SHIVAJI UNIVERSITY, KOLHAPUR - 416004,
MAHARASHTRA
PHONE:EPABX-2609000, www.unishivaji.ac.in, bos@unishivaji.ac.in
शिवाजी विद्यापीठ, कोल्हापूर -४१६००४,महाराष्ट्र
दूरध्वनी-ईपीएबीएक्स -२६०९०००, अभ्याससमंडळे विभाग दुरध्वनी ०२३१—२६०९०९४
०२३१—२६०९४८७

Estd. 1962
"A++" Accredited by
NAAC (2021)
With CGPA 3.52

SU/BOS/Science/104 **Date: 11/03/2025.**

To,

The Director
School of Nanoscience and Technology,
Shivaji University, Kolhapur.

Subject: Regarding Minor Change syllabi of B.Sc.- M.Sc. in Nanoscience and Technology as per NEP-2020 (2.0) degree programme under the Faculty of Science and Technology.

Ref: SU/BOS/Science/880/ Date: 28/12/2023 Letter.

Sir/Madam,

With reference to the subject mentioned above, I am directed to inform you that the university authorities have accepted and granted approval to the Minor Change in syllabi, nature of question paper and equivalence of B.Sc.- M.Sc. in Nanoscience and Technology as per NEP-2020 (2.0) degree programme under the Faculty of Science and Technology.

	B.Sc.- M.Sc. in Nanoscience and Technology as per NEP-2020 (2.0)
1	B.Sc.- M.Sc. in Nanoscience and Technology (5 Years Integrated), Part I & II

This syllabus, nature of question shall be implemented from the academic year 2025-2026 onwards. A soft copy containing the syllabus is attached herewith and it is also available on university website www.unishivaji.ac.in,NEP-2020@suk(Online Syllabus).

You are, therefore, requested to bring this to the notice of all students and teachers concerned.

Thanking you,

Dy Registrar
Dr. S. M. Kubal

Copy to:

1	The Dean, Faculty of Science & Technology	5	Appointment Section A & B
2	Director, Board of Examinations and Evaluation	6	I.T.Cell /Computer Centre
3	The Chairman, Respective Board of Studies	7	Eligibility Section
4	B.Sc.-M.Sc. Exam Section	8	Affiliation Section (T.1) (T.2)
9	IQAC Cell		

Shivaji University, Kolhapur

Accredited by NAAC with 'A++' Grade

NATIONAL EDUCATION POLICY (NEP-2020)
Syllabus for
B. Sc.-M. Sc. in Nanoscience and Technology,
(5 Years Integrated) Program,
Part-II, (NEP 2.0)

Syllabus to be implemented from the academic year
2024-25
(July 2024) onwards

Implementation: The implementation gradually as mentioned below –

B.Sc.-M. Sc. in Nanoscience and Technology (5 Years Integrated) Program

a) B.Sc.-M. Sc. (5 Years Integrated) Part – I from the Academic year 2023-24

b) **B.Sc. -M. Sc. (5 Years Integrated) Part – II from the Academic year 2024-25**

c) B.Sc. -M. Sc. (5 Years Integrated) Part – III from the Academic year 2025-26

d) B.Sc. -M. Sc. (5 Years Integrated) Part – IV from the Academic year 2026-27

e) B.Sc. -M. Sc. (5 Years Integrated) Part – V from the Academic year 2027-28

Programme: B.Sc.-M.Sc. in Nanoscience and Technology (5 Years Integrated)

(NST)

Course code Abbreviations

Sr. No.	Name	Short form
1	Major	DMJ/MJ
2	Minor	DMN/MN
3	Generic Elective Course	GEC
4	Interdisciplinary Course	IDC
5	Discipline Course	DSC
6	Open Elective Course	OE
7	Ability Enhancement Course (English)	AECC
8	Indian Knowledge System	IKS
9	Field Projects	FP
10	Community Engagement Practice	CEP
11	Co-Curricular Courses	CC
12	Research Project	RP
13	Value Education Courses ()	VEC
14	Vocational Skill course	VSC
15	Skill Enhancement Courses	SEC
16	Discipline Specific Elective Course	DSE
17	Multidisciplinary	MDC
18	Value Added Course: [(Maths +Biology), Env. Studies]	VAC
19	Major Mandatory	MM
20	Major Elective	ME
21	Research Methodology	RM

B.Sc.-M.Sc. in Nanoscience and Technology (5 Years Integrated) (NST)

List of course with the codes

Sr. No.	Name of the Course	Course Code
1	Physics	01
2	Chemistry	02
3	Biotechnology	03
4	Mathematics	04
5	Electronics	05
6	English	06
7	Nanoscience	07
8	Nanoscience and Technology	08
9	Statistics	09
10	Environmental Science	10
11	Biology	11
12	Nanobiotechnology	12

B.Sc.-M.Sc. in Nanoscience and Technology (5 Years Integrated), Part-II, SEM-III and SEM-IV

Sr. No.	Paper Code	Title of the Paper
SEM III		
1	NSTU0325MJL301C1	Thermal Physics and Statistical Mechanics
2	NSTU0325MJL302C1	Conductance, Corrosion, Electroplating, Electrochemistry, Thermodynamics, States of Matter, Chemical Kinetics, Gravimetric Analysis, Chromatographic Techniques, Water Analysis, Surface Chemistry, Petroleum Industries, Biofuels
3	NSTU0325MJL303C1	Fundamentals of Microbiology and Biochemistry
4	NSTU0325MDCL309C1	Statistical Techniques for Nanotechnology
5	NSTU0325MNL305C1	Electronic Instrumentation
6	NSTU0325VAC310C1	Environmental Studies
7	NSTU0325IKSC308C1	Indian Knowledge System- IKS in Nanoscience
8	NSTU0325MJP301C1	**Laboratory Course – I** (Thermal Physics and Statistical Mechanics)
9	NSTU0325MJP302C1	**Laboratory Course – II** (Conductance, Corrosion, Electroplating, Electrochemistry, Thermodynamics, States of Matter, Chemical Kinetics, Gravimetric Analysis, Chromatographic Techniques, Water Analysis, Surface Chemistry, Petroleum Industries, Biofuels)
10	NSTU0325MJP303C1	**Laboratory Course – III** (Fundamentals of Microbiology and Biochemistry)
11	(NSTU0325SECP304C1) + (NSTU0325SECP305C1)	**Laboratory Course – IV** (Statistical Techniques for Nanotechnology + Electronic Instrumentation)
SEM IV		
12	NSTU0325MJL301D1	Waves and Optics
13	NSTU0325MJL302D1	Coordination Chemistry, Semi-Micro Qualtitative Analysis, Transition Elements, Chelation, Carboxylic acids, Carbonyl Compounds, Amines, Diazonium Salts, Carbohydrates, Stereochemistry
14	NSTU0325MJL303D1	Fundamentals of Immunology and Nanodiagnostics
15	NSTU0325MDCL309D1	Introduction to Data Science, AI, and ML
16	NSTU0325MNL305D1	Analytical Instrumentation
17	NSTU0325VAC310D1	Environmental Studies

18	NSTU0325MJP301D1	**Laboratory Course – I** (Waves and Optics)
19	NSTU0325MJP302D1	**Laboratory Course – II** (Coordination Chemistry, Semi-Micro Qualtitative Analysis, Transition Elements, Chelation, Carboxylic acids, Carbonyl Compounds, Amines, Diazonium Salts, Carbohydrates, Stereochemistry)
20	NSTU0325MJP303D1	**Laboratory Course – III** (Fundamentals of Immunology and Nanodiagnostics)
21	(NSTU0325SECP304D1)] + (NSTU0325SECP305D1)]	**Laboratory Course – IV** (Statistical Techniques for Nanotechnology + Statistical Methods for Physical Sciences II + Electronic Instrumentation + Analytical Instrumentation)

The following shall be the courses of the studies under the NEP-2020 pattern (NEP 2.0)

B. Sc. - M. Sc. in Nanoscience and Technology (5 years integrated) - Part-II,

SEM-III and SEM-IV

NEP-2020 PATTERN (2025-26)

SEMESTER-I (Duration – 6 Months)																		
Sr. No.	Course Title	Teaching Scheme						Examination Scheme										
								Theory								Practical/SEC		
		Theory			Practical/SEC			Theory			Internal			Total		Total		
		No. of lectures	Hours	Credits	No. of Lectures	Hours	Credits	Max.	Min.	Hours	Max.	Min.	Hours	Max.	Min.	Max.	Min.	Hours
1	Thermal Physics and Statistical Mechanics	4	4	4	1	4	2	80	28	3	20	7	1	100	35	50	18	4
2	Conductance, Corrosion, Electroplating, Electrochemistry, Thermodynamics, States of Matter, Chemical Kinetics, Gravimetric Analysis, Chromatographic Techniques, Water Analysis, Surface Chemistry, Petroleum Industries, Biofuels	4	4	4	1	4	2	80	28	3	20	7	1	100	35	50	18	4
3	Fundamentals of Microbiology and	4	4	4	1	4	2	80	28	3	20	7	1	100	35	50	18	4

	Biochemistry																	
4	Statistical Techniques for Nanotechnology	4	4	4	1	4	2	80	28	3	20	7	1	100	35	50	18	4
5	Electronic Instrumentation	4	4	4				80	28	3	20	7	1	100	35			
6	Environmental Studies	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7	Indian Knowledge System-IKS in Nanoscience	2	2	2	-	-	-	40	14	2	10	04	1	50	18	-	-	-
	Total	**25**	**22**	**22**	**4**	**16**	**8**	**-**			**-**	**-**	**-**	**550**	**-**	**200**		**-**
	SEMESTER-II (Duration 6 months)																	
Sr. No.	Course Title	**Teaching Scheme**						**Examination Scheme**										
								Theory								Practical/SEC		
		Theory			Practical/SEC			Theory			Internal			Total		Total		
1	Waves and Optics	4	4	4	1	4	2	80	28	3	20	7	1	100	35	50	18	4
2	Coordination Chemistry, Semi-Micro Qualtitative Analysis, Transition Elements, Chelation, Carboxylic acids, Carbonyl Compounds, Amines, Diazonium Salts, Carbohydrates, Stereochemistry	4	4	4	1	4	2	80	28	3	20	7	1	100	35	50	18	4
3	Fundamentals of	4	4	4	1	4	2	80	28	3	20	7	1	100	35	50	18	4

	Immunology and Nanodiagnostics																	
4	Introduction to Data Science, AI, and ML	4	4	4	1	4	2	80	28	3	20	7	1	100	35	50	18	4
5	Analytical Instrumentation	4	4	4				80	28	3	20	7	1	100	35			
6	Environmental Studies	3	3	3	Project (1 Credit)			70	-	3	-	-	-	70	-	30	-	1
	Total	**23**	**23**	**23**	**4**	**16**	**9**	**-**	**-**	**-**	**-**	**-**	**-**	**570**	**-**	**230**	**-**	**-**
	Grand Total	**48**	**45**	**45**	**8**	**32**	**17**							**1120**		**430**	**-**	**-**

Note:- 1) Practical examination will be conducted semester wise.

