CURRICULUM & SYLLABI

Integrated MSc Mathematics

Effective from AY: 2024-25

NATIONAL INSTITUTE OF TECHNOLOGY WARANGAL

WARANGAL, TELANGANA

Table of Contents

Vision and Mission of the Institute
National Institute of Technology Warangal

VISION

Towards a Global Knowledge Hub, striving continuously in pursuit of excellence in Education, Research, Entrepreneurship and Technological services to the society

MISSION

- Imparting total quality education to develop innovative, entrepreneurial and ethical future professionals fit for globally competitive environment.
- Allowing stake holders to share our reservoir of experience in education and knowledge for mutual enrichment in the field of technical education.
- Fostering product-oriented research for establishing a self-sustaining and wealth creating centre to serve the societal needs.

Vision and Mission of the Department
Mathematics

VISION

To be among the best mathematics departments in the country, to build an international reputation as a center of excellence in mathematics and computational research, training, and education, and to inculcate Mathematical thinking to meet the challenges and growth of science and technology as well as the needs of industry and society, with moral and ethical responsibility.

MISSION

- To attract motivated and talented students by providing a learning environment where they can learn and develop the mathematical and computational skills needed to formulate and solve real-world problems.
- To foster an environment conducive to quality research and to train principled and highly skilled researchers with clear thinking and determination to meet the dynamic challenges of science and engineering.
- To keep up with the rapid advancements of technology while improving academic standards through innovative teaching and learning processes.
- To satisfy the country's human resource and scientific manpower requirements in mathematics through learner-centered contemporary education and research.

Integrated M.SC., Mathematics

Program Educational Objectives

PEO-1	Provide sufficient understanding of the fundamentals of mathematics with computational techniques, and program core to address challenges faced in mathematics and other related interdisciplinary fields.
PEO-2	Facilitate as a deep learner and progressive careers in teaching, academia, research organizations, national/international laboratories and industry
PEO-3	Develop models and simulation tools for real life problems by analysing and applying mathematical and computational tools and techniques.
PEO-4	Demonstrate effective communication and interpersonal, management and leadership skills to fulfil professional responsibilities, retaining scientific fervour in day-to-day affairs.
PEO-5	Engage in lifelong learning and adapt to changing professional and societal needs

Program Articulation Matrix

PEO / Mission Statements	PEO-1	PEO-2	PEO-3	PEO-4	PEO-5
To attract motivated and talented students by providing a learning environment where they can learn and understand the mathematical and computational skills needed to formulate and solve real-world problems.	2	3	2	3	2
To foster an environment conducive to quality research and to train principled and highly skilled researchers with clear thinking and determination capable of meeting the dynamic challenges of science and engineering.	3	3	3	2	2
To keep up with the rapid advancements of technology while improving academic standards through innovative teaching and learning processes	2	3	2	2	2
To satisfy the country's human resource and scientific manpower requirements in mathematics through learner-centered contemporary education and research.	3	2	3	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Program: Integrated M.Sc Mathematics

Program Outcomes

At the end of the program, the student will be able to:

PO-1	**Scientific knowledge:** Gain and apply the knowledge of Scientific and Mathematics, Physics and Chemistry fundamentals to understand the Nature and apply it to develop new theories and models.
PO-2	**Problem analysis**: Identify, formulate, research literature and analyze the complex scientific problems/phenomena reaching substantiated conclusions using principles of Mathematics, Physics, Chemistry, Engineering, Humanities and Management
PO-3	**Design/Development of solutions**: Design solutions for complex mathematics problems and find out solutions that meet the specified needs.
PO-4	**Conduct investigations of complex problems**: Use of research-based knowledge and research methods including design of physical/computational experiments, solutions for complex Scientific and Mathematical problems and evolve procedures appropriate to a given problem
PO-5	**Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern IT tools including prediction and modelling to complex real-life/ mathematical problems with an understanding of the limitations.
PO-6	The science and society: Function effectively as an individual, and as a member or leader in diverse teams to manage projects and in multidisciplinary environments
PO-7	**Environment and sustainability**: Demonstrate the knowledge of Numerical analysis and simulation, mathematical modelling and interpretation of data, and synthesis of the information to provide valid conclusions
PO-8	**Ethics:** . Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO-9	Career: Prepare students to qualify for various national and international competitive examinations. Join the software and IT industry with sound programming and mathematics-based computing knowledge.
PO-10	**Project management and Finance**: Demonstrate knowledge and understanding of the Mathematical principles and apply these to one's work as a member and leader in a team to manage projects and in multidisciplinary environments.
PO-11	**Life-long learning:** Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of scientific and technological changes for up to-date research and teaching methods.
PO-12	**Individual and team work:** Function effectively as an individual, member, or leader in diverse teams and multidisciplinary settings.

Program Specific Outcomes

PSO-1	Inculcate mathematical reasoning.
PSO-2	Prepare and motivate students for research studies in mathematics and related fields.
PSO-3	Provide advanced knowledge on Applied Mathematics and Scientific Computing topics, empowering the students to pursue higher degrees at reputed academic institutions.
PSO-4	Provide a systematic understanding of the concepts and theories of mathematics and their application in the real world- to an advanced level and enhance career prospects in a huge array of fields, viz. in industry, commerce, education, finance, and research.

CURRICULUM
Integrated M.Sc., Mathematics – Course Structure

1st Semester

S.No.	Code	Course Title	L-T-P	Credits
1	MA2101	Differential and Integral Calculus	**3-0-0**	**3**
2	PH2101	Mechanics, Waves and Oscillations	**3-0-0**	**3**
3	CY2101	General Chemistry	**3-0-0**	**3**
4	HS2161	Functional English-I	**2-0-2**	**3**
5	PH2103	Mechanics, Waves and Oscillations Laboratory	**0-1-2**	**2**
6	CY2103	General Chemistry Lab-I	**0-1-2**	**2**
7	IC1101	EAA-I (Games & Sports / Yoga & Wellness)	**0-0-0**	**0**
Total Credits				**16**

2nd Semester

S.No.	Code	Course Title	L-T-P	Credits
1	MA2102	Elementary Ordinary Differential Equations	**3-0-0**	**3**
2	PH2102	Heat and Thermodynamics	**3-0-0**	**3**
3	CY2102	Organic Chemistry – I	**2-0-2**	**3**
4	HS2162	Functional English-II	**0-1-2**	**2**
5	PH2104	Heat and Thermodynamics Laboratory	**0-1-2**	**2**
6	CY2104	General Chemistry Lab – II	**0-0-2**	**2**
7	HS2164	Foundation Couse in German	**2-0-2**	**3**
8	IC1102	EAA-II (Games & Sports / Yoga & Wellness)	**0-0-0**	**0**
Total Credits				**18**

3rd Semester

S.No.	Code	Course Title	L-T-P	Credits
1	MA2201	Modern Algebra	**3-1-0**	**4**
2	MA2203	Computer Programming in C	**3-0-2**	**4**
3	PH2201	Optics	**3-0-0**	**3**
4	CY2201	Inorganic Chemistry-1	**3-0-0**	**3**
5	CY2203	Physical Chemistry-1	**3-0-0**	**3**
6	PH2203	Optics Lab	**0-1-2**	**2**
7	CY2205	Inorganic Chemistry Lab	**0-1-2**	**2**
			Total Credits	**21**

4th Semester

S.No.	Code	Course Title	L-T-P	Credits
1	MA2202	Vector Calculus	**3-1-0**	**4**
2	MA2204	Linear Algebra	**3-0-2**	**4**
3	PH2202	Electricity and Magnetism	**3-0-0**	**3**
4	PH2204	Modern Physics	**3-0-0**	**3**
5	CY2202	Organic Chemistry-2	**3-0-0**	**3**
6	PH2206	Electricity and Magnetism Lab	**0-1-2**	**2**
7	CY2204	Organic Chemistry Lab	**0-1-2**	**2**
			Total Credits	**21**

5th Semester

S.No.	Code	Course Title	L-T-P	Credits
1	MA2301	Mathematical Analysis	**3-1-0**	**4**
2	PH2301	Basic Electronics	**3-0-0**	**3**
3	PH2303	Fundamentals of Nanomaterials & Applications	**3-0-0**	**3**
4	CY2301	Inorganic Chemistry-2	**3-0-0**	**3**
5	CY2303	Physical Chemistry-2	**3-0-0**	**3**
6	PH2305	Basic Electronics Laboratory	**0-1-2**	**2**
7	CY2305	Physical Chemistry Lab	**0-1-2**	**2**
			Total Credits	**20**

6th Semester

S.No	Code	Course Title	L-T-P	Credits
1	MA2302	Introductory Methods of Numerical Analysis	**3-1-0**	**4**
2	MA23xx	Professional Elective – 1	3-1-**0**	**4**
3	PH23xx	Professional Elective – 2	**3-0-0**	**3**
4	CY23xx	Professional Elective – 3	**3-0-0**	**3**
5	MA2390	Seminar & Technical Writing	**1-0-0**	**1**
6	MA2396	Minor Project	**0-0-4**	**2**
			Total Credits	**17**

After completing 6 semesters of Integrated M.Sc., the students will join in MSc. (Applied Mathematics) course.
The structure of 7, 8, 9 and 10 semesters is same as the structure of M.Sc.(Applied Mathematics) course

7th Semester

S.No.	Code	Course Title	L-T-P	Credits
1	MA16001	Real Analysis	**4-0-0**	**4**
2	MA16003	Ordinary Differential Equations	**3-0-0**	**3**
3	MA16005	Computer Programming in C++	**3-0-0**	**3**
4	MA16007	Numerical Analysis	**3-0-0**	**3**
5	MA160XX	Professional Elective – I	**3-0-0**	**3**
6	MA16009	C++ Lab	**0-1-2**	**2**
7	MA16011	Numeric Computing Lab	**0-1-2**	**2**
		Total Credits		**20**

8th Semester

S.No.	Code	Course Title	L-T-P	Credits
1	MA16002	Probability and Statistics	**4-0-0**	**4**
2	MA16004	Partial Differential Equations	**3-0-0**	**3**
3	MA16006	Topology	**3-0-0**	**3**
4	MA160XX	Professional Elective – II	**3-0-0**	**3**
5	MA160XX	Professional Elective – III	**3-0-0**	**3**
6	MA16008	Probability and Statistics with R Lab	**0-1-2**	**2**
7	MA16010	Symbolic Computing Lab	**0-1-2**	**2**
		Total Credits		**20**

9th Semester

S.No.	Code	Course Title	L-T-P	Credits
1	MA17001	Operations Research	**4-0-0**	**4**
2	MA17003	Functional Analysis	**3-0-0**	**3**
3	MA170XX	Professional Elective – IV	**3-0-0**	**3**
4	MA170XX	Professional Elective – V	**3-0-0**	**3**
5	MA17005	Operations Research Lab	**0-1-2**	**2**
6	MA17007	Software Lab	**0-1-2**	**2**
7	MA17091	Seminar and Technical writing	**0-0-4**	**2**
8	MA17093	Short term Industrial / Research Experience	**0-0-4**	**2**
			Total Credits	**21**

10th Semester

S.No.	Code	Course Title	L-T-P	Credits
1	MA170XX	Professional Elective–VI	**3-0-0**	**3**
2	MA170xx	Professional Elective–VII	**3-0-0**	**3**
3	MA17094	Comprehensive Viva-Voce	**0-0-4**	**2**
4	MA17098	Dissertation	**0-0-16**	**8**
			Total Credits	**16**

Professional Elective Courses:

Professional Elective-1		
S.No.	**Code**	**Course Title**
1	MA2322	Analytical Solid Geometry
2	MA2324	Theory of Equations
3	MA2326	Elementary Number Theory

Professional Elective-2		
S.No.	**Code**	**Course Title**
1	PH2322	Renewable energy sources
2	PH2324	Basic Photovoltaic Devices And Applications
3	PH2326	Physics of semiconductors

Professional Elective-3		
S.No.	**Code**	**Course Title**
1	CY2322	Instrumental analysis for industrialapplications
2	CY2324	Applied organic chemistry
3	CY2326	Environmental chemistry

Professional Elective-I		
S.No.	**Code**	**Course Title**
1	MA16021	Advanced Linear Algebra
2	MA16023	Classical Mechanics
3	MA16025	Mathematical Modelling

Professional Elective-II		
S.No.	**Code**	**Course Title**
1	MA16022	Algebra
2	MA16024	Integral Transforms and Integral Equations
3	MA16026	Differential Geometry and Tensor analysis

Professional Elective-III		
S.No.	**Code**	**Course Title**
1	MA16028	Complex Analysis
2	MA16030	Lie Group Methods for Differential Equations
3	MA16032	Iterative Methods

Professional Elective-IV		
S.No.	**Code**	**Course Title**
1	MA17021	Discrete Mathematics
2	MA17023	Distribution Theory
3	MA17025	Multivariate Data Analysis

Professional Elective-V		
S.No.	**Code**	**Course Title**
1	MA17027	Numerical Solutions of Differential Equations
2	MA17029	Dynamical Systems
3	MA17031	Analysis of Differential Equations

Professional Elective-VI		
S.No.	**Code**	**Course Title**
1	MA17022	Measure and Integration
2	MA17024	Finite Element Method
3	MA17026	Inventory, Queueing Theory and Non-Linear Programming

Professional Elective-VII		
S.No.	**Code**	**Course Title**
1	MA17028	Fluid Dynamics
2	MA17030	Graph Theory and Algorithms
3	MA17032	Finite Volume Methods

The Overall Credit Structure

Course Category	Credits (UG)	Credits (MSc)	Total Credits
Basic Science / program core	91	42	133
Humanities and Social Sciences	9	0	9
Professional Elective	10	21	31
Seminar and Technical Writing	1	2	3
Minor project	2	0	2
Short Term Industrial / Research Experience	0	2	2
Comprehensive Viva-Voce	0	2	2
Dissertation	0	8	8
Total Graded Credit Requirement	**113**	**77**	**190**

SYLLABI

Integrated M.Sc. Mathematics

1st Semester

MA2101 **3-0-0 (3)**

Differential and Integral Calculus

Pre-Requisites: None

Course Outcomes:

CO-1	To find the Taylor series expansion of a function.
CO-2	To find the maxima and minima of functions of several variables.
CO-3	To identify the convergence of an improper integral.
CO-4	To evaluate the surface area and volume of a solid of revolution.
CO-5	To compute the surface area and volume of regions using multiple integrations.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	2	2	–	–	–	–	–	–	–	–	–	–	–	–	–
CO-2	3	2	2	–	–	–	–	–	–	–	–	–	–	–	–	–
CO-3	2	2	2	–	–	–	–	–	–	–	–	–	–	–	–	–
CO-4	3	2	2	–	–	–	–	–	–	–	–	–	–	–	–	–
CO-5	3	2	2	–	–	–	–	–	–	–	–	–	–	–	–	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Differential Calculus: Taylor's theorem with remainders, Taylor's and Maclaurin's expansions, Curvature and Evolutes, Asymptotes, and Curve tracing.

Functions of several variables - partial differentiation, total differentiation, Euler's theorem and generalization, Change of variables – Jacobians, maxima, and minima of functions of several variables (2 and 3 variables) - Lagrange's method of multipliers.

Integral Calculus: Evaluation of lengths of plane curves, plane areas, volume, and surface area of a solid of revolution

Convergence of Improper integrals, Beta and Gamma integrals, Elementary properties of Beta and Gamma integrals, Differentiation under integral sign.

Double and triple integrals, computation of surface areas and volumes using multiple integrations, change of variables in double and triple integrals.

Learning Resources:

Text Books:

1. Shanti Narayanan, Differential Calculus, S. Chand, and Co., 2021
2. Shanti Narayanan, Integral Calculus, S. Chand, and Co., 2021

Reference Books:

1. George Thomas, J., Ross L. Finney, Calculus, Ninth Edition Pearson, 2018.
2. Sudhir R. Ghorpade, B. V. Limaye, A Course in Calculus and Real Analysis, Springer, 2018.
3. Sudhir R. Ghorpade, B.V.Limaye, A Course in Multivariable Calculus and Analysis, Springer, 2012.

PH2101 **3-0-0 (3)**

Mechanics, Waves and Oscillations

Pre-Requisite: **None**

Course Outcomes:

CO-1	Understand integration of vectors and Stokes greens and gauss theorems
CO-2	Identify and apply the laws of mechanics along with the necessary mathematics for solving numerical.
CO-3	Understand physical characteristics of SHM and obtaining solution of the oscillator using differential equations.
CO-4	Use Lissajous figures to understand simple harmonic vibrations of same frequency and different frequencies
CO-5	Solve wave equation of a longitudinal and transverse vibrations.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	3	2	2	–	–	–	–	–	–	–	–	–	–	–	–
CO-2	3	3	2	2	–	–	–	–	–	–	–	–	–	–	–	–
CO-3	2	3	2	2	–	–	–	–	–	–	–	–	–	–	–	–
CO-4	3	3	2	2	–	–	–	–	–	–	–	–	–	–	–	–
CO-5	3	3	2	2	–	–	–	–	–	–	–	–	–	–	–	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Scalar and Vector Fields: Scalar and vector fields, gradient of a scalar field and its physical significance. Divergence and curl of a vector field and related problems, vector integration: line, surface and volume integrals. Stokes, Gauss and Greens theorems, Laws of motion, motion of variable mass system, motion of a rocket, multi-stage rocket, conservation of energy and momentum, definition of rigid body, rotational kinematic relations, and equation of motion for a rotating body, angular momentum and inertial tensor.

Central Forces: Central forces – definition and examples, conservative nature of central forces, conservative force as a negative gradient of potential energy, equation of motion under a central force, gravitational potential and gravitational field, derivation of Kepler's laws. Galilean relativity, absolute frames, Michelson-Morley experiment, Postulates of special theory of relativity. Lorentz transformation, time dilation, length contraction, addition of velocities, mass-energy relation.

Simple Harmonic Oscillator: Simple harmonic oscillator and its solution, physical characteristics of SHM, torsion pendulum, - measurements of rigidity modulus, compound pendulum, measurement of ‗g', Lissajous figures, damped harmonic oscillator and its solution, comparison with undamped harmonic oscillator, logarithmic decrement, relaxation time, quality factor, differential equation of forced oscillator and its solution, amplitude resonance, velocity resonance, coupled oscillators.

Transverse wave propagation: Transverse wave propagation along a stretched string, general solution of wave equation and its significance, modes of vibration of stretched string clamped at ends, overtones, energy transport, transverse, longitudinal vibrations in bars- wave equation and its general solution, Boundary conditions, clamped free bar, free-free bar, bar supported at both ends.

Learning Resources:

Text books:

1. Halliday, Resnick, Walker, Fundamentals of Physics, Wiley India, 2013, Tenth Edition.

2. C. Kittel, W. Knight, M.A. Ruderman, Mechanics, Berkeley Physics Course. Vol.1, McGraw Hill, 2008, Fourth Edition.

Reference books:

1. Hugh D. Young, Roger A. University Physics, Freedman Pearson Education, 2017, Fourteenth Edition.
2. Daniel Kleppner, Robert Kolenkow, An introduction to Mechanics, McGraw Hill, 2017.

Online Resources:

1. https://nptel.ac.in/courses/115/106/115106119/.
2. https://onlinecourses.nptel.ac.in/noc20_ph22/preview.

PH2103 **0-1-2 (2)**

Mechanics, Waves and Oscillations Laboratory

Pre-Requisite: **None**

Course Outcomes:

CO-1	Measure different physical constants by simple and compound pendulum.
CO-2	Measure the different modulus of the materials.
CO-3	Study the different oscillations such as simple harmonic damped oscillations.
CO-4	Measure moment of inertia of different objects.
CO-5	Measure surface tension of different liquids.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	3	3	2	–	–	–	–	–	–	–	–	–	–	–	–
CO-2	3	3	3	2	–	–	–	–	–	–	–	–	–	–	–	–
CO-3	3	3	3	2	–	–	–	–	–	–	–	–	–	–	–	–
CO-4	2	3	3	2	–	–	–	–	–	–	–	–	–	–	–	–
CO-5	2	3	3	2	–	–	–	–	–	–	–	–	–	–	–	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

List of Experiments:

1. Determination of gll by simple and compound pendulum.
2. Moment of Inertia of a fly wheel.
3. Determine surface tension of a liquid through capillary rise method.
4. Determination of rigidity moduli by torsion Pendulum.
5. Study of Oscillations under bifilar suspension
6. Observation of Lissajous figures from CRO.
7. Velocity of transverse wave along a stretched string.
8. Study of damping of a bar pendulum.
9. Study of coupled oscillator.
10. Maxwell wheel for the verification of conservation of energy.
11. Determination of the shear modulus of steel, copper, aluminum and brass.
12. Determination of the centrifugal force as a function of the mass.

Learning Resources:

Text Books:

1. Physics Department Manual, NIT Warangal, 2021
2. S.P. Singh, Advanced Practical Physics by Pragati Prakashan, Anu books, Meerut, 2019.

Reference books:

1. R.K Shukla, Anchal Srivastava, Practical Physics, New Age International Private Limited, 2008.

2. C. Kittel, W. Knight, M.A. Ruderman, Berkeley Physics Course, Vol.1, Mechanics, McGraw Hill, 2008, Fifth Edition.

Online Resources:

1. https://www.phywe.com/physics/thermodynamics/
2. https://vlab.amrita.edu/index.php?sub=1&brch=74

CY2101 **3-0-0 (3)**

General Chemistry

Pre-Requisites: None

Course Outcomes:

CO-1	Understand the behaviour of electrons in the atom and molecule and relate the basic concepts of atomic/molecular chemistry to the behaviour of molecules in real world
CO-2	Interpret the characteristics of bonds and the properties of elements
CO-3	Identify the crystal structure of solids based on their miller indices
CO-4	Understand concepts of hybridization, bonding and physical properties of organic compounds
CO-5	Identify the type of intermediates formed in the sequence of organic reactions and their stability

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	2	2	2	1	2	–	–	–	–	–	–	–	–	–	–
CO-2	3	2	2	2	2	2	–	–	–	–	–	–	–	–	–	–
CO-3	3	2	2	1	2	1	–	–	–	–	–	–	–	–	–	–
CO-4	3	3	3	2	1	2	–	–	–	–	–	–	–	–	–	–
CO-5	3	2	2	1	2	3	–	–	–	–	–	–	–	–	–	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Atomic Structure and elementary quantum mechanics: Emergence of quantum mechanics, Probability Distribution of Electrons, Radial and Angular Probability Distribution, Orbitals and quantum numbers.

Chemical Bonding: Ionic solids, packing of ions in crystals, lattice energy, Madelung constant, polarity and polarizability of ions, Bonding theories, Covalent and ionic character, non-covalent interactions.

Solid state: Laws of crystallography, Bravais lattices and crystal systems, miller indices, band theory, X-ray diffraction by crystals, Bragg's equation.

Bonding and physical properties of organic molecules: Nomenclature and Physical properties, hybridization, resonance, Inductive effect, Hückel's rules, Concept of acids and bases, structural and solvent effect.

Basic reaction mechanism and intermediates: reactive intermediates and classification of reaction mechanism

Learning Resources:

Text Books:

1. O.P. Agarwal, Unified Chemistry paper I and II, Jai Prakash Nath Publications, 2019, Third Edition,
2. J. D. Lee, Concise Inorganic Chemistry, Wiley India, 2015, Fifth Edition.

3. R. T. Morrison, R. N. Boyd, S. K. Bhattacharjee, Organic Chemistry, Pearson Education, 2010, Seventh Edition.

Reference Books:

1. Samuel H. Maron, Carl F. Prutton, Principles of physical chemistry, Oxford & IBH Publishing, 2017, Fourth Edition.
2. K.L. Kapoor, A Textbook of Physical Chemistry, Macmillan Publisher India Limited, 2020 Volume 3, Fifth Edition.
3. T. W. Graham Solomons, C. B. Fryhle, Organic Chemistry, Wiley, Tenth Edition.
4. I. L. Finar, Organic Chemistry, Vol-1, Pearson Education, Sixth Edition.

