of reaction.
3. Explain / discuss / derive integrated rate laws, characteristics, expression for half-life and examples of zero order, first order, and second order reactions.
4. Determination of order of reaction by integrated rate equation method, graphical method, half-life method and differential method.
5. Explain / discuss the term energy of activation with the help of energy diagram.
6. Explanation for temperature coefficient and effect of temperature on rate constant k.
7. Derivation of Arrhenius equation and evaluation of energy of activation graphically.
8. Derivations of collision theory and transition state theory of bimolecular reaction and comparison.
9. Solve / discuss the problem based applying theory and equations.

2. Surface Chemistry [6L]

Introduction to surface chemistry - some basic terms related to surface chemistry adsorption, adsorption materials, factors affecting adsorption, characteristics of adsorption, types of adsorption, classification of adsorption isotherms, Langmuir adsorption isotherm, Freundlich's adsorption isotherm, BET theory (only introduction), application of adsorption, problems. *(**Ref. No:1**- 824-826, 832-837, **Ref. No: 2**- 1251-1264; **Ref. No: 3**- 932-938)*

Learning Outcomes

- Define / explain adsorption, classification of given processes into physical and chemical adsorption.
- Discuss factors influencing adsorption, its characteristics, differentiates types as physisorption and Chemisorption
- Classification of Adsorption Isotherms, to derive isotherms.
- Explanation of adsorption results in the light of Langmuir adsorption isotherm, Freundlich's adsorption Isotherm and BET theory.
- Apply adsorption process to real life problem.
- Solve / discuss problems using theory.

Reference Books (Physical Chemistry)

1. Atkins' Physical Chemistry by Peter Atkins, Julio de Paula, James Keeler -11th edition
2. Principles of physical chemistry by B.R. Puri, L.R. Sharma**,** M.S. Pathania
3. Essentials of Physical chemistry by BahlTuli-Revised Multicolour Edition 2009, S. Chand and Company Ltd.
4. Physical-Chemistry-4th Edition - Gilbert W. CastellanNarosa (2004).
5. Principles of ChemicalKinetics-2rdEdition- James E. House
6. Barrow, G.M. Physical Chemistry Tata McGraw- Hill (2007).
7. Principles of Physical Chemistry, Fourth Edition by S.H. Marron and C. F. Pruton
8. Kotz, J.C., Treichel, P.M. & Townsend, J.R. General Chemistry, Cengage Learning India Pvt. Ltd.: New Delhi (2009).
9. Mahan, B.H. University Chemistry, 3rd Ed. Narosa (1998).
10. Petrucci, R.H. General Chemistry, 5th Ed., Macmillan Publishing Co. New York, 1985).
11. Physical Chemistry by Thomas Engel, Philip Reid, Warren Hehre.

3. Errors in Quantitative Analysis [5 L]

Introduction to errors, limitations of analytical methods, classifications of errors, accuracy, precision, minimization of errors, significant figures and computation, methods of

expressing accuracy and precision: mean and standard deviations, reliability of results and numerical. ***(Ref-1:** 127-138, supplementary references- **Ref-2:** 62-75, **Ref-3:** 82-121)*

Learning Outcomes

- Define, explain and compare meaning of accuracy and precision.
- Apply the methods of expressing the errors in analysis from results.
- Explain / discuss different terms related to errors in quantitative analysis.
- Apply statistical methods to express his / her analytical results in laboratory.
- Solve problems applying equations.

4. Volumetric Analysis [13 L]

Introduction to volumetric analysis, classification of reactions in volumetric analysis, standard solutions, equivalents, normalities, and oxidation numbers, preparation of standard solutions, primary and secondary standards. **Types of Volumetric Analysis methods: 1. Neutralization titrations**: Theory of indicators, neutralization curves for strong acid strong base, weak acid strong base, weak base strong acid. Preparation of approximate 0.1 M HCl and standardization against anhydrous sodium carbonate, determination of Na_2CO_3 content in washing soda. **2. Complexometric Titrations:** Definition of complexing agent and complexometric titration, EDTA-as complexing agent (structure of EDTA and metal ion-EDTA complex), Types of EDTA titration (direct and back titration), pH adjustment and amount of indicator in EDTA titration, metal ion indicators (general properties, solochrome black – T, Patton and Reeder's indicator only), standard EDTA solution, determination of Ca(II) and Mg(II), total hardness of water. **3. Redox Titrations:** Definition of oxidizing agent, reducing agent, redox titration, $K_2Cr_2O_7$ and $KMnO_4$ as oxidizing agents, 1,10-phenanthroline as indicator in reduction titration, diphenyl amine as oxidation indicator, $KMnO_4$ as self-indicator, Standard $KMnO_4$ solution and standardization with sodium oxalate, Determination of H_2O_2. **4. Precipitation titrations:** precipitation reactions, determination of end point (formation of coloured ppt, formation of soluble coloured compound, adsorption indicator), standard $AgNO_3$ soln., standardization of $AgNO_3$ soln. – potassium chromate indicator- Mohr's titration, determination of chloride and bromide, determination of iodide. Problems based on analysis.

***(Ref-1:** Pages-257-275, 286, 295, 309 -322, 328-332, 340-351, 364-372.; supplementary reference **Ref-2:** 382-302, 322-334, 366-374, 437-452)*

Learning Outcome:

After studying the Volumetric Analysis student will able to-

1. Explain / define different terms in volumetric analysis such as units of concentration, indicator, equivalence point, end point, standard solutions, primary and secondary standards, complexing agent, precipitating agent, oxidizing agent, reducing agent, redox indicators, acid base indicators, metallochome indicators, etc.
2. Perform calculations involved in volumetric analysis.
3. Explain why indicator show colour change and pH range of colour change.
4. To prepare standard solution and **b.** perform standardization of solutions.
5. To construct acid – base titration curves and performs choice of indicator for particular titration.
6. Explain / discuss acid-base titrations, complexometric titration / precipitation titration / redox titration.
7. Apply volumetric methods of analysis to real problem in analytical chemistry / industry.

Reference Books: (Analytical Chemistry)

1. Vogel's Textbook of quantitative Chemical Analysis, 5th Ed. G. H. Jeffry, J. Basset, J. Mendham, R. C. Denney, Longman Scientific and Technical, 1989.
2. Analytical Chemistry, G. D. Christian, P. K. Dasgupta, K. A. Schug, 7th Ed, Wily, 2004.
3. Fundamentals of Analytical Chemistry- Skoog, west, Holler, Crouch, 9th Ed. Brooks / Cole, 2014/2004.
4. Basic Concept of Analytical Chemistry- S. M. Khopkar
5. Instrumental methods of chemical analysis- Chatwal Anand
6. Analytical Chemistry, G.R. Chatwal, Sham Anand.

CH-302: Inorganic and Organic Chemistry [2credit, 36 L]

Chapter No.	Chapter	No of Lectures
1	Molecular Orbital Theory of Covalent Bonding	13
2	Introduction to Coordination chemistry	05
3	Aromatic hydrocarbons	05
4	Alkyl and Aryl Halides	07
5	Alcohols, Phenols and Ethers	06

1. Molecular Orbital Theory of Covalent Bonding [13 L]

Introduction to Molecular Orbital Method (MOT) and postulates of MO theory, LCAO approximation, s-s combination of orbitals, s-p combination of orbitals, p-p combination of orbitals, p-d combination of orbitals, d-d combination of orbitals, non-bonding combination of orbitals, Rules for linear combination of atomic orbitals, example of molecular orbital treatment for homonuclear diatomic molecules: Explain following molecules with respect to MO energy level diagram, bond order and magnetism: *H_2^+ molecule ion, H_2 molecule, He_2^+ molecule ion, He_2 molecule, Li_2 molecule, Be_2 molecule, B_2 molecule, C_2 molecule, N_2 molecule, O_2 molecule, O_2^- and O_2^{2-} ion, F_2 molecule,* Heteronuclear diatomic molecules: *NO, CO, HF.*

(***Ref.-1:****89-112,* ***Ref-4:*** *278-292,* ***Ref-5:*** *33-38)*

Learning Outcome:

After studying the Molecular Orbital Theory student will able to-

1. Define terms related to molecular orbital theory (AO, MO, sigma bond, pi bond, bond order, magnetic property of molecules, etc).
2. Explain and apply LCAO principle for the formation of MO's from AO's.
3. Explain formation of different types of MO's from AO's.
4. Distinguish between atomic and molecular orbitals, bonding, anti-bonding and non-bonding molecular orbitals.
5. Draw and explain MO energy level diagrams for homo and hetero diatomic molecules. Explain bond order and magnetic property of molecule.
6. Explain formation and stability of molecule on the basis of bond order.
7. Apply MOT to explain bonding in diatomic molecules other than explained in syllabus.

2. Introduction to Coordination Compounds [5 L]

Double salt and coordination compound, basic definitions: *coordinate bond, ligand, types of ligands, chelate, central metal ion, charge on complex ion, calculation of oxidation state of central metal ion, metal ligand ratio*; Werner's work and theory, Effective atomic number, equilibrium constant ***(Ref-6: 138-140)***, *chelate effect, IUPAC nomenclature.*

*(**Ref.-1:** 194-200, 222-224; **Ref-4:** 483-492)*

Learning Outcome:

After studying the Introduction to Coordination Compounds student will able to-

1. Define different terms related to the coordination chemistry (double salt, coordination compounds, coordinate bond, ligand, central metal ion, complex ion, coordination number, magnetic moment, crystal field stabilization energy, types of ligand, chelate effect, etc.)
2. Explain Werner's theory of coordination compounds. Differentiate between primary and secondary valency. Correlate coordination number and structure of complex ion.
3. Apply IUPAC nomenclature to coordination compound.

Reference Books: (Inorganic Chemistry)

1. Concise Inorganic Chemistry, J. D. Lee, 5th Ed (1996) Blackwell Science
2. Inorganic Chemistry, James E. House, Academic Press (Elsevier), 2008
3. Inorganic Chemistry by Miessler and Tarr, Third Ed. (2010), Pearson.
4. Principles of Inorganic Chemistry, Brian W. Pfennig, Wiley (2015)
5. Inorganic Chemistry, Catherine Housecroft, Alan G. Sharpe, Pearson Prentis Hall, 2008.
6. Basics Inorganic Chemistry, Cotton and Wilkinson

3. Aromatic Hydrocarbons: [5 L]

Introduction and IUPAC nomenclature, preparation (Case benzene): from phenol, by decarboxylation, from acetylene, from benzene sulphonic acid. *Reactions* (Case benzene): Electrophilic substitution: nitration, halogenation and sulphonation. Friedel-Craft's reaction (alkylation and acylation) (up to 4 carbons on benzene). Side chain oxidation of alkyl benzenes (up to 4 carbons on benzene).

*(**Ref-1:** 493-513)*

Learning Outcome:

After studying the aromatic hydrocarbons student will able to-

1. Identify and draw the structures aromatic hydrocarbons from their names or from structure name can be assigned.

2. Explain / discuss synthesis of aromatic hydrocarbons.
3. Give the mechanism of reactions involved.
4. Explain /Discuss important reactions of aromatic hydrocarbon.
5. To correlate reagent and reactions.

4. Alkyl and Aryl Halides: [7 L]

Alkyl Halides (up to 5 Carbons): Introduction and IUPAC nomenclature, Types of Nucleophilic Substitution (SN^1, SN^2 and SNi) reactions. *Preparation:* from alkenes *and* alcohols. *Reactions:* hydrolysis, nitrite & nitro formation, nitrile & isonitrile formation. Williamson's ether synthesis: Elimination vs. substitution.

Aryl Halides: Introduction and IUPAC nomenclature, *Preparation:* (Chloro, bromo and iodo-benzene case): from phenol, Sandmeyer and Gattermann reactions. *Reactions (Chlorobenzene):* Aromatic nucleophilic substitution (replacement by –OH group) and effect of nitro substituent. Benzyne Mechanism: KNH_2/NH_3 (or $NaNH_2/NH_3$). Reactivity and Relative strength of C-Halogen bond in alkyl, allyl, benzyl, vinyl and aryl halides**.**

***(Ref.-1:** 165-211 and 943-967)*

Learning Outcome:

After studying the Alkyl and Aryl Halides student will able to-

1. Identify and draw the structures alkyl / aryl halides from their names or from structure name can be assigned.
2. Explain / discuss synthesis of alkyl / aryl halides.
3. Write / discuss the mechanism of Nucleophilic Substitution (SN^1, SN^2 and SNi) reactions.
4. Explain /Discuss important reactions of alkyl / aryl halides.
5. To correlate reagent and reactions.
6. Give synthesis of expected alkyl / aryl halides.

5. Alcohols, Phenols and Ethers (Up to 5 Carbons): [6 L]

Alcohols: Introduction and IUPAC nomenclature, *Preparation:* Preparation of 1o, 2o and 3o alcohols: using Grignard reagent, ester hydrolysis, reduction of aldehydes, ketones, carboxylic acid and esters. *Reactions:* with sodium, HX (Lucas test), esterification, oxidation (with PCC, alc. KMnO4, acidic dichromate, conc. HNO_3). Oppeneauer oxidation *Diols:* (Up to 6 Carbons) oxidation of diols. Pinacol-Pinacolone rearrangement.

Phenols (Phenol case): Introduction and IUPAC nomenclature, *Preparation:* Cumene hydroperoxide method, from diazonium salts. *Reactions:* Electrophilic substitution: Nitration, halogenation and sulphonation. Reimer-Tiemann Reaction, Gattermann-Koch Reaction, Houben–Hoesch Condensation, Schotten–Baumann Reaction. **Ethers (aliphatic and aromatic):** Cleavage of ethers with HI.

(***Ref-1:*** *213-244 and 889-912)*

Learning Outcome:

After studying the Alcohols and Phenols student will able to-

1. Identify and draw the structures alcohols / phenols from their names or from structure name can be assigned.
2. Able to differentiate between alcohols and phenols
3. Explain / discuss synthesis of alcohols / phenols.
4. Write / discuss the mechanism of various reactions involved.
5. Explain /Discuss important reactions of alcohols / phenols.
6. To correlate reagent and reactions of alcohols / phenols
7. Give synthesis of expected alcohols / phenols.

References: (Organic Chemistry)

1. Morrison, R.T. & Boyd, R.N. *Organic Chemistry*, Prentice Hall of India, Sixth Edition, **2002**, 283-308.

Other Reference Books for All Chapters:

2. Jonathan Clayden, Nick Greeves, Stuart Warren, Peter Wothers *Organic Chemistry* - Oxford University Press, USA, 2nd Ed.