2) Environmental Studies (NSTU0325VAC310C1+NSTU0325VAC310D1) examination will be conducted annually

SHIVAJI UNIVERSITY, KOLHAPUR
School of Nanoscience and Biotechnology
B. Sc. –M.Sc. in Nanoscience and Technology, (5 Years Integrated) Programme,
Part – II, Semester- III

Thermal Physics and Statistical Mechanics

(Theory: 60 Lectures)

Course Learning Outcomes:

After going through the course, the student should be able to

- Comprehend the basic concepts of thermodynamics, the first and the second law of thermodynamics, the concept of entropy and the associated theorems, the thermodynamic potentials and their physical interpretations.
- Learn about Maxwell's thermodynamic relations.
- Learn mean free path of molecular collisions, viscosity, thermal conductivity, diffusion
- Learn about the black body radiations, Stefan- Boltzmann's law, Rayleigh-Jean's law and Planck's law and their significance.
- Understand the concepts of microstate, macrostate, ensemble, phase space, thermodynamic probability and partition function.
- Learn the quantum statistical distributions, viz., the Bose-Einstein statistics and the Fermi-Dirac statistics.

Unit No.	Topics	Total Lectures
Unit I	**Basic Concepts and Laws of Thermodynamics:** Basic Concepts in Laws of Thermodynamics, Zeroth Law of thermodynamics and temperature, first law of thermodynamics and internal energy, Applications of First Law (General Relation between C_P & C_V, Work Done during Isothermal and Adiabatic Processes), reversible and irreversible processes, second law of thermodynamics, Entropy, Carnot heat engine, construction, working and derivation of efficiency. Carnot's theorem, Entropy changes in reversible & irreversible processes, Entropy-temperature diagrams, Third law of thermodynamics, Unattainability of absolute zero.	(15 Lectures)
Unit II	**1. Thermodynamic Potentials** Internal Energy, Helmholtz function, Enthalpy, Gibbs function, Maxwell's thermodynamical relations, Joule-Thomson effect, Clausius- Clapeyron equation, Expression for ($C_P - C_V$), TdS equations.	(15 Lectures)

	2. Transport Phenomena Concept of mean free path, expression for mean free path, Transport Phenomena: Viscosity, Conduction and Diffusion (for vertical case), Law of equipartition of energy (no derivation) and its applications to specific heat of gases; mono-atomic and diatomic gases.	
Unit III	**1. Theory of Radiation** Blackbody radiation and its importance, Experimental study of black body radiation spectrum, Concept of energy density, Derivation of Planck's law, Deduction of Wien's displacement law, Rayleigh-Jeans Law, Stefan Boltzmann Law and Wien's displacement law from Planck's law. 2. **Basic Concepts in Statistical Physics:** Concepts of phase space, macrostate and microstates, ensembles, a priori probability, thermodynamic probability, entropy and probability, partition function.	(15 Lectures)
Unit IV	**1. Maxwell-Boltzman Statistics**: M-B distribution law, evaluation of constants α and β, molecular speeds (most probable, average and r.m.s. speeds). **2. Quantum Statistics** Bose-Einstein (BE) distribution law, Photon gas, Fermi-Dirac (FD) distribution law, comparison of M.B., B.E., and F.D. statistics.	(15 Lectures)

Reference Books:

1. Heat and Thermodynamics, M.W. Zemansky and R. Dittman, (8^{th} Edn) McGraw Hill.
2. Text Book of Heat- J.B. Rajam, S. Chand and Company Ltd.
3. A Treatise on Heat- MeghnadSaha and B.N. Srivastava, Indian Press.
4. Heat and Thermodynamics- Brijlal and N. Subramanyam, S. Chand and Company Ltd.
5. Heat Thermodynamics and Statistical Physics- J.P. Agrawal, Satya Prakash, Pragati Publ.
6. Fundamentals of Heat - D. S. Mathur, S. Chand and sons.
7. The Physics of Waves and Oscillations- N. K. Bajaj, Tata McGraw-Hill Reprint 2022.
8. Physics of Degree Students- C. L. Arora and Dr. P. S. Hemne, S Chand & company
9. A Text Book of Sound- Khanna and Bedi, Atma Ram & Sons, Delhi.
10. Waves and Oscillations-N Subrahmanyam, BrijLal. Vikas 2nd edition, Reprint 2022
11. Elements of Properties of Matter-D.S. Mathur, S. Chand. 12. Electronic Instrumentation – H.S. Kalasi McHraw , Hill

SHIVAJI UNIVERSITY, KOLHAPUR
School of Nanoscience and Biotechnology
B. Sc. –M.Sc. in Nanoscience and Technology, (5 Years Integrated) Programme,
Part – II, SEM III
Laboratory Course – I
(Practical: 60 Lectures) (Credits: 02)
(Thermal Physics and Statistical Mechanics)

Sr. No.	Name of experiment
1	To determine the value of Stefan's constant.
2	To determine the coefficient of thermal conductivity of copper by Searle's apparatus.
3	To determine the coefficient of thermal conductivity of a bad conductor by Lee and Charlton's disc method.
4	To determine the temperature co-efficient of resistance by platinum resistance thermometer.
5	To study the variation of thermo e. m. f. across two junctions of a thermocouple with temperature. / To determine the surface tension of water by ripple method.
6	To record and analyze the cooling temperature of hot object as a function of time using a thermocouple.
7	To calibrate Resistance Temperature Device (RTD) using Null Method / Off Balance Bridge.
8	To determine the thermal conductivity of metal bar by Forbes's method.
9	To determine the temperature coefficient of resistance using post office box.
10	To verify the Stefan's fourth power law.
11	To determine the specific heat of graphite.
12	To determine the ratio of specific heat of air by Kundt's tube.
13	To determine Joules constant (J) by electrical method.
14	To determine the thermal coefficient of linear expansion of a metal rod.
15	To determine Mechanical equivalent of heat J by Callender and Barne's constant flow method.
16	To determine the constants of Ballistic Galvanometer (B. G).

Note: Maximum 10 experiments from Lab course

Reference Books:

1. B.Sc. Practical Physics – Harnam Singh , P.S. Hemane, S. Chand.
2. Advanced Practical Physics for students, B.L. Flint & H.T. Worsnop, 1971, Asia Publishing House.
3. Advanced level Physics Practical, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers.

4. A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition, 2011, Kitab Mahal, New Delhi.
5. B.Sc. Practical Physics, C. L. Arora, S. Chand & Company Pvt. Ltd., New Delhi.

SHIVAJI UNIVERSITY, KOLHAPUR
School of Nanoscience and Biotechnology
B. Sc. –M.Sc. in Nanoscience and Technology, (5 Years Integrated) Programme,
Part – II, Semester- III

Conductance, Corrosion, Electroplating, Electrochemistry, Thermodynamics, States of Matter, Chemical Kinetics, Gravimetric Analysis, Chromatographic Techniques, Water Analysis, Surface Chemistry, Petroleum Industries, Biofuels

(Theory: 60 Lectures)

Learning objectives/outcomes

- Learning and coherent understanding of conductivity and transport number of the aqueous solutions with different applications. Experimental determination of transport number and numerical problems.
- Knowledge and coherent understanding of basic concepts in thermodynamics and concept of Entropy will be gained by the student.
- Learning and understanding the knowledge about basic concepts in kinetics and third order reaction with characteristics, suitable examples, and methods for determination of order of reactions and numerical problems.
- Learning and coherent understanding of behavior of gases, ideal gas as model system and its extension to real gases. The dependence of physical state on P, V and T. Liquid crystals are essentials in all common and research devices, hence they are introduced with suitable examples.
- Learning and understanding of theoretical basis of adsorption phenomenon, dynamic nature of surface and its applications.
- Learning and understanding of basic concepts in gravimetric analysis.
- Students will learn the different water analysis techniques.
- Learning and understanding the knowledge about basic concepts in corrosion and electroplating, mechanism of corrosion, principle of electroplating.
- Learning and coherent understanding of column and ion exchange chromatography.
- Learning of working of petroleum industries, understanding of biofuels, copyrights and trademarks.

Unit No.	Topics	Total Lectures
Unit I	**Conductance, Corrosion, Electroplating and Electrochemistry:** **Conductance: (5L)** Introduction, Migration of ions. Hittorf's rule, Transference number, determination of transport number using Hittorf's method and moving boundary method, factors affecting transport number: nature of electrolyte, concentration, temperature, complex formation and degree of hydration. Conductivity, equivalent and molar conductivity and their variation with dilution for weak and strong electrolytes. Kohlrausch's law of independent	**(15)**

	migration of ions and its applications such as relations between ionic conductance, ionic mobility and transport number, determination of equivalent conductance at infinite dilution of weak electrolytes, determination of degree of ionization of weak electrolyte, solubility and solubility products of sparingly soluble salts. Conductometric titrations (only acid- base). Introduction to conductivity measurement of nanomaterials in solution, Zeta Potential (definition and examples only) **Corrosion and electroplating: (5L)** Introduction of corrosion, Electrochemical theory of corrosion, Factors affecting on corrosion: Position of metals in the electrochemical series on the basis of standard reduction potential. Purity of metal iii. Effect of moisture. Effect of oxygen (differential aeration principle). Hydrogen overvoltage, Methods of protections of metals from corrosion alloy formation, making metal cathodic, controlling external condition. Coating-galvanising, Tinning, electroplating, metal cladding, organic coating. **Electroplating: (2L)** Electrolysis, Faraday's laws, Cathode current Efficiency, Basic principles of electroplating, cleaning of articles, Electroplating of chromium by anodizing. **Electrochemistry: (3L)** Concept of EMF of a cell. Measurement of EMF of a cell. Nernst equation and its importance. Types of electrodes. Standard electrode potential. Nanophase electrochemistry (definition and application only)	
Unit II	**Thermodynamics, States of Matter and Chemical Kinetics:** **Thermodynamics: (5L)** Introduction, Concept of Entropy: Definition, mathematical expression, unit. Physical significance of Entropy. Entropy changes for reversible and irreversible processes in isolated systems. Entropy changes for an ideal gas as a function of V & T and as function of P & T. Entropy change in mixing of gases. Entropy change in phase transformations. Third law of thermodynamics, standard entropy, application of third law of thermodynamics in determination of absolute entropy, Entropy changes in chemical reactions. Numerical problems. Concept of Nano thermodynamics (definition with example only) **States of Matter: (5L)** Introduction, States of matter and their properties. Gaseous state: Postulates of Kinetic Theory of Gases and derivation of the kinetic gas equation. Ideal and Non-ideal gases, Deviation of real gases from ideal behavior, compressibility factor, causes of deviation. van der Waals equation of state for real gases. Explanation of real gas behavior by van der Waal's equation, Boyle temperature (derivation not required). Critical Phenomena: PV-isotherms of real gases (Andrew's isotherms), Continuity of state, Critical constants and their calculation from Vander	**(15)**