CY2103 **0-1-2 (2)**

General Chemistry Laboratory

Pre-Requisites: None

Course Outcomes:

CO-1	Know the basic knowledge of qualitative analysis
CO-2	Acquire hands on experience in the semi micro analysis of mixture of cations and anions
CO-3	Interpret the chemistry involved in the separation of ions in a mixture
CO-4	Identify individual cations and anions in a mixture
CO-5	Analyze the influence of interfering ions on identification of ions

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	2	2	2	2	–	–	–	–	–	–	–	–	–	–	–	–
CO-2	2	2	2	1	–	–	–	–	–	–	–	–	–	–	–	–
CO-3	2	2	2	2	–	–	–	–	–	–	–	–	–	–	–	–
CO-4	2	2	1	2	–	–	–	–	–	–	–	–	–	–	–	–
CO-5	2	1	2	1	–	–	–	–	–	–	–	–	–	–	–	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Qualitative inorganic analysis:

1. Dry test for cations and anions
2. Wet test for anions
3. Semi-micro analysis and Group separation:

   Anions: Nitrate (NO_3^-), Sulfate (SO_4^{2-}), Nitrite (NO_2^-), Chloride (Cl-), Bromide (Br−), Iodide (I-Acetate (CH_3COO^-), Carbonate (CO_3^{2-}), Sulphide (S^{2-}), Bromate (BrO_3^-), Iodate (IO_3^-), Phosphate (PO_4^{3-}).

   Cation: Silver (Ag^+), Potassium (K^+), Sodium (Na^+), Lead (Pb^{2+}), Copper (Cu^{2+}), Cadmium (Cd^{2+}), Tin (Sn^{2+}), Iron (Fe^{3+}), Chromium (Cr^{3+}), Cobalt (Co^{3+}), Nickel (Ni^{2+}), Manganese (Mn^{2+}), Zinc (Zn^{2+}), Barium (Ba^{2+}), Strontium (Sr^{2+}), Calcium (Ca^{2+}), Ammonium (NH_4^+).

4. Qualitative analysis of mixture of inorganic substances containing six radicals (interfering acid radicals: phosphate, fluoride and mixture of acid radicals: carbonate, sulfite, sulfide, nitrate, chloride, bromide, phosphate, arsenate, nitrate, iodate and sulfate)

Learning Resources:

Text Books:

1. G. Sevhla, Vogel's Textbook of Macro and Semi micro Qualitative Inorganic Analysis, Longman Inc., 1979, Fifth Edition.

HS2161 **2-0-2 (3)**

Functional English-I

Pre-Requisites: English proficiency above B1 level as per the CEFR (Common European Framework of Reference) for languages.

Course Outcomes:

CO-1	Infer explicit and implicit meaning of a given text.
CO-2	Build grammatically correct sentences using a variety of sentence structures and appropriate vocabulary.
CO-3	Demonstrate use of English speech sounds, stress and intonation in day-to-day situations/conversations/interactions.
CO-4	Develop active listening skills and strategies
CO-5	Compose cohesive and coherent paragraphs, emails, and letters.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO1	PSO2	PSO3	PSO4
CO-1	3	2	2	2	1	2	–	–	–	–	–	–	–	–	–	–
CO-2	3	2	2	2	2	2	–	–	–	–	–	–	–	–	–	–
CO-3	3	2	2	1	2	1	–	–	–	–	–	–	–	–	–	–
CO-4	3	3	3	2	1	2	–	–	–	–	–	–	–	–	–	–
CO-5	3	2	2	1	2	3	–	–	–	–	–	–	–	–	–	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Course Overview:

The course is designed to train students in receptive (listening and reading) as well as productive and interactive (speaking and writing) skills by incorporating a comprehensive, coherent and integrated approach that improves the learners' ability to effectively use English language in academic/ workplace contexts. The shift is from learning about the language to using the language. On successful completion of the course learners would be confident of appearing for international language qualification/proficiency tests such as IELTS, TOEFL, or BEC, besides being able to express themselves clearly in speech and competently handle the writing tasks and verbal ability component of campus placement tests. Activity based teaching-learning methods would be adopted to ensure that learners would engage in actual use of language both in the classroom and laboratory sessions.

Syllabus:

Listening (Lab): Types of listening- attentive, selective, pleasure; barriers to listening; effective listening strategies- Listening to motivational speeches.

Speaking (Lab): Ice-Breaking Activity, Introducing self and others

Reading: Intensive Reading Vs Extensive Reading, short stories, skimming and scanning

Writing: Structure of a paragraph and types of paragraphs- descriptive, argumentative, narrative, expository, persuasive- writing self- profiles, writing prompts

Grammar &Vocabulary: Phrasal verbs, Verbs, Tenses (Present, Past & Future)

Phonetics-Pronunciation: Introduction to speech sounds -Vowels and Consonants (Lab)

Listening (Lab): Short structured talks on specific topics. Task based listening activities.

Speaking: JAM Session- Hypothetical Situations, features of good conversation, situational dialogues, greetings, taking leave, making requests and seeking permissions, role play, discussion in pairs/ small groups on specific topics

Reading: Reading for global comprehension, summarizing, paraphrasing- skimming- scanning

Writing: Interpreting visual information, predicting, advanced features of good writing – use of cohesive devices and connectives, use of discourse markers.

Grammar & Vocabulary: Nouns, Pre- fixes and suffixes, vocabulary building.

Phonetics-pronunciation (Lab): Intonation- errors in pronunciation, influence of Mother Tongue (MTI), common Indian variants in pronunciation- differences in British and American pronunciation

Listening: Listening to motivational videos (Steve Jobs, Mark Zukerberg, renowned scientists- Einstein, C V Raman, Marie Curie, Grigori Perelman, Jennifer A. Doudna etc, Ted Talks) Listening for specific details. Listening Comprehension Tests. (Task based group activity)

Speaking: Telephone Etiquette, non-verbal communication, how to make effective formal presentations.
Reading: Identifying sequence of ideas; recognizing verbal techniques.

Writing: Official letter writing, e- mail etiquette, cover letter & resume writing- types- drafting e- resumes Grammar & Vocabulary: Idioms and Phrasal Verbs, Synonyms & Antonyms, technical vocabulary

Phonetics-Pronunciation (Lab): Structure of syllables, word stress and rhythm, weak forms and strong forms in context, basic rules of word accent, stress shift

Learning Resources:

Text Books:

1. Bailey, Stephen. Academic writing: A handbook for international students. Routledge, 2014.
2. M. Rizvi, Ashraf. Effective Technical Communication. 2nd ed., McGraw hill, 2017.

Reference Books:

1. Raymond Murphy, Murphy's English Grammar, Cambridge University Press 2004
2. Meenakshi Raman, Sangeeta Sharma, Technical Communication: English Skills for Engineers, Oxford University Press, 2009
3. Michael Swan, Practical English Usage, Oxford University Press, 1996
4. Chase, Becky Tarver. Pathways: Listening, Speaking and Critical Thinking. Heinley ELT; 2nd Edition, 2018.
5. Louis Rogers, Skillful Level 2 Reading & Writing Student's Book Pack (B1) Macmillan Educational, 2013.
6. Hewings, Martin. Cambridge Academic English (B2). CUP, 2012.

Online Resources:

1. https://www.bbc.co.uk/learningenglish/
2. https://www.talkenglish.com/speaking/basics/speaking_basics_ii.aspx
3. https://www.englishclub.com/speaking/
4. https://www.esolcourses.com/content/topicsmenu/listening.html
5. https://www.cambridgeenglish.org/learning-english/free-resources/writeand-improve/

2nd Semester

MA2102 **3-0-0 (3)**

Elementary Ordinary Differential Equations

Pre-Requisites: **None**

Course Outcomes:

CO-1	Test the plausibility of a solution to a differential equation that models a physical situation.
CO-2	Understand situations involving exponential growth or decay and second-order physical systems.
CO-3	Understand the existence and uniqueness of solutions.
CO-4	Solve homogeneous and non-homogeneous linear differential equations with constant coefficients.
CO-5	Solve second-order linear differential equations with variable coefficients.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	2	2	–	–	–	–	–	–	–	–	–	–	–	–	–
CO-2	3	2	2	–	–	–	–	–	–	–	–	–	–	–	–	–
CO-3	2	2	2	–	–	–	–	–	–	–	–	–	–	–	–	–
CO-4	3	2	2	–	–	–	–	–	–	–	–	–	–	–	–	–
CO-5	3	2	2	–	–	–	–	–	–	–	–	–	–	–	–	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Differential Equations of the first order: Linear Vs. Nonlinear Equations: Homogeneous Differential Equations, Differential Equations Reducible to Homogeneous Form - Exact differential equations, Integrating Factors - Linear equation, Reducible to Linear Form: Bernoulli's equations, Total Differential Equations. Existence and uniqueness of solutions (statement only); equations solvable for p, equations solvable for y, equations solvable for x and Clairaut's type; Applications: Newton's law of cooling, Law of natural growth and decay, orthogonal trajectories.

Differential Equations of Higher Order: Solution of homogeneous linear differential equations with constant coefficients, Solution of Non-homogeneous linear differential equations with constant coefficients, Legendre's equation, Cauchy-Euler equation;

Second-order linear differential equations with variable coefficients by the following methods: (i) complementary function is given, (ii) reducing to normal form, (iii) change of independent variable, (iv) variation of parameters.

Learning Resources:

Text Books:

1. Bronson Richard, Dr. Varsha Gejji, Differential Equations, Schaum Series, 2017, Third Edition.
2. George F. Simmons, Differential Equations with Applications and Historical Notes, McGraw-Hill, 2017, Second Edition.
3. William E. Boyce, Richard C. Diprima, Douglas B. Meade, Elementary differential equations and boundary value problems, Wiley, 2021.

Reference Books:

1. M.D. Rai Singhania, Ordinary and Partial Differential Equations, S. Chand and Co., 2020.
2. Earl A. Coddington, An Introduction to Ordinary Differential Equations, Dover Publications Inc.1989.

PH2102 **3-0-0 (3)**

Heat and Thermodynamics

Pre-Requisites: None

Course Outcomes:

CO-1	Gain knowledge in Kinetic theory of gases.
CO-2	Understand the nature of thermodynamic properties of matter like internal energy, enthalpy, entropy, temperature, pressure and specific volume.
CO-3	Understand the significance of first law and second of thermodynamics and their
CO-4	Understand the process of thermal conductivity, viscosity and diffusion in gases.
CO-5	Understand the interrelationship between thermodynamic functions and ability to use such relationships to solve practical problems.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	3	2	2	–	–	–	–	–	–	–	–	–	–	–	–
CO-2	3	3	3	2	–	–	–	–	–	–	–	–	–	–	–	–
CO-3	3	2	2	2	–	–	–	–	–	–	–	–	–	–	–	–
CO-4	3	3	3	2	–	–	–	–	–	–	–	–	–	–	–	–
CO-5	3	3	2	2	–	–	–	–	–	–	–	–	–	–	–	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Introduction to thermodynamic system, Zeroth law of thermodynamics, isothermal and adiabatic processes, indicator diagram–reversible and irreversible processes, Carnot's engine, Carnot's theorem, Second law of thermodynamics, Entropy, entropy measurement, entropy and disorder, entropy of universe, temperature entropy diagram.

Thermodynamic potentials – Maxwell's relations– Gibb's Helmholtz equation– importance Clausius Clapeyron equation, Stefan Boltzmann's law, ratio of specific heats, difference of two specific heats for a perfect gas, Joule Kelvin effect and its expression, Joule Kelvin effect for perfect gas and van der wall's gas. First order and second order phase transitions, Different methods of liquification's of gases, liquefaction of air by Linde's and Claude's methods, production of low temperatures, adiabatic demagnetization, refrigeration, working of vapor compression machine and vapor absorption machine.

Black body radiation, Stefan's law, distribution of energy in black body spectrum, statement of Wein's and Rayleigh-Jean's Law. Plank's quantum theory of radiation, derivation of Plank's Law. Wien's and Rayleigh-Jean's Law from Plank's radiation law.

Maxwell Boltzmann distribution law, Application to an ideal gas, MB distribution law of molecular speeds, mean speed, rms speed and most probable speed of a molecule, relation between them, quantum statistics, Bose Einstein distribution law, energy distribution of photon gas, Fermi Dirac distribution law, Fermi energy of electron gas.

Learning Resources:

Text Books:

1. Brij Lal, N. Subrahmanyam, P.S. Hemne, Heat and Thermodynamics, S Chand &co, 2001, Fourth Edition.
2. Mark W. Zemansky, Heat and Thermodynamics, Mc Graw Hill, 2017, Fifth Edition.

Reference Books:

1. Claus Borgnakke, Fundamentals of Thermodynamics, Wiley publisher, 2020.
2. Jean-philippe ansermet, Sylvain d. Brechet, Principles of Thermodynamics, Cambridge University Press, 2019
3. Robert F. Sekerka, Thermal Physics, Elsevier, 2015.

Online resources

1. https://onlinecourses.nptel.ac.in/noc20_ce27/preview
2. https://onlinecourses.nptel.ac.in/noc21_me35/preview

PH2104 **0-1-2 (2)**

Heat and Thermodynamics Laboratory

Pre-Requisites: **None**

Course Outcomes:

CO-1	Understands different heat transfer mechanisms.
CO-2	Learn to measure the thermal conductivity metals, glasses.
CO-3	Learn to measure the molar heat capacities of air.
CO-4	Understands to black body radiation
CO-5	Understand Seebeck, Joule-Thomson and Peltier effects.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	2	2	3	1	–	–	–	–	–	–	–	–	–	–	–	–
CO-2	3	2	2	2	–	–	–	–	–	–	–	–	–	–	–	–
CO-3	2	2	3	2	–	–	–	–	–	–	–	–	–	–	–	–
CO-4	2	3	2	1	–	–	–	–	–	–	–	–	–	–	–	–
CO-5	2	3	3	2	–	–	–	–	–	–	–	–	–	–	–	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

List of Experiments:

1. Study of Thermal conduction of solid bodies (metals and glasses).
2. Determination of Thermal conductivity of metals (Wiedmann-Franz law).
3. Study of phase changes of materials.
4. Determination of adiabatic coefficient of various gases.
5. Determination of specific heat of water.
6. Determine the molar heat capacities of air at constant volume C_v and at constant pressure C_p.
7. Determination of the Joule-Thomson coefficient of N_2 and CO_2.
8. Study of Peltier effect (a) cooling engine, (b) heat pump
9. Black Body Radiation: Determination of Stefan's Constant.
10. Verification of Newton's Law of Cooling.
11. Coefficient of thermal conductivity of a bad conductor using Lee's disc apparatus.
12. Study of Stirling engine working.

Learning Resources:

Text Books:

1. Heat and Thermodynamics Lab Manual, Department of Physics, NITW, 2021
2. S.P. Singh, Advanced Practical Physics, Pragati Prakashan, Anu books, Meerut, 2019.

Reference Books:

1. R.K Shukla, Anchal Srivastava, Practical Physics, New Age International Private Limited, 2008.

Online Resources:

1. https://www.phywe.com/physics/thermodynamics/
2. https://vlab.amrita.edu/index.php?sub=1&brch=194

CY2102 **3-0-0 (3)**

Organic Chemistry – I

Pre-Requisites: None

Course Outcomes:

CO-1	Utilize the concept of physical organic chemistry in organic reactions
CO-2	understand the synthesis and reactivity of various functional groups
CO-3	Understand the biological importance of heterocyclic compounds
CO-4	Analyse the functional group interconversion
CO-5	Know properties of hetero cyclic compounds

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	2	2	2	1	2	–	–	–	–	–	–	–	–	–	–
CO-2	3	2	2	2	2	2	–	–	–	–	–	–	–	–	–	–
CO-3	3	2	2	1	2	1	–	–	–	–	–	–	–	–	–	–
CO-4	3	3	3	2	1	2	–	–	–	–	–	–	–	–	–	–
CO-5	3	2	2	1	2	3	–	–	–	–	–	–	–	–	–	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Chemistry of organic functional groups: Alkanes, olefins, alkynes, halides, alcohols, phenols, ketones, aldehydes, carboxylic acids, ethers, derivatives of carboxylic acids, amines, nitro, azo and cyano compounds; synthesis and basic reactivity with mechanisms.

Functional group interconversion (oxidations and reductions) and Heterocyclic Compounds: Systematic nomenclature of heterocyclic compounds (Hantzsch Widman, replacement and fusion methods), biological importance of heterocyclic compounds. Preparation & Properties of Pyrrole, Furan, Thiophene, Preparation & Properties of Pyridine, quinoline, isouinoline, indole

Learning Resources:

Text Books:

1. R. T. Morrison, R. N. Boyd, S. K. Bhattacharjee, Organic Chemistry, Pearson Education, 2010, Seventh Edition.
2. I. L. Finar, Organic Chemistry, Vol-1, Pearson Education, Sixth Edition.

Reference Books:

1. T. W. Graham Solomonsm C. B. Fryhle, Organic Chemistry, Wiley, Tenth Edition.
2. E. L. Eliel, S. H. Wilen, Stereochemistry of Organic Compounds, Wiley.

CY2104 **0-1-2 (2)**

General Chemistry Lab– II

Pre-Requisites: None

Course Outcomes:

CO-1	Acquire hands on experience in experimental measurement of various physical quantities and understand the effect of impurity on Critical Solution Temperature of a system
CO-2	Understand the redox concept in titrations and photochemistry involved in blue printing
CO-3	Apply the concept of Nernst distribution law to understand the distribution of a solute in two immiscible liquids
CO-4	Apply various purification methods in the separation of organic mixtures
CO-5	Apply various chromatographic methods in the separation if organic compounds

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	2	2	2	1	2	–	–	–	–	–	–	–	–	–	–
CO-2	3	2	2	2	2	2	–	–	–	–	–	–	–	–	–	–
CO-3	3	2	2	1	2	1	–	–	–	–	–	–	–	–	–	–
CO-4	3	3	3	2	1	2	–	–	–	–	–	–	–	–	–	–
CO-5	3	2	2	1	2	3	–	–	–	–	–	–	–	–	–	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

1. Standardization of potassium permanganate
2. Determination of relative surface tension of a liquid with respect to water.
3. Determination of relative viscosity of a given liquid with respect to water at room temperature.
4. To study the effect of impurities (sodium chloride and succinic acid) on the critical solution temperature of organic solvent-water system
5. Determination of the distribution coefficient of acetic acid between water and cyclohexane
6. Blue printing of an object by photochemical reaction
7. Determination of acid strength in citrus fruit.
8. Determination of melting point, mixed melting point
9. Purification of organic compounds by recrystallization, sublimation, distillation
10. Separation of compounds by TLC and Column Chromatography
11. Determining Partition Coefficients of Sulfonamides by Reversed-Phase Chromatography
12. Single-stage preparation of Aspirin and Paracetamol

Learning Resources:

Text Books:

1. Practical Organic Chemistry-G. Mann & B.C Saunders, ELBS Edition and Longman Group Limited, 2002
2. Physical Chemistry Laboratory Manual by Department of Chemistry, NITW.
3. Amritha Anand, Ramesh Kumari, Physical Chemistry Laboratory Manual, Wiley distributors, Dreamtech Press, 2019

Reference Books:

1. Shoemaker D.P., Garland C.W., Nibler J.W., Experiments in Physical Chemistry, McGraw Hill, 2008, Eighth Edition.
2. J.B. Yadav, Advanced Practical Physical Chemistry, Krishna's Educational Publishers, 2019, Thirty Eighth Edition.
3. Text Book of Practical Organic Chemistry, Vogel A.I., ELBS, 2004, Fifth Edition.

HS2162 **2-0-2 (3)**

Functional English – II

Pre-Requisites: English proficiency above B1 level as per the CEFR (Common European Framework of Reference) for languages.

Course Outcomes:

CO-1	Select appropriate listening and reading strategies to meet the academic and professional needs.
CO-2	Acquire proficiency in oral and written communication
CO-3	Apply various techniques for effective oral presentations and group discussions.
CO-4	Demonstrate neutral accent while speaking, avoiding vernacular influence.
CO-5	Draft well-structured reports, SOPs, reviews, and conference abstracts

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	2	2	2	1	2	–	–	–	–	–	–	–	–	–	–
CO-2	3	2	2	2	2	2	–	–	–	–	–	–	–	–	–	–
CO-3	3	2	2	1	2	1	–	–	–	–	–	–	–	–	–	–
CO-4	3	3	3	2	1	2	–	–	–	–	–	–	–	–	–	–
CO-5	3	2	2	1	2	3	–	–	–	–	–	–	–	–	–	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Course Overview:

The course is designed to train students in receptive (listening and reading) as well as productive and interactive (speaking and writing) skills by incorporating a comprehensive, coherent and integrated approach that improves the learners' ability to effectively use English language in academic/ workplace contexts. The shift is from *learning about the language* to *using the language*. On successful completion of the course learners would be confident of appearing for international language qualification/proficiency tests such as IELTS, TOEFL, or BEC, besides being able to express themselves clearly in speech and competently handle the writing tasks and verbal ability component of campus placement tests. Activity based teaching-learning methods would be adopted to ensure that learners would engage in actual use of language both in the classroom and laboratory sessions

Syllabus:

Listening (Lab): Listening for global comprehension and summarizing.

Speaking (Lab): Discussing specific topics in pairs (or) small groups and reporting the discussion, complaining, apologizing.

Reading: Reading between the lines, Critical reading for evaluation.

Writing: SWOT Description and Analysis, Writing SOP, Letters for Internship/Fellowship.

Grammar & Vocabulary: Concord: Subject-Verb Agreement, Correction of sentence

Listening (Lab): Making predictions while listening to conversations (or) transactional dialogues.

Speaking (Lab): Role plays for practice of conversational English in academic contexts (formal and informal).

Reading: Intensive reading Vs extensive reading, reading biographies, magazines, books – fiction, non-fiction; skimming, scanning.

Writing: Writing reviews (books, biographies, short stories etc, writing technical reports- structure- feature-types- format and style

Grammar & Vocabulary: Gender inclusive language (gendered noun, gender- neutral noun), quantifying expressions, adjectives, adverbs, degrees of comparison, advanced vocabulary, scientific vocabulary.

Listening (Lab): Identifying key terms, understanding concepts, interpreting the concepts

Speaking (Lab): Formal oral presentations on topics from academic contexts- prerequisites of a group discussion.

Reading: Reading comprehension, The RAP strategy for in depth reading, intensive reading and extensive reading

Writing: Writing conference abstracts, image description, poster presentation

Grammar & Vocabulary: Reported speech, reporting verbs for academic purposes, correction of sentences, vocabulary and scientific vocabulary

Learning Resources:

Text Books:

1. Bailey, Stephen. Academic writing: A handbook for international students. Routledge, 2014.

Reference Books:

1. Raymond Murphy, Murphy's English Grammar, Cambridge University Press 2004
2. Meenakshi Raman, Sangeeta Sharma, Technical Communication: English Skills for Engineers, Oxford University Press, 2009
3. Michael Swan, Practical English Usage, Oxford University Press, 1996
4. Chase, Becky Tarver. Pathways: Listening, Speaking and Critical Thinking. Heinley ELT; 2nd Edition, 2018.
5. Louis Rogers, Skillful Level 2 Reading & Writing Student's Book Pack (B1) Macmillan Educational, 2013.
6. Hewings, Martin. Cambridge Academic English (B2). CUP, 2012.