3. Bahl, A. and Bahl, B.S. *Advanced Organic Chemistry*, S. Chand, **2010**.

4. Graham Solomon, T.W., Fryhle, C.B. & Dnyder, S.A. *Organic Chemistry*, John Wiley and Sons (2014).

5. Mc Murry, J.E. *Fundamentals of Organic Chemistry*, 7th Ed. Cengage Learning India Edition, 2013.

6. Sykes, P. *A Guidebook to Mechanism in Organic Chemistry*, Orient Longman, New Delhi (1988).

7. Finar, I. L. *Organic Chemistry* (Vol. I and II), E.L.B.S.

CH-303: Practical Chemistry-III [2 credit, 72* L]

* 72 L distributed as 58 L for performing practicals and 14 L for internal evaluation.

For practicals, see the manual prepared by BOS of Chemistry. The examination will be held according to this manual.

Instructions

1. **Use molar concentrations for volumetric /estimations/synthesis experiments.**
2. **Use optimum concentrations and volumes**
3. **Two burette method should be used for volumetric analysis (Homogeneous mixtures)**
4. **Use of Microscale technique is recommended wherever possible**

A. Chemical Kinetics: Integrated rate method: (Any Three)

1. To Study the Acid catalysed hydrolysis of an ester (methyl Acetate) and determine the rate constant (k). (first order reaction)
2. To study the kinetics of saponification reaction between sodium hydroxide and ethyl acetate.
3. To compare the relative strength of HCl and H_2SO_4 or HNO_3 by studying the kinetics of hydrolysis of methyl acetate.
4. Energy of activation of the reaction between $K_2S_2O_8$ and KI by initial rate method

To determine the order of the reaction with respect to $K_2S_2O_8$ by fractional life method following the kinetics of per sulphate-iodide reaction.

References:

i) Systematic experimental physical chemistry, S. W. Rajbhoj, T. K. Chondekar, Anjali publication.

ii) Practical Physical Chemistry, Vishwanathan and Raghwan , Viva book.

iii) Practical Chemistry, O. P. Pandey, D. N. Bajpai Dr. S. Giri, S Chand Publication

iv) Experiments in Chemistry, D. V. Jahagirdar, Himalaya Publication.

B. Inorganic quantitative / qualitative analysis (Any two)

1. Estimation of Fe(III) from given solution by converting it to Fe(II) using Zn metal and then by titrating with standard solution of $K_2Cr_2O_7$-A Green Approach (Ref.-1,3).
2. Determination of $BaCO_3$ content in a given sample by precise determination of volume of CO_2 (Ref-2).
3. Separation and Identification of metal ions by Paper Chromatography (Ref.,4,5)

References:

1. Iron Analysis by Redox Titration A General Chemistry Experiment, ***Journal of Chemical Education***, Volume 65, Number 2, February 1988.183.
2. A Precise Method for Determining the CO_2 Content of Carbonate Materials, ***Journal of Chemical Education***, Vol. 75, No. 12, December 1998.
3. Vogel's Textbook Quantitative Chemical Analysis, 3rd and 6th Ed.
4. Advanced Practical Chemistry, Jagdamba Sing et al, Pragati Prakashan, Merrut.
5. Practical Chemistry, Panday, Bajpai, Giri, S.Chand and Co.

C. Organic Qualitative Analysis (Two mixtures: solid-solid type)

1. **Separation of Two Components** from given binary mixture of organic compounds containing mono-functional group (Ex. - carboxylic acid, phenols, amines, amide, nitro, etc.) and systematic identification of each component qualitatively.

D. Organic Preparations (Any two)

1. Preparation of benzoic acid from ethyl benzoate (Identification and confirmatory Test of –COOH group, M.P and purity by TLC)
2. Acetylation of primary amine (Green approach)
3. Base catalyzed Aldol condensation (Green approach)
4. Preparation of Quinone from hydroquinone (Confirm the conversion by absence of phenolic –OH group in product, M.P and purity by TLC)

E. pH Metry (Compulsory)

4. To determine equivalence point of neutralisation of acetic acid by pH-metric titration with NaOH and to find best indicator for the titration.

F. Volumetric Analysis (Any two)

1. Estimation of Aspirin from a given tablet and find errors in quantitative analysis. (***Standardization of acid must be performed with standard Na2CO3 solution, prepared from dried anhydrous AR grade Na_2CO_3***)

2. Determination of acetic acid in commercial vinegar by titrating with standard NaOH. Express your results as average ± standard deviation. (***Standardization of base must be performed with standard KHP***)

3. Determination of Hardness of water from given sample by complexometric titration (Using E.D.T.A.) method and total dissolve solids by conductometry. Express your results as average ± standard deviation. (***Standardization of Na_2EDTA must be performed with standard Zn(II) solution***)

Reference:

1. Vogel's Textbook Quantitative Chemical Analysis, 3rd and 5th Ed.

2. Experiments in chemistry, D. V. Jahagirdar, Himalaya Publication.

Examination Pattern: At the time of examination student will have to perform one experiment. In case of organic qualitative analysis, after separation of binary mixture any one component has to be analysed according to OQA scheme. Distribution of 35 marks: 30 marks for experimental performance and 5 mark for oral.

To cope up with NACC criterion and to motivate and inculcate research culture among the students, interested students can be assigned mini-scale project. Project should be based either on applications of chemistry in day to day life or application or novel / applied synthesis / demonstrating principles of chemistry. The project work is equivalent to three experiments. ***Student performing project can be exempted from 3 experiments from two semester. (*from three different sections of two semester) and project will be evaluated by external examiner. Project being choice based activity; student will not get any exemption in external examination***. Systematic project report (Name page, certificate, introduction/theory, importance of project, learning outcome, requirements, safety precautions, procedure, observations, calculations, results and conclusions) be submitted separately in binding form duly certified by mentor teacher and HOD.

Illustrative list of some projects is given below for your perusal.

1. Synthesis of soap from different types of oils with respect to i) percent yield ii cost of obtaining 50 g soap (students will learn saponification or alkaline hydrolysis of oils – a chemical reaction for the synthesis of day to day life product, which oil is better for soap making).
2. Synthesis of biodegradable plastic (Principles demonstrated: Chemical reactions for mores safe products and to mitigate environmental pollution).
3. Synthesis of azo dyes and effect substituents of benzene ring on colour of azo dye (Principle demonstrated -Inductive effect a visible demonstration, strategy to charge the colour of dye, chemical reactions for industries).
4. Quality of Consumer products: identification reactions and Purity of $NaHCO_3$ (eating soda) of different brands by thermal decomposition. (Application of analytical chemistry and simple decomposition reaction for the determination of purity of consumer product)

5. Determination pH, surface tension, CMC and washing action of detergent of different brands for comparing their quality. (Application of chemistry principles in determination of quality of consumer product)
6. Removal of dyes / nitrophenols / by Fenton's process or by adsorption on activated charcoal. (Applications of principles of chemistry in mitigation of environmental pollution, an industrial application of chemistry).
7. Study of deionization water using cation and anion exchange resins / zeolites. Amount of zeolites / resin required for the softening of water. (Day to day life application of chemistry, student can apply their knowledge and can construct their own deionizer).
8. Preparation shampoo. Ingredients required, their proportion, mixing and testing.
9. Eudiometer: Determination of oxidation state, equivalent wt. and determine stoichiometry of the reaction between i) iron metal and HCl. Fe can have oxidation state +2 or +3. ii) Zn and HCl iii) Al and HCl. What happens with HNO_3? Why similar method cannot used to investigate reaction between HNO_3 and these metals?
10. Study stoichiometry of simple chemical reactions thereby determination of equivalent wt. of one of the reactant: i) $FeSO_4 7H_2O$ and $KMnO_4$ (determine equivalent wt. of $KMnO_4$) ii) Mn(II) and $KMnO_4$ (determine equivalent wt. of $KMnO_4$).Explain the concept of variable oxidation state and variable equivalent wt. for same substance i.e. mol. wt. is constant. (Known Fe^{2+} oxidizes to Fe^{3+} only).
11. Synthesis /isolation of essences, purity by TLC/ B.P. (at least two).
12. Synthesis and estimation of purity of aspirin (medicinal compound) by green chemistry route.
13. Compare the paracetamol content in tablet of different brands (at least three different brands).
14. Compare the vitamin-c content in tablet of different brands. (at least three different brands).
15. Determination of Avagdro Number (N) by various technics such as Brownian Moment, Electrodeposition, number of molecules in monolayer etc.
16. Hess Law verification
17 Determination of Farday constant and Avagadro number
18 To determine thermodynamic values of various compounds
19 To determine density of various substances
20 Preparation of Nylon and study its properties
21 Microscale techniques in Chemistry

References:

1. A laboratory manual for general, organic and biological chemistry, 3rd Ed. Pearson.
2. Safety-Scale Laboratory Experiments for Chemistry for Today: General, Organic and Biochemistry Seventh Edition, Spencer L. Seager, Michael R. Slabaugh, Cengage Learning, 2010
3. Laboratory Manual for Principles of General Chemistry, Bearen, 8th Ed. Wiley.
4. Green Chemistry Laboratory Manual for General Chemistry, Sally A. Henrie, CRC Press Taylor & Francis Group, and Informa Business. 2015
5. Experiments in General Chemistry, G. S. Weiss T. G. Greco L. H. Rickard, Ninth Edition, Pearson Education Limited, 2014.
6. Mini-scale and micro-scale organic chemistry laboratory experiments 7th Ed. Schoffstall, Gaddis, Mc-Graw-Hill Higher Education, 2004.
7. Journal of Chemical Education, ACS, (search relevant topics).

II. Students short activity (for both semesters)

These are the extra-time activities for the students which can be performed with the permission of mentor. Mentor can arrange a demonstration on these activities to explain basic principles of chemistry. **Teacher can design many such activities to explain theory that you taught in the class.** Systematic report of activity performed be written in journal. Sample list of small activities is given below. These short activities can be considered for internal evaluation. Some activities are given below.

1. Amphoteric nature of $Al(OH)_3$ (Principle demonstrated-demonstration of amphoteric nature substance and why $Al(OH)_3$ is used in antacid preparations)
2. Enzyme deactivation by Hg^{2+} (Principle demonstrated–catalyst deactivation and toxicity effect of Hg^{2+})
3. Adsorption of dyes on activated charcoal (Principle demonstrated and application- surface adsorption for removal of dyes from effluents)
4. Detection of adulteration in milk / chilli powder / turmeric power / food colours
5. Use of EXCEL in drawing of graphs and calculations.
6. Catalysis by Mn(II) in $KMnO_4$–Oxalic acid titration. (Principle, demonstrated - Homogeneous catalysis)
7. Identification of type of salt (strong acid – strong base, strong acid – weak base, weak acid – strong base) by hydrolysis reactions and indicators. (Principle demonstrated – hydrolysis reaction of salts, it really takes place)
8. Identification of inorganic ions in soft drinks / tooth paste, form of iodide in table salt / waste water / bore well water.

9. Spectrochemical series using $CuSO_4$ solution and i) NaCl, ii) KBr, iii) Ammonia, iv) ethylene diamine, v) salicylic acid [correlate colour with wavelength and predict ligand strength]
10. Green Chemistry principles in Organic Chemistry.

References: Journal of Chemical Education, ACS, (search relevant topics).

Learning Outcome- Practical Chemistry-III

1. Verify theoretical principles experimentally.
2. Interpret the experimental data on the basis of theoretical principles.
3. Correlate theory to experiments. Understand/verify theoretical principles by experiment observations; explain practical output / data with the help of theory.
4. Understand systematic methods of identification of substance by chemical methods.
5. Write balanced equation for the chemical reactions performed in the laboratory.
6. Perform organic and inorganic synthesis and is able to follow the progress of the chemical reaction by suitable method (colour change, ppt. formation, TLC).
7. Set up the apparatus / prepare the solutions - properly for the designed experiments.
8. Perform the quantitative chemical analysis of substances explain principles behind it.
9. Systematic working skill in laboratory will be imparted in student.

Important Notes:

i) Wherever feasible develop and practice micro or semi-micro methods from known / recommended procedures and the reference books. This is to i) minimize the cost of experiment, ii) reduce wastage of chemicals iii) reduce environmental pollution.

ii) Mentor should promote students to ***complete the Journal on the same day before leaving of the lab***. Ensure that the original data is retained and used by the candidate. Students may adjust the data from their lab work to reach close to theoretical values. If journal is completed before leaving the lab it will not encourage students to "adjust" the facts from their lab work. (**Ref-Journal of Chemical Education, Min J. Yang and George F. Atkinson, Designing New Undergraduate Experiments, Vol. 75, No. 7, July 1998**).

Internal Evaluation Strategy for practical (Both semester):

During start of the practical course methodology of internal evaluation should be discussed with students. Internal evaluation is a continuous assessment (CA). Hence during each practical, internal evaluation must be done with different tools. **Guidelines for internal evaluation:** To each practical 15 marks can be assigned which can be distributed as follows:

Overall performance and timely arrival	Interaction	Accuracy of results	Journal /Lab report	Post laboratory quiz / assignment / oral
4	2	2	5	2

At the end of semester, average of 12 experiments can be assigned as internal marks out of 15. Systematic record of internal evaluation must be maintained which is duly sign by mentor and student. If student is absent with prior-intimation her/his absentee will be considered but student will have to complete the experiment in the same week or in with the permission of mentor. Mentor or practical in-charge should arrange the practical for such students. Students performing projects (one mini project equivalent to three practical session) / student activities (4 to 6 activities equivalent to three practical session) can be assigned up to 3 marks out of 15.