	Waals equation. Liquid state: Liquid crystals: Difference between liquid crystal, solid and liquid. Classification, structure of nematic, smectic and cholestric liquid crystal. Thermography and seven segment cell. Numerical Problems. Plasma (definition and applications only) **Chemical Kinetics**: **(5L)** The concept of reaction rates. Order and molecularity of a reaction. Rate equations for zero, first, second order reactions (both for equal and unequal concentrations of reactants, derivation not required). Determination of order of reaction by integration method, graphical method and half-life. Derivation of third order rate constant considering reaction with equal initial concentration. Characteristics and examples of third order reaction. Concept of activation energy. Effect of temperature, pressure, catalyst and other factors on reaction rates. Theories of Reaction Rates: Collision theory and Activated Complex theory of bimolecular reactions. Comparison of the two theories (qualitative treatment only). Catalysis (definition, classification, including enzyme catalysis with examples). Concept of nanocatalysis (definition and application only)	
Unit III	**Gravimetric Analysis, Chromatographic Techniques and Water Analysis** **Gravimetric Analysis: (5L)** Introduction, Gravimetric analysis by precipitation: nucleation, crystal growth, digestion/ageing, filtration, drying, ignition, weighing, optimum condition for good precipitation, Physical nature of precipitate, Purity of precipitate: co-pecipitation, post-precipitation Organic precipitates and their applications. **Chromatographic Techniques: (6L)** Introduction, classification. Column chromatography: Introduction, types, Principle of adsorption column chromatography, solvent system, stationary phases, Methodology-Column packing, applications of sample, development, detection methods, recovery of components, Applications. Ion exchange chromatography: Introduction, Principle, Types and properties of ion exchangers, Methodology Column packing, application of sample, elution, detection/analysis, Applications. **Water Analysis (4L)** Physical analysis of water: pH, Conductance, Color, Odor, Turbidity and taste, Chemical Analysis Total dissolved solids, Hardness and its determination, Salinity, Alkalinity, Acidity Sulphates, Nitrates, Dissolved oxygen, Chemical oxygen demand, Biological oxygen demand.	**(15)**
Unit IV	**Surface Chemistry, Petroleum Industries, Biofuels** **Surface Chemistry**: **(8L)**	**(15)**

	Introduction, Adsorption as a surface phenomenon, Definition of adsorption, adsorbent, adsorbate. Characteristics of adsorption. Factors affecting adsorption, Types of adsorption, Distinction between physical and chemical adsorption. Adsorption isotherms: Freundlich adsorption isotherm, Langmuir adsorption isotherm. BET equation. Applications of adsorption. Concept of surface area, pore size, pore volume of nanomaterials. **Petroleum Industries and Biofuels: (7 L)** Petroleum industry Introduction, occurrence, composition of petroleum, resources, processing of petroleum, calorific value of fuel, cracking, octane rating (octane number), cetane number, flash point, petroleum refineries, applications of petrochemicals, synthetic petroleum, lubricating oils & additives. Biofuels: Biodiesel, Bio-ethanol. Concepts of sustainable development, circular economy, waste valorization, carbon credit,	

Reference Books:

1. Barrow, G.M. Physical Chemistry Tata McGraw-Hill (2007).
2. Castellan, G.W. Physical Chemistry 4th Ed. Narosa (2004).
3. Kotz, J.C., Treichel, P.M. & Townsend, J.R. General Chemistry, Cengage Learning India Pvt. Ltd.: New Delhi (2009).
4. Mahan, B.H. University Chemistry, 3rd Ed. Narosa (1998).
5. Petrucci, R.H. General Chemistry, 5th Ed., Macmillan Publishing Co.: New York (1985).
6. Essentials of Physical Chemistry, Bahl and Tuli. S. Chand, 2010.
7. Physical Chemistry, Danials and Alberty (2016)
8. University General Chemistry C.N.R.Rao (2016)
9. Principals of Physical Chemistry Puri, Sharma and Pathania 47ThEdison,Vishal
10. Publishing Co. Daryaganj Delhi. 110002 (2017-18)
11. Physical Chemistry A.J.Mee.(2015)
12. Advanced Physical Chemistry Gurudeep Raj (2017-18)
13. Physical Chemistry R.A.Aleberty. (2017-18)
14. Principles of Physical Chemistry by Puri, Sharma and Pathania, VishalPublishing
15. company Jalindhar
16. Essential of Physical Chemistry by Bahl B.S., Tuli G.D. and BahlArun, S.Chand and company Ltd. New Delhi
17. Modern Analytical Chemistry By David Harvey, McGRAW-Hill International Edition, 2000
18. Industrial chemistry by B.K.Sharma, Goel Publishing Housing, 16th edition 2011

19. Advanced Inorganic Chemistry, Vol.No.1, by Gurudeep Raj, Krishna Prakashan Media Ltd, Goel Publication, Meerut
20. Analytical chemistry by B.K. Sharma, Krishna Prakashan Media Ltd, Meerut, edition 3rd 2011
21. Principles of electroplating and electroforming by Blum and Hogaboom Chemical Process Industries by Shreve and Brink
22. Industrial Chemistry by Loutfy Madkor and Helen Njenga
23. Elementary Principles of Chemical Processes by Richard Felder and RonaldRousseau, John Wiley and Sons.
24. Hornyak, G.L., Tibbals, H.F., Dutta, J. and Moore, J.J., 2008. Introduction to Nanoscience and Nanotechnology. CRC press.

SHIVAJI UNIVERSITY, KOLHAPUR
School of Nanoscience and Biotechnology
B. Sc. –M.Sc. in Nanoscience and Technology, (5 Years Integrated) Programme,
Part – II, SEM III
Laboratory Course – II
(Practical: 60 Lectures) (Credits: 02)

(Conductance, Corrosion, Electroplating, Electrochemistry, Thermodynamics, States of Matter, Chemical Kinetics, Gravimetric Analysis, Chromatographic Techniques, Water Analysis, Surface Chemistry, Petroleum Industries, Biofuels)

A] Physical chemistry

1. To study the hydrolysis of methyl acetate in presence of HCl and H_2SO_4 and to determine the relative strength of acids.
2. To study the effect of acid strength on hydrolysis of an ester by using 0.5M HCl and 0.25M HCl.
3. To study the reaction rate of hydrolysis of an ethyl acetate by an alkali.
4. To study the reaction between potassium persulphate and Potassium iodide in solution with unequal concentration of the reactants.
5. To determine the degree of dissociation and dissociation constant of acetic acid at various dilutions and to verify Ostwald's dilution law conductometrically.
6. To determine the normality of the given strong acid by titrating it against the strong alkali conduct metrically.
7. To determine the normality of the given weak acid by titrating it against the strong alkali conductometrically.
8. To determine the percentage composition of a given liquid mixture by viscosity method (Density data to be given).
9. To determine the specific and molar refractions of benzene, toluene and xylene by Abbe's refractometer and to determine the refraction of CH_2 Group (Methylene group) (Students should determine densities).
10. To determine the specific rotation and unknown concentration of sugar solution.
11. Determination of adsorption coefficient of acetic acid-charcoal system.

B) Inorganic Chemistry

1) Gravimetric Analysis (Any two):

i) Gravimetric estimation of iron as Fe_2O_3 from a solution containing Ferrous ammonium sulphate and free sulphuric acid.

ii) Gravimetric estimation of barium as $BaSO_4$ from a solution containing barium chloride and free hydrochloric acid.

iii) Gravimetric estimation of nickel as $Ni(DMG)_2$ from a solution containing $NiSO_4.7H_2O$ and free sulphuric acid.

iv) Gravimetric estimation of aluminium as Aluminium oxinate from a solution containing aluminium sulphate or potash alum and free sulphuric acid.

2) Inorganic Preparations (Any One):

i) Preparations of sodium cuprous thiosulphate

ii) Preparation of tris (ethylene diamine) nickel (II) thiosulphate

3) Titrimetric Analysis (Any Two):

i) Analysis of Synthetic /Commercial Sample: To estimate Magnesium from talcum powder.

ii) Determination of alkali content from antacid tablet using HCl solution .

iii) Estimation of Calcium from chalk: To estimate amount of calcium from the chalk by titrimetric method. (By redox titration using $KMnO_4$ solution)

References:

1. Mendham, J.Vogel's Quantitative Chemical Analysis, Pearson 2009.
2. Khosla, B. D.; Garg, V. C. &Gulati, A.Senior Practical Physical Chemistry, R. Chand & Co: New Delhi (2011).
3. Findlay' Practical Physiccal Chemistry (Longmann)2015.
4. Practical Physical Chemistry : Gurtu (S Chand) 2014.
5. Systematic Experimental Physical Chemistry :Rajbhoj, Chandekar(Anjali Publication) 2016.
6. Advanced Practical Physical Chemistry: J.B. Yadav (Goel Publishing House) 2015.
7. Vogel's text book of Qualitative Inorganic analysis by A. I. Vogel .3rd and 6th edition
8. Vogel's text book of Quantitative Inorganic Chemistry by A. I. Vogel.
9. Physical Chemistry of Inorganic qualitative analysis by Kuricose & Rajaram.
10. Practical manual in water Analysis by Goyal & Trivedi
11. Practical Organic Chemistry by A.I. Vogel.
12. Hand book of Organic qualitative analysis by H.T. Clarke.
13. A Laboratory Hand Book of Organic qualitative analysis and separation by V.S.Kulkarni. Dastane Ramchandra & Co.

14. Practical Organic Chemistry by F.G. Mann and B.C. Saunders. Low – priced Text Book. ELBS. Longman
15. Advanced Practical Organic Chemistry by N.K. Vishnoi. Vikas Publishing House Private Limited.
16. Advanced practical chemistry by J. Singh, L. D. S. Yadav, R. K. P. singh, I. R. Siddiqui et.al, Pragati prakashan.

SHIVAJI UNIVERSITY, KOLHAPUR
School of Nanoscience and Biotechnology
B. Sc. –M.Sc. in Nanoscience and Technology, (5 Years Integrated) Programme,
Part – II, Semester- III

Fundamentals of Microbiology and Biochemistry

(Theory: 60 Lectures)

Course Learning Outcomes:

After going through the course, the student should be able to

- Understand the fundamentals of General Microbiology- History and Microbial evolution, classification, Prokaryotic and Eukaryotic cells with examples
- Learn the techniques of cultivation and maintenance of microorganisms, nutritional requirements, microbial growth and factors affecting to it, Bacterial reproduction and control measures of microorganisms.
- Study the biomolecules including structure, classification and significance of carbohydrates, lipids, proteins, enzymes, nucleic acids, vitamins and minerals, etc.
- Understand the helpfulness and harmfulness of the microbes to the humans, also the antimicrobial abilities of nanomaterials will be addressed.