Other Suggested Readings:

1. https://www.bbc.co.uk/learningenglish/
2. https://www.talkenglish.com/speaking/basics/speaking_basics_ii.aspx
3. https://www.englishclub.com/speaking/
4. https://www.esolcourses.com/content/topicsmenu/listening.html
5. https://www.cambridgeenglish.org/learning-english/free-resources/writeand-improve/

HS2164 **3-0-0 (3)**

Foundation Course in German

Pre-Requisites: **None**

Course Outcomes:

CO-1	Understand the basics of German Language, its pronunciation, its basic grammatical rules etc.
CO-2	Identify the features pertaining to the syntax and its usage.
CO-3	Analyse the sentences heard or read in its basic features without much delay or translation.
CO-4	Apply the rules of grammar and syntax while speaking, writing, reading or listening.
CO-5	Demonstrate their linguistic ability in the four faculties mentioned in CO4.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	1	2	3	2	–	–	–	–	–	–	–	–	–	–	–	–
CO-2	2	2	2	2	–	–	–	–	–	–	–	–	–	–	–	–
CO-3	3	2	1	3	–	–	–	–	–	–	–	–	–	–	–	–
CO-4	2	3	2	1	–	–	–	–	–	–	–	–	–	–	–	–
CO-5	1	2	1	3	–	–	–	–	–	–	–	–	–	–	–	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Alphabet (Alphabet) Buchstabieren (Spelling) Begrüssen / Grüssen Und Sich Verabschieden (Greetings and Saying 'Bye') Sich Selbst Und Andere Vorsellen (Introducing Oneself and others)

GRAMMAR: Personal pronomen: Ich, Du, Er, Sie, Es, Wir, Ihr, Sie, Sie) (Personal pronouns: I, You, He, She, It, We, You All, They, You) Verb Und Konjugation: Präsens (Verb And Conjugation: Present Tense)) Verben ,Haben8 Und ,Sein8 (Verbs: To Have And To Be) Zahlen (Null – Eine Milliarde (Numbers Zero – One Billion) Rechnen Auf Deutsch: +, - X, ÷ (Calculating In German) Telefonnummer Angeben (Giving The Phone Number) Deutsche Namen (German Names) Ja/Nein Fragen (Yes/No Questions)

GRAMMAR: Satzstruktur (Sentence Structure) Nominativ (Nominative – Subject Case) W- Fragen: Was, Wer, Wann, Woher, Wo, Wie Viele (W-Questions: What, Who, When, Where From, Where, How Many) Bestimmter Artikel: Der, Die, Das (Definite Articles; Der, Die, Das) Namen Der Deutschen Städte (Names of German Cities) Namen Der Länder (Names of Countries) Familienmitglieder (Members of The Family) Wer/Was Ist Das? / Wer/Was Sind Das? (Who Is This/What Is This? Who are They/What are They?)

GRAMMAR: Unbestimmter Artikel: Ein, Eine (Indefenite Articles; A, An) Plural Der Substantive (Plural Forms Of Nouns) Internationale Wörter (International Words) Aussagesatz (Statement) Fragesatz (Interrogative Sentence –Questions) Negation: Nicht, Kein/Keine (Negation: Not, No/None) Wochentage (Days of The Week) Monate (Months) Jahreszeiten (Seasons) Berufe (Professions) Uhrzeit (Telling The Time) Wichtige Feste (Important Festivals)

GRAMMAR: Ja/Nein/Doch (Yes/No/Of Course) Demonstrativpronomen: Dieser, Diese, Dieses, Diesen (Demonstrativpronomen: This, That) Imperativformen: Du/Ihr/Sie (Imperative Forms: You, You All) Possessivpronomen (Possessive Pronoun) Man (One) Essen/Getränke (Fo0d/Drinks)) Farben (Colors) Kleidungsstücke (Dresses) Körperteile (Parts of The Body) Schulsachen (Things for The School) Fächer (Subjects)

GRAMMAR: Akkusativ (Akkusative – The Object Case) Akkusativverben (Verbs in Accusative) Die Ordnungszahlen (Ordinal Numbers) Dativ (Dative -The Object Case) Genitiv (Genetive Case) Tageszeiten (Times of the Day) Sportarten (Different Kinds of Sports) Freizeitbeschäftigung (Hobbys) Lesetexte (Texts for Reading Comprehension) German Songs - Let Us Sing in German!

GRAMMAR: Modalverben: Können, Müssen, Wollen, Möchten, Sollen, Dürfen (Modal Verbs: Can, Must, Want, Like, Should, May) Perfekt (The Present Perfect Tense) Präteritum (Simple Past Tense) Futur I (Future Tense)

Learning Resources:

Text Books:

1. Rosi McNab, Get Started in German Absolute Beginner Course, Orion Publishing Group, 2012, First Edition (Hachette UK).
2. Maria Hamby, Beginning with German: Strategies to Maximize Your Understanding in German (A2 Level), Independently Published, 2021, First Edition (ThriftBooks) (Powell's Books).
3. Emil Otto, Introductory German Lessons, Publisher and year of publication not specified, Edition not specified.
4. Ben Denne, Easy German, Publisher and year of publication not specified, Edition not specified

3rd Semester

MA2201 **3-1-0 (4)**

Modern Algebra

Pre-Requisites: None

Course Outcomes:

CO-1	Discover the binary operations as basic entities which give specific mathematical structures
CO-2	Understand the group structure and possible subgroups
CO-3	Analyze the structure of rings and subrings
CO-4	Classify the groups and rings using isomorphisms between the respective mathematical structures
CO-5	Adapt with mathematical abstractness

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	2	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-2	3	2	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-3	2	2	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-4	3	2	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-5	3	2	2	-	-	-	-	-	-	-	-	-	-	-	-	-

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Groups: Binary operation, Definition and examples of Groups, preliminary lemmas; dihedral groups, symmetric groups, the quaternion group as special examples; Subgroups - Abelian and non-Abelian groups, Cyclic groups; permutation groups; Cosets, Lagrange's Theorem and its consequences on finite groups; a counting principle; Normal Subgroups and Quotient Groups; Centralizers, Normalizers, Centre of a group;

Mappings between Groups: Homomorphism between groups, the kernel of a group, fibers of Homomorphisms, isomorphism, Fundamental theorem of isomorphism on groups; Automorphisms; Cayley's Theorem; Permutation groups;

Rings: Definition of rings and various examples; units & zero divisors of a ring; special classes of rings (viz., division ring, integral domain, field), characteristic of an integral domain; homomorphisms on rings; Ideals and Quotient rings;

Learning Resources:

Text Books:

1. I. N. Herstein, Topics in Algebra, John Wiley & Sons, 1975, Second Edition.
2. David S. Dummit, Richard M. Foote, Abstract Algebra, Wiley, 2004, Third Edition.

Reference Books:

1. Vijay K. Khanna, S. K. Bhambri, A Course in Abstract Algebra, Vikas Publishing House, 2013, Fourth Edition.
2. Joseph A. Gallian, Contemporary Abstract Algebra, Cengage Learning, 2013, Eighth Edition.
3. John B. Fraleigh, A First Course in Abstract Algebra, Pearson, 2013, Seventh Edition.

MA2203 **3-0-2 (4)**

Computer Programming in C

Pre-Requisite: **None**

Course Outcomes:

CO-1	Implement programs using classes and objects.
CO-2	Able to understand the overloading concept.
CO-3	Specify the forms of inheritance and use them in programs.
CO-4	Analyze polymorphic behavior of objects and polymorphism.
CO-5	Understand virtual functions.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	3	3	2	–	2	–	–	–	–	–	–	–	–	–	–
CO-2	1	–	1	2	–	–	–	–	–	–	–	–	–	–	–	–
CO-3	1	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–
CO-4	3	2	3	–	–	–	–	–	–	–	–	–	–	–	–	–
CO-5	2	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

C Fundamentals: The C character set identifiers and keywords, data type & sizes, variable names, declaration, statements.

Operators & Expressions: Arithmetic operators, relational and logical operators, type, conversion, increment and decrement operators, bit wise operators, assignment operators and expressions, precedence and order of evaluation. Input and Output: Standard input and output, formatted output -- printf, formatted input scanf.

Flow of Control: Statement and blocks, if - else, switch, loops - while, for, do while, break and continue, go to and labels.

Fundamentals and Program Structures: Basic of functions, function types, functions returning values, functions not returning values, auto, external, static and register Variables, scope rules, recursion, function prototypes, C pre-processor, command line arguments.

Arrays and Pointers: One dimensional, two dimensional arrays, pointers and functions, multi-dimensional arrays.

Structures Union and File: Structure, union, structures and functions, arrays of structures, file read, file write.

Learning Resources:

Text Books:

1. B. S. Gottfried, "Programming with C", McGraw Hill Education, Fourth edition (2018).
2. B. W. Kernighan, D. Ritchie, "The C Programming Language", Pearson Education India, Second edition (2015).

Reference Books:

1. E Balagurusamy, "Computing Fundamentals and C Programming", McGraw Hill Education; Second edition (2017).
2. Y. Kanetkar, "Let Us C", BPB Publications, Sixteenth edition (2017).
3. E. Balagurusamy, "Programming in ANSI C", McGraw Hill Education India Private Limited, Seventh edition (2017).

Lab experiments

Programs on

1. Expression evaluation.
2. Conditional branching, iterations, pattern matching.
3. Function, recursion.
4. Arrays, pointers, parameter passing.

5 string using array and pointers.

6. Structures, union.

PH2201 **3-0-0 (3)**

Optics

Pre-Requisites: None

Course Outcomes:

CO-1	Understand the concepts of geometrical optics, its construction and importance in optical instruments.
CO-2	Understand and minimize the aberrations in lenses and its applications
CO-3	Explain the physics of image formation based on the fundamental principles of optics
CO-4	Analyze the intensity variation of light due to polarization, interference and diffraction.
CO-5	Analyze the optical applications using the concepts of interference, diffraction and polarization.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	3	2	2	–	–	–	–	–	–	–	–	–	–	–	–
CO-2	3	2	2	2	–	–	–	–	–	–	–	–	–	–	–	–
CO-3	3	3	2	2	–	–	–	–	–	–	–	–	–	–	–	–
CO-4	3	2	2	2	–	–	–	–	–	–	–	–	–	–	–	–
CO-5	3	3	2	2	–	–	–	–	–	–	–	–	–	–	–	–

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Geometric Optics: Optical path, Fermat's principle of Extreme path, applications, Law of reflection, refraction, cardinal points of an optical system, Image formation, Magnification, Cardinal points of a thick lens, focal length of a thick lens, Bi-convex lens, power of a thick lens, Telescopes types, advantages. Translation matrix, refraction matrix, system matrix for thick and thin lens, system matrix for two thin lenses. Dispersion by a prism, dispersive power, angular and chromatic dispersions.

Aberrations in lenses: Aberrations in lenses, Chromatic Aberration, Achromatic Combination of lenses, Monochromatic defects, Spherical aberration, Astigmatism, Coma, Curvature and Distortion, Minimizing aberration.

Interference: Huygens's wave theory of light-Laws of reflection and refraction.- Division of amplitude and wave front; Phase change on reflection: Stokes' treatment; Interference in Thin Films: parallel and wedge-shaped films; Fringes of equal inclination (Hai dinger Fringes); Fringes of equal thickness (Fizeau Fringes); Michelson Interferometer Application; Fabry- Perot interferometer.

Diffraction: Fresnel and Fraunhofer classes of diffraction, Fraunhofer diffraction at single, double ,multiple slits and circular aperture. Diffraction grating- Determination of wavelength of light using diffraction grating (Normal incidence and Minimum deviation); Resolving power; Rayleigh's criterion –limits of resolution for telescopes and microscope, Zone plate- construction and its comparison with convex lens.

Polarization: Polarization of light; Malus law; polarization by reflection; Brewster's law; Analysis of linearly and circularly polarized light; Polarization by double refraction and Huygen's theory; Nicol prism, Half wave and Quarter wave plates; Optical activity and Fresnel's theory, laurents half shade polarimeter; Biquartz polarimeter.- Photo Elasticity- Polariscope.

Learning Resources:

Text Books:

1. Ajoy Ghatak, Optics, McGraw Hill, 2015, Third Edition.
2. Francis Arthur Jenkins, Harvey Elliott White, Fundamentals of Optics, McGraw-Hill, 2018, Fifth Edition.

Reference Books:

1. Optics-Hecht, Zajak; Addison-Wesley, 2015, Third Edition.
2. V. Rajendran, Engineering Physics, Tata McGraw-Hill Education, 2009.

Online Resources:

1. https://nptel.ac.in/courses/122/107/122107035/
2. https://isaacphysics.org/concepts/cp_diffraction
3. https://www.rp-photonics.com/

PH2203 **0-1-2 (2)**

Optics Laboratory

Pre-Requisites: None

Course Outcomes:

CO-1	Understand phenomenon based on light and related theories
CO-2	Get skills to identify and apply formulas of optics and wave physics
CO-3	Understand the applications of diffraction and polarization
CO-4	Understand the applications of interference in design and working of interferometers.
CO-5	Understand the resolving power of different optical instruments.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	2	3	3	1	–	–	–	–	–	–	–	–	–	–	–	–
CO-2	2	3	3	1	–	–	–	–	–	–	–	–	–	–	–	–
CO-3	2	3	3	1	–	–	–	–	–	–	–	–	–	–	–	–
CO-4	2	3	3	1	–	–	–	–	–	–	–	–	–	–	–	–
CO-5	2	3	3	1	–	–	–	–	–	–	–	–	–	–	–	–

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

List of Experiments:

1. To determine the refractive index of a prism by using a spectrometer.
2. To find the wavelength of white light by a plane transmission diffraction grating.
3. To find the specific rotation of sugar solution by using a polarimeter.
4. To find the wavelength of Sodium light by Newton‘s ring.
5. To verify the expression for the resolving power of a Telescope.
6. To find refractive index of the given liquid samples and find Molar refraction and specific refraction
7. Polarization of Light & Verification of Malus Law
8. Determination the wavelength of He-Ne laser using diffraction grating.
9. Spectrometer- Determination of Cauchy's constants
10. Dispersive power of a prism
11. Determination of numerical aperture and acceptance angle of the optical fiber using laser
12. Determination of thickness of thin wire–Air Wedge
13. Brewster‘s Angle determination

Learning Resources:

Text Books:

1. Optics Lab Manual by Department of Physics, NITW, 2021.
2. S. K. Gupta, Engineering Physics Practical, Ninth Edition, Krishna Prakashan Media publishers, 2010

Reference Books:

1. Indu Prakash, Ramakrishna, A Text Book of Practical Physics, Kitab Mahal, New Delhi, 2011, Eleventh Edition.

2. Jr. W.D. Callister, Materials Science and Engineering: An Introduction, Wiley, New York, 2007, Seventh Edition.

Online Resources:

1. http://www-math.mit.edu/~gs/
2. https://nptel.ac.in/courses/111/106/111106051/

CY2201 **3-0-0 (3)**

Inorganic Chemistry-1

Pre-Requisites: None

Course Outcomes:

CO-1	Compare the periodic properties of elements in s & p block elements
CO-2	Understand the various theories of acids and bases
CO-3	Learn the concepts of electrode potentials, emf and factors influencing emf
CO-4	Apply various acid-base theories to understand strengths of acid bases
CO-5	Apply the knowledge of redox potentials in understanding the corrosion process

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	2	2	2	1	2	–	–	–	–	–	–	–	–	–	–
CO-2	3	2	2	2	2	2	–	–	–	–	–	–	–	–	–	–
CO-3	3	2	2	1	2	1	–	–	–	–	–	–	–	–	–	–
CO-4	3	3	3	2	1	2	–	–	–	–	–	–	–	–	–	–
CO-5	3	2	2	1	2	3	–	–	–	–	–	–	–	–	–	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Periodicity of Elements: s & p-block elements: Effective nuclear charge, screening effect, Slater rules, Atomic and ionic radii, Ionization enthalpy, Electron gain enthalpy, Electronegativity, Diagonal relationship, Inert pair effect.

Acids and bases: Arrhenius theory, Bronsted theory, Lewis theory, Lux theory, Strength of acid and bases, Hard and soft acids and bases, Superacids

Redox chemistry: Redox reaction and EMF, Electrodes and Electrochemical cells, Effect of pH, precipitation, complex formation on emf, Redox potential diagrams, Redox titrations, Practical applications, Corrosion,

Learning Resources:

Text Books:

1. J. D. Lee, Concise Inorganic Chemistry, Wiley India, 2015, Fifth Edition.
2. Catherine E. Housecroft, A. G. Sharpe, Inorganic chemistry, Pearson, 2018, Fifth edition.

Reference Books:

1. Huheey, J. H., Keiter, E. A., Keiter, R. L., Medhi, O. K., Inorganic Chemistry: Principle of structure and reactivity, Pearson Education India, 2006, Fourth Edition.
2. D. F. Shriver, P. W. Atkins, Inorganic Chemistry, Oxford University Press, 2006, Fourth Edition.

CY2203 **3-0-0 (3)**

Physical Chemistry-1

Pre-Requisites: None

Course Outcomes:

CO-1	Understand the differences among the colligative properties of solutions.
CO-2	Identify the physical states of matter based on their properties
CO-3	Interpret the distribution of solute between two immiscible solvents
CO-4	Apply phase rule to different systems for isolating the components
CO-5	Apply the concepts of colloids and adsorption in commercially viable technologies

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	2	2	2	1	2	–	–	–	–	–	–	–	–	–	–
CO-2	3	2	2	2	2	2	–	–	–	–	–	–	–	–	–	–
CO-3	3	2	2	1	2	1	–	–	–	–	–	–	–	–	–	–
CO-4	3	3	3	2	1	2	–	–	–	–	–	–	–	–	–	–
CO-5	3	2	2	1	2	3	–	–	–	–	–	–	–	–	–	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Liquid state and gaseous state: Liquid state: Vacancy theory of liquids, Physical properties of liquids: Vapor pressure, surface tension, Viscosity Gaseous State: Deviation of real gases from ideal behavior, van der Waals equation -Critical phenomenon, Andrew isotherms of CO_2 -The law of corresponding states-liquefaction of gases.

Solutions: Liquid-liquid mixtures: Raoult's law, Henry's law, Ideal and Non-ideal solutions, Partially miscible liquids, completely immiscible liquid mixtures- Nernst's distribution law and its Applications.

Phase rule: Components, Degree of freedom, Gibbs Phase rule, Phase equilibria of one component system and two component system**.**

Colloids and Surface Chemistry: Colloids: Preparation of sols, emulsions, gels, Micelles and reverse micelles, critical micelle concentration; Adsorption and its types, Langmuir theory of unilayer adsorption isotherm, BET isotherm and surface area analysis.

Dilute solutions and colligative properties: Colligative Properties: Lowering of Vapour Pressure, Osmotic Pressure, Elevation in Boiling Point, Depression in freezing point, applications of colligative properties. Abnormal behavior of solutions.

Learning Resources:

Text Books:

1. O. P. Agarwal, Unified Course in Chemistry-3, Jai Prakash Nath Publication, 2018.
2. G.M. Barrow Physical Chemistry, McGraw-Hill Education, 2008, Sixth Edition.
3. S. H. Maron, C. F. Prutton, Principles of Physical Chemistry, Macmillan, 1965, Fourth Edition.

Reference Books:

1. P. Atkins, J. de Paula, W. H. Freeman, Physical Chemistry, 2006, Eighth Edition.
2. S. K. Upadhyay, Chemical Kinetics and Reaction Dynamics, Springer, Netherlands, 2006.
3. A.J. Bard, L.R. Faulkner, Electrochemical Methods: Fundamentals and Applications, Wiley, 2000, Second Edition.
4. K. J. Laidler, J. H. Meiser, Physical Chemistry, Houghton Mifflin Company, Boston, 1999, Third Edition.

CY2205 **0-1-2 (2)**

Inorganic Chemistry Laboratory

Pre-Requisites: **None**

Course Outcomes:

CO-1	Gain hands on experience in the volumetric analysis
CO-2	Acquire the knowledge in estimation of metal content in ores
CO-3	Understand principles of volumetric titrations
CO-4	Understand the analysis of cations and anions by spectrophotometric method
CO-5	Analyze water samples for their hardness

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	2	2	2	1	2	–	–	–	–	–	–	–	–	–	–
CO-2	3	2	2	2	2	2	–	–	–	–	–	–	–	–	–	–
CO-3	3	2	2	1	2	1	–	–	–	–	–	–	–	–	–	–
CO-4	3	3	3	2	1	2	–	–	–	–	–	–	–	–	–	–
CO-5	3	2	2	1	2	3	–	–	–	–	–	–	–	–	–	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

1. Determination of Mn^{2+} in pyrolusite by permanganometric method.
2. Determination of Fe^{2+} in hematite by dichrometric method.
3. Determination of total hardness of water by complexometric method.
4. Determination of Al^{3+} by back titration method.
5. Determination of Zn^{2+} by precipitation titration method.
6. Determination of sulphate by spectrometric method.
7. Determination of fluoride by ion-selective method.
8. Determination of Cu^{2+} by conductometric titration method.
9. Determination of Ni^{2+} by colorimetry
10. Analysis of kidney stones by permanganometric titration.
11. Determination of calcium in milk powder by EDTA complexometry.

Learning Resources:

Text Books:

1. G H Jeffery, J Bassett, J Mendham and R C Denney, Vogel's Textbook of Quantitative Chemical Analysis, Longman Inc., 1989, Fifth Edition.
2. J. D. Woolins, Inorganic Experiments, John Wiley & Sons, 2010, Third Edition.

Reference Books:

1. Elias, A. J., A Collection of Interesting General Chemistry Experiments, Universities Press (India) Pvt. Ltd., 2002
2. Practical Inorganic Chemistry: Preparations, Reactions and Instrumental Methods, Springer, 1979, Second Edition.
3. Z. Szafran, R. M. Pike, M. M. Singh, Microscale Inorganic Chemistry: A Comprehensive Laboratory Experience, Wiley, 1991, First Edition.

4th Semester

MA2202 **3-1-0 (4)**

Vector Calculus

Pre-Requisites: MAI101

Course Outcomes:

CO-1	Find the derivative along a curve and directional derivatives.
CO-2	Evaluate and interpret gradient, divergence, curl and their related vector Identities
CO-3	Familiar with line, surface and volume integrals along with its applications
CO-4	Use theorems of Gauss, Green and Stokes to compute integrals.
CO-5	Addresses some of the problems of physics and engineering

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	2	2	–	–	–	–	–	–	–	–	–	–	–	–	–
CO-2	3	2	2	–	–	–	–	–	–	–	–	–	–	–	–	–
CO-3	2	2	2	–	–	–	–	–	–	–	–	–	–	–	–	–
CO-4	3	2	2	–	–	–	–	–	–	–	–	–	–	–	–	–
CO-5	3	2	2	–	–	–	–	–	–	–	–	–	–	–	–	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Vector differentiation: Introduction - Scalar and vector valued point functions, Derivatives, Curves, Tangents and length, Velocity and acceleration, Curvature and torsion of a curve, Level surfaces. Gradient of a scalar field and its geometrical interpretation, Directional derivative, Divergence of a vector field and its applications, Curl of a vector field and its applications, Vector identities.

Vector integration: Line integrals, Line integral independent of path, Work done by force, Circulation, Double Integrals, Green's theorem in the plane, Surfaces and surface integrals, Triple integrals, Divergence theorem of Gauss, Stoke's theorem, Proofs and problems based on these theorems.

Curvilinear Coordinates: Orthogonal curvilinear coordinates, Conditions for orthogonally fundamental triad of mutually orthogonal unit vectors. Gradient, Divergence, Curl and Laplacian operators in terms of orthogonal curvilinear coordinates, cylindrical polar coordinates and Spherical polar coordinates.

Learning Resources:

Text Books:

1. Shanti Narayan, P.K. Mittal, A Textbook of Vector Calculus, S Chand & Co Ltd, 2005.
2. Harry F. Davis, Arthur David Snider, Introduction to vector analysis, Allyn and Bacon Inc, Boston, 1975, Third Edition.

Reference Books:

1. Joseph George Coffin, Vector Analysis: An Introduction to Vector-Methods and Their Various Applications to Physics and Mathematics, John Wiley & Sons, Inc., 1911, Second Edition.
2. P.C.Matthews, Vector Calculus, Springer Undergraduate Mathematics Series, Springer-Verlag London, 1998, First Edition.
3. Murray Spiegel, Seymour Lipschutz and Dennis Spellman, Vector Analysis, Schaum's Outlines Series, 2017, Second Edition.