SEMSER-IV

CH-401: Physical and Analytical Chemistry [Credit: 2, 36 L]

Chapter No	Chapter	No of Lectures
1	Phase Equilibrium	09
2	Ideal and Real Solutions	09
3	Conductometry	06
4	Colorimetry	06
5	Column Chromatography	06

1. Phase equilibrium [9L]

Introduction; definitions of phase, components and degrees of freedom of a system; stability of phases, criteria of phase equilibrium. Gibbs phase rule and its thermodynamic derivation, phase diagrams of one- component systems- water, carbon dioxide and sulphur systems, problems. *(**Ref. No: 1**, Page No- 119 - 126, **Ref. No: 2**, Page No – 661-675,**Ref. No:4,** Page No 344- 354).*

Learning Outcomes

- Define the terms in phase equilibria such as- system, phase in system, components in system, degree of freedom, one / two component system, phase rule, etc.
- Explain meaning and Types of equilibrium such as true or static, metastable and unstable equilibrium.
- Discuss meaning of phase, component and degree of freedom.
- Derive of phase rule.
- Explain of one component system with respect to: Description of the curve, Phase rule relationship and typical features for i) Water system ii) Carbon dioxide system iii) Sulphur system
- **Reference Books (Physical Chemistry)**

1. Atkins' Physical Chemistry by Peter Atkins, Julio de Paula, James Keeler -11th edition
2. Principles of Physical chemistry by B.R. **Puri**, L.R. **Sharma**, M.S. Pathania
3. Essentials of Physical chemistry by Bahl Tuli-Revised Multicolour Edition 2009, S. Chand and Company Ltd.
4. Principles of Physical Chemistry, Fourth Edition by S.H. Marron and C. F. Pruton
5. Physical-Chemistry-4th Edition - Gilbert W. Castellan Narosa (2004).
6. Principles of Chemical Kinetics- 2rdEdition- James E. House.

7. Barrow, G.M. Physical Chemistry Tata McGraw- Hill (2007).
8. Kotz, J.C., Treichel, P.M. & Townsend, J.R. General Chemistry, Cengage Learning India Pvt. Ltd.: New Delhi (2009).
9. Mahan, B.H. University Chemistry, 3rd Ed. Narosa (1998).
10. Petrucci, R.H. General Chemistry, 5th Ed., Macmillan Publishing Co.: New York (1985).
11. Physical Chemistry by Thomas Engel**,** Philip Reid, Warren Hehre.

2. Ideal and real solutions [9L]

Introduction, chemical potential of liquids - ideal solutions, ideal dilute solutions - Raoult's and Henry's Law, liquid mixtures, phase diagram of binary systems : liquids - vapour pressure diagrams, temperature composition diagrams, liquid-liquid phase diagrams, solubility of partially miscible liquids-critical solution temperature, effect of impurity on partially miscible liquids, Problems. (***Ref. No:*** *1, Page Nos- 150-153, 155-157, 166 – 175,* ***Ref. No: 2****, Page No. - 750-775, 696-705****Ref. No:4****, Page No. 261-292, 298- 302).*

Learning Outcomes

- Define various terms, laws, differentiate ideal and no-ideal solutions.
- Discuss / explain thermodynamic aspects of Ideal solutions-Gibbs free energy change, Volume change, Enthalpy change and entropy change of mixing of Ideal solution.
- Differentiate between ideal and non-ideal solutions and can apply Raoult's law.
- Interpretation of i) vapour pressure–composition diagram ii) temperature- composition diagram.
- Explain distillation of liquid solutions from temperature – composition diagram.
- Explain / discuss azeotropes, Lever rule, Henrys law and its application.
- Discuss / explain solubility of partially miscible liquids- systems with upper **c**ritical. Solution temperature, lower critical solution temperature and having both UCST and LCST.
- Explain / discuss concept of distribution of solute amongst pair of immiscible solvents.
- Derive distribution law and its thermodynamic proof.
- Apply solvent extraction to separate the components of from mixture interest.
- Solve problem by applying theory.

3. Conductometry [6 L]

Introduction, Electrolytic Conductance, Resistance, conductance, Ohm's law, cell constant, specific and equivalent conductance, molar conductance, variation of equivalent and specific conductance with concentrations, Kohlrausch's law and its applications, conductivity cell, conductivity meter, Whetstone Bridge, determination of cell constant,

conductometric titrations (strong acid-strong base, strong acid-weak base, weak acid strong base) and Numericals. ***Ref-1:*** *398-402, 414-423, 433-434,* ***Ref-2:*** *519-527,* ***SupplementaryRef-3:*** *746-756,* ***Ref-4:*** *528-532.*

Learning Outcomes

- Explain / define different terms in conductometry such as electrolytic conductance, resistance, conductance, Ohm's law, cell constant, specific and equivalent conductance, molar conductance, Kohlrausch's law, etc.
- Discuss / explain Kohlrausch's law and its Applications, Conductivity Cell, Conductivity Meter, Whetstone Bridge.
- Explain / discuss conductometric titrations.
- Apply conductometric methods of analysis to real problem in analytical laboratory.
- Solve problems based on theory / equations.
- Correlate different terms with each other and derive equations for their correlations.

4. Colorimetry: [6 L]

Introduction, interaction of electromagnetic radiation with matter, essential terms: radiant power, transmittance, absorbance, molar, Lamberts Law, Beer's Law, Lambert-Beer's Law, molar absorptivity, deviations from Beer's Law, Colorimeter**:** *Principle, Construction and components, Working*. Applications–unknown conc. By calibration curve method, Determination of unknown concentration of Fe(III) by thiocynate method, Numericals. (***Ref-2:*** *645-651, 658-661, 690,* ***Ref-3:*** *97, 100, 159-172,* ***Ref-4:*** *144-153, 157-160,* ***Ref-6****-Relevent pages).*

Learning Outcomes

- Explain / define different terms in Colorimetry such as radiant power, transmittance, absorbance, molar, Lamberts Law, Beer's Law, molar absorptivity
- Discuss / explain / derive Beer's law of absorptivity.
- Explain construction and working of colorimeter.
- Apply colorimetric methods of analysis to real problem in analytical laboratory.
- Solve problems based on theory / equations.
- Correlate different terms with each other and derive equations for their correlations.

5. Column Chromatography [6 L]

Introduction, Principle of Column Chromatography, **Ion Exchange Chromatography:** Ion exchange resins, action of ion exchange resin (Ion exchange equilibria, Ion exchange capacity), Experimental technique, Application: i) Separation of

Metal ions / non-metal ions on Ion Exchange Chromatography (*Zn(II) and Mg(II), Cl^- and Br^-),* ii) Purification of water, (***Ref-2:*** *186-192, 205-209*) **Adsorption Chromatography – Liquid solid chromatography**: Introduction, the technique of conventional chromatography, column packing materials, Selection of solvent for adsorption chromatography, Adsorption column preparation and loading, Application – Purification of anthracene (***Ref-5:*** *209-215, 221*), Size Exclusion Chromatography*(Supplementary -* ***Ref-4:*** *pages 111-153, 212-215,* ***Ref-6****-Relevent pages)*

Learning Outcomes

- Explain / define different terms in column chromatography such as stationary phase, mobile phase, elution, adsorption, ion exchange resin, adsorbate, etc.
- Explain properties of adsorbents, ion exchange resins, etc.
- Discuss / explain separation of ionic substances using resins.
- Discuss / explain separation of substances using silica gel / alumina.
- Apply column chromatographic process for real analysis in analytical laboratory.

References (Analytical Chemistry)

1. Principles of Physical Chemistry, S.H. Marron and C. F. Pruton4th ed., Oxford and IBH publishing company / CBS, new Delhi.
2. Vogel's Textbook of quantitative Chemical Analysis, 5th Ed. G. H. Jeffry, J. Basset, J. Mendham, R. C. Denney, Longman Scientific and Technical, 1989.
4. Basic Concept of Analytical Chemistry- S. M. Khopkar
5. Vogel's Text Book of Practical Organic Chemistry, Furniss, Hannaford, Smith, Tatchel, 5th Ed., Longman Scientific and Technical, 2004.
6. Analytical Chemistry, G.R. Chatwal, Sham Anand.

CH-402: Inorganic and Organic Chemistry [2 credit, 36L]

Chapter No.	Chapter	No of Lectures
1	Isomerism in coordination complexes	02
2	Valance Bond Theory of Coordination Compounds	04
3	Crystal field Theory	12
4	Aldehydes and ketones	05
5	Carboxylic acids and their derivatives	05
6	Amines and Diazonium Salts	04
7	Stereochemistry of Cyclohexane	04

1. Isomerism in coordination complexes [2 L]

Introduction, polymerization isomerism, ionization isomerism, hydrates isomerism, linkage isomerism, coordination isomerism, coordination position isomerism, geometric isomerism, optical isomerism.

***(Ref-1:** 232-236)*

Learning Outcome:

After studying the aromatic hydrocarbons student will able to-

1. Isomerism in coordination complexes
2. Explain different types of isomerism in coordination complexes.

2. Valance Bond Theory of Coordination Compounds [4 L]

Aspects and assumptions of VBT, applications of VBT on the basis of hybridization to explain the structure and bonding in $[Ag(NH_3)_2]^+$, $[Ni(Cl_4)]^{2-}$, $[Ni(CN)_4]^{2-}$, $[Cr(H_2O_6)]^{3+}$, $[Fe(CN)_6]^{3-}$ (Inner orbital complex) and $[FeF_6]^{3-}$(outer orbital complex). Use of observed magnetic moment in deciding the geometry in complexes with C.N.4, limitations of VBT.

(**Ref-2:** 592-597, **Ref-3:**350-351).

Learning Outcome:

After studying the aromatic hydrocarbons student will able to-

1. Apply principles of VBT to explain bonding in coordination compound of different geometries.
2. Correlate no of unpaired electrons and orbitals used for bonding.
2. Identify / explain / discuss inner and outer orbital complexes.
4. Explain / discuss limitation of VBT.

3. Crystal Field Theory [12 L]

Shapes of d-orbitals, Crystal field Theory (CFT): Assumptions, Application of CFT to i) Octahedral complexes (*splitting of 'd' orbitals in Oh ligand field, effect of weak and strong ligand fields, colour absorbed and spectrochemical series, crystal splitting energy, Crystal field stabilization energy and factors affecting it, tetragonal distortion in Cu(II) complexes*) ii) Square planar complexes and iii) Tetrahedral complexes; spin only magnetic moment of Oh and Td complexes.

(Ref-1:*194-225).*

Learning Outcome:

After studying the aromatic hydrocarbons student will able to-

1. Explain principle of CFT.
2. Apply crystal field theory to different type of complexes (Td, Oh, Sq. Pl complexes)
3. Explain: i) strong field and weak field ligand approach in Oh complexes ii) Magnetic properties of coordination compounds on the basis of weak and strong ligand field ligand concept. iii) Origin of colour of coordination complex.
4. Calculate field stabilization energy and magnetic moment for various complexes.
5. To identify Td and Sq. Pl complexes on the basis of magnetic properties / unpaired electrons.
6. Explain spectrochemical series, tetragonal distortion / Jahn-Teller effect in Cu(II) Oh complexes only.

Reference Books: (Inorganic Chemistry)

1. Concise inorganic chemistry, J. D. Lee, 5th Ed (1996), Blackwell Science
2. Inorganic Chemistry, James E. House, Academic Press (Elsevier), 2008
3. Inorganic Chemistry by Miessler and Tarr, Third Ed. (2010), Pearson.

4. Aldehydes and Ketones (aliphatic and aromatic) [5 L]

(Formaldehyde, acetaldehyde, acetone and benzaldehyde)

Introduction and IUPAC nomenclature, *Preparation:* from acid chlorides and from nitriles. *Reactions* – Reaction with HCN, ROH, $NaHSO_3$, NH_2-G derivatives. Iodoform test, Aldol Condensation, Cannizzaro's reaction, Wittig reaction, Benzoin condensation, Clemenson reduction and Wolff Kishner reduction. Meerwein-Pondorff Verley reduction. (***Ref-1:*** *657-700 and 797-816*)

Learning Outcome:

After studying the aldehydes and ketones student will able to-

1. Identify and draw the structures aldehydes and ketones from their names or from structure name can be assigned.
2. Explain / discuss synthesis of aldehydes and ketones.
3. Write / discuss the mechanism reactions aldehydes and ketones.
4. Explain /Discuss important reactions of aldehydes and ketones.
5. To correlate reagent and reactions of aldehydes and ketones
6. Give synthesis of expected aldehydes and ketones.
7. Perform inter conversion of functional groups.

5. Carboxylic acids and their derivatives [5 L]

Carboxylic acids (aliphatic and aromatic): Introduction and IUPAC nomenclature, *Preparation:* Acidic and Alkaline hydrolysis of esters. *Reactions:* Hell–Vohlard - Zelinsky Reaction.

Carboxylic acid derivatives (aliphatic): (up to 5 carbons) *Preparation:* Acid chlorides, Anhydrides, Esters and Amides from acids and their inter conversion. Reaction: Comparative study of nucleophilicity of acyl derivatives. Reformatsky Reaction, Perkin condensation. *(**Ref-1:** 713-745 and 753-785).*

Learning Outcome:

After studying the carboxylic acids and their derivatives student will able to-

1. Identify and draw the structures carboxylic acids and their derivatives from their names or from structure name can be assigned.
2. Explain / discuss synthesis of carboxylic acids and their derivatives.
3. Write / discuss the mechanism reactions carboxylic acids and their derivatives.
4. Explain /Discuss important reactions of carboxylic acids and their derivatives.
5. Correlate reagent and reactions of carboxylic acids and their derivatives
6. Give synthesis of expected carboxylic acids and their derivatives.
7. Perform inter conversion of functional groups.

6. Amines and Diazonium Salts: [4 L]

Amines (Aliphatic and Aromatic): Introduction and IUPAC nomenclature, *Preparation* from alkyl halides, Gabriel's Phthalimide synthesis, Hofmann Bromamide reaction. *Reactions:* Hofmann vs. Saytzeff elimination, Electrophilic substitution (Case Aniline): nitration, bromination, sulphonation.

Diazonium salts: Preparation from aromatic amines. (***Ref-1:** 821-877)*

Learning Outcome:

After studying the amines and diazonium Salts student will able to-

1. Identify and draw the structures amines from their names or from structure name can be assigned.
2. Explain / discuss synthesis of carboxylic amines.
3. Write / discuss the mechanism reactions carboxylic amines.
4. Explain /Discuss important reactions of carboxylic amines.
5. To correlate reagent and reactions of carboxylic amines.
6. Give synthesis diazonium salt from amines and reactions of diazonium salt.
7. Perform inter conversion of functional groups.

7. Stereochemistry of Cyclohexane: [4 L]

Bayer's strain theory, heat of combustion of cycloalkanes, structure of cyclohexane, axial and equatorial H atoms, conformations of cycloalkane, stability of conformations of cyclohexane, methyl and t-butyl monosubstituted cyclohexane, 1,1 and 1,2 dimethyl cyclohexane and their stability.