Unit No.	Topics	Total Lectures
Unit I	**Understanding Microbiology** Fundamentals, History and Evolution of Microbiology. Classification of microorganisms: Microbial taxonomy, Microbial phylogeny and current classification of bacteria. Microbial Diversity, Morphology and cell structure of major groups of microorganisms e.g. Bacteria, Algae, Fungi, Protozoa and Unique features of viruses.	**15**
Unit II	**Microbial world** Cultivation and Maintenance of microorganisms: Nutritional categories of microorganisms, methods of isolation, Purification and preservation. Microbial growth, Growth curve, Generation time, synchronous batch and continuous culture, measurement of growth and factors affecting growth of bacteria. Bacterial Reproduction: Transformation, Transduction and Conjugation. Endospores and sporulation in bacteria. Control of Microorganisms: By physical, chemical and chemotherapeutic Agents	**15**
Unit III	**Study of Biomolecules:** **Carbohydrates:** Monosaccharides, Disaccharides, Polysaccharides, Classification. Introduction to: Structural Polysaccharides, Storage Polysaccharides, Complex Polysaccharides **Lipids:** Lipid Classification, Fatty Acids, Triacylglycerols, Glycerophospholipids, Sphingolipids Cholesterol. Storage Lipids, Lipids as Signals, Cofactors, and Pigments. **Nucleic acids:** Deoxyribose nucleic acid (DNA) Ribonucleic acid (RNA) Components of Nucleic acids, Nucleotides, Purines and Pyrimidines,	**20**

	Structure and types of nucleic acids **Proteins:** Overview of amino acids and protein, Peptide bond, Primary, Secondary, Tertiary and Quaternary Structures. Fibrous protein, globular proteins. Protein Stability, Biological functions of proteins, Proteins as biocatalysts (Enzymes). **Vitamins and Minerals:** Importance and role of vitamins, Types of vitamins, water soluble and fat soluble vitamins. Minerals, micronutrients, macronutrients, roles and functions, disorders of mineral deficiency.	
Unit IV	**Microbes and humans** Helpful microorganisms: Microbes in Household Products, in Industrial Products, in Sewage Treatment, in Production of Biogas, Microbes as Biocontrol Agents, as Biofertilisers Harmful Microorganisms, Common Human Diseases caused by Microorganisms, Microbial Control Antimicrobial activity, nanomaterials as antimicrobial agents, concept of MIC, MBC.	**10**

Note:

Reference Books:

1. Prescott's Microbiology, McGraw Hill; 10th edition
2. General Microbiology by Stanier, Adelberg and Ingraham, The Macmillan Press Ltd, Hong Kong
3. Lehninger's Principles of Biochemistry by D. L. Nelson and M. M. Cox, CBS Publications, 2000
4. Biochemistry by Lubert Stryer, 4th Edition

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Part – II, SEM III
Laboratory Course – III
(Practical: 60 Lectures) (Credits: 02)

(Fundamentals of Microbiology and Biochemistry)

Course Learning outcomes:

After going through the course, the student should be able to

- Understand and perform the preparation of media & sterilization methods, Methods of Isolation of bacteria from different sources and study of colony characteristics, bacterial staining, etc.
- Learn the separation of Amino acids by paper chromatography
- Able to demonstrate of Principles of Colorimetry
- Estimation of amino acid, proteins, carbohydrates by different methods
- Evaluate the nanomaterials as antimicrobial agents

Sr. No.	Name of experiment
1	Isolation of bacteria & their biochemical characterization.
2	Staining methods: simple staining, Gram staining, spore staining, negative staining, hanging drop.
3	Preparation of media & sterilization methods, Methods of Isolation of bacteria from different sources.
4	Determination of bacterial cell size by micrometry.
5	Enumeration of microorganism - total & viable count.
6	Preparation of buffers.
7	Separation of Amino acids by paper chromatography.
8	Qualitative tests for Carbohydrates, lipids and proteins.
9	Principles of Colorimetry: i) Verification of Beer's law, estimation of protein. ii) To study relation between absorbance and % transmission.
10	Determination of total amino acid concentration by ninhydrin method.
11	Estimation of protein concentration by i) Biuret method ii) Lowry method
12	Estimation of reducing sugar concentration by DNSA method
13	Estimation total sugar concentration by i) Phenol-H2SO4 method ii) Anthrone method
14	Enrichment and isolation of metal tolerance microorganisms
15	Test of microbial metal tolerance
16	Demonstration of metal nanomaterials as antimicrobials

Reference Books:

1. Practical Microbiology, by Maheshwari D.K., S Chand & Company
2. Practical Biochemistry: An Introductory Course by Fiona Frais.
3. Textbook of Practical Biochemistry by David Plummer.
4. Laboratory Mannual in Biochemistry by S. Jayaraman.

SHIVAJI UNIVERSITY, KOLHAPUR
School of Nanoscience and Biotechnology
B. Sc. –M.Sc. in Nanoscience and Technology, (5 Years Integrated) Programme,
Part – II, Semester- III

Statistical Techniques for Nanotechnology

(Theory: 60 Lectures)

Course Learning Outcomes:

On successful completion of this course, the student should be able to:

- Identify and differentiate between primary and secondary data and distinguish between ungrouped and grouped data.
- Construct discrete and continuous frequency distributions.
- Create graphical presentations of data, including histograms, frequency curves, and boxplots.
- Compute various statistical measures
- Define correlation and regression in the context of ungrouped data.
- Analyze bivariate data using scatter diagrams.
- Calculate Karl Pearson's coefficient of correlation and Spearman's Rank Correlation coefficient.
- Understand the concept of regression, lines of regression, and the least square method.
- Compute regression coefficients and establish the relationship between correlation and regression coefficients.
- Introduce the concept of multiple linear regression.

Unit No.	Particulars	No. of Lectures
I	**Nature and Graphical Representation of Data** Data, Classification of data: Primary and secondary data, ungrouped and grouped data, qualitative data (attributes), and quantitative data (variables). Scales of measurements, Discrete and continuous frequency distribution, Graphical presentation of data: Histogram, frequency curve, ogive curve, Boxplot.	15

II	**Measures of Central Tendency** Concept of central tendency, criteria for good measures of central tendency. Arithmetic mean (A.M.), A.M., Mean of pooled data, Weighted A.M. Geometric mean (G.M.), Harmonic mean (H.M.), median, mode, and their properties. Computations of A.M., G.M., H.M., median, and mode for ungrouped and grouped data. Comparison between averages in accordance with requirements of good average.	**15**
III	**Measures of Dispersion** Concept of dispersion, requirements of a good measure of dispersion, measures of dispersion, absolute and relative measures of dispersion. Range, mean deviation, standard deviation, and their relative measures. Variance, coefficient of variation, and its use. Concepts and measures of skewness and kurtosis.	**15**
IV	**Correlation and Regression** Correlation and regression (for ungrouped data): Bivariate data, concept of correlation, scatter diagram, Karl Pearson's coefficient of correlation, Spearman's Rank Correlation coefficient. Regression: concept, lines of regression, least square method, regression coefficients, relation between correlation and regression coefficients. Concept of multiple linear regression.	**15**

Reference:

1. Bhat B. R., Srivenkatramana T. and Madhava Rao K. S. (1996): Statistics: A Beginner's Text, Vol. 1, New Age International (P) Ltd.
2. Goon A.M., Gupta M.K., and Dasgupta B.: Fundamentals of Statistics Vol. I and II, World Press, Calcutta.
3. Hogg R. V. and Crag R. G.: Introduction to Mathematical Statistics Ed.4.
4. Hoel P. G. (1971): Introduction to Mathematical Statistics, Asia Publishing House.
5. Mood A. m., Graybill F. A. and Boes D. C. (1974): Introduction to the Theory of Statistics, McGraw Hill.

6. Rohatgi V. K. and Saleh A. K. Md. E. (2002): An Introduction to probability and statistics. John wiley & Sons (Asia)
7. Snedecor G.W. and Cochran W. G. (1967): Statistical Methods, Lowa State University Press.
8. Waiker and Lev.: Elementary Statistical Methods.
9. Gupta S. C. and Kapoor V. K.: Fundamentals of Mathematical Statistics.
10. Martin B. R. (2012): Statistics for Physical Sciences-An Introduction
11. Stanford J. L. and Vardeman S. B. (1994): Statistical Methods for Physical Science (Volume 28)

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B. Sc. –M.Sc. in Nanoscience and Technology, (5 Years Integrated) Programme,
Part – II, Semester- III

Name of Paper: Electronic Instrumentation

(Theory: 60 Lectures)

Course Learning Outcomes:
On successful completion of this course, the student should be able to:

- Understand basic principles of electronic instrumentation.
- Understand the basic principles of measurement and error, SI units, and standard of measurement.
- Apply problem-solving skills to various instrumentation domains
- Understand physical and technical knowledge of sensors, actuators, and signal conditioning systems.
- Describe basic laws and phenomena that define the behavior of sensors and actuators
- Apply knowledge about the working principles and architecture of a large number of sensors and their elements.
- Analyze various approaches, procedures, and results related to impendence measurement, voltage, and current measurements.
- Understand the basic principles and apply knowledge related to data converter and data acquisition systems.