MA2204 **3-1-0 (4)**

Linear Algebra

Pre-Requisites: None

Course Outcomes:

CO-1	Demonstrate the knowledge of vector space and subspaces.
CO-2	Find rank and nullity of a linear transformation and the corresponding matrix.
CO-3	Test the consistency of system of linear algebraic equations.
CO-4	Solve eigenvalue problems.
CO-5	Illustrate the concept of inner products and orthogonalization.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	2	2	–	–	–	–	–	–	–	–	–	–	–	–	–
CO-2	3	2	2	–	–	–	–	–	–	–	–	–	–	–	–	–
CO-3	2	2	2	–	–	–	–	–	–	–	–	–	–	–	–	–
CO-4	3	2	2	–	–	–	–	–	–	–	–	–	–	–	–	–
CO-5	3	2	2	–	–	–	–	–	–	–	–	–	–	–	–	–

Syllabus:

System of Linear Equations: Elementary row operations, Row echelon form, Row reduced echelon form, Determinant, Rank of a matrix, Inverse of a matrix by elementary operations. Solutions of Homogeneous and Non-homogeneous linear system of equations.

Diagonalization of Matrices: Characteristic equation, Eigenvalues and eigenvectors of a matrix, Cayley-Hamilton Theorem and its use in finding inverse of a matrix and in finding higher powers of a matrix, Similar matrices, Diagonalization of square matrices.

Vector Spaces and Linear Transformations: Vector spaces, Subspaces, Linear dependence and independence, Span of a set, Basis and dimension, Direct sum, Quotient space. Linear transformations, Range and null space, Rank and nullity, Change of basis.

Orthogonality: Inner Product, Length, and Orthogonality-Orthogonal Sets.

Learning Resources:

Text Books:

1. Stephen H. Friedberg, Arnold J. Insel, Lawrence E. Spence, Linear Algebra, Pearson Education, 2022, Fifth Edition.
2. Gilbert Strang, Introduction to Linear Algebra, Wellesley-Cambridge Press, 2009, Fourth Edition.

Reference Books:

1. K. Hoffman, R. Kunze, Linear Algebra, Pearson Education, 2005, Second Edition.
2. S. Lang, Linear Algebra, Undergraduate Texts in Mathematics, Springer-Verlag, 2004.
3. M. Thamban Nair, Arindama Singh, Linear Algebra, Springer, 2018.

Online Resources:

1. http://www-math.mit.edu/~gs/
2. https://nptel.ac.in/courses/111/106/111106051/

PH2202 **3-0-0 (3)**

Electricity and Magnetism

Pre-Requisites: None

Course Outcomes:

CO-1	Demonstrate the application of Coulomb‘s law for the electric field.
CO-2	Understand the relation between electric field and potential.
CO-3	Calculate the magnetic forces that act on moving charges and the magnetic fields
CO-4	Apply Gauss‘s law of electrostatics to solve a variety of problems.
CO-5	Understand the concepts of induction and self-induction.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	3	2	3	–	–	–	–	–	–	–	–	–	–	–	–
CO-2	3	3	2	2	–	–	–	–	–	–	–	–	–	–	–	–
CO-3	3	2	2	2	–	–	–	–	–	–	–	–	–	–	–	–
CO-4	3	3	2	1	–	–	–	–	–	–	–	–	–	–	–	–
CO-5	3	3	2	1	–	–	–	–	–	–	–	–	–	–	–	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Electrostatics : Electric Field and Electric Potential- Electric flux. Gauss' Law with applications to charge distributions with spherical, cylindrical and planar symmetry; Electrostatics- Coulomb‘s law and applications, Laplace's and Poisson equations, The Uniqueness Theorem, Potential and Electric Field due to an arbitrary charged wire, sphere, disc, electric dipole, Force and Torque on a dipole, Energy stored in an electric field; Electrostatic energy of system of charges- Electrostatic energy of a charged sphere, Conductors in an electrostatic Field, Surface charge and force on a conductor, Capacitance of a system of charged conductors, Parallel-plate capacitor.

Magnetism : *Magnetic Field*- Lorentz force, Biot-Savart's Law, Magnetic force between current elements, Ampere's Circuital Law, Maxwell's corrections in Ampere's law; Curl and Divergence of B, vector potential, magnetic flux, Calculation of B for circular and solenoid currents, Magnetic Force on (i) point charge (ii) current carrying wire (iii) between current elements. Torque on a current loop in a uniform Magnetic Field; Intensity of magnetization, Relation between B, H and M.

AC & DC currents: *Steady currents*-Electric current and drift velocity, current density, equation of continuity, electric resistivity and conductivity, Wiedemann-Frenz Law; *Alternating Current*- Mean and r.m.s value of current, emf with sinusoidal wave form, Reactance, Impedance, Phase angle, power dissipation in AC circuit, Power factor, vector diagram, Faraday's Law, Lenz's Law, Self Inductance and Mutual Inductance, LR, CR and LCR, Resonance, Q-factor -Transformer and motors.

Electromagnetic Waves: Maxwell‘s Equations, Displacement current term, Plane Electromagnetic Waves, Energy Carried by Electromagnetic Waves, Momentum and Radiation Pressure, The Electromagnetic Spectrum.

Learning Resources:

Text Books:

1. Edward M. Purcell, Electricity and Magnetism, Cambridge Press, 2013, Third Edition.
2. D.J. Griffiths, Introduction to Electrodynamics, Cambridge Press, 2017, Fourth Edition.

Reference Books:

1. S.Mahajanand Choudhury, Electricity, Magnetism & Electromagnetic Theory, Tata McGraw Hill, 2012.
2. J.H.Fewkes, Yearwood, Electricity and Magnetism, Vol.I, Oxford Univ. Press, 2005.
3. Ajoy Ghatak, K Thyagarajan, Ravi Varshney, Problems and Solutions in Electromagnetics, Viva Books Private Limited, 2015.

Online Resources:

1. https://ocw.mit.edu/courses/physics/8-022-physics-ii-electricity-and-magnetism-fall-2004/lecture-notes/
2. https://examupdates.in/electricity-and-magnetism-notes/

PH2204 **3-0-0 (3)**

Modern Physics

Pre-Requisites: None

Course Outcomes:

CO-1	Understand the main aspects of the inadequacies of classical mechanics as well as understanding of the historical development of quantum mechanics.
CO-2	Describe the main features of Schrodinger equation and the idea of probability interpretation associated with wave-functions.
CO-3	Apply the basic properties of nuclei like density, size, binding energy, nuclear
CO-4	Forces and structure of atomic nucleus, liquid drop model and nuclear shell model and mass formula.
CO-5	Estimate the decay rates and lifetime of radioactive decays like alpha, beta, gamma decay.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	2	2	2	–	–	–	–	–	–	–	–	–	–	–	–
CO-2	3	2	2	1	–	–	–	–	–	–	–	–	–	–	–	–
CO-3	3	2	2	2	–	–	–	–	–	–	–	–	–	–	–	–
CO-4	3	2	2	1	–	–	–	–	–	–	–	–	–	–	–	–
CO-5	3	2	2	2	–	–	–	–	–	–	–	–	–	–	–	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Failures of classical mechanics- Quantum theory of Light, Planck‘s quantum, Planck‘s constant and light as a collection of photons, Photo-electric effect and Compton scattering, Problems with Rutherford model-instability of atoms and observation of discrete atomic spectra.

Wave Particle Duality, matter waves and De Broglie wavelength; Davisson-Germer experiment. wave packets. Superposition of two waves, Group and Phase velocities. Heisenberg Uncertainty Principle, Illustration of the Principle through Experiments. Two slit interference experiment with photons, atoms & particles, eigen values and eigen functions, normalization; Schrodinger equation-particle in a box, Particle in finite potential well-Quantum mechanical tunneling.

Size and structure of atomic nucleus and its relation with atomic weight; Impossibility of an electron being in the nucleus as a consequence of the uncertainty principle. Nature of nuclear force, N-Z graph,semi-empirical mass formula and binding energy.

Stability of the nucleus; Law of radioactive decay; Mean life and half-life; Alpha decay; Beta decay: energy released, spectrum and Pauli's prediction of neutrino; Gamma ray emission, energy-momentum conservation: electron-positron pair creation by gamma photons in the vicinity of a nucleus. Fission and fusion: mass deficit, relativity and generation of energy; Classification of Elementary Particles.

Learning Resources:

Text Books:

1. Arthur Beiser, Concepts of Modern Physics, McGraw-Hill, 2015, Fifth Edition.
2. E.H. Wichman, Quantum Physics, Berkeley Physics, Vol.4, 2008, Tata McGraw-Hill Co.
3. R.A. Serway, C.J. Moses, C.A.Moyer, Modern Physics, Cengage Learning, 2005.

Reference Books:

1. Fishbane and Gasiorowicz, Modern Physics – Bernstein, Pearson Education, 2015, Fourth Edition.
2. J.R. Taylor, C.D. Zafiratos, M.A. Dubson, Modern Physics, PHI Learning, 2012, Third Edition.
3. R. Gautreau, W. Savin, Theory and Problems of Modern Physics, Schaum`s outline, TMH, 2011, Second Edition.

Online Resources:

1. http://web.sbu.edu/physics/courses/physics-203p.pdf
2. https://drive.google.com/file/d/1OPregBXJ2ldBYeoWh1v9KCxQwzvzlYqY/view
3. http://higgs.physics.ucdavis.edu/9D_part1.pdf

PH2206 **0-1-2 (2)**

Electricity and Magnetism Laboratory

Pre-Requisites: None

Course Outcomes:

CO-1	Demonstrate the construction, functioning and uses of different electrical bridge circuits, and
CO-2	Analyse the experimental data, sources of error and their estimation in detail
CO-3	Understand the characteristics of RC and LRC circuit.
CO-4	Understand the concepts of self-induction and mutual induction via standard methods.
CO-5	Understand Faraday's laws

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	2	3	3	1	–	–	–	–	–	–	–	–	–	–	–	–
CO-2	2	3	3	2	–	–	–	–	–	–	–	–	–	–	–	–
CO-3	2	3	3	2	–	–	–	–	–	–	–	–	–	–	–	–
CO-4	2	3	3	1	–	–	–	–	–	–	–	–	–	–	–	–
CO-5	2	3	3	2	–	–	–	–	–	–	–	–	–	–	–	–

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

List of Experiments:

Measurements with a multimeter.

1. Study characteristics of a series RC circuit.
2. Measurement of response curve of a Series LCR circuit and determine the (a) Resonantfrequency, (b) Impedance at resonance, (c) Quality factor Q, and (d) Band width.
3. Measurement of response curve of a parallel LCR circuit and determine the (a) Anti-resonant frequency and (b) Quality factor Q.
4. Measurement of low resistance using Carey foster bridge.
5. Measurement of field strength B and its variation in a solenoid
6. **D**etermine self-inductance of a coil by Anderson's bridge.
7. Verification of superposition and maximum power transfer theorems.
8. Determine self-inductance of a coil by Rayleigh's method.
9. Determine the mutual inductance of two coils by Absolute method.
10. Determination of the resistance of a galvanometer by Kelvin‘s method using P. O box.
11. Study of rise and decay of current in LR circuit with a source of constant EMF.
12. Determination of velocity of sound in air.
13. Study of electromagnetic induction and verification of Faraday‘s law.

Learning Resources:

Text Books:

1. Electricity and Magnestism Lab Manual, Department of Physics, NITW, 2021
2. Indu Prakash, Ramakrishna, A Text Book of Practical Physics, Kitab Mahal, New Delhi, 2011, Eleventh Edition.

CY2202 **3-0-0 (3)**

Organic Chemistry-2

Pre-Requisites: None

Course Outcomes:

CO-1	Learn the chemistry of biomolecules, carbohydrates, Terpenoids and alkaloids
CO-2	Interpret the change in the biological or materials property of a molecule based on the stereochemistry of molecules
CO-3	Understand the principle of spectroscopy
CO-4	Apply the concept of stereochemistry in preparation and separation of stereo chemicals at industrial scale
CO-5	Apply the concepts of electronic, vibrational and NMR spectroscopy for structural elucidation of organic compounds

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	2	3	3	1	–	–	–	–	–	–	–	–	–	–	–	–
CO-2	2	3	3	2	–	–	–	–	–	–	–	–	–	–	–	–
CO-3	2	3	3	2	–	–	–	–	–	–	–	–	–	–	–	–
CO-4	2	3	3	1	–	–	–	–	–	–	–	–	–	–	–	–
CO-5	2	3	3	1	–	–	–	–	–	–	–	–	–	–	–	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Basic Stereochemistry: Chiral molecules, optical isomerism, specific rotation, Enantiomer & Diastereomers, Meso compound, Racemic mixture, classifications of chiral molecules based on symmetry Relative and Absolute configuration, Racemization and Resolution methods, Erythro, Threo-nomenclature, Geometrical isomerism

Spectroscopy: Electromagnetic spectrum, Franck-Condon principle, Born-Oppenheimer approximation.

Electronic spectroscopy: Beer-Lambert law, electronic transitions, wavelength and absorption shifts, Woodward-Fieser rules of dienes.

Vibrational spectroscopy: Hooke's law, selection rules, characteristic infrared absorptions of various functional groups, structural elucidation.

NMR spectroscopy: Principle, Processional frequency, orientation of protons in the magnetic field, number of signals, chemical shift, spin-spin coupling, coupling constant (J), applications.

Chemistry of biomolecules: Amino acids, Proteins, Peptides, Coenzymes, Lipids & Fatty acids.

Carbohydrates: Classification, Structures and conformational studies and Reactions of monosaccharides, Oligosaccharides, Polysaccharides, and unnatural sugars.

Terpenoids and Alkaloids: Classification, Structure and synthesis.

Learning Resources:

Text Books:

1. S.M. Mukherjee, S. P. Singh, Reaction Mechanism in Organic Chemistry, Macmillan India Limited, 2009.
2. W. Carruthers, Some Modern Methods of Organic Synthesis, Cambridge University Press, Cambridge. 2007, Fourth Edition.

Reference Books:

1. P. S. Kalsi, Stereochemistry of Organic Compounds
2. Silvestin, Bacceler, Applications of Spectroscopy to Organic Compounds, Pergaman Press, 2003.
3. Michael B. Smith, Organic Synthesis, Mc Graw-Hill, 2004, Second Edition.
4. William Kemp, Macmillan, Organic Spectroscopy, 2009, Third Edition.

Online Resources:

1. https://www2.chemistry.msu.edu/faculty/reusch/VirtTxtJml/intro1.htm
   (A virtual Textbook of Organic Chemistry)

CY2204 **0-1-2 (2)**

Organic Chemistry Laboratory

Pre-Requisites: None

Course Outcomes:

CO-1	Understand the physical properties and solubility of the organic molecules.
CO-2	Identify the organic compounds using chemical tests.
CO-3	Understand the reactivity of functional groups present in the molecules.
CO-4	Use the derivatization techniques to confirm the compound present in given mixture.
CO-5	Apply the experimental organic chemistry for the preparation of value added product.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	2	2	2	1	2	–	–	–	–	–	–	–	–	–	–
CO-2	3	2	2	2	2	2	–	–	–	–	–	–	–	–	–	–
CO-3	3	2	2	1	2	1	–	–	–	–	–	–	–	–	–	–
CO-4	3	3	3	2	1	2	–	–	–	–	–	–	–	–	–	–
CO-5	3	2	2	1	2	3	–	–	–	–	–	–	–	–	–	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Qualitative and quantitative analysis of organic compounds: Identification of each of the component (organic compounds) by using: Preliminary examination, separation and identification organic compounds (extra elements).

Green chemistry experiments: Extraction of natural products: Extraction and Identification of DNA from from Green peas.

Extraction

1. Isolation of (+)-Limonene from Orange Oil
2. Isolation of Plant Pigments from Green and Red Leaves
3. Caffeine Extraction from Tea and Coffee
4. Isolation of Essential Oils by Preparative Gas Chromatography
5. Analysis of Racemic and (*S*)-Ibuprofen

Organic reactions

1. A S_N1 Reaction: Synthesis of *tert*-Butyl Chloride
2. Kinetics of a S_N1 Reaction
3. Counterion Effects in the Nucleophilic Substitution Reaction of the Acetate Ion with Alkyl Bromides in the Synthesis of Esters
4. Conversion of Alcohols into Alkyl Chlorides Using Cyanuric Chloride
5. Gabriel Synthesis of *n*-Octylamine Under Phase-Transfer Catalysis: The First Step
6. Green Esterification: The Synthesis of Aromas in the Presence of an Acid Resin
7. Synthesis and Characterization of Biodiesel Propyl Esters to Determine the Fatty Acid Content of Unknown Plant Oils
8. Synthesis of Dimedone

Learning Resources:

Text Books:

1. G. Mann, B.C Saunders, Practical Organic Chemistry, ELBS Edition and Longman Group Limited, 2002.
2. Text Book of Practical Organic Chemistry, Vogel A. I., Fifth Edition, ELBS, 2000

5th Semester

MA2301 **3-1-0 (4)**

Mathematical Analysis

Pre-Requisites: MAI101

Course Outcomes:

CO-1	Know the fundamental principles of real numbers that underpin the formal development of
CO-2	Apply the understanding of the theory of sequences and series
CO-3	Understand the concepts related to metric spaces such as continuity.
CO-4	Apply the mean value theorems and the fundamental theorem of calculus.
CO-5	Adapt with the skills in constructing mathematical arguments

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	2	2	–	–	–	–	–	–	–	–	–	–	–	–	–
CO-2	3	2	2	–	–	–	–	–	–	–	–	–	–	–	–	–
CO-3	2	2	2	–	–	–	–	–	–	–	–	–	–	–	–	–
CO-4	3	2	2	–	–	–	–	–	–	–	–	–	–	–	–	–
CO-5	3	2	2	–	–	–	–	–	–	–	–	–	–	–	–	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Sequence and Series of Real Numbers: Equivalence and countability of sets, real numbers, least upper bounds and greatest lower bounds; Sequences of real numbers – convergence and divergence of sequences, bounded and monotone sequences, operations on sequences, limit superior and limit inferior, Cauchy sequences; Series of real numbers – convergence and divergence, series with non-negative terms, alternating series, conditional and absolute convergence of series, rearrangement of series, Tests of absolute convergence – comparison test, ratio test, root test; powers series and radius of convergence; series whose terms form a non-increasing sequence; summation by parts.

Metric Spaces and Continuous Functions: Limit of a function on the real line; metric spaces; point set topology on metric spaces; open sets; closed sets; limits in metric spaces; continuous functions on metric spaces.

Calculus: Definition of Riemann integral; existence; properties of Riemann integral; derivatives; mean value theorems; fundamental theorem of calculus.

Learning Resources:

Text Books:

1. Richard R. Goldberg, Methods of Real Analysis, John Wiley & Sons, Reprint by Oxford and IBH Publishing, 2020, Second Edition.

Reference Books:

1. Robert G. Bartle, Donald R. Sherbert, Introduction to Real Analysis, Wiley India, 2014, Fourth Edition.

2. Ajit Kumar, S. Kumaresan, A Basic Course in Real Analysis, CRC Press, 2016, Special Indian Edition.
3. Tom M. Apostol, Mathematical Analysis, Addison-Wesley, 1974, Second Edition.

PH2301 **3-0-0 (3)**

Basic Electronics

Pre-Requisites: None

Course Outcomes:

CO-1	Understand operating principles of electronic components like diode, Zener diode, BJT and
CO-2	Comprehend the functioning and biasing of transistors and study their characteristics
CO-3	Comprehend the I-V characteristics of BJT, FET and J-FET devices
CO-4	Understand functioning of amplifiers and oscillators and be able to design related circuits as well
CO-5	Understand and appreciate number systems and the functioning of basic logic gates

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	2	2	2	–	–	–	–	–	–	–	–	–	–	–	–
CO-2	3	2	2	2	–	–	–	–	–	–	–	–	–	–	–	–
CO-3	3	2	2	2	–	–	–	–	–	–	–	–	–	–	–	–
CO-4	3	2	2	2	–	–	–	–	–	–	–	–	–	–	–	–
CO-5	3	2	2	2	–	–	–	–	–	–	–	–	–	–	–	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

PN Junction Diode: Basics, ideal diode, PN junction diode, V-I characteristics, Zener diode, Half, full wave (center tapped and Bridge) rectifiers, RC and LC filters, Design of un-regulated DC power supply, Clipping and Clamping circuits, voltage multiplier circuits.

BJT: Construction and Operation, CE, CB and CC characteristics, DC load line and bias point, fixed, emitter feedback, collector feedback, and voltage divider biasing circuits, Thermal stability, switching circuits, Constant Current sourcs, transistor power dissipation, switching.

Field effect transistors (FET): JFET, Construction, Working, and characteristics, Biasing in ohmic and active regions, Trans-conductance, amplification and switching, MOSFET, CMOS introduction.

Amplifiers and Oscillators: Classification, RC-coupled CE amplifier – frequency response. Feedback circuits, noise, input and output impedances. Emitter follower and Darlington pair. RC oscillators- RC phase shift and Wien‘s bridge oscillators, LC oscillators- Hartley and Colpitt oscillators.

Digital Electronics: Binary, octal, decimal and hexadecimal number systems, Booleon algebra, -Basic and Universal Gates, Half adder, Full adder and parallel adder logic circuits. Logic families and their characteristics.

Learning Resources:

Text Books:

1. David A. Bell, Electronic Devices and Circuits, Oxford University Press, 2008, Fifth Edition
2. Albert Malvino, David, Electronic Principles, McGraw-Hill, 2016, Fifth Edition.

Reference Books:

1. Robert L. Boylestad, Louis Nashelsky, Electronic Devices and Circuit Theory, Pearson education, 2013, Fifth Edition.
2. Jacob Millman, Chrisots C. Halkias, Satyabrata Jit Millman, Electronic Devices and Circuits, McGraw Hill, 2007, Second Edition.

Online Resources:

1. https://nptel.ac.in/courses/117/103/117103063/
2. https://nptel.ac.in/courses/117/107/117107095/

PH2303 **3-0-0 (3)**

Fundamentals of Nanomaterials and Applications

Pre-Requisites: None

Course Outcomes:

CO-1	Understand why nanomaterials exhibit varying properties compared to their bulk
CO-2	Distinguish various nanostructured materials based on size, shape, properties and functionalities
CO-3	Comprehend and choose appropriate method for synthesis of nano-structured materials
CO-4	Understand characterization techniques and estimate grain size and bandgap using formulations
CO-5	Understand and appreciate applications of various nanomaterials in a variety of fields

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	2	3	3	2	–	–	–	–	–	–	–	–	–	–	–	–
CO-2	3	3	3	2	–	–	–	–	–	–	–	–	–	–	–	–
CO-3	3	3	3	1	–	–	–	–	–	–	–	–	–	–	–	–
CO-4	2	3	3	2	–	–	–	–	–	–	–	–	–	–	–	–
CO-5	2	3	4	2	–	–	–	–	–	–	–	–	–	–	–	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Introduction to miniaturization: Historical background, Development of nanomaterials, units, Scaling laws, organization of matter- atoms, molecules, clusters and supramolecules.- Structure and Bonding, Hierarchical, molecular and crystalline structures - Bulk to surface transition, Quantum size effects, density of states, band gap and dimensionality, surface reconstruction, self-assembly.

Classification of Nanomaterials: Nomenclature of nanomaterials, 2D materials, Carbon based materials, self-assembled nanomaterials, core-shell particles, Nano metals, Nano- composites, contemporary nano-structured / nano-dimensional thin films

Physical and chemical methods for synthesis of Nanomaterials: Top down and bottom up approaches - Mechanical milling, evaporation, IGCT, vapour transport, molecular beam epitaxy, laser deposition, Colloidal and sol-gel techniques, size distribution, properties variation and yield of nanomaterials, Bio-inspired and template methods.