***(Ref-1:** 283-308*).

Learning Outcome:

After studying the aromatic hydrocarbons student will able to-

1. Draw the structures of different conformations of cyclohexane.
2. Define terms such as axial hydrogen, equatorial hydrogen, confirmation, substituted cyclohexane, etc.
3. Convert one conformation of cyclohexane to another conformation and should able to identify governing structural changes.
4. Explain / discuss stability with respect to potential energy of different conformations of cyclohexane.
5. Draw structures of different conformations of methyl / t-butyl monosubstituted cyclohexane (axial, equatorial) and 1, 2 dimethyl cyclohexane.
6. Identify cis- and trans-isomers of 1, 2 dimethyl substituted cyclohexane and able to compare their stability.

Reference Books: (Organic Chemistry)

1. Morrison, R.T. and Boyd, R.N. *Organic Chemistry*, Prentice Hall of India, Sixth Edition, 2002, 283-308.

Other Reference Books for all chapters:

2. Jonathan Clayden, Nick Greeves, Stuart Warren, Peter Wothers, ***Organic Chemistry***- Oxford University Press, USA, 2nd Ed.

3. Bahl, A. and Bahl, B.S. *Advanced Organic Chemistry,* S. Chand**,** 2010**.**

4. Graham Solomon, T. W., Fryhle, C. B. and Dnyder, S. A. ***Organic Chemistry***, John Wiley and Sons (2014).

5. Mc Murry, J.E. ***Fundamentals of Organic Chemistry***, 7th Ed. Cengage Learning India Edition, 2013.

6. Sykes, P. ***A Guidebook to Mechanism in Organic Chemistry***, Orient Longman, New Delhi (1988).

7. Finar, I.L. *Organic Chemistry* (Vol. I & II), E.L.B.S.

CH-403: Practical Chemistry-IV [2 credit, 72* L]

* 72 L will be distributed as 58 L performing practical and 14 L for internal evaluation.

Instructions:

1. **Use molar concentrations for volumetric /estimations/synthesis experiments.**
2. **Use optimum concentrations and volumes**
3. **Two burette method should be used for volumetric analysis (Homogeneous Mixtures)**
4. **Use of Microscale technique is recommended wherever possible.**

Conductometry (Compulsory)

a) To determine the cell constant of the given cell using 0.01 M KCl solution and determine dissociation constant of a given monobasic weak acid.

b) To investigate the conductometric titration of any one of the following a) Strong acid against strong base b) Strong base against weak acid. (***standardization of base must be performed with KHP***)

Chromatography (compulsory)

1. Separation of binary mixture of cations by Column Chromatography by ion exchange resins / cellulose (any one mixture) (Co + Al, Cu + Mg, Zn+Mg). Separation of cations must be confirmed by qualitative test

References:

i. Vogel's Textbook Quantitative Chemical Analysis, 3rd, 6th Ed.

ii) Experiments in chemistry, D. V. Jahagirdar, Himalaya publication.

Ideal and Real solutions (Any two)

1. To study the variation of mutual solubility temperature with concentration for the phenol - water system
2. To study the effect of added electrolyte on the critical solution temperature of phenol-water system and to determine the concentration of the given solution of electrolyte.
3. To obtain the temperature-composition phase diagram for a two component liquid system with maximum (or minimum) boiling point and to determine the maximum (or minimum) boiling point and composition.

Adsorption (Compulsory)

1. To verify the Freundlich and Langmuir adsorption isotherm for adsorption of acetic acid on activated charcoal.

References:

i) i) Systematic experimental physical chemistry, S. W. Rajbhoj, T. K. Chondekar, Anjali publication.

ii) Practical Physical Chemistry, Vishwanathan and Raghwan , Viva book.

iii) Practical Chemistry, O. P. Pandey, D. N. Bajpai Dr. S. Giri, S Chand Publication

Synthesis of Coordination compounds (any two)

1. Synthesis of sodium cobaltinitrite (a laboratory chemical) from Co(II) salt and $NaNO_2$ salts. Comment on colour and magnetic properties of the complex. (Ref.-1, 2)
2. Synthesis of potassium Tris(oxalate)aluminium(III) using Al metal powder(Scrap aluminium). Comment on colour and magnetic properties of the complex. (Ref-2, 3, 4)
3. Synthesis of Tris(acetylacetone)iron(III) by green chemistry method by reaction between $Fe(OH)_3$ and acac. Comment on colour and magnetic properties of the complex. (Ref.- 5,6).
4. Synthesis of Tris(ethylenediamine)nickel(II) from Ni(II) salt, ethylediamine and sodium thiosulfate. Comment on colour and magnetic properties of the complex. (Ref.-7)

Inorganic colorimetric investigations (Any two)

1. Prepare standard solutions of $KMnO_4$ / $CuSO_4$, record their absorbance and Verify Beer's Law and determine unknown concentration. **(Compulsory)**
2. Prepare solution of Fe(III) and $SCN^-$of in different molar proportion, record their absorbance and calculate equilibrium constant of $[Fe(SCN)]^{2+}$ complex (Ref.-9,10)
3. Prepare solution of Fe(III)/Cu(II) and salicylic acid in different molar proportion and determine metal ligand ratio in Fe(III) or Cu(II)–Salicylic acid complex. (Ref.-11, 12, 13)

References

1. Handbook of Preparative Inorganic Chemistry, Volume 2, Second Edition, Edited By Georg Braue R, Academic Press, New York, London, 1965. (Page-1541)

2. Practical Chemistry, Panday, Bjpai, Giri, S.Chand and Co.

3. McNeese, T.J.; Wierda, D.A. Synthesis of Potassium Tris(oxalato)aluminate(III) Trihydrate. ***Journal of Chemical Education***,1983, 60(11), 1001.

4. Inorganic Syntheses Vol -1 by H S Booth. First Ed, 1939. (page-36).

5. Novel Synthesis of Tris(acetylacetonato)-iron(III), ***Journal of Chem. Soc. Dalton Trans.*** 1983

6. Metal Acetylacetonate Synthesis Experiments: Which Is Greener?, ***Journal of Chemical Education,*** 2011, 88, 947–953, dx.doi.org/10.1021/ed100174f

7. Experimental Inorganic/Physical Chemistry: An Investigative, Integrated Approach to Practical Project Work, Mounir A . Malati, Woodhead Publishing Limited, 1999.
8. Vogel's Textbook Quantitative Chemical Analysis, 6th Ed.
9. Colorimetric Determination of the Iron(III)-Thiocyanate Reaction Equilibrium Constant with Calibration and Equilibrium Solutions Prepared in a Cuvette by Sequential Additions of One Reagent to the Other, ***Journal of Chemical Education***, Vol.88 No.3 March 2011.
10. Experiments in chemistry, D. V. Jahagirdar, Himalaya publication.
11. A spectrophotometric study of complex formation between Fe(III) and salicylic acid, Kinya Ogawa, Nobuko Tobe, Bulletin of chemical society of Japan, 39, 227-232, 1966.
12. Salicylate determination by complexation with Fe(III) and optical absorbance spectroscopy
13. Determination of Equilibrium Constants of Metal Complexes from Spectrophotometric Measurements: An Undergraduate Laboratory Experiment, ***Journal of Chemical Education***, Vol. 76, No. 9, September 1999.

Organic Estimations (any two)

1. **Determination of molecular weight:** Determination of molecular weight of organic acid by titration against standardized NaOH - a) monobasic acid or b) dibasic acid
2. **Estimation of amides:** Determine the amount of acetamide in given solution by volumetric method. (Standardization of acid must be performed)
3. **Estimation of Ethyl benzoate:** To determine the amount of ethyl benzoate in given solution volumetrically. (Standardization of acid must be performed).

References:

i) Vogel's textbook of practical organic chemistry
ii) Comprehensive Practical Organic Chemistry by V.K. Ahluwalia and Renu Aggarwal

Examination Pattern: At the time of examination student has to perform one experiment either from inorganic sections or organic section. 50% students must be assigned inorganic chemistry and 50% organic chemistry experiment. In case of organic qualitative analysis, after separation of binary mixture any one compound has to be analysed. Distribution of or 35 marks: 30 marks for experimental performance and 5 mark for oral.

Section - C: Industrial Visit

Visit any Chemical / Pharmaceutical / Polymer / Research Institutes / Sugar Factories / waste water treatment plant, etc. and submit report.

Learning Outcomes

1. Verify theoretical principles experimentally

2. Interpret the experimental data on the basis of theoretical principles.
3. Correlate the theory to the experiments. Understand / verify theoretical principles by experiment or explain practical output with the help of theory.
4. Understand systematic methods of identification of substance by chemical methods.
5. Write balanced equation for all the chemical reactions performed in the laboratory.
6. Perform organic and inorganic synthesis and able to follow the progress of the chemical reaction.
7. Set up the apparatus properly for the designed experiments.
8. Perform the quantitative chemical analysis of substances and able to explain principles behind it.

SPPU S. Y. B. Sc. Microbiology Sem I and Sem II Syllabus 2020-21

Titles of the Papers

Semester	Paper Code	Paper	Paper title
III	MB 211	I	Medical Microbiology and Immunology
	MB212	II	Bacterial Physiology and Fermentation Technology
	MB 213	III	Practical based on MB211 & MB 212
IV	MB 221	I	Bacterial Genetics
	MB 222	II	Air, Water and Soil Microbiology
	MB 223	III	Practical based on MB221 & MB 222

S. Y. B. SC. MICROBIOLOGY SYLLABUS (SEM I)

MB – 211: MEDICAL MICROBIOLOGY AND IMMUNOLOGY		**[30]**
Credit I	**MEDICAL MICROBIOLOGY**	**(15)**
1	**Definitions:** Incubation period, Viability, Susceptibility, Pathogenicity, Virulence, Pathogenesis, Lab diagnosis, Epidemic, Sporadic, Endemic, Pandemic	**2**
2	**Study of following pathogens with respect to –**Classification, Morphological, Cultural and Biochemical characters, Antigenic structure, Viability characteristics, Pathogenicity, Pathogenesis, Symptoms, Laboratory diagnosis, Epidemiology, Prophylaxis and Chemotherapy: **Bacteria:** a) *Escherichia coli* b) *Staphylococcus aureus* **Fungi:** a) *Candida* b) *Dermatophytes*	**8**

3	**Introduction to Chemotherapy** i. Selective toxicity, Bioavailability MIC, MBC, LD_{50} ii. Antagonism and synergism in drug administration iii. Antibiotic sensitivity, iv. Antibiotic misuse/antibiotic overuse v. Concept of drug resistance (e.g. MRSA, ESBL)	**5**
Credit II	**IMMUNOLOGY**	**(15)**
1	**Immunity:** Definition, types (Innate and acquired, active and passive, humoral and cell mediated)	**2**
2	**Formation of blood cells** (hematopoiesis) Myeloid and lymphoid lineages and differentiation process Lymphocytes types	4
3	**Antigens and antibodies: definition and concept**	1
4	**Immunohematology** a. ABO and Rh blood group systems b. Bombay blood group c. Biochemistry of blood group substances d. Inheritance of ABH antigens e. Medico legal applications of blood groups	6
5	**Active and Passive Immunization** a. Active Immunization Whole organism vaccines i. Attenuated vaccines ii. Inactivated Vaccines b. Passive Immunization Transfer of preformed antibodies c. Latest Immunization schedule in India	2

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1. Davis B.D., Delbacco, 1990 Microbiology 4th edition, J.B. Lippincott Co. NY
2. Wolfgang K. Joklik, 1992, Zinsser Microbiology 20th Edition, McGraw-Hill Professional Publishing.
3. Dey, N.C and Dey, TK. 1988, Medical Bacteriology, Allied Agency, Calcutta, 17th Edition
4. Ananthnarayana, R. and C.E, Jayaram Panikar, 1996 Textbook of microbiology, 5th edition, Orient Longman.
5. David Greenwood, 1995, Antimicrobial Chemotherapy, 3rd Edition, Oxford University Press.
6. Mukherjee, K.L 1988 Medical Laboratory Technology, Vol III, 10th Edition, Tata Mc.
7. Medical Microbiology edited by Samuel Baron. Fourth edition. (University of Texas Medical Branch of Galvesion)
8. Sherris, John C, Ed, Medical Microbiology: an Introduction to infectious diseases. Elsevier Publication IInd edition.
9. Virulence mechanisms of bacterial pathogens (Second edition) by Roth, Bolin, Brogden Minion and Michael.
10. Kuby J. Graw-Hill Pub Co(1996) Immunology 3rd Ed. W. H. Freeman & Co.
11. Sudha Gangal, Shubhangi Sontakke. (2012) Textbook of Basic and Clinical Immunology. Universities Press Private limited.
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13. Roitt Evan, Brostoff J. Male D. (1993) Immunology 6th Ed., Mosby & Co. London.
14. Roitt I. M. (1988) Essentials of Immunology, ELBS, London.
15. Roitt M. (1984) Essentials of Immunology, P. G. Publishers Pvt. Ltd., New Delhi.
16. Talwar G. P. (1983) Handbook of Immunology, Vikas Publishing Pvt. Ltd. New Delhi.
17. Stites D. P., Stobo J. D., Fudenberg H. H. and Wells J. V., (1982), Basic and Clinical Immunology, 4th Ed., Lange Medical Publications, Maruzen Asia Pvt. Ltd., Singapore.
18. William E., Md. Paul. Fundamental Immunology 5th edition (August 2003): By Lippincott Williams & Wilkins Publishers

MB – 212: BACTERIAL PHYSIOLOGY AND FERMENTATION TECHNOLOGY [30]		
Credit I	**BACTERIAL PHYSIOLOGY**	[15]
1.	**Enzymes**	**(7)**
	a. Introduction to Enzymes: Properties of enzymes, Nature of active site, Structure of active site, commonly occurring amino acids at active site. Ribozymes, coenzymes, apoenzymes, prosthetic group and cofactors.	2
	b. Nomenclature & classification as per IUB (up to class level).	2
	c. Models for catalysis – i. Lock and key ii. Induced fit iii Transition state.	1
	d. Effect of pH & temperature, substrate concentration & enzyme concentration, activators, and inhibitors of enzyme	2
2	**Bacterial Physiology**	**(8)**
	a. Definitions of Metabolism, catabolism, anabolism, respiration, and fermentation	**1**
	b. Metabolic pathways (with structures) 1. Embden Meyerhof Parnas pathway (Glycolysis) 2. Hexose monophosphate pathway 3. Entner Doudoroff pathway 4. Phosphoketolase pathway (Pentose and hexose) 5. TCA cycle (with emphasis on amphibolism) and Glyoxylate bypass 6. Gluconeogenesis and its significance	 1 1 1 1 2 1