Unit No.	Particulars	No. of Lectures
I	**Principle of Measurements** **Measurement and error:** Static and dynamic characteristics of an instrument, error in the measurements and types of static error, dynamic response of an instrument, significant figure and rounding off the numbers, statistical analysis: Mean, standard deviation, and coefficient of variation. **System of units of measurement**: fundamental and derived units, international system of units, other system of units. **Standard of measurements:** classification of standard, the standard for mass, length, and volume, electrical standard, international standards.	12
II	**Sensors and Actuators** Classification of the transducer, selecting of the transducer, Electrical Transducers and their parameters; Types of Transducers: Electroacoustic transducers (microphone and speaker), Force/Pressure	18

	transducers (resistance pressure transducer, strain gauge, and load cell), Temperature Transducers (Thermistor, Thermocouple and RTD), Fiber Optical sensors, Smart sensors, signal conditioner: Introduction to Instrumentation Amplifier and active filters.	
III	**Measurement techniques** **Impendence measurement:** Introduction, resistance measurement-Voltmeter-Ammeter method and Whetstone Bridge method, measurement of low resistance: Kelvin's bridge method, Inductance measurement: Maxwell's bridge, capacitance measurement: Schering bridge, frequency measurement: Wien bridge, Q-meter, complex impendence measurement meters, and digital LCR Q-meter. **Voltage and Current measurement:** Introduction, basic DC ammeter, basic DC voltmeter.	**18**
IV	**Data Converter and Data Acquisition System** **Data converter:** D/A converter: Weighted resistor network and R-2R network, A/D Converter: A/D Converter circuit: parallel comparator, successive approximation, and dual slope ADC. **Data Acquisition System:** Block diagram of DAS, the objective of DAS, single-channel and multi-channel Data Acquisition System, computer-based data acquisition system, and data loggers.	**12**

Reference Books:

1. H. S. Kalsi, Electronic Instrumentation, TMH(2006)
2. W.D. Cooper and A. D. Helfrick, Electronic Instrumentation and Measurement Techniques, Prentice-Hall (2005).
3. Instrumentation Measurement and analysis: Nakra B C, Chaudry K, TMH
4. E.O.Doebelin, Measurement Systems: Application and Design, McGraw Hill Book - fifth Edition (2003).
5. Joseph J Carr, Elements of Electronic Instrumentation and Measurement, Pearson Education (2005)
6. David A. Bell, Electronic Instrumentation and Measurements, Prentice Hall (2013).
7. Oliver and Cage, “Electronic Measurements and Instrumentation”, TMH (2009).
8. Alan S. Morris, “Measurement and Instrumentation Principles”, Elsevier (Butterworth Heinemann- 2008).
9. A. K Sawhney, Electrical and Electronics Measurements and Instrumentation, Dhanpat Rai, and Sons (2007).
10. C. S. Rangan, G. R. Sarma, and V. S. Mani, Instrumentation Devices and Systems, Tata Mcgraw Hill (1998).

SHIVAJI UNIVERSITY, KOLHAPUR
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B. Sc. –M.Sc. in Nanoscience and Technology, (5 Years Integrated) Programme,
Part – II, SEM III
Laboratory Course – IV
(Practical: 60 Lectures) (Credits: 02)

(Statistical Techniques for Nanotechnology + Electronic Instrumentation)

Course Learning Outcomes of Statistics Lab:
On successful completion of this course, the student should be able to:

- Apply knowledge of the graphical presentation of the frequency distribution
- Analyze the data and evaluate the central tendency, dispersion, skewness & kurtosis
- Apply knowledge of correlation and regression
- Understand multiple regression and partial and multiple correlations

Course Learning Outcomes of Instrumentation Lab:
On successful completion of this course, the student should be able to:

- Apply knowledge of electronic instrumentation
- Design experiments in the laboratory on real components
- Evaluate the sensors, actuators, and signal conditioning systems
- Interpret the acquired data and measured results

Name of Experiments
Statistics Lab 1. Graphical presentation of the frequency distribution 2. Measures of central tendency 3. Measures of dispersion 4. Correlation Analysis 5. Regression Analysis
Instrumentation Lab (Any Five) 1. Study of Uncertainty & Errors 2. Study of Load Cell 3. Study of LVDT 4. Study of Thermistors 5. Study of LDR 6. Study of Photodiode 7. Study of Phototransistor 8. Study of Analog to Digital Converter 9. Study of Digital to Analog Converter 10. Study of Fiber optic sensor

SHIVAJI UNIVERSITY, KOLHAPUR
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B. Sc. –M.Sc. in Nanoscience and Technology, (5 Years Integrated) Programme,
Part – II, Semester- III

Indian Knowledge System- IKS in Nanoscience
(Theory: 30 Lectures)

Course objectives/outcomes
On completion of this course, the students will be able to understand:

CO1	*Importance of Ancient knowledge and unique aspects of IKS and its relevance in modern day's studies and research.*
CO2	*Nature of contributions made by ancient Indian scientist.*
CO3	*Develop familiarity with science and technology heritage of ancient India.*
CO4	*Basic framework to health and disease management as spelt out in Ayurevda.*

Unit No.	Topics	Total lecture
I	**Introduction to Indian Knowledge System (IKS)** *Importance of Ancient knowledge*, Define Indian knowledge system, historicity and some unique aspects of IKS	05
II	**Ancient mathematics and astronomy:** *Unique aspects of mathematics,* great mathematicians and their contribution, arithmetic, geometry, trigonometry, binary mathematics. *Unique of Indian astronomy*, historical development of astronomy in India, astronomical instruments.	10
III	**Metals & metal working:** *Wootz steel:* rise and fall of great Indian technology, mining and ore extraction, gold extraction process, zinc production, copper mining and extraction process, copper alloys, mercury, lead and silver, extraction of iron from biotite by ayurvedic method, Apparatus used for extraction of metallic components.	10
IV	**Health and wellness:** *Ayurevda,* disease management, diagnostic techniques, drugs and physical therapy.	05

References & text books:

1. Introduction to Indian knowledge system concepts and applications, B. Mahadevan, V. R. Bhat, Nagendra PRN, PHI learning pvt. Ltd. (2022).
2. Glimpses of Indian engineering and technology, R. P. Kulkarni, Munshiram Manoharlal Publishers pvt. Ltd. (2018).
3. Vedic science and technology, S. Biswal, B. L. Ray, B. K. Print world. (2009).
4. Mathematics, Astronomy and biology in Indian tradition, D. P. Chadopadhaya, Munshiram Manoharlal Publishers pvt. Ltd. (1995).

SHIVAJI UNIVERSITY, KOLHAPUR
School of Nanoscience and Biotechnology
B. Sc. –M.Sc. in Nanoscience and Technology, (5 Years Integrated) Programme,
Part – II, SEM IV

Waves and Optics

(Theory: 60 Lectures)

Course Learning Outcomes:

After going through the course, the student should be able to

- Recognize and use a mathematical oscillator equation and wave equation, and derive these equations for certain systems.
- Understand the principle of superposition of waves, so describe the formation of standing waves.
- Understand the ultrasonic sound and applications of ultrasonic sound.
- Understand and explain the working mechanisms of electroacoustic transducers such as microphones and loudspeakers.
- Understand the basics of acoustics of hall.
- Explain several phenomena we can observe in everyday life that can be explained as wave phenomena.
- The cardinal points help us define the image properties of an optical system
- Use the principles of wave motion and superposition to explain the Physics of polarization, interference and diffraction.

Unit No.	Topics	Total Lectures
Unit I	**1. Superposition of Harmonic Oscillations** Linearity and superposition principle, Superposition of two collinear harmonic oscillations for oscillations having equal frequencies: Analytical method, oscillations having different frequencies (Beats), Superposition of two perpendicular harmonic oscillations: for oscillations having equal frequencies (Analytical method). Oscillations having different frequencies (Lissajous figures), Uses of Lissajous figures. **2. Coupled Oscillations** Frequencies of coupled oscillatory systems, normal modes and normal co-ordinates, energy of coupled oscillations, energy transfer in coupled oscillatory system.	(15 Lectures)

Unit II	1. **Wave Motion and Ultrasonic Waves** Wave Motion: Transverse waves on a string, travelling and standing waves on a string, Normal modes of a string, Group velocity and Phase velocity, Plane waves, Spherical waves. Ultrasonic waves: Piezo-electric effect, Production of ultrasonic waves by Piezoelectric oscillator, Detection of ultrasonic waves, Properties of ultrasonic waves, Applications of ultrasonic wave. 2. **Sound and Acoustics of Buildings** Sound: Transducers and their characteristics, Pressure microphone, Moving coil loudspeaker, Intensity and loudness of sound, Decibels, Intensity levels, Acoustics of buildings: Reverberation and time of reverberation, Absorption coefficient, Sabine's formula for reverberation time, Acoustic aspects of halls and auditoria	(15 Lectures)
Unit III	1. **Cardinal Points** Cardinal points of an optical system (definitions only), graphical construction of image using cardinal points, Newton's formula, relation between f and f' for any optical system, relation between lateral, axial and angular magnifications. 2. **Interference** Principle of Superposition, Coherence and condition for interference, Division of amplitude and division of wave front, Lloyds single mirror (determination of wavelength of light of monochromatic source), Interference in thin parallel films (reflected light only), Wedge shaped films, Newton's rings and its application for determination of wavelength and refractive index of light. 3. **Diffraction** Fraunhofer diffraction, Fresnel's diffraction, Elementary theory of plane diffraction grating, Determination of wavelength of light using diffraction grating, Theory of Fresnel's half period zones, Zone plate (construction, working and its properties), Fresnel's diffraction at straight edge.	(20 Lectures)

Unit IV	1. **Resolving Power of Optical Instruments** Resolution, resolving power (RP) of optical instruments, Rayleigh's criterion for the limit of resolution, Modified Rayleigh's criterion, comparison between magnification and resolution, RP of plane diffraction grating, RP of a prism. 2. **Polarization of Light** Idea of polarization, polarization by double refraction, Huygens explanation of double refraction through uniaxial crystal, Nicol prism (construction, working), production of circularly and elliptically polarized light, optical rotation - laws of rotation of plane of polarization, polarimeter.	(10 Lectures)

Reference Books:

1) The Physics of Waves and Oscillations- N. K. Bajaj, Tata McGraw-Hill Reprint 2022.
2) Physics of Degree Students- C. L. Arora and Dr. P. S. Hemne, S Chand & company
3) A Text Book of Sound- Khanna and Bedi, Atma Ram & Sons, Delhi.
4) Waves and Oscillations-N Subrahmanyam, BrijLal. Vikas 2nd edition, Reprint 2022
5) Electronic Instrumentation – H.S. Kalasi McHraw , Hill
6) Optics – Ajoy Ghatak, 2021, McGraw Hill.
7) A Textbook of Optics- N. Subrahnmanyam, Brij Lal, M.N. Avadhanulu, S.Chand.
8) A Textbook of Light- D.N. Vasudeva, Atma ram and Sons.
9) Waves and Optics – M. N. Avadanulu , TVS Arun Murthy, S. Chand.
10) Fundamentals of Optics – Devraj Singh PHI Learning.
11) Elements of Properties of Matter-D.S. Mathur, S. Chand.

SHIVAJI UNIVERSITY, KOLHAPUR
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Part – II, SEM IV
Laboratory Course – I
(Practical: 60 Lectures) (Credits: 02)
(Waves and Optics)

Sr. No.	Name of experiment
1	To investigate the motion of coupled oscillators.
2	To determine the frequency of an electrically maintained tuning fork by Melde's experiment and to verify λ2– T Law.
3	To study Lissajous figures by using CRO.
4	To determine coefficient of viscosity of water by capillary flow method (Poiseuille's method).
5	To determine velocity of sound in air by Kundt's tube and audio oscillatoror Phase shift method (CRO and microphone).
6	To determine viscosity of liquid by Searle's viscometer.
7	To determine velocity of sound in air by resonating bottle.
8	To determine frequency of a crystal oscillator.
9	To determine the Resolving Power of a Prism.
10	To determine the Resolving Power of a Plane Diffraction Grating.
11	To determine wavelength of sodium light using diffraction due to straight edge/Biprism.
12	To determine wavelength of sodium light using Newton's Rings.
13	Determine thickness of thin film using interference in wedge shaped thin film.
14	Goniometer I-To study cardinal points of optical system.
15	Goniometer II- To study the equivalent focal length of optical system.
16	To study angle of specific rotation of sugar using Polarimeter.