Nanomaterial characterization techniques: X-Ray Diffraction, Grain Size estimation, UV- Vis spectroscopy, Effect of grain size - Scanning and Transmission electron microscopy, Particle size analyzer, scanning probe/tunneling and Atomic force microscopy and surface techniques.

Applications of Nanomaterials: Mechanical, magnetic, electrical, optical, biocompatibility, toxicity,

chemical, gas and bio-sensing, battery and energy harvesting applications, textiles, cosmetics, drug delivery, Magnetic hyperthermia, defense, and other contemporary applications.

Learning Resources:

Text Books:

1. Sulabha K. KulkarnI, Nanotechnology: principles and practices Springer publications, 2019, Third Edition.
2. T. Pradeep, NANO, The Essentials, Tata McGraw-Hill, 2008

Reference Books:

1. Edward L. Wolf, Nanophysics and Nanotechnology, Wiley-VCH, 2015, Third Edition.
2. Robert Vajtai, Springer Handbook of Nanomaterials, 2013.
3. B. Rogers, J Adams, S. Pennathur, Nanotechnology the Whole Story, CRC Press, 2013.

Online Resources:

1. https://www.classcentral.com/subject/nanotechnology

PH2305 **0-1-2 (2)**

Basic Electronics Laboratory

Pre-Requisites: None

Course Outcomes:

CO-1	Comprehend the operating principles of electronic components like resistor, diode, LED etc.
CO-2	Design circuits for studying the characteristics of rectifier diode, LED and photo-diodes
CO-3	Analyse output wave forms and also measure voltage and current of half and full wave rectifiers
CO-4	Verify the characteristics of NPN (CE, CB and CC configurations) transistor and FET
CO-5	Verify truth tables of basic digital logic gates and troubleshoot related circuits in general

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	2	3	3	1	–	–	–	–	–	–	–	–	–	–	–	–
CO-2	2	3	3	1	–	–	–	–	–	–	–	–	–	–	–	–
CO-3	2	3	3	1	–	–	–	–	–	–	–	–	–	–	–	–
CO-4	2	3	3	1	–	–	–	–	–	–	–	–	–	–	–	–
CO-5	2	3	3	1	–	–	–	–	–	–	–	–	–	–	–	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Experiments:

1. Obtain I-V characteristics of semiconductor rectifier diode, LED, and Photo-diode
2. To observe waveform at the output of half wave rectifier and to measure DC voltage, DC current, ripple factor with and without a filter capacitor
3. To observe waveform at the output of full wave rectifier and to measure DC voltage, DC current, ripple factor with and without a filter capacitor
4. To observe waveform at the output of bridge rectifier and to measure DC voltage, DC current, ripple factor with and without a filter capacitor
5. To construct clamper circuits on breadboard and to observe waveforms at the output of clamper circuits
6. To construct clipper circuits on breadboard and to observe waveforms at the output of clipper circuits
7. To obtain common emitter, common base and common collector characteristics of NPN transistor
8. To design and construct common emitter amplifier circuit on breadboard and to measure gain at different frequencies and to plot the frequency response
9. To understand the working of transistor as a switch. To draw DC load line for given circuit.
10. To observe input-output waveforms of common collector (CC) amplifier and to measure gain of amplifier at different frequencies and to plot the frequency response
11. To obtain characteristics of field effect transistor (FET) and to measure gain of FET common source (CS) amplifier.
12. To construct and verify truth table of basic digital logic gates OR, AND, NOT, NAND, NOR, EX-OR, EX-NO

Learning Resources:

Text Books:

1. Electronics Lab Manual, Department of Physics, NITW,2021
2. Albert Paul Malvino, Patrick Hoppe, David J. Bates, Experiments Manual for Use with Electronic Principles, MCG Hill, 2015

Reference Books:

1. Albert Malvino, David J Bates, Problems and Solutions in Basic Electronics, McGraw Hill Education, 2011, Special Indian Edition.
2. Jacob Millman, Chrisots C. Halkias, Satyabrata Jit, Electronic Devices and Circuits with simulation, McGraw Hill, 2009.

Online Resources:

1. http://vlabs.iitkgp.ac.in/be/

CY2301 **3-0-0 (3)**

Inorganic Chemistry-2

Pre-Requisites: None

Course Outcomes:

CO-1	understand the general chemistry of d and f block elements
CO-2	Understanding the general chemistry of main group elements
CO-3	Learn bonding theories in coordination compounds
CO-4	Interpret the biological importance of organometallic compounds
CO-5	Apply theories of bonding in the interpretation of colour and magnetic properties of coordination compounds

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	2	2	2	1	2	–	–	–	–	–	–	–	–	–	–
CO-2	3	2	2	2	2	2	–	–	–	–	–	–	–	–	–	–
CO-3	3	2	2	1	2	1	–	–	–	–	–	–	–	–	–	–
CO-4	3	3	3	2	1	2	–	–	–	–	–	–	–	–	–	–
CO-5	3	2	2	1	2	3	–	–	–	–	–	–	–	–	–	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Transition Metal Chemistry: d-block elements: oxidation state, complex formation, color and magnetic properties, organometallic compounds and their biological importance

Inner Transition Metal Chemistry: Lanthanides and actinides: Oxidation state, separation, physical properties, super heavy elements, Nuclear fuels

Main group Chemistry: Polyhedral boranes and carboranes: structure, bonding and electron count, Isolobal analogy, boron heterocycles, P-N compounds, S-N heterocycles

Coordination Chemistry: Theories of metal-ligand bonding- Valence bond theory and crystal field theory, Limitations, applications

Learning Resources:

Text Books:

1. J. D. Lee, Concise Inorganic Chemistry, Wiley India, 2015, Fifth Edition.
2. Catherine E. Housecroft, A. G. Sharpe, Inorganic chemistry, Pearson, 2018, Fifth Edition.

Reference Books:

1. William F. Trench, Introduction to Real Analysis, Library of Congress Cataloging-in-Publication Data, 2010, Second Edition.
2. Tom M. Apostol, Mathematical Analysis, Addison Wesley, 1974, Second Edition.

CY2303 **3-0-0 (3)**

Physical Chemistry-2

Pre-Requisites: None

Course Outcomes:

CO-1	Identify the unique vocabulary of thermodynamics for explaining the basic concepts associated with it.
CO-2	Apply the laws of thermodynamics to closed and open systems undergoing different thermodynamic processes and evaluate the feasibility of a thermodynamic cycle.
CO-3	Apply the knowledge of electrochemistry in understanding electrochemical energy systems
CO-4	Analyze the types of reactions and theories of reaction rates.
CO-5	Perceive the theories of ionization and electrochemistry for analysing electrochemical processes.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	2	2	2	1	–	–	–	–	–	–	–	–	–	–	–	–
CO-2	2	1	2	2	–	–	–	–	–	–	–	–	–	–	–	–
CO-3	2	1	1	1	–	–	–	–	–	–	–	–	–	–	–	–
CO-4	2	2	2	1	–	–	–	–	–	–	–	–	–	–	–	–
CO-5	2	1	1	2	–	–	–	–	–	–	–	–	–	–	–	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Thermodynamics: First Law of Thermodynamics: Enthalpy, Heat Capacity, Joule-Thomson Effect, Isothermal Expansion of an Ideal Gas, Thermochemistry, Second Law of Thermodynamics**:** Spontaneous, Irreversible Process, The Carnot Cycle, Entropy, Helmholtz Free Energy, Gibbs-Helmholtz Equations, Clausius-Clapeyron equation, Van't Hoff Isotherm and Isochore.

Electrochemistry: Kohlrausch Law, Transport Numbers, Arrhenius theory of electrolyte dissociation, ostwald's dilution law, Debye-Huckel Theory of Strong Electrolytes- Debye-Huckel-Onsagar Equation, Activity and Activity coefficients, Ionic strength, Electrochemical Cells and EMF: Nernst equation, Reference Electrodes, Concentration cells, liquid junction potential and its determination, applications of emf measurements, Rechargeable Batteries, Fuel Cells

Chemical Kinetics: Order of a reaction**,** Effect of Temperature on Reaction Rates. Theories of Reaction Rates**:** collision theory (mathematical treatment). Collision theory of bimolecular gaseous reactions (overview).

Learning Resources:

Text Books:

1. O. P. Agarwal, Unified Course in Chemistry-3, Jai Prakash Nath Publication, 2018.
2. G.M. Barrow, Physical Chemistry, Tata McGraw-Hill Education, 2008, Sixth Edition.
3. S. H. Maron and C. F. Prutton, Principles of Physical Chemistry, Macmillan, 1965, Fourth Edition.

Reference Books:

1. P. Atkins, J. de Paula, W. H. Freeman, Physical Chemistry, 2006, Eighth Edition.
2. S. K. Upadhyay, Chemical Kinetics and Reaction Dynamics, Springer, Netherlands, 2006.
3. A.J. Bard, L.R. Faulkner, Electrochemical Methods: Fundamentals and Applications, Wiley, 2000, Second Edition.
4. K. J. Laidler, J. H. Meiser, Physical Chemistry, Houghton Mifflin Company, Boston, 1999, Third Edition.

CY2305 **0-1-2 (2)**

Physical Chemistry Laboratory

Pre-Requisites: **None**

Course Outcomes:

CO-1	Relate qualitative and quantitative concepts of physical chemistry for solving problems in physical chemistry with appropriate methodologies
CO-2	Demonstrate procedures and methods applied in analytical and practical tasks of physical chemistry
CO-3	Identify the appropriate instrumental technique to measure the physical property of interest
CO-4	Apply the scientific process in the design, conduct, evaluation and reporting of experimental investigations
CO-5	Assess and mitigate risks when working with chemicals and hazardous substances

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	1	2	1	2	–	–	–	–	–	–	–	–	–	–	–	–
CO-2	1	1	1	1	–	–	–	–	–	–	–	–	–	–	–	–
CO-3	1	1	1	1	–	–	–	–	–	–	–	–	–	–	–	–
CO-4	1	2	1	1	–	–	–	–	–	–	–	–	–	–	–	–
CO-5	1	2	2	1	–	–	–	–	–	–	–	–	–	–	–	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

1. Determination of dissociation constant of a weak acid and verification of Ostwald's dilution law
2. Determination of concentrations of strong acid/weak acid using conductometry
3. Determination of concentrations of strong acid/weak acid by potentiometry
4. Evaluation of E^o values of $Zn|Zn^{2+}$ and $Cu|Cu^{2+}$ Electrodes and measurement of emf by constructing the Daniel cell.
5. Determination of the concentration of strong/weak acid by pH metry
6. Measurement of pH of given samples of milk, juice, soap, detergent and shampoo.
7. To study the kinetics of acid hydrolysis of methyl acetate
8. To study the kinetics of acid-catalysed iodination of acetone
9. Iodine Clock reaction
10. Determination of decomposition of hydrogen peroxide in the presence of ferric chloride.
11. Verification of Beer-Lambert's and determination of the concentration of given $KMnO_4$ solution using spectrophotometer
12. Determination of specific rate constant of oxidation of alcohol by potassium dichromate
13. Spectrophotometric Determination of Critical Micelle Concentration.
14. Verification of Freundlich's Adsorption isotherm for the adsorption of acetic acid on charcoal

Learning Resources:

Text Books:

1. Shoemaker D.P., Garland C.W. and Nibler J.W. Experiments in Physical Chemistry, McGraw Hill, 2008, Eighth Edition.
2. S.W. Rajbhoj and T.K. Chondheka,Systematic Experimental Physical Chemistry, Anjali Publication, 2013, Third Edition.

Reference Books:

1. A. J. Elias, A Collection of Interesting General Chemistry Experiments, Universities Press, 2007, Revised Edition.
2. Alexander Findley, Practical Physical Chemistry, Wiley, 1972, Ninth Edition.
3. R.C. Das, B. Behera, Experiments in Physical Chemistry, McGraw-Hill, 1984.

6th Semester

MA2302 **3-1-0 (4)**

Introductory Methods of Numerical Analysis

Pre-Requisites: **None**

Course Outcomes:

At the end of the course, the student will be able to

CO1	find the roots of nonlinear equations numerically
CO2	interpolate the given data by different interpolating polynomials
CO3	find the value of the derivative at a tabulated point
CO4	evaluate the definite integrals using Newton quadrature formula

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	2	2	2	2	1	2	2	2	-	-	-	-	-	-	-	-
CO-2	2	2	2	2	1	2	2	2	-	-	-	-	-	-	-	-
CO-3	1	2	2	2	1	2	2	2	-	-	-	-	-	-	-	-
CO-4	2	2	2	2	1	2	2	2	-	-	-	-	-	-	-	-

1 – Slightly; 2 – Moderately; 3 – Substantially

Syllabus:

Solutions of Algebraic and Transcendental equations: The Bisection Method- Method of False position, Newton Method and Its Extensions- Error Analysis for Iterative Methods- Accelerating Convergence

Solution of linear algebraic system of equations: Gauss-Seidel iteration methods, Solution of tridiagonal system, Ill conditioned equations.

Interpolation: Unequally spaced data – Lagrange's and Newton's divided difference formulae, Equally spaced data –finite differences, finite difference (Forward, Backward, and central) operators and their properties, Newton forward and Backward difference interpolation formula, Central difference interpolation formula

Numerical differentiation: Differentiation: Finite difference approximations for first and second order derivatives.

Numerical Integration- Newton Cotes formula, Composite Trapezoidal, Simpson 1/3, and 3/8 rules.

Numerical solution of ordinary differential equations: Taylor's, Euler method, Modfied Euler method, Runge-Kutta 4th order method

Learning Resources:

Text Books:

1. Numerical Analysis: Mathematics of Scientific Computing, D. Kincaid and W. Cheney, 3rd Edition., American Mathematical Society, 2009.
2. Numerical Methods for Engineers and Scientists, M.K. Jain, SRK Iyengar and R.K Jain, New Age International, 2008.
3. Computer Oriented Numerical Methods, V. Rajaraman, Third Edition, Prentice Hall of India, 2006.

Reference Books:

1. Introduction to Numerical Analysis, F.B.Hildebrand, Dover Publications Inc, 2003
2. Introductory Methods of Numerical Analysis, S.S.Sastry, Prentice Hall of India, 2012
3. Elementary Numerical Analysis: An Algorithmic Approach, S.D. Conte and C. de Boor, Mc-GrawHill, 1981.

Professional Elective - 1

MA2322 **3-1-0 (4)**

Analytical Solid Geometry

Pre-Requisites: **None**

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

CO1	To understand the fundamental concepts of 3D geometry
CO2	To describe some of the surfaces using 3D geometry
CO3	To explain the properties of planes, lines, spheres and cones.
CO4.	To interpret the problems geometrically and then to get the solution.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	2	2	2	1	2	2	1	–	–	–	–	–	–	–	–
CO-2	3	2	2	2	1	1	2	2	–	–	–	–	–	–	–	–
CO-3	2	2	2	2	1	2	1	2	–	–	–	–	–	–	–	–
CO-4	3	2	2	2	1	2	2	1	–	–	–	–	–	–	–	–
CO-5	3	2	2	–	–	–	–	–	–	–	–	–	–	–	–	–

Syllabus:

The Plane: Equation of plane in terms of its intercepts on the axis, Equations of the plane through the given points, Length of the perpendicular from a given point to a given plane, Bisectors of angles between two planes, Combined equation of two planes, Orthogonal projection on a plane.

Sphere: Definition-The Sphere through four given points-Equations of a Circle - Intersection of a Sphere and a Line - Equation of a tangent Plane - Angle of Intersection of Two Spheres Radical Plane.

Cones: Definition-Condition that the General Equation of second degree Represents a Cone Cone and a Plane through its Vertex - Intersection of a Line with a Cone - The Right Circular Cone.

Cylinders: Definition of a cylinder. Equation to the cylinder whose generators intersect a given conic and are parallel to a given line, Enveloping cylinder of a sphere. The right circular cylinder. Equation of the right circular cylinder with a given axis and radius.

Learning Resources:

Text Books

1. Analytical Solid Geometry, Shanti Narayan and P K Mittal,S. Chand Limited, 2007 (7th edition).
2. Elementary Treatise on Coordinate Geometry of Three Dimensions, R. J. T. Bell, Macmillan India Ltd, 1994.

Reference Books:

1. A Text Book of Analytical Geometry of Three Dimensions, P.K. Jain and Khaleel Ahmed Wiley Eastern Ltd., 1999.

MA2324 **3-1-0 (4)**

Theory of Equations

Pre-Requisites: **None**

Course Outcomes:

At the end of the course, the student will be able to

CO1	Able to solve some of the polynomial equations.
CO2	use the Descartes's rule of sign to find the nature of roots
CO3	Location of the roots of an equation.
CO4	understand Cardon's, Ferrari's and Descartes' method to find roots of cubic and biquadratic equations
CO5	Illuminating sequel to geometry, algebra and analytic geometry.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	2	2	2	1	2	2	2	–	–	–	–	–	–	–	–
CO-2	3	2	2	2	1	2	2	2	–	–	–	–	–	–	–	–
CO-3	2	2	2	2	1	2	2	2	–	–	–	–	–	–	–	–
CO-4	3	2	2	2	1	2	2	2	–	–	–	–	–	–	–	–
CO-5	2	2	2	–	–	–	–	–	–	–	–	–	–	–	–	–

Syllabus:

Graphical representation of a polynomial – Maxima and minima values of polynomials Theorems relating to the real roots of equations - Existence of a root in the general equation - Imaginary roots – Theorem determining the number of roots of an equation – Equal roots – Imaginary roots occurring in pairs - Synthetic division - Diminishing the roots of equation by a given number.

Formation of equation whose roots are functions of the roots of a given equation - Descartes' rule of signs for positive roots - Descartes' rule of signs for negative roots - The fundamental theorem of algebra.

Relations between the roots and coefficients of equation and related theorems - Applications of the theorem - Depression of an equation when a relation exists between two of its roots – The cube roots of unity - Symmetric functions of the roots - Common roots and multiple roots .

Transformation and numerical solution of algebraic equations – Location of the roots of an equation – Binomial and reciprocal equations – Solutions of cubic equations (Cardon's method) - Ferrari's and Descartes' solution of biquadratic equations.

Learning Resources:

Text Books:

1. Theory of equations, H.W. Turnbull, Oliver and Boyd, Edinburgh and London, Interscience Publishers Inc, 1952, 4th Edition.
2. An introduction to the modern theory of equations, Florian Cajori, The Macmillan Company, New York, London, 1919

Reference Books:

1. Theory of Equations, C. C. Mac Duffee, John Wiley, New York; Chapman & Hall, London, 1954.
2. Higher Algebra, Hall and Knight, MacMillan and Co., 1989, 3rd Edition.
3. First Course in the Theory of Equations, Leonard Eugene Dickson, John Wiley & Sons, Inc. New York; Chapman & Hall, London, 1992.

MA2326 **3-1-0 (4)**

Elementary Number Theory

Pre-Requisites: None

Course Outcomes:

CO-1	Demonstrate the knowledge of distribution of prime numbers.
CO-2	Utilize the Chinese remainder theorem to solve simultaneous linear congruences.
CO-3	Illustrate number theoretic functions and their properties.
CO-4	Solve equations involving quadratic residues.
CO-5	Solve certain types of Diophantine equations.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	2	2	–	–	–	–	–	–	–	–	–	–	–	–	–
CO-2	3	2	2	–	–	–	–	–	–	–	–	–	–	–	–	–
CO-3	2	2	2	–	–	–	–	–	–	–	–	–	–	–	–	–
CO-4	3	2	2	–	–	–	–	–	–	–	–	–	–	–	–	–
CO-5	3	2	2	–	–	–	–	–	–	–	–	–	–	–	–	–

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Divisibility: Division algorithm, Greatest common divisor, Euclidean algorithm, Least common multiple, Prime numbers and their properties, Fundamental theorem of arithmetic.

Congruences: Introduction to congruences, Linear congruences, The Chinese remainder theorem, Divisibility tests. Arithmetic functions and its properties, Mobius inversion formula, The Euler φ function and other multiplicative functions, Fermat's little theorem, Euler's theorem, and Wilson's theorem.

Quadratic Residues: Primitive roots, Quadratic residues, Legendre symbol, Law of quadratic reciprocity, The Jacobi symbol-properties.

Diophantine Equations: Diophantine equations, Pythagorean triples, Sums of squares.

Learning Resources:

Text Books:

1. Ivan Niven, Herbert S. Zuckerman, Hugh L. Montgomery, An Introduction to the Theory of Numbers, Wiley, 1991, Fifth Edition.
2. Kenneth H. Rosen, Elementary Number Theory and its Applications, Addison-Wesley, 2011, Sixth Edition.

Reference Books:

1. H. Davenport, James H. Davenport, The Higher Arithmetic: An Introduction to the Theory of Numbers, Cambridge University Press, 2008, Eighth Edition.
2. David M. Burton, Elementary Number Theory, Mc Graw Hill, 2011.

Online Resources:

1. https://ocw.mit.edu/courses/mathematics/18-781-theory-of-numbers-spring-2012/index.html
2. https://nptel.ac.in/courses/111/103/111103020/

Professional Elective - 2

PH2322 **3-0-0 (3)**

Renewable Energy Sources

Pre-Requisites: None

Course Outcomes:

CO-1	Understand the Need, importance and scope of non-conventional and alternate energy
CO-2	Understand role significance of solar energy.
CO-3	Understand the role of ocean energy in the Energy Generation and importance of Wind
CO-4	get the utilization of Biogas plants and geothermal energy
CO-5	Comprehend the concept of energy Conservation

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	2	2	–	–	–	–	–	–	–	–	–	–	–	–	–
CO-2	3	2	2	–	–	–	–	–	–	–	–	–	–	–	–	–
CO-3	3	2	2	–	–	–	–	–	–	–	–	–	–	–	–	–
CO-4	3	2	2	–	–	–	–	–	–	–	–	–	–	–	–	–
CO-5	3	2	2	–	–	–	–	–	–	–	–	–	–	–	–	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Solar Energy: Solar Radiation, Measurements of Solar Radiation, Flat Plate And Concentrating Collectors, Solar Direct Thermal Applications, Solar Thermal Power Generation, Fundamentals of Solar Photo Voltaic Conversion, Solar Cells, Solar PV Power Generation, Solar PV Applications.

Wind Energy: Wind Energy Estimation, Types of Wind Energy Systems, Performance, Site Selection, Details of Wind Turbine Generator.

Ocean Energy: Ocean Thermal Energy Conversion (OTEC), Principle of operation, development of OTEC plants, Tidal and wave energy, Potential and conversion techniques, mini-hydel power plants.

Bio-Mass: Principles of Bio-Conversion, Anaerobic/aerobic digestion, types of Bio-gasdigesters, gas yield, combustion characteristics of bio-gas, utilization for cooking.

Geothermal Energy: Resources, types of wells, methods of harnessing the energy, scope in India.

Energy Conservation: Principles of energy conservation, the different energy conservation appliances, cooking stoves, Benefits of improved cooking stoves over the traditional cooking stoves.

Learning Resources:

Text Books:

1. G.D. Rai, Non-Conventional Energy Sources, Khanna Publishers, 2011, Third Edition.
2. B H Khan, Non-Conventional Energy Resources, McGraw Hill, 2009, Second Edition.