Credit II	**FERMENTATION TECHNOLOGY**	**15**
1.	**Concept of fermentation technology** a. Microbial biomass- based fermentation (Biofertilizer, biopesticide, Probiotics) b. Production of Primary metabolites (Organic acids, amino acids, vitamins, enzymes) c. Production of Secondary metabolites (Antibiotics) d. Production of recombinant products (insulin and growth hormones) e. Production of Fermented food products (Cheese, yoghurt) f. Microbial bio transformation (Steroid transformation)	3
2	**Strains of industrially important microorganisms:** i. Desirable characteristics of industrial strain ii. Principles and methods of primary and secondary screening iii. Master, working and seed culture; development of inoculum iv. Preservation and maintenance of industrial strains.	**4**
3	**Design of a Fermenter (typical CSTR Continuous stirred Tank Reactor):** Different parts and their working	1
4	**Monitoring of different fermentation parameters** (Temperature, pH, aeration, agitation, foam)	2
5	**Types of fermentations: Batch, continuous, dual**	**2**
6	**Media for industrial fermentations:** Constituents of media (Carbon source, nitrogen source, amino acids vitamins, minerals, water, buffers, antifoam agents, precursors, inhibitors, and inducers)	**2**
7	**Contamination: Sources, precautions, and consequences**	**1**

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1. Conn E., Stumpf P.K., Bruuening G., Doi RH. (1987) Outlines of Biochemistry 5th Ed , John Wiley and Sons, New Delhi. (Unit I & II)
2. Moat A.G. & Foster J.W. (1988) Microbial Physiology 2nd Ed. John Wiley and Sons New York. (Unit II & III)
3. Nelson D. L. & Cox M. M. (2005) Lehninger's Principles of Biochemistry, 4th edition, W. H. Freeman & Co. NY (Unit II & III)
4. Voet D. & Voet J. G. (1995) Biochemistry, 2nd Ed.. John Wiley & sons New York. (Unit II & III)
5. Madigan M. T., Martinko J. M. (2006) Brock's Biology of Microorganisms. 11th Edition. Pearson Education Inc. (Unit I, II& III)
6. Prescott L. M., Harley J. P. and Klein D. A. (2005) Microbiology, 6th Edition. MacGraw Hill Companies Inc.(Unit II)
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11. Peter F. Stanbury. Principles of Fermentation Technology, 2E, Elsevier (A Division of Reed Elsevier India Pvt. Limited), 2009
12. Prescott, S.C. and Dunn, C. G., (1983) Industrial Microbiology, Reed G. AVI tech books.
13. Reed G. Ed. Prescott and Dunn's Industrial Microbiology. 4th Ed., CBS Pub. New Delhi.
14. Stanbury, P. F. and Whittaker, A. (1984) Principles of Fermentation technology, Pergamon press.

S. Y. B. SC. MICROBIOLOGY SYLLABUS (SEM II)

MB 221- BACTERIAL GENETICS [30]		
Credit I		**(15)**
1	**Understanding DNA**	**9**
	i. Experimental evidences for nucleic acid as genetic material. a. Discovery of transforming material (hereditary material): Griffith's experiment b. Avery and MacLeod experiment c. Gierer and Schramm d. Fraenkel-Conrat & Singer experiment (TMV virus) e. Hershay & Chase experiment	6
	ii. Types of nucleic acids (DNA and RNAs)	1
	iii. Structure of DNA a. Structure of Nitrogen bases, Nucleoside, Nucleotide and polynucleotide chain b. Bonds involved in DNA structure c. Different forms of DNA	2
2	**Prokaryotic DNA replication**	7
	i. Models of DNA replication. (Conservative, semiconservative, and Dispersive) ii. Meselson and Stahl's experiment (semiconservative)	2
	iii. Six basic rules of DNA replication iv. Enzymes, proteins and other factors involved in DNA replication. v. Modes of DNA replication Rolling circle mechanism, theta and linear DNA replication	5

	Credit II	**(15)**
1	**Gene expression** i. Concept of Genetic code and its properties **ii.** Concept of transcription and translation	2
2	**Mutations and reversions** Concept of Mutation and Types of mutations: Nonsense, Missense, Silent, Conditional lethal- temperature sensitive, Amber, Reverse, suppressor i. Spontaneous Mutation a. Discovery of spontaneous mutation (Fluctuation test) b. Mechanism of spontaneous mutation c. Isolation of Mutants: Replica plate technique ii. Concept of Induced Mutations a. Base pair substitution (Transitions, Transversions), Insertions and deletions- Frame /Phase shift mutations b. Physical Mutagenic agent: UV and Xray c. Chemical mutagenic agents ➢ Base analogues (2amino purine, 5bromo uracil), ➢ HNO2, Alkylating agents ➢ Intercalating agents (EtBr, acridine orange)	8
3	**Plasmid genetics** i. Types of plasmids ii. Properties of Plasmid iii. Plasmid replication iv. Plasmid incompatibility v. Plasmid curing vi. Plasmid amplification Concept	5

References:

1. Bruce A. (2008), Molecular Biology of the Cell, 5th Edn. Publisher: Garland Science, New York.
2. David Freidfelder, (1987). Molecular Biology, 2nd Edn. Jones & Bartlett Pub.
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5. Hayes, W. (1964), The Genetics of Bacteria and their Viruses, CBS Pub. New Delhi.
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14. R. J. Brooker, Genetics: analysis and principles, 6th edition, ISBN10: 1259616029 ISBN13: 9781259616020
15 Pawar and Daginawala, General Microbiology Vol.I and II, 1st Edition, Himalaya Publishing House, Mumbai
16. Genetics - Analysis and Principles, Robert J Brooker, Benjamin-Cummings Pub Co; Edition:1st (September 1, 1998) ISBN-10: 0805391754, ISBN-13: 978-0805391756.

MB – 222: Air, Water and Soil Microbiology		[30]
Credit I	**AIR MICROBIOLOGY and WATER MICROBIOLOGY**	**15**
1	**AIR MICROBIOLOGY**	**05**
	a. Air flora i. Transient nature of air flora ii. Droplet, droplet nuclei, and aerosols	1
	b. Methods of Air sampling and types of air samplers i. Impaction on solids ii. Impingement in liquid iii. Sedimentation iv. Centrifugation	2
	c. Air sanitation: Physical and chemical methods	1
	d. Air borne infections	1
2	**WATER MICROBIOLOGY**	**10**
	a. Types of water: surface, ground, stored, distilled, mineral and de-mineralized water	1
	b Recommended Bacteriological standards of Water Quality i. Maharashtra pollution control board (MPCB) Main Functions of MPCB Water quality standards for best designated usages ii. Central pollution control board, (CPCB)	1

	Main Functions of CPCB Designated Best Use Water Quality Criteria	
	c. Water purification methods	1
	d. Water borne Infections	1
	e. Indicators of faecal pollution i. *Escherichia coli* ii. *Bifidobacterium* iii. *Streptococcus faecalis* iv. *Clostridium perfringens* v. New indicators: *Campylobacter* and *Pseudomonas*	2
	f. **Bacteriological analysis of water for potability** i. Bacteriological standards of potable water: Bureau of Indian standards (BIS) World health Organization (WHO) ii. Presumptive coliform count iii. Confirmed test iv. Completed test v. Eijkman test vi. Membrane filter technique	4
Credit II	**SOIL MICROBIOLOGY**	**15**
	a. Rhizosphere microflora and its role in the rhizosphere	1
	b. Role of microorganisms in composting and humus formation	2
	c. Biofertilizers: Bacterial, Cyanobacterial, fungal and their large-scale production	

		3
	d. Biocontrol agents: Bacterial, Viral, Fungal and their large-scale production	3
	e. Brief account of microbial interactions: Symbiosis, Neutralism, Commensalism, Competition, Ammensalism, Synergism, Parasitism, and Predation	3
	f. Role of microorganisms in elemental cycles in nature: Carbon, Nitrogen	3

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19. WHO guidelines for drinking water quality Volume I

20. MPCB, CPCB, BIS and WHO websites.

S. Y. B. Sc. Microbiology Practical Course MB 213

Semester I: Practical course based on MB211 & MB 212		
Expt. No.	**Topics**	**No. of Practicals**
1	**Measurements of cell dimension by micrometry using 10x,45x,100x objectives**	**1**
2	**Blood grouping**	**1**
3	**I. Biochemical characterization of bacteria:** a. Sugar utilization test (minimal medium + sugar) b. Sugar fermentation test c. IMViC d. Enzyme detection – Gelatinase, Catalase, Oxidase e. Oxidative-fermentative test **II. Isolation and identification of *E. coli, Staphylococcus aureus* and *Candida* from clinical samples using** a. Gram staining, motility/ slide culture b. Cultural and biochemical characterization	**6**
4	**Primary screening of industrially important organisms:** a. Organic acid / Antibiotic producing microorganisms by crowded plate technique b. Microorganisms producing industrially important enzyme- amylase	**2**
5	**Industrial visit**	**1**
	Total	**11**

S. Y. B. Sc. Microbiology Practical Course MB 223

Semester II: Practical course based on MB221 & MB 222		
Expt. No.	**Topics**	**No. of Practicals**
1	Air sampling using an air sampler calculation of air flora from different locations with the knowledge of respective standards of bacterial and fungal counts.	**1**
2	**Air Flora:** a. Diversity determination. b. Simpson index and settling velocity determination	**1**
3	**I. Bacteriological tests for potability of water** a. MPN, Confirmed and Completed test. b. Membrane filter technique (Demonstration)	**4**
4	**Enrichment, Isolation, Preparation and Application of Bioinoculant (Azo-Rhizo / Blue Green Algae (cyanobacteria)**	**2**
5	a. Induction of mutations by using physical mutagen (e.g. UV rays) and chemical mutagen (e.g. HNO2) b. Isolation of mutants by any suitable method c. Demonstration of UV survival curve	**3**
	Total	**11**

Savitribai Phule Pune University

(Formerly University of Pune)

Three Year B.Sc. Degree Program in Botany

(Faculty of Science & Technology)

S.Y.B.Sc Botany

Choice Based Credit System Syllabus

To be implemented from Academic Year 2020- 2021

Title of the Course: B. Sc Botany

1. Structure of Course:

Structure B.Sc. Botany syllabus					
Year	Semester	Course Type	Course code	Course Name	Credits
1	1	Compulsory Course	BO 111	Plant life and utilization I	2
			BO 112	Plant morphology and Anatomy	2
			BO 113	Practical based on BO 111 & BO 112	1.5
	2	Compulsory Course	BO 121	Plant life and utilization II	2
			BO 122	Principles of plant science	2
			BO 123	Practical based on BO 121 & BO 122	1.5
2	**3**	**Compulsory Course**	**BO 231**	**Taxonomy of Angiosperms and Plant Ecology**	**2**
			BO 232	**Plant Physiology**	**2**
			BO 233	**Practical based on BO 231 & BO 232**	**2**
	4	**Compulsory Course**	**BO 241**	**Plant Anatomy and Embryology**	**2**
			BO 242	**Plant Biotechnology**	**2**
			BO 243	**Practical based on BO 241 & BO 242**	**2**
3	5	Discipline Specific Elective Course	BO 351	Botany Theory Paper 1	2
			BO 352	Botany Theory Paper 2	2
			BO 353	Botany Theory Paper 3	2
			BO 354	Botany Theory Paper 4	2
			BO 355	Botany Theory Paper 5	2
			BO 356	Botany Theory Paper 6	2
			BO 357	Botany Practical Paper 1	2
			BO 358	Botany Practical Paper 2	2
			BO 359	Botany Practical Paper 3	2
		Skill Enhancement course	BO 3510	Botany Theory Paper 7	2
			BO 3511	Botany Theory Paper 8	2
3	6	Discipline Specific Elective Course	BO 361	Botany Theory Paper 1	2
			BO 361	Botany Theory Paper 2	2
			BO 362	Botany Theory Paper 3	2
			BO 363	Botany Theory Paper 4	2
			BO 364	Botany Theory Paper 5	2
			BO 365	Botany Theory Paper 6	2
			BO 366	Botany Practical Paper 1	2
			BO 367	Botany Practical Paper 2	2
			BO 368	Botany Practical Paper 3	2
		Skill Enhancement course	BO 3610	Botany Theory Paper 7	2
			BO 3611	Botany Theory Paper 8	2

2. Equivalence of Previous Syllabus:

Old Course (2014 Pattern)	**New Course (2020 CBCS Pattern)**
BO-211: Taxonomy of Angiosperms and Plant community	BO 231: Taxonomy of Angiosperms and Plant Ecology
BO-212:Plant Physiology	BO 232: Plant Physiology
BO-221: Plant Anatomy and Embryology	BO 241: Plant Anatomy and Embryology
BO-222: Plant Biotechnology	BO 242: Plant Biotechnology
Practical based on theory courses (Paper I and Paper II)	Semester III: Practical based on BO 231 & BO 232 Semester IV: Practical based on BO 241 & BO 242

S.Y.B.Sc. Botany CBCS Pattern
(Semester III, Paper I) 2020-2021
BO 231: Taxonomy of Angiosperms and Plant Ecology - 2 Credits (30 Lectures)

Sr. No.	Topic Details	No. of Lectures
	Credit-I	**15**
1.	**Introduction to Angiosperms Taxonomy** Definition, scope, objectives and importance of taxonomy Exploration, Description, Identification, Nomenclature and classification Concept of Systematics with brief historical background	**02**
2.	**Systems of classification** Comparative account of various systems of classification Artificial system- Carl Linnaeus Natural system- Bentham and Hooker Phylogenetic system- Engler and Prantl APG system- A brief review	**05**
3.	**Study of Plant Families** Study of following families with reference to systematic position (As per Bentham and Hooker's system of classification), salient features, floral formula, floral diagram and any five examples with their economic importance – Annonaceae, Brassicaceae, Myrtaceaee, Rubiaceae, Solanaceae, Apocynaceae, Nyctaginaceae and Amaryllidaceae	**08**
	Credit-II	**15**
4.	**Botanical Nomenclature** Concept of nomenclature, brief history, Binomial nomenclature International Code for Nomenclature of Algae, Fungi and Plants (ICN)-Principles, Rules and Recommendations; 'Type' specimen and its types (Holotype, Paratype, Isotype, Lectotype, Neotype). Concept of Typification. Ranks and endings of taxa names, Coining of Genus and Species names Single, double and multiple authority citations	**05**
5.	**Introduction to ecology** Definition, concept, scope, and interdisciplinary approach, autecology and synecology. Species diversity: definition, concept, scope, and types: Alpha, Beta and Gamma diversity. Methods of vegetation sampling: quadrat method, transect method, plot less method Genetic Diversity: definition, nature and origin of genetic variations Species Diversity: definition, origin of species diversity, diversity indices, species abundance Ecosystem Diversity: definition, major ecosystem types of the world, Hotspots in India – concept and basis of 'hotspot' identification.	**06**
6.	**Ecological grouping of the plants** Ecological grouping of the plants with reference to their significance of adaptive external and internal features: a) Hydrophytes, b) Mesophytes c) Xerophytes d) Halophytes with examples.	**04**