Note: Maximum 10 experiments from Lab course

Reference Books:

1. B.Sc. Practical Physics – Harnam Singh , P.S. Hemane, S. Chand.
2. Advanced Practical Physics for students, B.L. Flint & H.T. Worsnop, 1971, Asia Publishing House.
3. Advanced level Physics Practical, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers.

4. A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition, 2011, Kitab Mahal, New Delhi.
5. B.Sc. Practical Physics, C. L. Arora, S. Chand & Company Pvt. Ltd., New Delhi.

SHIVAJI UNIVERSITY, KOLHAPUR
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B. Sc. –M.Sc. in Nanoscience and Technology, (5 Years Integrated) Programme,
Part – II, Semester- IV

Coordination Chemistry, Semi-Micro Qualitative Analysis, Transition Elements, Chelation, Carboxylic acids, Carbonyl Compounds, Amines, Diazonium Salts, Carbohydrates, Stereochemistry

(Theory: 60 Lectures)

Learning objectives/outcomes

- Learning and understanding basic concepts about coordination complexes.
- Gain knowledge about applications of chelates in Analytical chemistry.
- Student will be capable of understanding the properties of 3d series elements.
- Understanding the properties of 4f elements.
- Student will learn the basic knowledge about the qualitative analysis of inorganic compounds.
- To impart knowledge about the synthesis, reactivity and applications of carboxylic acids.
- Knowledge about classification, preparation and applications of amines and diazonium salts.
- Understanding the classification, configuration and structure of carbohydrates.
- Student will be capable of understanding the nomenclature and reactivity of aldehydes and ketones.
- Student will learn the basic knowledge of conformational analysis of some organic compounds.

Unit No.	Topics	Total Lectures
Unit I	**Coordination Chemistry, Inorganic Semi-Micro Qualitative Analysis** **Coordination Chemistry: (8L)** Introduction-Definition and formation of co-ordinate covalent bond in BF_3– NH_3, $[NH_4]^+$ and H_2O. Terminology- Description of the terms- ligand, co-ordination number, coordination sphere. Effective atomic number rule. Distinguish between double salt and complex salt. Werner's theory. Postulates. The theory as applied to cobalt amines viz. $CoCl_3.6NH_3$, $CoCl_3.5NH_3$, $CoCl_3.4NH_3$, $CoCl_3.3NH_3$, IUPAC nomenclature of coordination compounds. Isomerism in complexes with C.N. 4 and 6. Geometrical Isomerism, Optical Isomerism. Structural Isomerism- Ionization Isomerism, Hydrate Isomerism, Coordination Isomerism, Linkage Isomerism and Co-ordination position Isomerism Valance bond theory of transition metal complexes with respect to,	**(15)**

	C.N. = 4, complexes of Cu and Ni, C.N. = 6 complexes of Fe and Co Valence Bond Theory (VBT): Inner and outer orbital complexes of Cr, Fe, Co, Ni and Cu (coordination numbers 4 and 6). Structural and stereoisomerism in complexes with coordination numbers 4 and 6. Drawbacks of VBT. IUPAC system of nomenclature. **Inorganic Semi-Micro Qualitative Analysis: (7L)** Theoretical principles involved in qualitative analysis. Applications of solubility product and common ion effect in separation of cations into groups. Applications of complex formation in a) Separation of II group into IIA and IIB sub-groups. b) Separation of Copper from Cadmium. c) Separation of Cobalt from Nickel. d) Separation of Cl^-, Br^-, I^-. e) Detection of NO_2^-, NO_3^- (Brown ring test). Application of oxidation and reduction in a) Separation of Cl^-, Br^-, I^-in mixture b) Separation of NO_2^- and NO_3^- in mixture.	
Unit II	**Chemistry of Elements of 3d, 4f Series Elements, Chelation** **3d Series Elements: (6L)** Position of elements in periodic table Characteristics of d-block elements with special reference to i) Electronic structure ii) Oxidation states, stability of oxidation states of Fe with respective to Latimer diagram iii) Magnetic character iv) Colored ions v) Complex formation. **4f Series Elements: (6L)** Position of lanthanides in periodic table, Occurrence Characteristics of 4f elements with special reference to 1. Electronic configuration 2. Oxidation states 3. Magnetic properties	**(15)**

	4. Lanthanide contraction Separation of lanthanides by ion exchange method. **Chelation: (3L)** A brief introduction with respect to ligands, chelating agent, chelation and metal chelates. Structural requirements of chelate formation. Difference between metal chelate and metal complex. Classification of chelating agents (with specific illustration of bidentate chelating agents). Application of chelation with respect to chelating agents - EDTA and DMG.	
Unit III	**Carboxylic acids and derivatives, Carbonyl Compounds, Amines, Diazonium Salts** **Carboxylic acids and derivatives: (6L)** Carboxylic acids (aliphatic and aromatic) Preparation: Acidic and Alkaline hydrolysis of esters. Monocarboxylic acid: Introduction, Methods of Formation from Alcohols, Aldehydes, Ketones, Nitriles and Alkyl benzenes. Halo acids: a) Synthesis of halo acids-Mono, Di, Tri- chloro acetic acid by HVZ reaction b) Reactions - Substitution reaction of Monochloro acetic acid by Nucleophile OH^-, I^-, CN^- and NH_3, Hydroxy acids: Citric acid, Methods of formation of Citric acid from glycerol. Chemical Reactions: Reaction of citric acid: acetylation by acetic anhydride, reduction by HI, action of heat. Di carboxylic acids: Introduction, Method of formation of succinic acid from ethylene dibromide, maleic acid, Chemical Reactions: Action of heat, Action of $NaHCO_3$, C_2H_5OH in presence of Acid. Method of formation Phthalic acid from o-xylene and Naphthalene, Chemical Reactions of Phthalic acid : Action of heat, reaction with sodalime, ammonia. Carboxylic acid derivatives: Introduction, Acid halide derivative: Acetyl chloride: Synthesis from acid, by action with PCl_3 and $SOCl_2$. Reaction with water, alcohol (Mechanism of esterification is expected) and ammonia. Acid anhydride derivative: Synthesis of acetic anhydride by dehydration of acetic acid. Reactions with water, alcohol and ammonia. Hell – Vohlard - Zelinsky Reaction. Carboxylic acid derivatives (aliphatic): (Upto 5 carbons). Comparative study of nucleophilicity of acyl derivatives. Use of carboxylic acids and derivatives for nanoparticle synthesis and stabilization like citric acid, oxalic acid. (examples with schemes only). **Carbonyl Compounds: (5L)** Introduction, Nomenclature of aliphatic and aromatic aldehydes and ketones. Structure and reactivity of Carbonyl group. Reactions of	**(15)**

	Carbonyl Compounds- Mechanism and applications of ----- i) Aldol condensation, ii) Claisen and Benzoin Condensation, iii) Perkins reaction, iv) Cannizaros reaction, v) Knoevenagel condensation and vi) Reformatsky reaction. vii) Perkin condensation. **Amines, Diazonium Salts: (4L)** Amines: i) Introduction, Classification and Nomenclature ii) Methods of preparation: a) From alkyl halide by amonolysis b) By reduction of nitriles or cyanides c) From unsubstituted amides (Hoffmann degradation), d) By Gabrial synthesis (From Phthalamide). iii) Reactions: Carbylamine reaction, Schotten-Baumann reaction, Electrophilic substitution (Aniline) - Nitration, Bromination, Sulphonation. Diazonium salt: i) Introduction. ii) Preparation of Benzene diazonium chloride. iii) Reactions of Benzene diazonium chloride. a) Replacement reaction -Sandmeyers reaction. b) Coupling reactions: Synthesis of Congo red. Concept of catalytic reduction reaction of p-nitrophenol to p-amino phenol towards circular economy.	
Unit IV	**Carbohydrates, Stereochemistry** Carbohydrates: (11L) Introduction Classification of carbohydrates, reducing and non-reducing sugars. Physical properties of glucose and fructose. Killiani's synthesis of Glucose from D- Arabinose. Determination of structure of D-Glucose. a) Open chain structure of D- Glucose. b) Configuration of D- Glucose from D- Arabinose. c) Ring structure of D- Glucose. d) Size of ring in D- Glucose by methylation Method. e) Haworth projection for D- Glucose. Cyclic structure of Fructose. Structures of Disachharides: a) Linkage between Monosachharides. b) Open chain and Haworth cyclic structures of Sucrose, Lactose and Maltose. Structures of Polysachharides: a) Starch b) Cellulose Concept of glucose as reducing agent for nanoparticle synthesis, nanocellulose and their sources. **Stereochemistry: (4L)** Basic Concept of stereochemistry, Introduction to D/L, d/l, R/S, E/Z nomenclature, Stereochemistry of Carbohydrate (few examples) and Symmetry elements and operations (concepts only)	**(15)**

References:

1. Morrison, R. T. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd.
2. (Pearson Education).
3. Stereochemistry conformation & Mechanism, 9th Edition, By P.S.Kalasi, Publisher:
4. New Age International, 2017
5. Stereochemistry of carbon compounds by Eliel.
6. Stereochemistry of Organic Compounds by D. Nasipuri.

7. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd.
8. (Pearson Education).
9. Finar, I. L. Organic Chemistry (Volume 2), Dorling Kindersley (India) Pvt. Ltd.
10. Organic Chemistry. Volume I, II, III by S.M. Mukharjee, S.P. Singh and R.P. Kapoor.
11. Wiley Eastern Limited (New Age International)
12. Advanced Organic Chemistry by, B.S. Bahl, ArunBahl. S.Chand& Company, Ltd.
13. Chemistry by R. L. Madan, S. Chand and Company Ltd.
14. Kotz, J.C., Treichel, P.M. & Townsend, J.R. General Chemistry Cengage Learning India Pvt. Ltd., New Delhi (2009).
15. Mahan, B.H. University Chemistry 3rd Ed. Narosa (1998).
16. Petrucci, R.H. General Chemistry 5th Ed. Macmillan Publishing Co.: New York (1985).
17. Cotton, F.A. & Wilkinson, G. Basic Inorganic Chemistry, Wiley.
18. Shriver, D.F. & Atkins, P.W. Inorganic Chemistry, Oxford University Press.
19. Wulfsberg, G. Inorganic Chemistry, Viva Books Pvt. Ltd.
20. Rodgers, G.E. Inorganic & Solid State Chemistry, Cengage Learning India Ltd., 2008
21. Inorganic chemistry, Principles of structure and reactivity by J.E. Huheey and etal
22. Vogels text book of Qualitative Inorganic analysis by A. I. Vogel .3rd and 6th edition
23. Advanced Inorganic Chemistry by Agrawal Keemtilal (Pragati Prakashan)
24. Theoretical Inorganic chemistry by C.Day & J.Selbin IInd edition
25. Principles of inorganic chemistry by Puri Sharma & Kalia
26. Modern Inorganic chemistry by R.D.Madan (S.Chand)
27. Inorganic Chemistry by J.D.Lee
28. Chemistry for Degree students by R.L.Madan (S.Chand Publication
29. Concise Coordination Chemistry by Ramlingam, Ramgopalan
30. Hornyak, G.L., Tibbals, H.F., Dutta, J. and Moore, J.J., 2008. Introduction to Nanoscience and Nanotechnology. CRC press.

SHIVAJI UNIVERSITY, KOLHAPUR
School of Nanoscience and Biotechnology
B. Sc. –M.Sc. in Nanoscience and Technology, (5 Years Integrated) Programme,
Part – II, SEM IV
Laboratory Course – II
(Practical: 60 Lectures) (Credits: 02)

(Coordination Chemistry, Semi-Micro Qualtitative Analysis, Transition Elements, Chelation, Carboxylic acids, Carbonyl Compounds, Amines, Diazonium Salts, Carbohydrates, Stereochemistry)

A) Inorganic Chemistry

1) Inorganic Preparations (Any One):

i) Preparation of hexammine nickel (II) chloride

ii) Preparation of tetrammine copper (II) sulphate.

2) Semi-micro Qualitative Analysis:

Analysis of binary mixtures with non interfering cations and anions (at least 6 mixtures to be analyzed)

i) Following anions are to be given : Cl^-, Br^-, I^-, NO_3^-, CO_3^{2-}, SO_4^{2-} , S^{2-}, (insoluble CO_3^{2-} may be given)

ii) Following cations are to be given: Cu^{2+}, Cd^{2+} Al^{+3}, Fe^{+3}, Cr^{+3}, Zn^{+2}, Mn^{+2}, Ni^{+2}, Co^{+2}, Ca^{+2}, Ba^{+2}, Mg^{+2}, NH^{4+}, K^+

Note:- Use of spot tests to be made whenever possible.

3) Titrimetric Analysis:

i) Fertilizer analysis: To determine percentage of nitrogen in the given sample of a nitrogenous fertilizer (ammonium sulphate). Known weight of the sample to be taken by the student. For preparing its solution which is to be refluxed with known excess of alkali. Standard HCl solution to be supplied.

ii) Determination of total hardness of water using 0.01M EDTA solution.

(Students should standardize the given EDTA solution by preparing 0.01M $CaCl_2$ solution. using $CaCO_3$ salt.)

B) Organic Chemistry:

1) Organic Qualitative Analysis : Identification of at least Eight Organic compounds with reactions including two from acids, two from phenols, two from bases and two from neutrals. Acids – Succinic acid, Phthalic acid, alicylic acid, Aspirin.

Phenols – Alpha-Naphthol, o-nitrophenol, p-nitrophenol.

Bases – o, m- and p-nitroanilines, Diphenyl amine.

Neutrals – Urea, Acetanilide, Carbon tetrachloride, Bromobenzene, Methyl acetate, Nitrobenzene, Naphthalene, Anthracene, Ethyl methyl ketone.

Note: A systematic study of an organic substance involves reactions in the determination of elements and functional group.

2) Organic Quantitative Analysis:

I) Estimations (Any Three)

i) Estimation of acetone.

ii) Estimation of vitamin C.

iii) Estimation of Phenol by Bromination method

iv) Estimation of formaldehyde by sodium sulphite method

v) Estimation of ester.

II) Organic preparations

i) p-nitro acetanilide from acetanilide.

ii) Acetanilide from aniline using anhydrous $ZnCl_2$ and Zn dust.

iii) Phthalimide from phthalic anhydride.

iv) Benzoic acid from benzamide.

3) Demonstration of Thin layer chromatography. Separation, identification and determination of Rf values

References:

1. Mendham, J.Vogel's Quantitative Chemical Analysis, Pearson 2009.
2. Khosla, B. D.; Garg, V. C. &Gulati, A.Senior Practical Physical Chemistry, R. Chand & Co: New Delhi (2011).
3. Findlay' Practical Physiccal Chemistry (Longmann)2015.
4. Practical Physical Chemistry : Gurtu (S Chand) 2014.
5. Systematic Experimental Physical Chemistry :Rajbhoj, Chandekar(Anjali Publication) 2016.
6. Advanced Practical Physical Chemistry: J.B. Yadav (Goel Publishing House) 2015.
7. Vogel's text book of Qualitative Inorganic analysis by A. I. Vogel .3rd and 6th edition
8. Vogel's text book of Quantitative Inorganic Chemistry by A. I. Vogel.
9. Physical Chemistry of Inorganic qualitative analysis by Kuricose & Rajaram.
10. Practical manual in water Analysis by Goyal & Trivedi

11. Practical Organic Chemistry by A.I. Vogel.
12. Hand book of Organic qualitative analysis by H.T. Clarke.
13. A Laboratory Hand Book of Organic qualitative analysis and separation by V.S.Kulkarni. Dastane Ramchandra & Co.
14. Practical Organic Chemistry by F.G. Mann and B.C. Saunders. Low – priced Text Book. ELBS. Longman
15. Advanced Practical Organic Chemistry by N.K. Vishnoi. Vikas Publishing House Private Limited.
16. Advanced practical chemistry by J. Singh, L. D. S. Yadav, R. K. P. singh, I. R. Siddiqui et.al, Pragati prakashan.

SHIVAJI UNIVERSITY, KOLHAPUR
School of Nanoscience and Biotechnology
B. Sc. –M.Sc. in Nanoscience and Technology, (5 Years Integrated) Programme,
Part – II, Semester- IV

Fundamentals of Immunology and Nanodiagnostics

(Theory: 60 Lectures)

Course Learning Outcomes:

After going through the course, the student should be able to

- Understand basics of Immunology terms and concepts- Immunity, Immune system, cells and organs of the immune system, Antigen, Antibody, etc.
- Can deal with T- lymphocytes and B-lymphocytes immune response, Antibody MHC complexes, Autoimmune & Immunodeficiency diseases, Vaccines, Vaccination, ELIZA, RIA, etc.
- Can understand different techniques and applications of nanoparticles, nanochips, nanobiosensor, nanoprobes, etc. in nanodiagnostics of different diseases.
- Can understand applications of nanotechnology in immunology.

Unit No.	Topics	Total Lectures
Unit I	**Basics of Immunology:** Introduction, History, Phylogeny, Overview of immune system, innate and adaptive immunity, hematopoiesis, cells and organs of immune system **Antigen:** Introduction to the concept of immunogenicity, antigenicity, factors influencing immunogenicity, epitopes, haptens, pattern recognition receptors. **Antibody:** Basic structure of antibody, antibody classes and biological activities, antigenic determinants and immunoglobulins	**15**
Unit II	**Concepts of immunology:** Action of antibodies, Introduction to Major Histocompatibility complexes (MHC) – class I & class II, antigen processing and presentation. Co-receptors, Cluster of differentiation (CD), cytokines T-lymphocytes & immune response T-cell receptors, T-cell activation and differentiation (cytotoxic T-cell, helper T-cell, suppressor T-cells), B-lymphocytes & immune response, B-cell receptors, B-cell activation and differentiation. Monoclonal antibodies, Hybridoma technology,	**15**
Unit III	**Concepts of immunity developments:** Pathogen defense strategies, primary and secondary immune response, Activation of Innate Immune Defenses, Hypersensitivity: introduction, features and mechanisms, inflammation, autoimmunity autoimmune diseases, Immunodeficiency.	**15**

	The Complement System - Nomenclature of Complement Proteins, complement activation pathways Vaccines & Vaccination – passive & active immunization, adjuvants, cytokines, DNA vaccines, recombinant vaccines, bacterial vaccines, viral vaccines, vaccines to other infectious agents,.	
Unit IV	**Immunodiagnostics and Nanodiagnostics** Immunodiagnostics, Immunoassays: Immunofluorescence assays (IFAs), Radioimmunoassay (RIA), Enzyme-linked immunosorbent assay (ELISA), introduction to Immunohistochemistry and Flow Cytometry Nanotechnology in Diagnosis (Nanodiagnostics), Nanostructures for use in diagnostic and therapeutic applications (Nanotube, Nanocrystals, Nanobots, Nanowires, Quantum Dots), Nanoparticle-based platforms in Nanodiagnostics: Nanofluidics Microarray, Protein Nonobiochips, Microelectromechanical systems (MEMS), Nano Biosensors, Concepts of Nanobodies, Difference between Antibodies and Nanobodies, Uses of Nanobodies, Limitations of Nanobodies	**15**

Note:

Reference Books:

1. Abbas AK, Lichtman AH, Pillai S. (2007). Cellular and Molecular Immunology. 6th edition Saunders Publication, Philadelphia.
2. Delves P, Martin S, Burton D, Roitt IM. (2006). Roitt's Essential Immunology. 11th edition Wiley-Blackwell Scientific Publication, Oxford.
3. Goldsby RA, Kindt TJ, Osborne BA. (2007). Kuby's Immunology. 6th edition W.H. Freeman and Company, New York.
4. Murphy K, Travers P, Walport M. (2008). Janeway's Immunobiology. 7th edition Garland Science Publishers, New York.
5. Peakman M, and Vergani D. (2009). Basic and Clinical Immunology. 2nd edition Churchill Livingstone Publishers, Edinberg.
6. Richard C and Geiffrey S. (2009). Immunology. 6th edition. Wiley Blackwell Publication.