Reference Books:

1. Twidell, Wier, Renewable Energy Resources, CRC Press (Taylor & Francis) , 2008
2. D.O. Hall, R.P. Overeed, Biomass Renegerable Energy, John Wiley and Sons, 2008

Online Resources:

1. https://nptel.ac.in/courses/115/105/115105127/
2. https://nptel.ac.in/courses/103/103/103103206/

PH2324 **3-0-0 (3)**

Photovoltaic Devices and Applications

Pre-Requisites: None

Course Outcomes:

CO-1	Fundamentals of PV systems and its various applications.
CO-2	The principle of direct solar energy conversion to power using PV technology.
CO-3	The structure, materials and operation of solar cells, PV modules, and arrays.
CO-4	The socio-economic and environmental merits of photovoltaic systems for a variety of applications.
CO-5	The prospects of photovoltaic technology for sustainable power generation.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	2	3	3	2	–	–	–	–	–	–	–	–	–	–	–	–
CO-2	3	3	3	2	–	–	–	–	–	–	–	–	–	–	–	–
CO-3	3	3	3	1	–	–	–	–	–	–	–	–	–	–	–	–
CO-4	2	3	3	2	–	–	–	–	–	–	–	–	–	–	–	–
CO-5	2	3	4	2	–	–	–	–	–	–	–	–	–	–	–	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Introduction: Semiconductors, PN junction, abrupt and graded junctions, junction in equilibrium, biasing, energy band diagram, hetero and Schottky junctions, built-in voltage, junction capacitance.

The Photovoltaic (PV) Effect: Need for Solar cells, Various generations of solar cells, photovoltaic effect - Principle, design and working of solar cells, energy level alignment, basic equations, characteristics, efficiencies.

Physical Aspects of Solar Cell Efficiency: Energy losses in solar cells, I-V characteristics of a PV module, maximum power point, cell efficiency, fill factor, Effect of irradiation, temperature and relative humidity.

Design, Fabrication and Applications of PV cells: Design and various fabrication techniques for solar PV systems, Building-integrated photovoltaic unit, stand-alone devices for distributed power supply in remote and rural areas, solar cars, aircraft, space solar power satellites. Socio-economic and environmental merits of photovoltaic systems.

Learning Resources:

Text Books:

1. Ashcroft, N., D. Mermin, Holt, Solid State Physics, Rinehart and Winston, 2021, Third Edition.
2. Bube R., Photovoltaic Material, Imperial college press,1998.

Reference Books:

1. Kittel, Charles, Introduction to Solid State Physics, Eighth Edition, John Wiley & Sons, 2004.
2. Angèle Reinders, Pierre Verlinden, Wilfried van Sark, Photovoltaic Solar Energy: From Fundamentals to Applications, Wiley publishers, 2017

Online Resources:

1. https://www.nrel.gov/docs/legosti/old/1448.pdf

PH2326 **3-0-0 (3)**

Physics of Semiconductor Devices

Pre-Requisites: None

Course Outcomes:

CO-1	Understand the basic properties of semiconductors including the band gap, charge carrier
CO-2	Knowledge of semiconductor carrier properties and statistics.
CO-3	Analyze PN junctions in semiconductor devices under various conditions.
CO-4	Explain the working, design considerations and applications of various semiconducting devices including p-n junctions, BJTs and FETs.
CO-5	Understand BJT switching

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	2	-	-	-	–	–	–	–	–	–	–	–	–	–	–
CO-2	3	3	3	-	-	–	–	–	–	–	–	–	–	–	–	–
CO-3	2	3	2	3	2	–	–	–	–	–	–	–	–	–	–	–
CO-4	3	3	3	2	2	–	–	–	–	–	–	–	–	–	–	–
CO-5	3	2	-	-	-	–	–	–	–	–	–	–	–	–	–	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Semiconductors: Energy Band and Charge Carriers: Energy bands in semiconductors, Types of semiconductors, Charge carriers, Intrinsic and extrinsic materials. Carrier concentration: Fermi Level, Electron and hole concentration equilibrium, Temperature dependence of carrier concentration, compensation, and charge neutrality. Conductivity and mobility, Effect of temperature, Doping and high electric field.

Optical Excitation in Semiconductor: Optical absorption, carrier generation, Carrier lifetime, diffusion length and photo conductivity, Direct and indirect recombination and trapping, Photoconductive devices. Diffusion of carriers, Einstein relation, Continuity equation, Carrier injection, Diffusion length. Haynes-Shockley experiment.

Junctions: p-n junction and contact potential, Fermi levels, Space charge, Reverse and Forward bias, Zener, and Avalanche breakdown. Capacitance of p-n junction, Schottky barriers; Schottky barrier height, C-V characteristics, current flow across Schottky barrier: thermionic emission, Rectifying contact and Ohmic contact.

Field Effect Transistors: JEFT amplifying and switching, Pinch off and saturation, Gate control, I-V characteristics. MOSFET, Operation, MOS capacitor, Debye screening length, Effect of real surfaces; Work function difference, Interface charge, Threshold voltage and its control, MOS C-V analysis and time dependent capacitance. Output and transfer characteristics of MOSFET.

Bipolar Junction Transistors (BJT): Fundamentals of BJT operation. Minority carrier distribution, Solution of diffusion equation in base region, Terminal current, Current transfer ratio, Ebers-Moll equations, Charge control analysis. BJT switching: Cut off, Saturation, Switching cycle.

Learning Resources:

Text Books:

1. Sze, S.M., Physics of Semiconductor Devices, John Wiley, 2008, Third Edition.
2. Tyagi, M.S., Introduction to semiconductor materials and devices, John Wiley, 2008, First Edition.

Reference Books:

1. Mishra, Umesh K., Singh, Jaspreet, Semiconductor Device Physics and Design, Springer, 2008, First Edition.
2. Pierret, R.F., Semiconductor Device Fundamentals, Pearson, 2006, First Edition.

Online Resources:

1. https://nptel.ac.in/courses/108/108/108108122/
2. https://www.coursera.org/specializations/semiconductor-devices#courses

Professional Elective - 3

CY2322 **3-0-0 (3)**

Instrumental Analysis for Industrial Applications

Pre-Requisites: None

Course Outcomes:

CO-1	Explain the theoretical principles behind the instrumental techniques and their applications.
CO-2	Model concepts and techniques in instrumental analysis independently towards industrial applications.
CO-3	Analyze instrumental results for deriving conclusions with relevance to experimental evidences.
CO-4	Assess the appropriateness of an instrumental method for the analysis of samples in various formats and from complex matrices.
CO-5	Design experimental methodology for determining analytes of interest of domestic and industrial applications.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	**3**	**2**	**2**	**2**	**1**	**2**	–	–	–	–	–	–	–	–	–	–
CO-2	3	**2**	2	2	2	2	–	–	–	–	–	–	–	–	–	–
CO-3	3	2	2	1	2	1	–	–	–	–	–	–	–	–	–	–
CO-4	3	3	3	**2**	1	2	–	–	–	–	–	–	–	–	–	–
CO-5	3	2	2	1	2	3	–	–	–	–	–	–	–	–	–	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

UV-Visible Spectrophotometry and Fluorescence: Overview of bioorganic chemistry- historical connection between organic and biological chemistry; weak interactions in organic Beer-Lambert's law, Instrumentation of Absorption Spectrophotometer, Quantitative analysis, limitations, Enzyme linked immunosorbent analysis (ELISA), Molecular fluorescence, influencing factors, basic instrumentation, standardization, quantitative methods, Applications,Diagnostics of biomarkers.

Thermoanalytical methods: Thermogravimetry, Differential thermal analysis, differential scanning calorimetry, Principle, Block diagram, Applications.

Chromatography methods: Gas chromatography, High performance liquid chromatography, size exclusion chromatography, Principle, Basic instrumentation, terminology, NPC, RPC,Qualitative and Quantitative applications, Capillary Electrophoresis: Principle and application.

Surface area and Particle size Analyses: BET- Principle, Pore width, particle size and surface area analysis, Dynamic light scattering – Principle, instrumentation and applications.

X-ray spectroscopic and diffraction methods: X-ray absorbance and fluorescence, Principle, instrumentation, quantitative analysis. X-ray diffraction, Principle, Crystal structure and size analyses. Medical diagnostics, Analysis of geological samples and ores.

Microscopic methods: SEM, Principle, Sample preparations, Surface morphology and particle size analysis, TEM, Principle, Sample preparation, Surface morphology, and Structural determination of nanoparticles. Metal and non-metal nanocomposites, industrial materials.

Atomic spectrometry and atomic absorption: Atomization, Flame atomic emission and absorption, flame emission photometer, flame absorption spectrometer, spectral interferences, and quantitative aspects. Analysis of geological samples and ores.

Electroanalytical methods: Ion selective electrodes, Electrochemical sensors, Ion selective and Potentiometric sensors, Amperometry, Principles, Applications.

Learning Resources:

Text Books:

1. Douglas A. Skoog, F. James Holler, Stanley R. Crouch, Principles of Instrumental Analysis, Cengage Learning India, 2020, 7th Edition.
2. Russel S. Drago, Physical Methods for Chemists, Saunders College Publishing, 2016, 2nd Edition.

Reference Books:

1. D. L. B. Wetzel, George Charalambous, Instrumental Methods in Food and Beverage Analysis (Developments in Food Science), Elsevier, 1998.
2. Michael D. Cole, The Analysis of Controlled Substances (Analytical Techniques in the Sciences (AnTs), Wiley, 2003.
3. Erno Pungor, G. Horvai, A Practical Guide to Instrumental Analysis, CRC Press, 2020.

CY2322 **3-0-0 (3)**

Applied Organic Chemistry

Pre-Requisites: None

Course Outcomes:

CO-1	Apply the theoretical knowledge of organic chemistry for the synthesis of molecules with industrial importance
CO-2	Use the knowledge of organic chemistry in paint, agriculture, and cosmetic industry
CO-3	Understand the essentials of organic chemistry in drug synthesis
CO-4	Use the knowledge of organic chemistry for the development of sustainable synthetic processes
CO-5	Apply the knowledge of organic chemistry in food industry

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	3	2	2	2	3	–	–	–	–	–	–	–	–	–	–
CO-2	3	2	2	3	3	2	–	–	–	–	–	–	–	–	–	–
CO-3	3	2	3	3	2	3	–	–	–	–	–	–	–	–	–	–
CO-4	3	3	3	3	2	3	–	–	–	–	–	–	–	–	–	–
CO-5	2	3	1	3	1	2	–	–	–	–	–	–	–	–	–	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Paints, Varnishes and Soaps: **Paints & Varnishes:** Primary constituents of paints, Dispersion medium (solvent), binder Pigments, formulation of paints and varnishes. Requirements of a good paint.

Surface Coatings: Objectives of coatings surfaces, preliminary treatment of surface, classification of surface coatings. Paints and pigments-formulation, composition and related properties. Oil paint, Vehicle, modified oils, Pigments, toners and lakes pigments, Fillers, Thinners, Enamels, emulsifying agents. Special paints (Heat retardant, Fire retardant, Eco-friendly paint, Plastic paint), Dyes, Wax polishing, Water and Oil paints, additives. **Soaps:** manufacture of soaps by hot and cold process, classification of soaps, cleansing of soap and classification of detergents (anionic and cationic).

Fertilizers and Pesticides: **Fertilizers:** natural fertilizers, nitrogenous fertilizer (NH_4NO_3, urea), phosphatic fertilizer (superphosphate, TSP, polyphosphate), potash fertilizer (KCl, KNO_3, K_2SO_4), bio fertilizers.

Pesticides: classification, structure of some important pesticides (DDT, BHC, allethrin and pyrethrin).

Insecticides: Pesticides – classification of Insecticides, fungicides, herbicides as organic and inorganic – general methods of application and toxicity. Safety measures when using pesticides.

Insecticides: Plant products – Nicotine, pyrethrin – Inorganic pesticides – borates. Organic pesticides – D.D.T. and BHC. **Fungicides and Herbicides:** Fungicide: Sulphur compounds, Copper compounds, Bordeaux mixture. Herbicides: Acaricides – Rodenticides. Attractants – Repellents. Preservation of seeds.

Chemistry of Essential oils, Perfumes and Cosmetics: **Essential oil:** Definition–occurrences–Methods of production from plants–Steam distillation and expression method. **Perfumes:** Formulations–Requirements for a good perfume–Compositions of perfumes–classification of perfumery materials–

animals-synthetic formulations–manufacturing and packaging process of perfumes. **Cosmetics:** Face cream–Sun screen lotion–shaving cream–composition and formulation–Uses and hazards, Sprayer–Hand lotion–nail lacquers–nail bleaches–hair oil–hair dyes–composition and formulations–Uses and hazards

Chemistry of Drugs: Classification of drugs based on structure and action: Antibacterial: sulfa drugs, synthesis of sulfathiazole, sulfapyridine, Antibiotics: β-Lactam antibiotics and synthesis of penicillin, chloramphenicol, Antiviral drugs: Azidothimidine, acyclovir; Antipyretics: Paracetamol, Analgesics: Analgine, Non-steroidal anti-inflammatory drugs: Ibuprofen, Antimalarial: Chloroquine, Antacids: Ranitidine

Engineering Materials: Energy materials, soft materials, smart materials, organic electronics, semiconductors, insulators, corrosion inhibitors

Introduction to Green Chemistry: Principles of green chemistry (12 principles), Green reagents (water and bio-based), solvents (green solvents eg. Water), and alternative reaction media (ionic liquids), multicomponent reactions, atom economy (examples: Diels-Alder reaction, Claisen rearrangement), sustainable organic chemistry

Food Chemistry: **Flavouring agents:** Definition of flavours–Classification–Chemical composition–common characteristics–Formulations–Uses and hazards, Preserving agents, antioxidants.

Sugar industry: Double sulphitation process. Refining and grading of sugar. Saccharin: synthesis and use as a sugar substitute – aspartame (structure and synthesis). Ethanol: manufacture from molasses by fermentation.

Learning Resources:

Text Books:

1. G. R. Chatwal, Gurudeep, Synthetic Organic Chemistry, Himalaya Publishers, 2009.
2. Ashutoshkar, Medicinal Chemistry, New Age Publications, 2010, Fifth Edition.
3. V. K. Ahluwalia, M. Kidwai, New Trends in Green Chemistry, New Age Publications, 2004
4. B. Srilakshmi , Food Science, New age International Pvt. Ltd. Publishers, III ed. 2003.

Reference Books:

1. John W. Nicholson, Chemistry and Physics of Modern Materials, Royal Society of Chemistry, 2012, Third Edition.
2. A. S. Khanna, High-Performance Organic Coatings, Elsevier, 2008
3. P.T. Anastas and J.C. Warner, Green Chemistry: Theory and Practice, Oxford University Press, 2000.
4. H.D. Belitz, Werner Grosch, Peter Schieberle, Food Chemistry, Springer Science & Business Media, 2009, Fourth Edition.

CY2326 **3-0-0 (3)**

Environmental Chemistry

Pre-Requisites: None

Course Outcomes:

CO-1	Identify relationship between chemical exposure and effects on physiological systems.
CO-2	Understand causes and effects of environmental pollution and mitigation strategies.
CO-3	Apply basic chemical concepts to analyze chemical processes involved in different environmental problems (air, water & soil).
CO-4	Describe water purification and waste treatment processes and the practical chemistry involved.
CO-5	Discuss local and global environmental issues based on the knowledge gained throughout the course.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	2	2	2	1	2	–	–	–	–	–	–	–	–	–	–
CO-2	3	2	2	2	2	2	–	–	–	–	–	–	–	–	–	–
CO-3	3	2	2	1	2	1	–	–	–	–	–	–	–	–	–	–
CO-4	3	3	3	2	1	2	–	–	–	–	–	–	–	–	–	–
CO-5	3	2	2	1	2	3	–	–	–	–	–	–	–	–	–	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Chemistry of Atmosphere: Origin, composition and structure of atmosphere-particles, ions and radicals in the atmosphere, Greenhouse effect-Causes, consequences and abatement of Greenhouse effect-Ozone depletion- Causes, consequences and abatement of ozone depletion, Photochemical smog-Effects and control.

Air Pollution-Monitoring and Control: Air sampling techniques-Sources and effects, of oxidesof sulphur, oxides of nitrogen, oxides of carbon, Monitoring of air pollutants by Instrumental methods, Monitoring and Control of particulate pollution- Monitoring of air pollutants by Instrumental methods, Control of air pollution by raw material change, process modification, adsorption, absorption and combustion methods.

Water Pollutants and waste water treatment: Water and Environment; Types of Pollutants, Pollution indicators, Waste water Constituents, water Quality requirements, various methods of waste water treatment.

Soil chemistry: Nature and composition of soil, Acid base and ion exchange reactions in soil, macronutrients in soil, Micronutrients in soil, Nitrogen, phosphorous and potassium in soil, Fertilizers, wastes and pollutants in soil, Soil loss and degradation, Agriculture and health.

Solid Waste Management and environmental impact assessment: Solid waste disposal and management: classification and origin, methods of solid waste disposal, Microbiology involved in solid waste disposal, Environmental Impact Assessment, Environmental Impact Assessment process in India-Environmental acts and rules.

Learning Resources:

Text Books:

1. G. S. Sodhi, Fundamental Concepts of Environmental Chemistry, Narosa publishing House, 2005, Second Edition.
2. M. N. Rao, A.K. Datta, Waste water treatment, Oxford Publications, 2013, Third Edition.

Reference Books:

1. J. Glynn Henry, Garry W. Heinke, Environmental Science and Engineering, Prentice-Hall, Inc., New Jersey, USA, 1996, Second Edition.

7th Semester

MA16001 **4-0-0 (4)**

Real Analysis

Pre-Requisites: None

Course Outcomes:

CO-1	Find whether a given function can be Riemann integrable
CO-2	Test whether a given improper integral can be convergent
CO-3	Examine uniform convergence of a given sequence of functions
CO-4	Examine uniform convergence of a given series of functions
CO-5	Expand a given function into a Fourier series

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	3	2	2	2	3	–	–	–	–	–	–	–	–	–	–
CO-2	3	2	2	3	3	2	–	–	–	–	–	–	–	–	–	–
CO-3	3	2	3	3	2	3	–	–	–	–	–	–	–	–	–	–
CO-4	3	3	3	3	2	3	–	–	–	–	–	–	–	–	–	–
CO-5	2	3	1	3	1	2	–	–	–	–	–	–	–	–	–	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Introduction: Real number system, Elementary topology, Continuous functions, Continuity and Compactness, Continuity and Connectedness, Differentiation

Riemann Stieltje's integral: Definition and existence of the integral, Properties of the integral, Integration and differentiation of integral with variable limits.

Improper integrals: Definitions and their convergence, Tests of convergence, β and Γ functions.

Uniform convergence: Tests for uniform convergence, Theorems on limit and continuity of sum functions, Term by term differentiation and integration of series of functions.

Power series: Convergence and their properties.

Fourier Series: Dirichlet conditions, Existence, Problems, Half range sine and cosine series.

Learning Resources:

Text Books:

1. Walter Rudin, Principles of Mathematical Analysis, McGraw Hill, 2017, Third Edition.
2. Brian S.Thomson, Andrew M.Bruckner, Judith B.Bruner, Elementary Real Analysis, Prentice Hall International, 2008, Second Edition.

Reference Books:

1. William F. Trench, Introduction to Real Analysis, Library of Congress Cataloging-in-Publication Data, 2010, Second Edition.
2. Tom M. Apostol, Mathematical Analysis, Addison Wesley, 1974, Second Edition.

MA16003 **3-0-0 (3)**

Ordinary Differential Equations

Pre-Requisite: **None**

Course Outcomes:

CO-1	Determine linearly independent solutions and general solution of a non-homogeneous differential equations
CO-2	Find power series solution to a differential equation containing variable coefficients
CO-3	Analyse the stability of Autonomous Systems.
CO-4	Discuss the existence and uniqueness of solution for an initial value problem
CO-5	Use Green's function to solve a non-homogeneous boundary value problem

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	3	2	2	2	3	–	–	–	–	–	–	–	–	–	–
CO-2	3	2	2	3	3	2	–	–	–	–	–	–	–	–	–	–
CO-3	3	2	3	3	2	3	–	–	–	–	–	–	–	–	–	–
CO-4	3	3	3	3	2	3	–	–	–	–	–	–	–	–	–	–
CO-5	3	3	3	3	2	3	–	–	–	–	–	–	–	–	–	–

Syllabus:

First Order Equations: Picard's theorem, Non-Local existence theorem.

Second Order Equations: Linear dependence and independence, A formula for the Wronskian, the non-homogeneous equations, linear equations with variable coefficients, reduction of the order of the homogeneous equation, Sturm comparison theorem, Sturm separation theorem.

Stability: Autonomous Systems. The Phase Plane and Its Phenomena, Types of Critical Points. Stability, Critical Points and Stability for Linear Systems.

Systems of Differential Equations: Existence theorems, homogeneous linear systems, non-homogeneous linear systems, linear systems with constant coefficients, eigenvalues and eigenvectors, diagonal and Jordan matrices.

Boundary Value Problems: Two-point boundary value problems, Green's functions, construction of Greens functions, non-homogeneous boundary conditions.

Learning Resources:

Text Books:

1. G.F. Simmons, Differential Equations with Applications and Historical Notes, McGraw Hill, 2017, Second Edition.
2. E.A. Coddington, An Introduction to Ordinary Differential Equations, Dover Publications, 1989, First Edition.

Reference Books:

1. M. Braun, Differential Equations and Their Applications, Springer-Verlag, 1983, Third Edition
2. P.J. Collins, Differential and Integral Equations, Oxford University Press, 2006, First Edition.

MA16005 **3-0-0 (3)**

Computer Programming in C++

Pre-Requisites: **None**

Course Outcomes:

CO-1	Implement programs using classes and objects
CO-2	Able to understand the overloading concept
CO-3	Specify the forms of inheritance and use them in programs
CO-4	Analyze polymorphic behavior of objects
CO-5	Understand virtual functions and polymorphism

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	3	3	2	–	2	–	–	–	–	–	–	–	–	–	–
CO-2	1	–	1	2	–	–	–	–	–	–	–	–	–	–	–	–
CO-3	2	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–
CO-4	3	2	3	–	–	–	–	–	–	–	–	–	–	–	–	–
CO-5	2	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Problem solving techniques: Algorithmic approach, characteristics of algorithm, Problem solving strategies: Top-down approach, Bottom-up approach, Time and space complexities of algorithms.

Number systems and data representation: Basics of C++, Basic data types, Numbers, Digit separation, Reverse order, writing in words, Development of Elementary School Arithmetic Testing System, Problems on Date and factorials, Solutions using flow of control constructs

Conditional statements: If-else, Switch-case constructs, Loops - while, do-while, for.

Functions: Modular approach for solving real time problems, user defined functions, library functions, parameter passing - call by value, call by reference, return values, Recursion,

Introduction to Pointers and Arrays: Sorting and searching algorithms, Large integer arithmetic, Single and Multi-Dimensional Arrays, passing arrays as parameters to functions, Magic square and matrix operations using Pointers and Dynamic Arrays, Multidimensional Dynamic Arrays String processing, File operations.

Structures and Classes: Declaration, member variables, member functions, access modifiers, function over loading, Problems on Complex numbers, Date, Time, Large Numbers.

Learning Resources:

Text Books:

1. Walter Savitch, Problem Solving with C++, Pearson, 2014, tenth Edition.
2. Cay Horstmann, Big C++, Wiley, 2009, Second Edition.

Reference Books:

1. R.G. Dromey, How to Solve it by Computer, Pearson, 2008.

Other Suggested Readings:

1. https://nptel.ac.in/courses/106/105/106105151/
2. https://onlinecourses.nptel.ac.in/noc21_cs38/preview

MA16007 **3-0-0 (3)**

Numerical Analysis

Pre-Requisites: None

Course Outcomes:

CO-1	Construct the Polynomial to the given data.
CO-2	Evaluate the integrals numerically.
CO-3	Find the roots of nonlinear equations.
CO-4	Approximate the function by a polynomial.
CO-5	Solve Initial value problems numerically.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	3	3	2	–	2	–	–	–	–	–	–	–	–	–	–
CO-2	2	2	2	–	–	3	–	–	–	–	–	–	–	–	–	–
CO-3	3	3	3	1	–	–	–	–	–	–	–	–	–	–	–	–
CO-4	3	2	3	1	1	2	–	–	–	–	–	–	–	–	–	–
CO-5	3	3	3	–	–	3	–	–	–	–	–	–	–	–	–	–

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Numerical solution of nonlinear equations: Method of false postion, Newton method, Muller's method, Birga-Vita method, Bairstow's method, Graffe's root squaring method, finding the complex roots, system of non-linear simultaneous equations.