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IMPORTANT WEBSITES

THE FAMILIES OF FLOWERING PLANTS- L. Watson and M.J. Dallwitz
https://www.delta-intkey.com/angio/index.htm
ANGIOSPERM PHYLOGENY WEBSITE, version 14.
http://www.mobot.org/MOBOT/research/APweb/
THE PLANTS OF THE WORLD ONLINE PORTAL
http://www.plantsoftheworldonline.org/
INTERNATIONAL PLANT NAME INDEX (IPNI)
https://www.ipni.org/
TROPICOS
https://www.tropicos.org/home
BIODIVERSITY HERITAGE LIBRARY
https://www.biodiversitylibrary.org/
BOTANICUS DIGITAL LIBRARY
https://www.botanicus.org/
INTERNET ARCHIVE- DIGITAL LIBRARY
https://archive.org/
DATABASE OF PLANTS OF INDIAN SUBCONTINENT
https://sites.google.com/site/efloraofindia/
BOTANICAL SURVEY OF INDIA
https://bsi.gov.in/content/1416_1_FloraofIndia.aspx
FLOWERS OF INDIA
http://www.flowersofindia.net/
eFLORAS OF WORLD
http://www.efloras.org/

S.Y.B.Sc. Botany CBCS Pattern
(Semester III, Paper II) 2020-2021
BO 232: Plant Physiology - 2 Credits (30 Lectures)

Credit I:

1. Introduction to Plant Physiology **2L**

Scope and applications of plant physiology

2. Absorption of water **3L**

2.1 Role of water in plants
2.2 Mechanisms of water absorption with respect to crop plants
2.3 Factors affecting rate of water absorption

3. Ascent of sap **3L**

3.1 Introduction and definition.
3.2 Transpiration pull or cohesion-tension theory, evidences and objections
3.3 Factors affecting ascent of sap

4. Transpiration **7L**

4.1 Definition
4.2 Types of transpiration – cuticular, lenticular and stomatal
4.3 Structure of stomata
4.4 Mechanism of opening and closing of stomata –Steward's hypothesis, active K+ transport mechanism
4.5 Factors affecting the rate of transpiration
4.6 Significance of transpiration
4.7 Antitranspirants
4.8 Guttation
4.9 Exudation

Credit II:

5. Nitrogen metabolism **7L**

5.1 Introduction and role of nitrogen in plants
5.2 Nitrogen fixation by *Rhizobium* and BGA
5.2.1 Symbiotic nitrogen fixation, nitrogenase enzyme- structure and function
5.2.2 Non-symbiotic nitrogen fixation
5.3 Importance and production technique of BGA
5.4 Denitrification, ammonification and nitrification
5.5 Reductive amination and transamination

6. Seed dormancy and germination **4L**

6.1 Definition, types of seed dormancy and germination
6.2 Methods to break seed dormancy
6.3 Metabolic changes during seed germination
6.4 Role of phytohormones to improve seed germination
6.5 Vigor Index

7. Physiology of flowering **4L**

7.1 Photoperiodism – Concept, definition, short day plants, long day plants and day neutral plants.

7.2 Phytochrome theory, role of phytohormones in induction and inhibition of flowering
7.3 Applications of photoperiodism
7.4 Vernalization–concept and definition, mechanism of vernalisation, applications of vernalisation and devernalization

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S.Y.B.Sc. Botany CBCS Pattern
Practical (Semester III Paper III) 2020-2021
BO 233: Practical based on BO 231 & BO 232

Practical based on Taxonomy of Angiosperms and Plant Ecology, and Plant Physiology

Sr. No.	Title	No. of Practical
	Taxonomy of Angiosperms and Plant Ecology	
1	Study of tools of taxonomy and ecological instruments (any four each)	1
2	Description of flowering plant in botanical terms	1
3	Study of plant families (any four)	3
4	Study of ecological adaptations in Hydrophytes with any two examples	1
5	Study of ecological adaptations in Xerophytes with any two examples	1
6	Study of vegetation by list count quadrat method.	1
	Plant Physiology	
7	Perform phytochemical test for starch and protein in germinating and non germinating seeds	1
8	Isolation of Leaf Protein Concentration (LPC) from suitable plant material.	1
9	Determination of Diffusion Pressure Deficit (DPD)	1
10	Determine rate of transpiration under different conditions of Sunlight, Shade and Wind	1
11	Demonstration of the following **a.** Commercial biofertilizers **b.** Imbibition in seeds **c.** Ringing experiment **d.** Arc Auxanometer **e.** Spectrophotometer **f.** Nitrogen fixing bacteria / BGA (specimen/ slide)	1
12	Calculate seed germination percentage and vigor index	1
13	Botanical excursion tour and visit to Floriculture industry / Soil testing center / Seed testing center	1

N.B. Botanical excursion tour and submission of report along with herbarium of any five weeds of the following (List of Weeds attached).

List of weeds

Acanthospermun hispidum DC. Asteraceae

Aerva javanica (Burm.f.) Juss. ex Schult. Amaranthaceae

Aeschynomene americana L. Fabaceae Tropical America

Ageratum conyzoides L. Asteraceae America

Alternanthera paronychioides St. Hill. Amaranthaceae Tropical America

Alternanthera philoxeroides (Mast.) Griseb. Amaranthaceae America

Alternanthera pungens Kunth Amaranthaceae Tropical America

Alternanthera sessilis (L.) R.Br. ex DC. Amaranthaceae Tropical America

Amaranthus spinosus L. Amaranthaceae Tropical America

Antigonon leptopus Hk. & Arn. Polygonaceae America

Argemone mexicana L. Papaveracae West Indies

Asclepias curassavica L. Apocynaceae Tropical America
Bidens pilosa L. Asteraceae Tropical America
Blainvillea acmella (L.) Philipson Asteraceae Tropical America
Blumea eriantha DC. Asteraceae Tropical America
Blumea lacera (Burm.f.) DC. Asteraceae Tropical America
Boerhavia erecta L. Nyctaginaceae Tropical America
Cardamine hirsuta L. Brassicaceae Tropical America
Cassia absus L. Caesalpiniaceae Tropical America
Cassia occidentalis L. Caesalpiniaceae South America
Cassia pumila Lam. Caesalpiniaceae Tropical America
Cassia tora L. Caesalpiniaceae South America
Celosia argentea L. Amaranthaceae Tropical America
Chrozophora rottleri (Geis.) Spreng. Euphorbiaceae Tropical Africa
Cleome viscosa L. Capparaceae Tropical America
Conyza canadensis (L.) Cronquist Asteraceae South America
Coronopus didymus (L.) Smith Brassicaceae South America
Cronton bonplandianum Baillon Euphorpiaceae South America
Crotalaria pallida Dryand Fabaceae Tropical America
Crotalaria retusa L. Fabaceae Tropical America
Cryptostegia grandiflora R.Br. Apocynaceae Madagascar
Cuscuta chinensis Lam. Cuscutaceae Mediterranean
Cuscuta reflexa Roxb. Cuscutaceae Mediterranean
Cyperus difformis L. Cyperaceae Tropical America
Cyperus iria L. Cyperaceae Tropical America
Datura innoxia Mill. Solanaceae Tropical America
Dicoma tomentosa Cass. Asteraceae Tropical America
Digera muricata (L.) Mart. Amaranthaceae North America
Eclipta prostrata (L.) L. Asteraceae Tropical America
Eichhornia crassipes (Mart.) Solms Pontederiaceae Tropical America
Emilia sonchifolia (L.) DC. Asteraceae Tropical America
Eupatorium adenophorum Spreng. Asteraceae Central America
Eupatorium odoratum L. Asteraceae South America
Euphorbia heterophylla L. Euphorbiaceae Tropical America
Euphorbia hirta L. Euphorbiaceae Tropical America
Galinsoga parviflora Cav. Asteraceae Tropical America
Hyptis suaveolens (L.) Poit. Lamiaceae South America
Ipomoea carnea Jacq. Convolvulaceae Tropical America
Ipomoea hederifolia L. Convolvulaceae Tropical America
Ipomoea obscura (L.) Ker Gawl. Convolvulaceae Tropical Africa
Ipomoea pes-tigridis L. Convolvulaceae Tropical Africa
Lagascea mollis Cav. Asteraceae Tropical America
Lantana camara L. Verbenaceae Tropical America
Malachra capitata (L.) L. Malvaceae Tropical America

Malvastrum coromandelianum (L.) Garcke Malvaceae Tropical America
Martynia annua L. Pedaliaceae Tropical America
Mecardonia procumbens (Mill.) Small Scrophulariaceae Tropical America
Mikania micrantha Kunth Asteraceae Tropical America
Oxalis corniculata L. Oxalidaceae Europe
Parthenium hysterophorus L. Asteraceae Tropical America
Physalis minima L. Solanaceae Tropical America
Pistia stratiotes L. Araceae Tropical America
Portulaca oleracea L. Portulacaceae South America
Prosopis juliflora (Sw.) DC. Mimosaceae Mexico
Ruellia tuberosa L. Acanthaceae Tropical America
Scoparia dulcis L. Scrophulariaceae Tropical America
Solanum nigrum L. Solanaceae Tropical America
Solanum torvum Sw. Solanaceae West Indies
Sonchus oleraceus L. Asteraceae Mediterranean
Spilanthes radicans Jacq. Asteraceae South America
Synedrella nodiflora (L.) Gaertn. Asteraceae West Indies
Tridax procumbens L. Asteraceae Tropical America
Waltheria indica L. Sterculiaceae Tropical America
Xanthium indicum Koenig Asteraceae Tropical America
Youngia japonica (L.) DC. Asteraceae South America

SEMESTER IV

S.Y.B.Sc. Botany CBCS Pattern
(Semester IV, Paper I) 2020-2021
BO 241: Plant Anatomy and Embryology- 2 Credits (30 Lectures)

Credit-I Plant anatomy: (15 Lectures)

1. Introduction 2L

1.1 Definition

1.2 Scope of plant anatomy

2. Epidermal tissue system 3L

2.1 Structure, types and functions of epidermis

2.2 Structure, types and functions of Stomata

2.3 Epidermal outgrowths- non-glandular and glandular

2.4 Motor cells

3. Mechanical tissue system 3L

3.1 Principles involved in distribution of mechanical tissues with one example each

a) Inflexibility,

b) Incompressibility,

c) Inextensibility and

d) Shearing stress

3.2 Vascular tissue system: Structure and function of xylem, phloem and cambium

4. Normal secondary growth 3L

4.1 Introduction

4.2 Normal secondary growth in dicotyledonous stem

4.3 Development of annual rings, periderm, bark, tyloses and lenticel

5. Anomalous secondary growth 4L

5.1 Introduction

5.2 Causes of anomalous secondary growth

5.3 Anomalous secondary growth in:

a) Dicotyledonous stem (*Bignonia*),

b) Dicotyledonous root (*Raphanus*),

c) Monocotyledonous stem (*Dracaena*)

Credit-II Plant Embryology (15 Lectures)

7. Introduction 1L

7.1 Definition and scope of plant embryology

8. Microsporangium and male gametophyte 4L

8.1 Structure of tetrasporangiate anther

8.2 Types of tapetum

8.3 Sporogenous tissue

8.4 Microsporogenesis: process and its types

8.5 Types of microspore tetrad

8.6 Male gametophyte: structure and development of male gametophyte

9 Megasporangium and female gametophyte **4L**

9.1 Structure
9.2 Types of ovules
9.3 Types of megaspore tetrads
9.4 Female gametophyte: structure of typical embryo sac
9.5 Types of embryo sacs – monosporic, bisporic and tetrasporic

10. Pollination and Fertilization: **3L**

10.1 Introduction and definition
10.2 Types of pollination
10.3 Germination of pollen grain
10.4 Entry of pollen tube- porogamy, mesogamy and chalazogamy
10.5 Double fertilization and its significance.

11. Endosperm and embryo **3L**

11.1 Endosperm: Types – nuclear, helobial and cellular.
11.2 Structure of Dicotyledonous and Monocotyledonous embryo.

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4. Eams and Mc Daniel,An Introduction to Plant Anatomy, McGraw –Hill Book Co. Ltd and Kogakusha Co, Tokyo, Japan
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6. Esau, Plant Anatomy, Wiley Toppan Co. California, USA
7. Pijush Roy, Plant Anatomy. New Central Book Agency Ltd, Kolkata
8. Pandey S N and Ajanta Chadha, Plant Anatomy and Embryology, Vikas Publishing House, Pvt, Ltd, New Delhi
9. Bhojwani S S and Bhatnagar S P, An Embryology of Angiosperms
10. Maheshwari P, An introduction to Embryology of Angiosperm
11. Nair P K K Essentials of Palynology.

S.Y.B.Sc. Botany CBCS Pattern
(Semester IV, Paper II) 2020-2021
BO 242: Plant Biotechnology (2 Cr- 30 Lectures)

Credit I:

Chapter 1 Introduction to Plant Biotechnology 3L

1.1 History and definition
1.2 Scope and importance of plant biotechnology
1.3 Current status of biotechnology in India.

Chapter 2 Plant Tissue Culture 8L

2.1 Concept of plant tissue culture and cellular totipotency
2.2 Basic techniques: Types of culture, Media preparation, sterilization, inoculation, incubation, hardening
2.3Applications with reference to: Micropropagation, Somaclonal variation, Haploid production, Protoplast fusion & Somatic hybrids, Embryo rescue, Production of secondary metabolites.
2.4 Commercial Plant Tissue culture laboratories in Maharashtra and India.