SHIVAJI UNIVERSITY, KOLHAPUR
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B. Sc. –M.Sc. in Nanoscience and Technology, (5 Years Integrated) Programme,
Part – II, SEM IV
Laboratory Course – III
(Practical: 60 Lectures) (Credits: 02)
(Fundamentals of Immunology and Nanodiagnostics)

Course Learning outcomes:

After going through the course, the student should be able to

- Understand and perform the preparation of media & sterilization methods, Methods of Isolation of bacteria from different sources and study of colony characteristics, bacterial staining, etc.
- Learn the separation of Amino acids by paper chromatography
- Able to demonstrate of Principles of Colorimetry
- Estimation of amino acid, proteins, carbohydrates by different methods
- Evaluate the nanomaterials as antimicrobial agents

Sr. No.	Name of experiment
1	Differential leucocytes count
2	Total leucocytes count
3	Total RBC count
4	Double diffusion.
5	Immunodiffusion.
6	Radial Immunodiffusion.
7	Rocket Immunodiffusion
8	Immunofluorescence
9	Haemagglutination assay
10	Haemagglutination inhibition assay
11	Separation of serum from blood
12	Double immunodiffusion test using specific antibody and antigen
13	ELISA
14	Dot Elisa
15	Preparation of nanoformulation and its evaluation.
16	Demonstration of design of nanodiagnostics device

Note:

Reference Books:

1. Abbas AK, Lichtman AH, Pillai S. (2007). Cellular and Molecular Immunology. 6th edition Saunders Publication, Philadelphia.
2. Delves P, Martin S, Burton D, Roitt IM. (2006). Roitt's Essential Immunology. 11th edition Wiley-Blackwell Scientific Publication, Oxford.

3. Goldsby RA, Kindt TJ, Osborne BA. (2007). Kuby's Immunology. 6th edition W.H. Freeman and Company, New York.
4. Murphy K, Travers P, Walport M. (2008). Janeway's Immunobiology. 7th edition Garland Science Publishers, New York.
5. Peakman M, and Vergani D. (2009). Basic and Clinical Immunology. 2nd edition Churchill Livingstone Publishers, Edinberg.
6. Richard C and Geiffrey S. (2009). Immunology. 6th edition. Wiley Blackwell Publication.

SHIVAJI UNIVERSITY, KOLHAPUR
School of Nanoscience and Biotechnology
B. Sc. –M.Sc. in Nanoscience and Technology, (5 Years Integrated) Programme,
Part – II, Semester- IV

Introduction to Data Science, AI, and ML

(Theory: 60 Lectures)

Course Learning Outcomes:

On successful completion of this course, the student should be able to:

- Understand the concept of data science and Big Data and its key components
- Explain the Classical and Axiomatic definitions of probability.
- Apply theorems on probability, including conditional probability and Bayes' theorem.
- Identify random variables and explore probability distributions such as Bernoulli, Binomial, Exponential, Weibull, and Normal Distributions.
- Discuss important properties and applications of probability distributions, especially in nanotechnology.
- Define sampling and explore types of sampling methods.
- Apply sampling methods to practical situations.
- Understand Exploratory Data Analysis (EDA) and its components.
- Differentiate between Artificial Intelligence and Machine Learning.
- Understand Supervised and Unsupervised machine learning techniques.
- Evaluate the various machine learning models.

Unit No.	Particulars	No. of Lectures
I	**Data Science, Probability and Probability Distributions** Understanding Data Science and its applications, Historical perspective and evolution of data science, Concept of Big data, Key components: Statistics, Programming, Domain Knowledge. Random experiments, sample space and classification of sample spaces, Classical and Axiomatic definition of probability, some	**20**

	theorems on probability, conditional probability, Bayes theorem, and applications Random variable, Probability distribution: Bernoulli distribution, Binomial distribution, Exponential distribution, Weibull and Normal Distribution, probability mass function and probability density function, mean and variance of these distributions, Important properties of these distributions, applications in nanotechnology.	
II	**Sampling and Exploratory Data Analysis** Sampling, Types of sampling: Simple random sampling (SRS), SRS with replacement, SRS without replacement, Stratified and cluster sampling and its applications. Exploratory Data Analysis (EDA): Variable identification, Missing values treatment, Outlier treatment, Variable transformation, Variable creation.	**15**
III	**Introduction to Artificial Intelligence and Machine Learning** Artificial Intelligence: Introduction, history, definition, concepts, applications; Artificial Intelligence vs Machine Learning; Machine Learning: Introduction, history, definition, concepts.	**10**
IV	**Types of Machine Learning Algorithms** Introduction to Supervised Learning: Classification and Regression Techniques - Decision Tree and Classification and Regression Tree (CART), Artificial Neural Network (ANN), Support Vector Machine (SVM), k-nearest neighbor (KNN). Introduction to Unsupervised Learning: Clustering - k-means clustering, Association Rule Mining algorithm; Reinforcement Learning: concept, definition and components. Model Evaluation: Introduction, Performance Measures, Confusion Matrix, R2 and mean square error.	**15**

References:

1. Rohatgi V.K., Saleh A. K. and Md. Ehsan: An Introduction to Probability and Statistics.
2. Kale B. K.: A first course on parametric inference.
3. Cochran W. G.: Sampling techniques.
4. Murthy M. N.: Sampling Theory and Methods.
5. Gupta S. C. and Kapoor V. K.: Fundamentals of Mathematical Statistics.
6. Martin B. R. (2012): Statistics for Physical Sciences-An Introduction
7. Stanford J. L. and Vardeman S. B. (1994): Statistical Methods for Physical Science (Volume 28)
8. Berson and Smith S.J. (1997): Data warehousing, Data Mining, and OLAP, McGraw-Hill.
9. Breiman J.H Friedman, R.A. Olshen and stone C.J. (1984) : Classification and Regression Trees, Wadsworth and Brooks / Cole.
10. Han, J., Kamber, M. and Pei, J., (2022). Data Mining Concept and Techniques, 3rd Edition, MK Publishers, 2014.
11. Mausam, An Introduction to Artificial Intelligence, NPTEL Lecture notes.
12. Mitchell T.M. (1997): Machine Learning, McGraw-Hill.
13. Russell, S and Norvig P., Artificial Intelligence: A Modern Approach, Prentice-Hall, Third Edition (2009)

SHIVAJI UNIVERSITY, KOLHAPUR
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Part – II, Semester- IV

Name of Paper: Analytical Instrumentation

(Theory: 60 Lectures)

Course Learning Outcomes:
On successful completion of this course, the student should be able to:

- Understand the operating principles and techniques of analytical instrumentation
- Understand how light interacts with matter and how it can be used for quantitative analysis
- Apply problem-solving skills to various scientific domains
- Analyze the basic components of spectroscopic instrumentation
- Knowledge of procedures and instrumental methods of analytical sciences
- Understand the basic concepts of instrumentation, data acquisition, and data processing
- Apply a working knowledge of UV-Vis spectroscopy, Fluorescence Spectroscopy, Phosphorescence Spectroscopy, IR spectroscopy, RAMAN spectroscopy, XRD, AAS, AES, SEM, AFM, etc.
- Evaluate the acquired data and measured results
- Provide practical experience in selected instrumental methods of analysis

Unit No.	Particulars	No. of Lectures
I	**Ultraviolet and Visible Spectroscopy** Introduction, nature of electromagnetic radiation, electromagnetic spectrum, a brief review of atomic and molecular theory. **Ultraviolet and Visible Spectrophotometry**: Instrumentation, radiation sources, detectors, readout module, filters, monochromators, and performance, a grating system for single beam and double beam UV/Vis spectrophotometry.	18
II	**Fluorescence, Phosphorescence Spectroscopy** **Fluorescence Spectrophotometry**: Introduction, Theory of Fluorescence, instrumentation for fluorescence measurement: Sources,	12

	Monochromator, and Detectors. **Phosphorescence Spectrophotometry**: Introduction, Theory of Phosphorescence, instrumentation for Phosphorescence measurement: Sources, Monochromator, and Detectors.	
III	**Infrared, Raman, and X-ray diffraction** **Infrared Spectrophotometry**: Introduction, Theory of IR spectroscopy, Instrumentation, radiation sources, detectors, readout module. **Raman Spectroscopy**: Introduction, Theory of Raman spectroscopy, Instrumentation, radiation sources, detectors, readout module. **X-Ray Diffraction (XRD)**: Introduction, Theory of XRD, Production of X-rays and X-ray spectra, instrumental units, detectors for measurement of X-ray radiation.	**18**
IV	**Atomic Absorption and Flame Emission Spectroscopy and Microscopy techniques** **Atomic Absorption Spectrometry (AAS)**: Introduction, Theory of AAS, Instrumentation for Atomic Absorption Spectrometry, Nebulizer and atomizer. **Atomic Emission Spectroscopy (AES)**: Introduction, Theory of AES, Instrumentation, spectroscopic sources, atomic emission spectrometer. **Microscopy Techniques**: Introduction of Scanning Electron Microscopy (SEM), and Atomic Force Microscopy (AFM).	**12**

Reference Books:

1. Skoog & Lerry, Instrumental Methods of Analysis, Saunders College Publications, New York
2. H.H. Willard, Instrumental Methods of Analysis, CBS Publishers.
3. D.C. Harris, Quantitate Chemical Analysis, W.H.Freeman
4. Christian G.D, Analytical Chemistry, John & Sons, Singapore
5. Skoog, West and Holler, Analytical Chemistry, Saunders College Publications, New York
6. Vogel's Textbook of Qualitative Chemical Analysis, ELBS
7. J.A. Dean, Analytical Chemistry Notebook, McGraw Hill
8. John H. Kennedy, Analytical Chemistry: Principles, Saunders College Publication

SHIVAJI UNIVERSITY, KOLHAPUR
School of Nanoscience and Biotechnology
B. Sc. –M.Sc. in Nanoscience and Technology, (5 Years Integrated) Programme,
Part – II, SEM IV
Laboratory Course – IV
(Practical: 60 Lectures) (Credits: 02)
(Introduction to Data Science, AI and ML+ Analytical Instrumentation)

Course Learning Outcomes:
On successful completion of this course, the student should be able to:

- Apply knowledge of various statistical techniques
- Understand and apply the principles of Bernoulli and binomial distribution
- Understand and apply the principles of exponential and normal distribution
- Interpret the data and results with the help of statistical tools
- Understand and apply the Supervised and Unsupervised machine learning techniques

Course Learning Outcomes of Instrumentation Lab:
On successful completion of this course, the student should be able to:

- Apply knowledge of analytical instrumentation
- Evaluate various spectroscopic and microscopic methods
- Interpret the acquired data and measured results
- Knowledge of procedures and instrumental methods of analytical sciences
- Understanding the basic concepts of instrumentation, data acquisition, and data processing

Name of Experiments
Statistics Lab 1. Calculation of probabilities 2. Applications of Bernoulli and binomial distribution 3. Applications of exponential and normal distribution 4. Sampling and EDA 5. Supervised Learning 6. Unsupervised Learning
Analytical Instrumentation Lab (Any Five) 1. Data interpretation and plotting 2. Studies on UV-visible spectrophotometer 3. Studies on X-ray diffractions 4. FT-IR spectra interpretation 5. FT-RAMAN spectra interpretation 6. Fluorescence spectra interpretation 7. Phosphorescence spectra interpretation 8. Scanning Electron Microscope image interpretation 9. Atomic Force Microscope Image Interpretation 10. Analysis of atomic absorption spectra