Approximation: Norms, Least square (using monomials and orthogonal polynomials), Uniform and Chebyshev approximations.

Interpolation: Existence, Uniqueness of interpolating polynomial - finite differences, finite difference operators and their properties, Inverse interpolation, Hermite interpolation, spline interpolation.

Numerical differentiation: The value of derivative at a tabulated and non-tabulated point

Numerical integration: Gaussian Quadrature methods (Gauss-Legendre, Gauss-Chebyshev, Gauss-Laguerre and Gauss-Hermite integration methods), Romberg integration, Method of undetermined coefficients,

Numerical solution of ordinary differential equations: Initial value problems: Single step methods; Taylor's, Higher Order Taylors methods, Runge-Kutta methods, Error analysis; Multi-step methods: Adam- Bashforth, Nystorm's, Adams- Moulton's methods, Milne's predictor-corrector methods; System of IVP's and higher orders IVP's., Shooting method, Cubic spline method, solution of a nonlinear differential equation by Quasilinearization method, Collocation method.

Learning Resources:

Text Books:

1. MK Jain, SRK Iyengar and RK Jain, Numerical Methods for Engineers and Scientists, New Age International Private Limited, 2022, Eighth Edition.
2. C.F.Gerald and P.O.Wheatley, Applied Numerical Analysis, Pearson Education India, 2007, Seventh Edition.

Reference Books:

1. K. Atkinson, An Introduction to Numerical Analysis, John Wiley,1989, Second Edition
2. F.B. Hildebrand, Introduction to Numerical Analysis, Dover Publisher Inc., 2003, Second Edition.
3. Richard L.Burden and J.Douglas Faires, Numerical Analysis, 9th Edition, Brooks/Cole, Cengage Learnin

MA16009 **0-1-2 (2)**

C++ Lab

Pre-Requisites: **NIL**

Course Outcomes:

CO-1	Design and test programs to solve mathematical and scientific problems.
CO-2	Develop and test programs using control structures.
CO-3	Implement modular programs using functions.
CO-4	Develop program using arrays and matrices.
CO-5	Develop program using pointers and structures.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	2	3	2	3	3	3	–	–	–	–	–	–	–	–	–	–
CO-2	1	3	3	2	2	2	–	–	–	–	–	–	–	–	–	–
CO-3	1	2	3	3	2	1	–	–	–	–	–	–	–	–	–	–
CO-4	2	2	2	3	1	1	–	–	–	–	–	–	–	–	–	–
CO-5	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Programs using
1. conditional control constructs.
2. loops (while, do-while, for).
3. user defined functions and library functions.
4. arrays, matrices (single and multi-dimensional arrays).
5. pointers (int pointers, char pointers).
6. Programs on structures.

MA16011 **0-1-2 (2)**

Numerical Computing Lab

Pre-Requisites: **None**

Course Outcomes:

CO-1	Develop programs for computational problems
CO-2	Write programs for algebraic and transcendental equations
CO-3	Write the programs to solve a system of linear equations
CO-4	Write programs for the numerical approximation of a definite integral
CO-5	Write programs for the solution of initial value problems

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	1	3	2	2	2	2	–	–	–	–	–	–	–	–	–	–
CO-2	2	3	2	3	2	1	–	–	–	–	–	–	–	–	–	–
CO-3	2	3	2	3	2	–	–	–	–	–	–	–	–	–	–	–
CO-4	3	2	2	2	1	–	–	–	–	–	–	–	–	–	–	–
CO-5	2	3	2	3	1	–	–	–	–	–	–	–	–	–	–	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Programs Based on Numerical methods:

1. Programs for solution of quadratic equation
2. Solution of algebraic and transcendental equations
3. Solution of system of linear equations by Gauss-Seidel method
4. Solution of system of linear equations by Gaussian elimination method
5. Finding the Inverse of a matrix
6. Solution of Tridiagonal system by Thomas algorithm
7. Formulation of finite differences table for a given data
8. Finding the value of a function using Lagrange interpolation
9. Numerical integration
10. Euler's and modified Euler's methods, Runge-Kutta methods

8th Semester

MA16002 **4-0-0 (4)**

Probability and Statistics

Pre-Requisites: **None**

Course Outcomes:

CO-1	Determine the mean, standard deviation and mth moment of a probability
CO-2	Apply theoretical model to fit the empirical data
CO-3	Differentiate between Large and small sample tests
CO-4	Use the method of testing of hypothesis for examining the validity of a hypothesis
CO-5	Estimate the parameters of a population from knowledge of statistics of a sample

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	2	3	3	1	1	2	–	–	–	–	–	–	–	–	–	–
CO-2	2	3	3	1	1	2	–	–	–	–	–	–	–	–	–	–
CO-3	2	3	3	–	–	2	–	–	–	–	–	–	–	–	–	–
CO-4	3	3	2	–	–	1	–	–	–	–	–	–	–	–	–	–
CO-5	2	3	1	–	2	3	–	–	–	–	–	–	–	–	–	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Random variables: Review of probability; Probability distributions with discrete and continuous random variables - Joint probability mass function, Marginal distribution function, Joint density function - Independent random variables - Mathematical Expectation - Moment generating function - Chebyshev's inequality - Weak law of large numbers - Bernoulli trials

Theoretical Probability Distributions: Binomial, Negative Binomial, Geometric, Poisson, Normal, Rectangular, Exponential, Gaussian, Beta and Gamma distributions and their moment generating functions; Fit of a given theoretical model to an empirical data.

Sampling and Testing of Hypothesis: Introduction to testing of hypothesis - Tests of significance for large samples - t, F and Chi-square tests; ANOVA - one-way and two-way classifications.

Correlation and Regression: Scatter diagram - Linear and polynomial fitting by the method of least squares - Linear correlation and linear regression - Rank correlation - Correlation of bivariate frequency distribution.

Learning Resources:

Text Books:

1. S.C. Gupta and V.K. Kapur, Fundamentals of Mathematical Statistics, S.Chand & Sons, New Delhi, 2008, Twelfth Edition.
2. V.K. Rohatgi and A.K. Md. Ehsanes Saleh, An Introduction to Probability theory and Mathematical Sciences, Wiley, 2001, Third Edition.

Reference Books:

1. Richard A. Johnson, Miller and Freund's Probability and Statistics for Engineers, Pearson, 2018, Ninth Edition.
2. J. S. Milton and J. C. Arnold, Introduction to Probability and Statistics, McGraw Hill, 2017, Fourth edition.

MA16004 **3-0-0 (3)**

Partial Differential Equations

Pre-Requisites: **None**

Course Outcomes:

CO-1	Solve linear and nonlinear first order partial differential equations
CO-2	Demonstrate the concept of characteristic curves and characteristic strips
CO-3	Solve higher order partial differential equations with constant coefficients
CO-4	Find canonical forms of second order partial differential equations
CO-5	Utilize the knowledge of PDES in solving various physical problems

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	2	3	–	–	2	–	–	–	–	–	–	–	–	–	–
CO-2	3	2	2	–	–	1	–	–	–	–	–	–	–	–	–	–
CO-3	3	3	3	–	–	2	–	–	–	–	–	–	–	–	–	–
CO-4	3	1	2	–	–	–	–	–	–	–	–	–	–	–	–	–
CO-5	3	3	3	–	–	1	–	–	–	–	–	–	–	–	–	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Equations of the First Order: Formulation; Classification of first order partial differential equations (PDEs); Lagrange's method, Cauchy problem, and method of characteristics for linear and quasilinear PDEs; Paffian equation, Condition for integrability; First order non-linear equations, Complete integrals, Envelopes and singular solutions, Method of Charpit and Method of characteristics.

Equations of higher order: Method of solution for the case of constant coefficients; Classification of second order equations; Reduction to canonical forms; Method of solution by separation of variables.

Wave equation: d'Alembert solution of the wave equation, Domain of dependence and range of influence; Method of separation of variables; Inhomogeneous wave equation, Duhamel's principle.

Diffusion equation: Fundamental solution of heat equation, Method of separation of variables, Solutions of heat equation with homogeneous and non-homogeneous boundary conditions; Inhomogeneous heat equation, Duhamel's principle.

Laplace's equation: Basic concepts; Types of boundary value problems; The maximum and minimum principles; Boundary value problems; Method of separation of variables, green function solution.

Learning Resources:

Text Books:

1. I. Sneddon, Elements of Partial Differential Equations, Dover Publications, 2006, First Edition.
2. Tyn Myint-U and Lokenath Debnath, Birkhauser, Linear Partial Differential Equations for Scientists and Engineers, Bostan, 2007, Fourth Edition.

Reference Books:

1. P. Prasad and R. Ravindran, Partial Differential Equations, New Age International (P) Ltd., New Delhi, 2010, Second Edition.
2. T. Amaranath, An Elementary Course in Partial Differential Equations, Narosa Publishing House, New Delhi, 2003, Second Edition.

MA16006 **3-0-0 (3)**

Topology

Pre-Requisites: **None**

Course Outcomes:

CO-1	Compare nature of spaces with different topologies
CO-2	Understand connectedness and compactness in spaces with different topologies
CO-3	Categorize spaces based on countability and separation axioms
CO-4	Combine results in proving results such as Urysohn Lemma and Urysohnmetrization theorem
CO-5	Understand the notion of completeness with its importance in Baire's Categorytheorem

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	2	3	3	2	2	–	–	–	–	–	–	–	–	–	–
CO-2	3	1	3	3	-	1	–	–	–	–	–	–	–	–	–	–
CO-3	3	2	3	3	2	3	–	–	–	–	–	–	–	–	–	–
CO-4	3	2	3	3	-	2	–	–	–	–	–	–	–	–	–	–
CO-5	3	–	3	3	–	–	–	–	–	–	–	–	–	–	–	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Topological Spaces and Continuous Functions: Definition; Order topology, Product topology, Subspace topology; Closed sets; T_1 axiom and Hausdorff spaces;Continuous functions, Homeomorphisms; Product and box topologies; Metric topology.

Connectedness and Compactness in Topological Spaces: Connected spaces, Components of a space, Compact spaces.

Countability and Separation Axioms: Countability axioms, Separation axioms, Normal spaces, Urysohn Lemma, Urysohn Metrization Theorem; Brief introduction to: Tietze Extension Theorem, Tychonoff theorem, Stone-Cech Compactification.

Completeness: Complete metric spaces, Baire's Category Theorem.

Learning Resources:

Text Books:

1. James R. Munkres, Topology, Prentice Hall of India, 2007, Second Edition
2. George F. Simmons, Introduction to Topology and Modern Analysis, McGraw Hill Inc., 2004, Eighth Edition.

Reference Books:

1. Fred H. Croom, Principles of Topology, Cengage Learning, 2016, First Edition
2. John L. Kelley, General Topology, Springer, 1991, Second Edition.

MA16008 **0-1-2 (2)**

Probability and Statistics with R Lab

Pre-Requisites: **None**

Course Outcomes:

CO-1	Analyze discrete and continuous random variables using PMF, CDF, and PDF.
CO-2	Explore mean, variance, and mathematical expectation for independent random variables.
CO-3	Apply Binomial, Negative Binomial, Geometric, and Poisson distributions in statistical analysis.
CO-4	Understand and utilize Normal, Rectangular, Exponential, Gaussian, Beta, and Gamma distributions.
CO-5	Conduct hypothesis tests including Z-test, t-test, F-test, and Chi-square test, and apply ANOVA techniques for one-way and two-way classifications.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	2	3	3	1	1	2	–	–	–	–	–	–	–	–	–	–
CO-2	2	3	3	1	1	2	–	–	–	–	–	–	–	–	–	–
CO-3	2	3	3	–	–	2	–	–	–	–	–	–	–	–	–	–
CO-4	3	3	2	–	–	1	–	–	–	–	–	–	–	–	–	–
CO-5	2	1	3	–	–	1	–	–	–	–	–	–	–	–	–	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

1. Random Variables - Working with discrete and continuous random variables - Understanding probability mass function, cumulative distribution function, probability density function.
2. Mean and Variance: Exploring independent random variables and mathematical expectation.
3. Working with Binomial, Negative Binomial, Geometric, and Poisson distributions
4. Understanding Normal, Rectangular, Exponential, Gaussian, Beta, and Gamma distributions
5. Application of moment generating functions
6. Sampling and Testing of Hypothesis: Conducting Z-test, t, F, and Chi-square tests.
7. Understanding and applying ANOVA - one-way and two-way classifications
8. Applying the method of maximum likelihood estimation
9. Correlation and Regression

MA16010 **0-1-2 (2)**

Symbolic Computing Lab

Pre-Requisites: **None**

Course Outcomes:

CO-1	Acquire proficiency in using matlab and Mathematica to study Matrices
CO-2	Demonstrate the use of matlab and Mathematica to understand and interpret the core concepts inlinear algebra
CO-3	Find general solution of system of linear equations
CO-4	Apply matlab and Mathematica to decompose the matrices, finding eigen values and eigen vectors
CO-5	Apply matlab and Mathematica to find orthogonal basis

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	2	2	–	–	–	–	–	–	–	–	–	–	–	–	–
CO-2	3	2	2	–	–	–	–	–	–	–	–	–	–	–	–	–
CO-3	2	2	2	–	–	–	–	–	–	–	–	–	–	–	–	–
CO-4	3	2	2	–	–	–	–	–	–	–	–	–	–	–	–	–
CO-5	3	2	2	–	–	–	–	–	–	–	–	–	–	–	–	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

1. Introduction to matlab and Mathematica - The Scilab Environment – manipulating the command line, working directory, comments, variables, the Scilab menu bar.
2. Scalars and Vectors – introduction, initializing vectors in Scilab, mathematical operationson vectors, relational operations on vectors, logical operations on vectors, built-in logical functions.
3. Mathematical functions on scalars and complex numbers.
4. Arithmetic operators for Vectors, Matrices, basic matrix processing.
5. Finding inverse, determinant, transpose, and exponentiation of a Matrix.
6. Reducing to Row/Column echelon form.
7. Linear combination and Solving linear equations.
8. Matrix factorization (for example, Cholesky, LU, SVD).
9. Eigen values and eigen vectors.
10. Finding the orthogonal basis.
11. Subspace intersection, sum and intersection of subspaces.

9th Semester

MA17001 **4-0-0 (4)**

Operations Research

Pre-Requisites: **None**

Course Outcomes:

CO-1	Formulate a LPP and understand graphical solution
CO-2	Determine the solution of a LPP by simplex methods
CO-3	Application of post optimality analysis
CO-4	Solution of transportation and assignment problems
CO-5	Determine the solution of I LPP
CO-6	Apply search techniques to unconstrained optimization problems.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	1	3	–	–	2	–	–	–	–	–	–	–	–	–	–
CO-2	2	2	3	–	–	1	–	–	–	–	–	–	–	–	–	–
CO-3	2	2	3	2	2	2	–	–	–	–	–	–	–	–	–	–
CO-4	3	2	2	1	–	1	–	–	–	–	–	–	–	–	–	–
CO-5	3	2	3	–	–	1	–	–	–	–	–	–	–	–	–	–
CO-6	2	2	3	2	2	2	–	–	–	–	–	–	–	–	–	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Linear Programming: Lines and hyperplanes - convex sets, convex hull - Formulation of a Linear Programming Problem - Theorems dealing with vertices of feasible regions and optimality - Graphical solution - Simplex method (including Big-M method and two-phase method) - Revised simplex method - Dual problem - Duality theory - Dual simplex method – Post optimality analysis.

Transportation problem: Existence of solution - Degeneracy - MODI method (including the theory). Assignment problem, Travelling Salesman Problem.

Integer Programming: Gomory's cutting plane method for an all integer linear programming problem and a mixed integer linear programming problem.

Dynamic programming: Principle of optimality, Recursive relations, Solution of LPP, Simple examples.

One-dimensional search methods: Sequential search, Fibonacci search and Golden section search.

Multi-dimensional search methods: Gradient methods (Steepest descent/ascent methods), Conjugate gradient method (Fletcher-Reeves's method).

Learning Resources:

Text Books:

1. H. A. Taha, Operations research: an introduction, Pearson Education Limited, 2017, Tenth Edition.
2. M. S. Bazaraa, H. D. Sherali, & C. M. Shetty, Nonlinear programming: theory and algorithms, John Wiley and Sons, 2013, Third Edition.
3. M. S. Bazaraa, J. J. Jarvis, & H. D. Sherali, Linear programming and network flows, John Wiley and Sons, 2009, Fourth Edition.

Reference Books:

1. J.C. Pant, Introduction to Optimization: Operations Research, Jain Brothers, 2007, Seventh Edition.
2. E. K. Chong, & S. H. Zak, An introduction to optimization, John Wiley & Sons, 2004, Second Edition.
3. S. S. Rao, Engineering optimization: theory and practice, John Wiley & Sons, 2019, Fifth Edition.

MA17003 **3-0-0 (3)**

Functional Analysis

Pre-Requisites: **None**

Course Outcomes:

CO-1	Understand the nature of Banach spaces.
CO-2	Understand the nature of Hilbert spaces.
CO-3	Prove the open mapping theorem, closed graph theorem and uniformboundedness principle.
CO-4	Apply results of this course in solving operator equations.
CO-5	Understand the dual of a Hilbert space, including the adjoint of an operator, and apply projection theorems.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	2	3	3	2	2	–	–	–	–	–	–	–	–	–	–
CO-2	3	2	3	3	2	2	–	–	–	–	–	–	–	–	–	–
CO-3	3	1	3	3	2	2	–	–	–	–	–	–	–	–	–	–
CO-4	3	2	3	3	2	3	–	–	–	–	–	–	–	–	–	–
CO-5	2	3	1	2	1	1	–	–	–	–	–	–	–	–	–	–

Syllabus:

Banach spaces: Normed linear spaces - Banach spaces, Definition and some examples -Incomplete normed linear spaces - Bounded linear operators - Hahn-Banach theorem.

Dual Spaces: Conjugate (or dual) spaces - Natural imbedding of normed linear space N in itssecond conjugate N^{**} - the open mapping theorem - Closed graph theorem - the conjugate of an operator - The Uniform boundedness principle

Hilbert spaces: Definition and basic properties - Orthogonal complements - orthonormal sets - Bessel's inequality - Riesz representation theorem.

Dual of a Hilbert space: The dual of a Hilbert space - adjoint of an operator - projections and projection theorem

Learning Resources:

Text Books:

1. George F. Simmons, Introduction to Topology and Modern Analysis, McGraw Hill Inc.,2004, Eighth Edition.
2. Erwin Kreyszig, Introductory Functional Analysis with Applications, John Wiley and Sons, 2007, Third Reprint of First Edition.

Reference Books:

1. J. Conway, A Course in Functional Analysis, Springer, 2007, Second Edition.

2. Casper Goffman and George Pedrick, A First Course in Functional Analysis, AMSChelsea Publishing, 1983, Second Edition.

MA17005 **0-1-2 (2)**

Operations Research Lab

Pre-Requisites: **None**

Course Outcomes:

CO-1	Write a program to solve an Linear Programming Problem (LPP) by simplex method
CO-2	Write a program to solve an LPP by Big-M method
CO-3	Write a program to solve an LPP by two-phase method
CO-4	Write a program to solve an LPP by revised simplex method
CO-5	Write a program to solve a transportation problem

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	1	3	2	3	2	2	–	–	–	–	–	–	–	–	–	–
CO-2	1	3	2	3	2	2	–	–	–	–	–	–	–	–	–	–
CO-3	1	3	2	3	2	2	–	–	–	–	–	–	–	–	–	–
CO-4	1	3	2	3	2	2	–	–	–	–	–	–	–	–	–	–
CO-5	1	3	2	3	2	2	–	–	–	–	–	–	–	–	–	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus

Simple programs dealing with fundamentals of C/C++ language for

1. Simplex method
2. Big-M method
3. Two phase method
4. Revised simplex method
5. Dual simplex method
6. Solution of a transportation problem by north west corner rule
7. Initial basic feasible solution for a transportation problem by Vogel's approximation method
8. Assignment problem

MA17007 **0-1-2 (2)**

Software Lab

Pre-Requisites: **MA17027**

Course Outcomes:

CO-1	Recall the fundamental concepts of C/CPP/Fortran
CO-2	Write a program for second order linear boundary value problem (BVP) using finite difference
CO-3	Write a program for second order nonlinear BVP using finite difference schemes
CO-4	Adapt the finite difference schemes to write a program for Schmidt's two level, Crank-Nicolson's two level for heat conduction problem
CO-5	Develop programs for wave equation using explicit and implicit methods
CO-6	Develop programs for Laplace equation and Poisson equation using explicit and implicit methods

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	2	3	2	3	2	1	-	-	-	-	-	-	-	-	-	-
CO-2	2	3	2	3	2	1	-	-	-	-	-	-	-	-	-	-
CO-3	2	3	2	3	2	2	-	-	-	-	-	-	-	-	-	-
CO-4	2	3	2	3	2	1	-	-	-	-	-	-	-	-	-	-
CO-5	2	3	2	3	2	2	-	-	-	-	-	-	-	-	-	-
CO-6	2	3	2	3	2	1	-	-	-	-	-	-	-	-	-	-

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Revision: Write a program for Tridiagonal Matrix Algorithm (TDMA) - Thomas Algorithm

Ordinary Differential Equations - Finite Difference Methods:

(1) Write a program using finite difference schemes for

- Second order linear BVP with both Dirichlet boundary conditions
- Second order linear BVP with both Neumann boundary conditions
- Second order linear BVP with right Neumann and left Dirichlet boundary conditions
- Second order linear BVP with left Neumann and right Dirichlet boundary conditions

(2) Write a program for second order non-linear BVP using finite difference schemes

Partial Differential Equations - Finite Difference Methods:

(1) Write a program using finite difference schemes for

- One dimensional heat conduction problem: Schmidt's Scheme (two level)
- One dimensional heat conduction problem: Crank- Nicolson's Scheme (two level)

(2) Write a program using finite difference schemes for

- One-dimensional wave equation

Laplace equation: Explicit and Implicit Methods

MA17091 **0-0-4 (2)**

Seminar and Technical Writing

Pre-Requisites: **None**

Course Outcomes:

CO-1	Consolidate ideas based on expert talks attended
CO-2	Prepare a well-organized report employing elements of critical thinking and technical writing
CO-3	Demonstrate the ability to describe, interpret and analyze the subject matter and develop competence in presenting

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	2		2			3	3		2	3		3				
CO-2	2		2			3	3		2	3		3				
CO-3	2		2			3	3		2	3		3				

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Description:

In Seminar and Technical Writing, every student is expected to prepare a well-organized report based on one / all of the following:

- by attending at least 5 expert lectures/ invited talks/ Seminar/ Popular lectures etc. organized by the institute/any of the departments, ideally in a specific domain or with the same theme.
- prepare a business or marketing plan based on patent search

The student is expected to consolidate the ideas from these lectures/patent searches and may even include material from other sources to strengthen the content of the report. The student should prepare a well-organized report based on the above and present it to the panel constituted by the department, for evaluation.

Evaluation Criteria:

The student will be evaluated by the panel based on the below criteria.

Criteria	Description	Weightages
I	Clarity on the topic	
II	List of lectures attended	
III	Report	
IV	Presentation	
V	Response to questions	

Evaluation Criteria-CO Mapping

CO / Criteria	CO1	CO2	CO3
I	X		
II	X		
III		X	
IV			X
V			X

MA17093 **0-0-4 (2)**

Short-term Industrial/ Research Experience

Pre-Requisites: **None**

Course Outcomes:

CO-1	Apply engineering principles to real-world problems, gaining practical experience
CO-2	Plan, manage and execute the work with ethical consideration
CO-3	Review the social and environmental impact of the work
CO-4	Communicate the learnings through report and presentation

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	3	3	3	3							3				
CO-2	2	2	2	2	2			3	3		3	3				
CO-3						3	3					3				
CO-4										3		3				

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Description:

Every student has to undergo either a Summer Internship / EPICS / Research project. The summer internship may be undergone in an Industry/Research organization or any premier academic Institution, including NIT Warangal for 6-8 weeks. The EPICS/research project shall be registered under the guidance of any faculty member in the institute. The student is required to submit a report and present the work before an evaluation committee, nominated by the Head of the Department.