Chapter 3 Single Cell Protein (SCP) 4L

3.1 Concept and definition
3.2 Importance of proteins in diet
3.3 Production of SCP from *Spirulina* and Yeast
3.4 Importance & acceptability of SCP

Credit II:

Chapter 4 Plant Genetic Engineering 5L

4.1 Introduction, concept
4.2 Tools of genetic engineering (restriction enzymes, ligases, plasmid vectors)
4.3 Gene cloning Technique
4.4 Applications of plant genetic engineering: insect pest resistance, abiotic stress tolerance, herbicide resistance

Chapter 5 Genomics, Proteomics and Bioinformatics 5L

5.1 Genomics- concept, types, methods used for whole genome sequencing
5.2 Proteomics-concept, types, methods used in proteome analysis
5.3 Bioinformatics-concept, database and its classification, data retrieval tools.

Chapter 6 Bioremediation 2L

6.1 Introduction and concept
6.2 Microbial remediation
6.3 Phytoremediation

Chapter 7 Biofuel technology 3L

7.1 Definition, Concept and types of Renewable and nonrenewable energy sources
7.2 Definition and concept of Biogas, Bioethanol, Biobutanol, Biodiesel & Biohydrogen

References

1. B.D. Singh (4th Edn 2012) Biotechnology-expanding horizons, Kalyani Publishers.
2. K.S. Bilgrami & A.K. Pandey (2007) Introduction to Biotechnology CBS Publishers and Distributors PVT LTD
3. M.K. Razdan (2002) Introduction to Plant Tissue Culture. Oxford and IBH Publishing Co., New Delhi.
4. H.S. Chawla (2005) Introduction to Plant Biotechnology. Oxford and IBH Publishing Co. New Delhi.

S.Y.B.Sc. Botany CBCS Pattern
Practical (Semester IV Paper III) 2020-2021
BO 243: Practical based on BO 241 & BO 242

Sr. No.	Title	No. of Practical
	Plant Anatomy and Embryology	
1	Study of epidermal tissue system – non-glandular and glandular trichomes, multilayered epidermis, typical stomata (Dicotyledonous and Monocotyledonous).	2
2	Study of mechanical tissues and their distribution in root, stem and leaves.	1
3	Study of normal secondary growth in dicot stem – *Annona* /*Moringa* (Double stained temporary preparation).	1
4	Study of anomalous secondary growth in *Bignonia* and *Dracaena* stem (Double stained temporary preparation).	1
5	Study of tetrasporangiate anther and types of ovules with the help of permanent slides	1
6	Study of dicot and monocot embryo.	1
	Plant Biotechnology	
7	Instruments/equipments used in plant tissue culture laboratory: Principle and working of Autoclave, oven, laminar air flow cabinet, micropipette, culture bottles/tubes with cotton plug	1
8	Preparation & sterilization of MS medium	1
9	Surface sterilization and Inoculation of nodal sector, leaf, anther and maize embryo	2
10	Laboratory cultivation of *Spirulina*	1
11	Demonstration practical on transgenic crops viz; Bt-Cotton, Golden rice	1
12	Demonstration of principle and working of agarose gel electrophoresis, centrifuge, spectrophotometer	1
13	Visit to plant tissue culture laboratory	1

SYBSC & SYBSC (Computer Science)

ENGLISH

(Ability Enhancement Course-AEC)

(Choice Based Credit System-35:15-Pattern)
(w. e. f- 2020- 2021)

(03 Credit Course-2+1)

Text: ***Horizons: English in Multivalent Contexts (***Board of Editors- Orient BlackSwan)

Preamble:

This is an ABILITY ENHANCEMENT COURSE. Considering the needs of students and the requirements of professional sectors, the syllabus of this paper is designed to enhance linguistic and professional skills of the students. In the age of technology, it's high time for the students to acquire and exercise the skill and sub-skills of using English in multivalent contexts.

The paper aims at a balanced up-gradation of the students, focussing on their ability enhancement. Hence, to avoid a lopsided professional development, the humane values are also taken care of by accommodating literature section in the syllabus. The other units cater to the needs of enhancing speaking ability, writing ability, the ability to face an interview, the ability of using soft skills effectively while planning one's work and working on the plans. By and large, the present syllabus is an attempt to galvanise the existing competencies of the students and enhancing their abilities for a better performance and better results.

Each semester shall have 2+1=3 credits for teaching (One credit is for practical/discussion purpose). However, each credit is equal to 15 hours, so this course shall have 45 teaching hours. In addition to that there shall be 03 hours allotted to internal evaluation. **(3x15=45+3=48).**

Objectives:

1. To introduce the use of English in multimedia
2. To acquaint the students with the language skills in multivalent contexts
3. To acquaint and enlighten students regarding the speaking skill in various contexts
4. To acquaint and familiarize the students with advanced writing skills in different contexts
5. To acquaint and familiarize the students with soft skills
6. To minimize the gap between the existing communicative skills of the students and the skills they require at professional level
7. To develop competence among the students to appreciate and analyze short stories and poetry

Semester-III

Text: ***Horizons: English in Multivalent Contexts (***Board of Editors- Orient BlackSwan)

Content-

UNIT-I- LITERATURE **10 Clock Hours**

1. **Short Story:**
   i) 'A Shadow': R. K. Narayan
2. **Poetry:**
   i) La Belle Dame sans Merci: John Keats
   ii) Where the Mind is without Fear: Rabindranath Tagore
3. **Practical/Discussion** **05 Clock Hours**

UNIT-II-CONVERSATIONAL SKILL **10 Clock Hours**

(Sample Dialogues, Useful Expressions and Exercises)

1. Introducing Yourself and Others
2. Asking, Giving and Refusing Permission
3. Describing Daily Routine
4. Complaining and Apologizing
5. **Practical/Discussion** **05 Clock Hours**

UNIT-III-INTERVIEW TECHNIQUES **10 Clock Hours**

1. Job Application Letter
2. Resume Writing
3. GDPI
4. Presentations
5. **Practical/Discussion** **05 Clock Hours**

Semester-IV

Text: ***Horizons: English in Multivalent Context (***Board of Editors- Orient BlackSwan)

UNIT-I-LITERATURE **10 Clock Hours**

1. **Short Story:**
   i) My Lost Dollar: Stephen Leacock
2. **Poetry:**
   i) The Bird Sanctuary: Sarojini Naidu
   ii) Stopping by Woods on a Snowy Evening: Robert Frost
3. **Practical/Discussion:** **05 Clock Hours**

UNIT-II-WRITING SKILLS **10 Clock Hours**

(Sample Passages, Useful Techniques and Exercises)

1. Notices
2. Agenda
3. Minutes
4. Content Writing
5. **Practical/Discussion** **05 Clock Hours**

UNIT-III-SOFT SKILLS AND PERSONALITY DEVELOPMENT **10 Clock Hours**

(Sample Situations, Useful Techniques and Exercises)

1. An Introduction to Soft Skills
2. SWOC Analysis
3. Goal Setting
4. Project Management
5. **Practical/Discussion** **05 Clock Hours**

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BIBLIOGRAPHY:

1. Adair, John. Effective Communication, London: Pan Macmillan Ltd. 2003.

2. Amos, Julie-Ann. Handling Tough Job Interviews. Mumbai: Jaico Publishing, 2004.

3. Baron, N.S., (2008).Always On: Language in an Online and Mobile World. Oxford University Press. Oxford.

4. Borg, James.(2010). Body Language: 7 Easy Lessons to Master the Silent Language. FT Press.

5. Collins, Patrick. Speak with Power and Confidence. New York: Sterling, 2009.

6. Kroehnert, Gary. Basic Presentation Skills. Sidney: McGraw Hill, 2010.

7. Linda B., Iris V. (2001). Intercultural Communication in the Global Workplace. 2nd Edition. Tata McGraw

8. Mitra, B. (2011). Personality Development & Soft Skills.1st edition. Oxfor.

9. Moore, Ninja-Jo, et al. Nonverbal Communication: Studies and Applications. New York: Oxford University Press, 2010.

10. Nelson, Paul E. & Judy C. Pearson, Confidence in Public Speaking.

11. Prasad, H. M. How to Prepare for Group Discussion and Interview. New Delhi: Tata McGraw-Hill Publishing Company Limited, 2001.

12. Pease, Allan. Body Language. Delhi: Sudha Publications, 1998.

13. Raman, Meenakshi & Sangeeta Sharma. Technical Communication: Principles and Practice. Second Edition. New Delhi: Oxford University Press, 2011.

14. Rutherford, Andrea J. Basic Communication Skills for Technology: Second Edition. Delhi: Pearson Education, 2007.

15. Sharma, R. C. & Krishna Mohan. Business Correspondence and Report Writing: Third Edition. New Delhi: Tata McGraw-Hill Publishing company Limited, 2007.

WEB LINKS:

http://networketiquette.net/

https://public.wsu.edu/~brians/errors/

http://users3.ev1.net/~pamthompson/body_language.htm

http://www.albion.com/netiquette/corerules.html

http://www.bbc.co.uk/worldservice/learningenglish/radio/specials/15

35_questionanswer/page15.shtml

http://www.colostate.edu/Depts/Speech/rccs/theory44.html

http://www.dailywritingtips.com/

EVALUATION PATTERN

Considering the choice-based credit system (CBCS) and the semester pattern, both Semesters-III & IV will have a uniform evaluation pattern of **50 marks** each. There will be an '**Internal Examination**' for **15 marks** and **Semester-end Examination** for **35 marks**.

The Internal Examination for **15 marks** will be conducted in two parts.

1) Practical Examination for 05 marks:

(The choices like Group Discussion, Mock Interviews, Seminar, Project Presentation, Role Play, Home Assignment, Library Work, Lecture Notes etc. can be considered.)

2) A Mid-semester Written Test for 10 marks:

The Mid-semester Written Test will be based on the book prescribed for the syllabus. The test aims at assessing students' writing competence in general. Hence, descriptive and essay type questions can be considered while setting the question paper.

Semester-end Examination:

The Semester-end Examination will have a uniform question paper pattern for both semesters. The pattern of the question paper is given below.

SEMESTER-END EXAMINATION

Question Paper Patterns

(Sem-III)

Marks: 35 **Time: 2 Clock Hours**

Instructions:

1. All questions are compulsory.

2. Figures to the right indicate full marks.

Q.1) Long-answer question on Unit-1

(Any 1 out of 2) (15)

Q.2) Short notes on Unit-2

(Any 2 out of 3) (10)

Q.3) Short notes on Unit-3

(Any 2 out of 3) (10)

(Sem-IV)

Marks: 35 **Time: 2 Clock Hours**

Instructions:

1. All questions are compulsory.

2. Figures to the right indicate full marks.

Q.1) Long-answer question on Unit-1

(Any 1 out of 2) (15)

Q.2) Short notes on Unit-2

(Any 2 out of 3) (10)

Q.3) Short notes on Unit-3

(Any 2 out of 3) (10)

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University of Pune

S.Y.B.Sc.
Environmental Science
Revised Syllabus 2020-21
Course Design

Semester	Paper	Course code	Course Title	Credits	Marks Distribution			
					Internal	University	Subtotal	Total
I	I	EVS – 231	Ecology & Ecosystem	02	15	35	50	150
	II	EVS – 232	Natural Resource Conservation and Management	02	15	35	50	
	III	EVS – 233	Practical Course Based on EVS - 231 & EVS – 232	02	15	35	50	
II	I	EVS-241	Biological Diversity & its Conservation	02	15	35	50	150
	II	EVS-242	Environmental Pollution Control Technology	02	15	35	50	
	III	EVS-243	Practical Course Based on EVS - 241 & EVS - 242	02	15	35	50	
				Total = 12				300

Semester – I, Paper – I, EVS – 231

Ecology & Ecosystem

(Total Lectures- 40)

Unit No.	Name of the Unit	Content	Lectures
1.	**Ecology**	• **Introduction & Interdisciplinary nature of Ecology.** • **Levels of Organisation –** a) Biological / Ecological Spectrum. b) Ecological Hierarchy by Barett et al. • **Ecological Classification based on –** a) Taxonomic Affinity (From Kingdom to Species Level Ecology). b) Habitat Types (Terrestrial & Aquatic Ecology). c) Levels of Organisation (Autecology & Synecology – Population, Community, Biome & Ecosystem Ecology)	**08**
2.	**Ecosystem Structure & Function – Energy Flow**	• **Concept** of the Ecosystem. • **Macro & Micro-ecosystems …etc.** • **Ecosystem Structure** – Abiotic & Biotic Components. • **Ecosystem Function : Functional attributes-** a) Food Chain – Grazing & Detritus. b) Food Web & Ecosystem Stability c) Ecological Energetics – i) Energy Input. ii) Energy Flow – Single Channel & Y shaped models. d) Productivity of Ecosystem – i) Primary Production – GPP & NPP. ii) Secondary Production. iii) Standing Crop (Biomass). e) Ecological Pyramids – of Number, Biomass & Energy with examples	**08**
3.	**Ecosystem Function : Nutrient Cycling**	• **Concept of –** a) Macro & Micro-nutrients, deficiency syndrome, Functions b) Nutrient Cycling-- Biogeochemical Cycles – • **Gaseous Cycles** – Hydrological, Carbon & Nitrogen Cycles. • **Sedimentary Cycles** – Phosphorus & Sulphur Cycles. • **Human Impact** on Biogeochemical Cycles. • **Ecosystem Nutrient Cycling Model – Intra-system Cycling & Extra-system Transfers.** a) Nutrient Inputs. b) Biotic Accumulation of Nutrient. c) Nutrient Outputs.	**08**

4.	**Population Ecology**	• **Introduction & Basic Concepts.** • **Population Characteristics** – a) Size & Density. b) Dispersion – Random, Aggregate & Uniform. c) Natality (Potential & Realised). d) Fecundity e) Mortality (Potential & Realised). f) Survivorship Curves. g) Age & Sex Structure. h) Life Table and Viability analysis • **The Concept of Carrying Capacity.** • **Population Growth –** a) Growth Curves – Exponential & Logistic. b) Population Fluctuation. c) Biotic Potential & Environmental Resistance.	**08**
5.	**Community Ecology and Succession**	• **Characteristics of Community** - Species Diversity, Growth form & Structure, Dominance, Succession, Trophic Structure, Ecological Niche, Ecotone & Edge Effect. • **Characters used in Community Structure-** a) Analytical Characters – i) Quantitative. ii) Qualitative. b) Synthetic Characters. • **Inter-specific & Intra-specific Relationships.** • **Causes** of Succession. • **Basic Types** – Primary, Secondary, Autogenic, Allogenic …etc. • **Mechanism** of Succession – a) Nudation. b) Invasion. c) Competition, Co-action & Reaction. d) Stabilisation (Climax). • **Models** of succession – a) Hydrosere. b) Lithosere.	**08**

Semester – I , Paper – II, EVS – 232

Natural Resources & their Management (Total Lectures- 40)

Unit No.	Name of the Unit	Content	Lectures
1.	**Resources**	• **Meaning and Definition** • **Classification of Resources** 1. On the basis of Origin: Biotic & Abiotic 2. On the basis of recovery rate: Renewable and Non Renewable 3. Natural and Artificial Resources 4. Material and Energy Resources • **Importance and Scope** of Resources • **Nature** of Resources : Regenerative and Assimilative Capacity of Earth • **Man's Interaction with Natural Resources**: 1. An important resource 2. A waste sink 3. Cultural Significance • **Problems** associated with Natural Resources	**08**
2.	**Forest and Mineral Resources**	A. **Forest Resources** : • Function of Forest : Protective, Productive, Regulative and Accessory • Importance of Forest : Ecological and Economical • Human Interaction with Forest : Overexploitation, Deforestation (Causes and Effects) • Forest Management in India—JFM, EDP, Protected Areas • Case studies on Timber extraction, Dam construction and its effect on tribal people B. **Mineral Resources** • Origin of Mineral Resources with examples • Need of Mineral Resources • Overexploitation of Mineral Resources • Effects of Mining on Ecosystem with case studies. • Conservation of Mineral resources and its importance	**08**
3.	**Food Resources**	• **World Food Problems**: a) Increasing World Food Demand. b) Nutritional deficiency in food. c) Food Distribution. • **The Green Revolution in India**- Concept, Its Impacts in India. • Introduction of Hybrid Varieties-HYV and Genetically Modified Crops. • Effects of Modern Agriculture technologies • Genetically Modified Crops & Regulations in India • **Fertilizer-Pesticide Problems** –NPK Fertilizers	**08**

4.	**Water Resources**	• **Use and over-utilization** of surface and ground water, • Under-ground water pollution • Water Crisis--- the reasons • Conflicts over water ---World and India • **Conservation & Management** a) Traditional Methods. b) Rain-water Harvesting & Ground Water Recharge. c) Watershed Management– the concept. d) Flood and flood plain management	**08**
5.	**Land Resource**	• **Traditional & Modern Agricultural Systems** • **Major causes of soil degradation**: Soil erosion, Pollution , Use of fertilisers, pesticides, heavy metals, Plastic pollution • **Consequences of soil erosion** a) Decline of soil fertility b) Water logging c) Salinity d) Shifting / jhum cultivation • **Soil conservation methods** • **Sustainable Agriculture Methods**	**08**

Semester – II, Paper – I, EVS -241,

Biological Diversity & its Conservation (Total Lectures- 40)

Unit No.	Name of the Unit	Content	Lectures
1.	**Biological Diversity – Ecosystem Diversity**	**Biological Diversity---** • The Concept, Definition • Levels – Ecosystem, Species & Genetic. • Methods of assessment of Biological diversity **Ecosystem Diversity** • Classification of Ecosystem – a) Udvardy's Classification. b) Bailey's Classification. c) Olsen's Classification. d) Holdridge's Classification. • **Major Ecosystem types of India** with their physical & biological characteristics. • **Major Ecosystem types of the World** with their physical & biological characteristics. • **Importance of Ecosystem in maintaining Ecological balance**	**08**
2.	**Species Diversity**	a) **Species Diversity** at Local , National and International Level b) Special features and Latest estimates for major groups of Plants, Animals & Microbes. • **Measuring Species Diversity** – Species Richness, Species Abundance and Species Evenness. • **Factors** affecting global distribution of Species Richness – Latitudinal, Altitudinal, Rainfall gradients, temperature …etc. • **Endemism** – a) The Concept. b) Types with Examples. c) Endemism in India. • **Centers of Diversity** – a) The Concept. b) Centers of Diversity : Analyses at Global Level – • **Concept of hotspot** i) Myer's Hot-spots. ii) Mega-diversity Centers / Countries. **c) Western Ghat as a Hot-spot.** d) **India as a Mega-diversity Country**.	**08**
3.	**Genetic Diversity**	• **Meaning & Introduction** to Genetic Variations in Species. • **Nature & Origin** of Genetic Variations. • **Factors** affecting Genetic Diversity. • **Darwin's theory of Evolution and Lamarck's theory of Natural Selection** • **Measurement of Genetic Diversity** – a) Based on DNA & Chromosomes. b) Molecular Marker Techniques. • **Transgenic Organisms**. • **Diversity in Domesticated Species** –	**08**

		a) Variations since the first domestication to the present. • Land Races, Advanced Cultivars, Wild Relatives of Cultivated Plants & Feral Plants.	
4.	**Significance & Threat to Biodiversity**	**(Significances)** • Ecological Significances – Contribution of Biodiversity to various Eco- Services. • Non Ecological Significances – Nutritional, Medicinal, Aesthetic, Cultural, Commercial Values …etc. • Optional Values, Use of microorganism in remediation of pollution **(Threats)** • Threats with suitable Examples – a) Large Scale Dev. Projects – Habitat Destruction & Fragmentation. b) Changing Agri. & Forestry Practices. c) Invasion by Introduced Species. d) Over-exploitation. e) Environment Pollution. f) Global Climate Change. g) Loss of Traditional Knowledge. h) Nature of Legal & Mgmt. System – Human Wildlife Conflict. i) Genetically Modified Organisms ...etc.	**08**
5.	**Biodiversity Conservation**	• **Conservation Methods** – In-situ & Ex-situ methods with Example. • **National Conservation Efforts –** a) The laws – Environment Protection Act, Forest Act, Wildlife Act, Biodiversity Act 2002 b) Involving People's Participation – NBSAP, PBR c) Involving Community Participation – JFM, EDP d) People's Movement – Silent Valley Movement, Beej Bachao Andolan • **International Conservation Efforts –** a) IUCN – The World Conservation Union. b) CBD. c) CITES. • **Traditional Methods of Conservation** – Sacred Groves / Ponds / Species, Periodic restrictions on resource harvesting …etc. • **Need & Awareness**.	**08**

Semester – II, Paper – II, EVS – 242

Environmental Pollution Control Technology

(Total Lectures- 40)

Unit No.	Name of Unit	Content	Lectures
1	**Air Quality Parameters and Monitoring**	**Air Quality Monitoring** • **National standards** for ambient air quality by WHO • **Site and Parameter selection**, • **Air Sampling Techniques** • **Monitoring** of important **ambient air components** such as Particulate matter (PM) of 10 micron or less in size and 2.5 micron and less in size, Oxides of Sulfur, Nitrogen, Carbon monoxide • **Methods of analysis of SOx , NOx** • **Monitoring tools/instruments** used for the same and its work principle, Stack gases monitoring technique • **Plume behaviour**	**08**
2	**Water Quality Monitoring**	• **Purpose/objectives** of monitoring • **Water Quality Monitoring Protocol** • **Collection of sample** (types of sample, chain of custody, sampling method, number of samples, sample containers, sample volume, etc.) • **Sample preservation**, handling & storage guidelines/criteria • **Water quality monitoring** on field test parameters, off-field test parameters • **Waste Water Treatment**: a) Primary Treatment – Screening, Grit removal, Sedimentation b) Secondary Treatment - • Aerobic Method- i) Activated Sludge Process. ii) Trickling Filter. iii) Rotating Contractor iv) Oxidation Pond • Anaerobic Method. d) Tertiary Treatment – Disinfection (Chlorination). e) Biogas—one stage and second stage digester, Principle	**08**
3	**Soil Quality Monitoring**	• **Objectives** of soil monitoring/testing • **Sampling** and sample units; sample number, frequency and timing; Sampling methodology a. Site selection b. Infield sampling technique c. Describing the soil profile d. Site description e. Setting a transect instruments / Equipment used	**08**

		• Guidelines for handling and storage of samples • Physiochemical and Biological parameters **Biological Method to control soil pollution---** a) To reduce dependency on chemicals – Use of Bio fertilizers & Bio pesticides, Conservational Tillage, Mixed Cropping, Crop rotation, Biological Pest Mgmt., Organic Farming b) Bio / Phyto-remediation of contaminated sites. **Soil carbon Flux**	
4	**Forest Monitoring**	• **Classification of forests** • **Measurement of individual trees:** a. Measurement of diameter and girth of trees b. Measurement of heights of trees c. Measurement of form of trees d. Measurement of volume of felled trees e. Measurement of volume of standing trees f. Determination of age of trees • **Forest inventory** • **Kinds of sampling**, sampling units, sampling intensity	**08**
5.	**Noise Quality Parameters**	**Noise and Vibration Monitoring** • Measuring techniques for noise & vibration • Noise monitoring methods • The Basic Noise Unit; Lmax, SEL, Leq(h), Ldn, 24-Hour Exposure from All Events • **Noise Control Techniques-** Sound Insulation, Sound Absorption, Vibration Damping and Isolation • **Noise Control at Source—** a) Selection & Maintenance of machines. b) Control over vibrations. c) Installation of barriers / enclosures. d) Using protective equipment e) Noise proof walls	**08**

Semester I, Paper-III

Practical Course Based on EVS -231 & EVS- 232.

Sr. No.	Description	Practical Type	Practical Sessions
1.	Measurement of Primary Productivity of grassland by Harvest Method.	Field + Laboratory.	**01**
2.	Estimation of Total Chlorophyll from plants in Clean & Polluted Environment.	Laboratory.	**01**
3.	Study of grassland vegetation by List Count Quadrat Method to determine the Frequency, Density & Abundance.	Field + Laboratory	**01**
4.	Determination of Frequency & Abundance of species across terrestrial – aquatic transitional zone, by Line Transect Method.	Field + Laboratory	**01**
5.	Determination of Density of species across terrestrial – aquatic transitional zone by Belt Transect Method.	Field + Laboratory	**01**
6.	Field visit to study Watershed Mgmt. Techniques.	Visit.	**01**
7.	Visit to Nature Interpretation / Information Centre.	Visit.	**01**
8.	Visit to National Park / Wildlife Sanctuary to study Wildlife & various Inter-specific & Intra-specific Relations.	Visit.	**≥ 01 Day**
9.	Continuation of the use of Social Media for e-networking & dissemination of ideas on Environmental Issues Pertaining to the Course.	---	**≥ 02**
10.	Identification of advanced cultivars in the Local market	Visit.	**01**
11.	Field visit to study Rain water Harvesting technique	Visit.	**01**
12.	Determination of minimum area and number of quadrates for vegetation	Field + Laboratory	**01**
13.	Determination of Shannon Diversity Index of a vegetation (Data sheet)	Laboratory.	**01**
14.	Determination of Simpson Diversity Index of a vegetation (Data sheet)	Laboratory.	**01**
15.	Visit to Soil Survey Department.	Visit.	**01**
16.	Study of Soil sampling techniques	Visit.	**01**

Semester II, Paper-III

Practical Course Based on EVS -241 & EVS- 242.

Sr. No.	Description	Practical Type	Practical Sessions
1.	Sampling of Air by High Volume Sampler	Field + Laboratory	**01**
2.	Determination of Optimum Dose of Alum (Coagulant) required for water.	Laboratory.	**01**
3.	Determination of Turbidity of water. (Turbidimeter / Nephelometer)	Laboratory.	**01**
4.	Determination of Residual Chlorine from treated water.	Laboratory.	**01**
5.	Determination of Dissolved Oxygen in water by Winkler's method	Laboratory.	**01**
6.	Determination of Nitrate from water (Calorimeter)	Laboratory.	**01**
7.	Determination of Phosphate from water. (Colorimeter)	Laboratory.	**01**
8.	Determination of Soluble Salts from Soil.	Laboratory.	**01**
9.	Determination of Available Nitrogen from soil.	Laboratory.	**01**
10.	Study of Water Sampling and Preservation techniques	Field + Laboratory	**01**
11.	Measurement of sounds by DB meter / SLM in silent, industrial, residential and commercial zones and Analysis	Field + Laboratory	**01**
12.	Estimation of AGB, BGB and Carbon from sampling of trees	Field + Laboratory	**01**
13.	Determination of Lime required for Acidic soil	Laboratory	**01**
14.	Estimation of Productivity of Lake using DO method	Field + Laboratory	**02**
15.	Estimation of NOx content of given samples	Laboratory.	**01**
16.	Estimation of SOx content of given samples	Laboratory.	**01**

Reference Books

- Understanding Environment; Chokkar K. B., Pandya M. & Raghunathan M.; Centre for Environment Education; Sage Publication, New Delhi.
- An Advanced Textbook on Biodiversity – Principles & Practice; Krishnamurthy K.V.; Oxford & IBH Publishing Co. Pvt. Ltd.; New Delhi.
- Ecology – Principles & Applications; Chapman J. L. & Reiss M. J.; Cambridge University Press.
- Fundamentals of Ecology; Odum P.E.; Natraj Publishers; Dehradun; 3 Edt..
- Ecology, Environment & Resource Conservation; Singh J.S., Singh S.P. & Gupta S.R.; Annamaya Publishers; New Delhi.
- Ecology & Environment; Sharma P.D.; Rastogi Publication; Meerut; 11 Rev. Edt..
- Environment Science; Tyler M.G.; Wadsworth Publishing Co.; 1997.
- Perspective in Environmental Studies; Kaushik & Kaushik; New Age International Pvt. Ltd. Publishers.
- Environmental Science; Santra S.C.; New Central Book Agency (P) Ltd.; 2 Edt..
- Environmental Chemistry, Dey A. K.; New Age International Publishers; 6 Edt..
- Air Pollution; Rao M.N. & Rao H.V.N.; Tata McGraw Hill; New Delhi; 1989.
- Environmental Pollution Control & Environmental Engineering; Rao C. S.; Tata McGraw Hill; New Delhi; 1994.
- Pollution Management; Agarwal S.K.
- Environmental Science; Daniel Chiras.
- Waste Water Engineering, Treatment, Disposal & Reuse; Metcalf & Eddy.
- Manual for Field Ecology; Mishra R.
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