Evaluation Criteria:

The student will be evaluated by the panel based on the below criteria. Weightage for each criterion will be determined by the panel and will be informed to the students.

Criteria	Description	Weightages
I	Relevance of the area of work	
II	Performance of the Task	
III	Crucial learnings from the work	
IV	Report Preparation	
V	Presentation and Response to questions	

Evaluation Criteria-CO Mapping

CO / Criteria	CO1	CO2	CO3	CO4
I	X			
II		X		
III			X	
IV				X
V				X

10th Semester

MA17094 **0-0-4 (2)**

Comprehensive Viva-Voce

Pre-Requisites: **None**

Course Outcomes:

CO-1	Comprehend the knowledge gained in the course work
CO-2	Demonstrate the ability in problem solving
CO-3	Communicate effectively using engineering terminology

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	3	3	3						2		3				
CO-2	3	3	3	3						2		3				
CO-3	2	2	2	2						3		3				

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Description:

In Comprehensive viva-voce each student will be evaluated for their overall comprehension of the course work and laboratory training that they have undergone. The students will be expected to answer questions orally, write down simple equations, draw plots, schematics, write simple code etc. as questioned by the panel. Assessment will be done by the panel based on the student response.

MA17098 **0-0-16 (8)**

Dissertation

Pre-Requisites: **None**

Course Outcomes:

CO-1	Identify the materials and methods for carrying out experiments/develop a code.
CO-2	Execute the research methodology with a concern for society, environment and ethics
CO-3	Analyse, discuss and justify the results/trends and draw valid conclusions.
CO-4	Prepare the report as per recommended format and present the work orally adhering to stipulated time.
CO-5	Explore the possibility to publish/present a paper in peer reviewed journals/conference proceedings without plagiarism.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	2		3	3	2	3
CO-2	2		3	3	2	3
CO-3	3		3	3	2	3
CO-4	3	3	3	3	3	3
CO-5	3	3	3			3

1 - Slightly; 2 - Moderately; 3 - Substantially

Description:

Students are expected to choose real-world contemporary problem and apply the engineering principles learned, to solve the problem through building prototypes or simulations or writing codes or establishing processes/synthesis/correlations etc. The department constituted panel will decide the suitability and worthiness of the project.

Dissertation Evaluation:

i. The dissertation shall be submitted as per the schedule given in the academic calendar.

ii. The dissertation supervisor will periodically review the progress of the student and finally give his/her assessment of the work done by the student.

iii. The Dissertation Part – B will be evaluated for 100 marks, with the following weightages:

Sub-component	**Weightage**
a) Periodic evaluation by Guide	40 marks
b) Mid-term review	20 marks
c) End Semester viva-voce examination	40 marks

The midterm review will be conducted by a committee constituted by the Head of the Department. The end semester examination will be conducted by an External Examiner along with the evaluation committee constituted by the Head of the Department.

Evaluation Criteria:

The student will be evaluated by the panel based on the below criteria as a continuation of Dissertation Part A. Weightage for each criterion will be determined by the panel and will be informed to the students.

Task	Description	Weightages
IV	Performance of the Task	
V	Dissertation Preparation	
VI	Review (Presentation & Understanding)	
VII	Viva-Voce	
VIII	Publications /Possibility of publication	

Evaluation Criteria-CO Mapping:

CO / Criteria	CO1	CO2	CO3	CO4	CO5
IV	X	X			
V				X	
VI			X		
VII				X	
VIII					X

Refer to PG regulations for any further information regarding mid-term review, end-sem evaluation, template for report preparation and plagiarism.

Professional Elective – I

MA16021 **3-0-0 (3)**

Advanced Linear Algebra

Pre-Requisites: **None**

Course Outcomes:

CO-1	Test the consistency of system of linear algebraic equations
CO-2	Verify rank nullity theorem for a given linear transformation
CO-3	Find eigenvalues and canonical forms of a linear operator
CO-4	Identify the importance of orthogonal property in the spectral theory
CO-5	Demonstrate the knowledge of bilinear form and its nature

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	–	2	2	–	–	–	–	–	–	–	–	–	–	–	–
CO-2	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
CO-3	3	2	2	–	–	–	–	–	–	–	–	–	–	–	–	–
CO-4	3	–	3	–	–	–	–	–	–	–	–	–	–	–	–	–
CO-5	3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Review of Vector Spaces-Subspaces- Bases and Dimension-Coordinates. Linear Transformations-The algebra of Linear Transformations – Isomorphism - Representation of Transformations by Matrices - Linear Functionals.

Annihilating polynomial, Invariant subspaces. Simultaneous triangularization, Simultaneous diagonalization, Jordan form.

Direct-sum Decompositions - Invariant Direct sums - The primary Decomposition theorem- Cyclic Subspaces and Annihilators, Companion matrix of the monic polynomial.

Inner Product Spaces: Orthogonality: Inner product, Inner product Spaces, Cauchy – Schwarz inequality, Norm, Orthogonality, Gram – Schmidt orthonormalization, Orthonormal basis, Expansion in terms of orthonormal basis, Orthogonal complement, Decomposition of a vector with respect to a subspace and its orthogonal complement.,

Bilinear forms - Symmetric Bilinear Forms - Skew Symmetric Bilinear Forms - Groups preserving Bilinear Forms

Learning Resources:

Text Books:

1. K.Hoffman and R.Kunze, Linear Algebra, Prentice Hall of India, New Delhi, 2003, Second Edition.
2. Sheldon Axler, Linear Algebra Done Right, Springer Nature, 2015, Third Edition
3. David C. Lay, Steven R. Lay, Judi J. McDonald, Linear algebra and its applications, Pearson, 2016, Fifth edition.

Reference Books:

1. Lipschitz, Linear Algebra, Schaum Series
2. H.Friedberg etal, Linear Algebra, PHI(2007).
3. P.Halmos,D Vanostrand, Finite Dimensional Vector Spaces, Princeton.

MA16023 **3-0-0 (3)**

Classical Mechanics

Pre-Requisites: **None**

Course Outcomes:

CO-1	Develop equations of motion for a system of particles
CO-2	Analyze the motion of a rigid body under translation
CO-3	Explain Euler's theorems for the motions of rigid bodies
CO-4	Analyze the motion of a rigid body under rotation about a fixed point
CO-5	Develop Lagrange's and Hamiltonian equations for body

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	2	3	3	–	–	2	–	–	–	–	–	–	–	–	–	–
CO-2	3	2	3	–	–	1	–	–	–	–	–	–	–	–	–	–
CO-3	2	2	2	–	–	–	–	–	–	–	–	–	–	–	–	–
CO-4	2	3	3	–	–	1	–	–	–	–	–	–	–	–	–	–
CO-5	3	2	1	–	–	2	–	–	–	–	–	–	–	–	–	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Systems of Particles: Linear and angular momentum; Rate of change of angular momentumof a system of particles with respect to the fixed and moving frames of reference; Effect of impulsive forces on the systems of particles.

Rigid Body: Moments of inertia; Kinetic energy and angular momentum of a rigid body rotating about a fixed point and about a fixed axis; General motion of a rigid body; Motion of a rigid body parallel to a fixed plane under finite and impulsive forces.

Rotational Motion: Euler's motion under no forces, Effects of earth's rotation, Eulerian angles.

Lagrangian Mechanics: Generalized coordinates, Velocities and forces; Motion of a top - Lagrange's equations of motion.

Learning Resources:

Text Books:

1. F. Chorlton, Textbook on Dynamics, CBS Publication, 2002, Second Edition
2. J. L. Synge and B. A. Griffith, Principles of Mechanics, McGraw Hill, 1987, Third Edition.

Reference Books:

1. G. R. Fowles and G. L. Cassiday, Analytical Mechanics, Cengage Learning, 2004, Seventh Edition.
2. Murray R. Spiegel, Theory & Problems of Theoretical Mechanics, Schaum's Outline Series, McGraw Hill, 2017, Reprint of First Edition.

MA16025 **3-0-0 (3)**

Mathematical Modelling

Pre-Requisites: **None**

Course Outcomes:

CO-1	Learn modelling through Ordinary Differential Equations of the first-order.
CO-2	Modelling through a system of ordinary differential equations of the first order
CO-3	Modelling through ordinary differential equations of the second order
CO-4	Learn modelling through partial differential equations.
CO-5	Learn modelling through partial differential equations.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–
CO-2	3	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–
CO-3	2	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–
CO-4	3	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–
CO-5	3	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Introduction: Mathematical Modelling: Need, Techniques, Classifications and Simple Illustrations.

Mathematical Modelling through Ordinary Differential Equations of the first order: Linear Growth and Decay Models. Non-linear growth and decay models, Compartment models.

Mathematical Modelling, through a system of Ordinary differential equations of the first order: Prey-predator models, Competition models, Epidemics: simple epidemic model, Susceptible-infected-susceptible (SIS) model, SIS model with constant number of carriers. Medicine: Model for Diabetes Mellitus. Models with removal, and models with immigration.

Mathematical Modelling through Ordinary Differential Equations of the Second order: Mathematical Modelling of the Planetary Motions, Circular Motion, and Motion of Satellite Order, Electric Circuits.

Introduction to difference equations, Mathematical Modelling through difference equations: In Economics and Finance, In Population Dynamics and Genetics, In Probability Theory.

Mathematical Modelling through Partial Differential Equations: Situation giving rise to partial differential equation models, Mass Balance Equations: First Method of Getting PDE Models, Momentum Balance Equations.

Learning Resources:

Text Books:

1. W.J. Meyer, Concepts of Mathematical Modelling, Dover Publications Inc, 2004, First Edition.
2. Brian P. Ingalls, Mathematical Modeling in Systems Biology: An Introduction, MIT Press, 2022, First Edition.

Reference Books:

1. B. Barnes, and G. R. Fulford, Mathematical Modelling with Case Studies, CRC press, 2009, Third Edition
2. Seyed M. Moghadas, Majid Jaberi-Douraki, Mathematical Modelling: A Graduate Textbook, Wiley, 2018, First Edition.

Professional Elective – II

MA16022 **3-0-0 (3)**

Algebra

Pre-Requisites: **None**

Course Outcomes:

CO-1	Analyze the structure of groups
CO-2	Distinguish the properties among ring structures
CO-3	Understand extension of fields and their constructions
CO-4	Apply the concepts and results to solve problems of Modern Algebra
CO-5	Construct proofs that arise in various algebraic structures

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	1	2	2	2	2	–	–	–	–	–	–	–	–	–	–
CO-2	3	2	2	2	2	2	–	–	–	–	–	–	–	–	–	–
CO-3	3	2	2	2	2	2	–	–	–	–	–	–	–	–	–	–
CO-4	3	3	2	3	2	2	–	–	–	–	–	–	–	–	–	–
CO-5	3	1	2	3	2	2	–	–	–	–	–	–	–	–	–	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Groups: Group actions; Cayley's theorem; Class equation, Automorphisms; Sylow theorems and applications;

Rings: Ring homomorphisms and quotient rings; Quadratic integer rings; Properties of ideals; Ring of fractions; The Chinese Remainder Theorem;

Classes of Rings: Euclidean domains – norm, division algorithm, field norm on quadratic integer rings, results; Principal ideal domains – properties and results, Dedekind-Hasse norm; Unique factorization domains – irreducible elements, prime elements, associates, properties and results; Polynomial rings over fields, polynomial rings that are UFDs, irreducibility criteria;

Fields: Brief introduction to fields, field extensions, finite fields;

Learning Resources:

Text Books:

1. David S. Dummit and Richard M. Foote, Abstract Algebra, John Wiley & Sons, 2004, Third Edition.
2. I. N. Herstein, Topics in Algebra, John Wiley & Sons, 1975, Second Edition.

Reference Books:

1. Michael Artin, Algebra, Pearson, 2016, Second Edition.
2. Joseph A. Gallian, Contemporary Abstract Algebra, Cengage Learning, 2013, Eighth Edition.

MA16024 **3-0-0 (3)**

Integral Transforms and Integral Equations

Pre-Requisites: **None**

Course Outcomes:

CO-1	Understand the concepts of certain integral transforms
CO-2	Solve differential equations using Laplace transforms
CO-3	Find the solution of BVP's using Fourier transforms
CO-4	Solve finite difference equations by using Z transforms
CO-5	Solve an integral equation
CO-6	Find the Greens function to a differential equation/integral equation

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	2	3	–	–	2	–	–	–	–	–	–	–	–	–	–
CO-2	3	2	2	–	–	1	–	–	–	–	–	–	–	–	–	–
CO-3	2	2	2	–	–		–	–	–	–	–	–	–	–	–	–
CO-4	2	2	3	–	–	1	–	–	–	–	–	–	–	–	–	–
CO-5	3	1	2	–	–	1	–	–	–	–	–	–	–	–	–	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Laplace Transform: Definition; Functions of exponential order and examples; Transforms of elementary, transcendental and special functions; Transforms of derivatives and integrals; Transforms of periodic, unit-step and impulse functions; The inverse transform –Properties, Partial fraction, Convolution theorem; Solution of differential equations by the use of the transform - Laplace inverse integral, Solution of Laplace equation (in two dimensions), One-dimensional heat and wave equations. Demonstrations with simple examples.
Fourier Transform: The Fourier transform, Inverse Fourier transform, Fourier transform properties, Convolution integral, Convolution theorem, Correlation, Correlation theorem, Parseval's theorem, Wave from sampling, Sampling theorem, Frequency sampling theorem. Demonstrations with simple examples.

Z-transform: Z-transform, Inverse Z-transform, Z-transform properties, Solution of linear difference equations by using Z-transform. Discrete Fourier Transform - Fourier transform of sequences, Discrete Fourier transform, transfer function.

Integral equations: Classification of integral equations, Connection with differential equations, Integral equations of the convolution type, Method of successive approximations, the resolvent, Fredholm theory, Laplace and Fourier transforms with applications to integral equations. Green's functions: Non-homogeneous boundary value problems, one-dimensional Green's function.

Learning Resources:

Text Books:

1. R.V. Churchill, Operational Mathematics, McGraw Hill, 1972.
2. F. B. Hildebrand, Methods of Applied Mathematics PHI, New Jercy, 1960.
3. E. I. Jury, Theory and applications of Z-Transform method, John Wiley, 1964.

Reference Books:

1. I.N. Snedden, The use of Integral Transforms, Tata Mc-Grawhill, 1979
2. John W. Dettman, Mathematical methods in Physics & Engineering, McGraw Hill, NewYork, 1962

MA16026 **3-0-0 (3)**

Differential Geometry and Tensor Analysis

Pre-Requisites: **None**

Course Outcomes:

CO-1	Determine the directions of tangent, normal and binormal at point on the given
CO-2	Find the geodesic curve on a given surface
CO-3	Find surfaces of constant curvature
CO-4	Form tensor quantities and find the corresponding metric tensors
CO-5	Expose students to mathematical applications of tensor algebra to handle diverse

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	2	2	3	–	–	1	–	–	–	–	–	–	–	–	–	–
CO-2	3	2	1	–	–	1	–	–	–	–	–	–	–	–	–	–
CO-3	2	1	2	–	–	–	–	–	–	–	–	–	–	–	–	–
CO-4	2	1	2	–	–	–	–	–	–	–	–	–	–	–	–	–
CO-5	2	2	1	–	–	1	–	–	–	–	–	–	–	–	–	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Local curve theory: Serret-Frenet formulation, Fundamental existence theorem of space curves.

Plane curves and their global theory: Rotation index, Convex curves, Isoperimetric inequality, Four vertex theorem.

Local surface theory: First fundamental form and arc length, Normal curvature, Geodesic curvature and Gauss formulae, Geodesics, Parallel vector fields along a curve and parallelism, the second fundamental form and the Weingarten map, Principal, Gaussian, Mean and normal curvatures, Riemannian curvature and Gauss's theorem Egregium, Isometrics and fundamental theorem of surfaces.

Global theory of surfaces: Geodesic coordinate patches, Gauss-Bonnet formula andEuler characteristic, Index of a vector field, Surfaces of constant curvature.

Tensor Analysis: N-dimensional space, Covariant and contravariant vectors, Contraction, Second & higher order tensors, Quotient law, Fundamental tensor, Associate tensor, Angle between the vectors, Principal directions, Christoffel symbols, Covariant and intrinsic derivatives.

Learning Resources:

Text Books:

1. R. S. Millman and G. D. Parker, Elements of Differential Geometry, Prentice Hall Inc.,1977, First Edition.
2. Barry Spain, Tensor Calculus, Dover Publications, 2003, Reprint of First Edition.

Reference Books:

1. S. Kumaresan, A Course in Differential Geometry and Lie Groups, Texts and Readings in Mathematics, 22, Hindustan Book Agency, New Delhi, 2002, First Edition.
2. I. N. Snedden, The Use of Integral Transforms, Tata McGraw-Hill, 1974, First Edition.

Professional Elective – III

MA16028 **3-0-0 (3)**

Complex Analysis

Pre-Requisites: None

Course Outcomes:

CO-1	Introduce the analyticity of complex functions and study their applications.
CO-2	Evaluate complex integrals and expand complex functions.
CO-3	Determine and classify the zeros and singularities of the complex functions.
CO-4	Evaluate improper integrals by residue theorem.
CO-5	Learn the uniqueness of conformal transformation.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	3	2	–	–	2	–	–	–	–	–	–	–	–	–	–
CO-2	3	1	2	–	–	1	–	–	–	–	–	–	–	–	–	–
CO-3	3	2	1	–	–	2	–	–	–	–	–	–	–	–	–	–
CO-4	3	2	3	–	–	1	–	–	–	–	–	–	–	–	–	–
CO-5	3	3	3	–	–	2	–	–	–	–	–	–	–	–	–	–

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Functions of Complex Variables: Complex variable - Functions of a complex variable - Continuity - Differentiability – Analytic functions.

Complex Integration: Cauchy's theorem - Cauchy's integral formula - Morera's theorem - Cauchy's inequality - Liouville's theorem. Series Expansions: Taylor's theorem - Laurent's theorem - Zeros of an analytic function - Singularities

Contour Integration: Residues - Cauchy's residue theorem – contour integration - the fundamental theorem of algebra - Poisson's integral formula. Analytic continuation - branches of a many-valued function - contour integration with branch, Riemann surface. The maximum modulus theorem - mean values of f(z). Rouche's theorem and its applications.

Geometry aspects of Analytical functions: Conformal mapping– Bilinear transformation - Transformation by elementary functions-uniqueness of conformal transformation - representation of any region on a circle.

Learning Resources:

Text Books:

1. R.V. Churchill and J.W. Brown, Complex Variables and Applications, McGraw Hill, Tokyo, 2013, Ninth Edition.
2. John B. Conway, Functions of One Complex Variable, Springer, India, 1995, Second Edition.

Reference Books:

1. S. Ponnusamy and Herb Silverman, Complex Variables with Applications, Birkhauser, Boston, Birkhauser Boston Incorporation publishers, 2006, First Edition.
2. Murray Spiegel, Seymour Lipschutz, John Schiller, and Dennis Spellman, Complex Variable, Schaum's Outlines Series, McGraw Hill, 2017, Revised Second Edition.

MA16030 **3-0-0 (3)**

Lie Group Methods for Differential Equations

Pre-Requisites: **None**

Course Outcomes:

CO-1	Show competence in the field of ordinary and partial differential equations
CO-2	Show analytic skills and working knowledge in Lie's integration methods
CO-3	Solve linear and non-linear differential equations
CO-4	Reduce a vast amount of nonlinear second-order ordinary equations used in applications to four
CO-5	Know the terminology in group analysis of differential equations

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	2	3	–	–	2	–	–	–	–	–	–	–	–	–	–
CO-2	3	3	3	–	–	2	–	–	–	–	–	–	–	–	–	–
CO-3	3	2	3	–	–	1	–	–	–	–	–	–	–	–	–	–
CO-4	3	2	2	–	–	2	–	–	–	–	–	–	–	–	–	–
CO-5	3	2	2	–	–	1	–	–	–	–	–	–	–	–	–	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Introduction to Lie group analysis: Lie group of transformations – Groups, Group oftransformations; One parameter Lie groups of transformations - Infinitesimal transformations -First order theorem of Lie - Infinitesimal generators - Invariant functions - Canonical coordinates - Invariants of points - Curves and surfaces - Extended infinitesimal - Extended transformations (Prolongations) - Symmetry reductions - Multi parameter Lie groups of transformations.

Group analysis of ordinary differential equations: Invariance of ordinary differential equations - Prolongation techniques - Calculation of Lie symmetry groups - Differential equations admitting a given group - Invariant solutions - Group classification for ordinary differential equations - Symmetry analysis for systems of ordinary differential equations.

Group analysis of partial differential equations: Invariance of partial differential equations-Prolongation formulae - Determining equations - Infinitesimal of partial differential equations - Invariant solutions - Group classification for partial differential equations - Lie symmetries for systems of partial differential equations.

Learning Resources:

Text Books:

1. G.W. Bluman, S. Kumei, Symmetries and Differential Equations, Springer-Verlag, NewYork, 1989, First Edition.
2. L.V. Ovsiannikov, Group Analysis of Differential Equations, Academic Press, New York,1982 (Moscow, Nauka, 1978, in Russian), First Edition.

Reference Books:

1. P. Olver, Applications of Lie groups to Differential Equations, Springer-Verlag, Berlin,1993, Second Edition.
2. P. E. Hydon, Symmetry Methods for Differential Equations: A Beginner's Guide, Cambridge University Press, 2010.

MA16032 **3-0-0 (3)**

Iterative Methods

Pre-Requisites: **None**

Course Outcomes:

CO-1	Solve differential equations using ADM.
CO-2	Get solutions of differential equations by HPM.
CO-3	Find solutions of fluid dynamics problems using HAM.
CO-4	Apply VIM for ODEs.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	2	2	3	–	2	2	–	–	–	–	–	–	–	–	–	–
CO-2	2	3	3	–	2	2	–	–	–	–	–	–	–	–	–	–
CO-3	2	2	3	–	2	1	–	–	–	–	–	–	–	–	–	–
CO-4	2	2	3	–	2	2	–	–	–	–	–	–	–	–	–	–

Syllabus:

Adomian Decomposition Method (ADM): The ADM for solving differential equations, Convergence of ADM, ADM in several dimensions, Solving boundary value problems using ADM, Modified ADM, Mathematica code of ADM.

Homotopy Perturbation Method (HPM): The HPM algorithm, Convergence analysis, Applications.

Homotopy Analysis Method (HAM): The HAM algorithm, Convergence analysis, The role of auxiliary parameter, Control of convergence, Relation to ADM and HPM, Applications of HAM to solve nonlinear equations.

Variational Iteration Method (VIM): The VIM algorithm, Convergence of VIM, Applications to solve ordinary differential equations, Solving system of fractional differential equations using ADM.

Learning Resources:

Text Books:

1. G. Adomian, Solving frontier problems in Physics: The decomposition method, Kluwer Academic Publishers, London, 1994.
2. S. Liao, Beyond perturbation: introduction to the homotopy analysis method, , CRC press, 2003.
3. Belal Batiha, Variational Iteration Method and its applications, LAP Lambert Academic Publishing, 2012.

Professional Elective – IV

MA17021 **3-0-0 (3)**

Discrete Methematics

Pre-Requisites: **None**

Course Outcomes:

CO-1	Apply Propositional logic and First order logic to determine the validity of the statement
CO-2	Construct induction proofs involving summations, inequalities, and divisibility
CO-3	Implement the principles of counting, permutations and combinatory to solve real world problems to solve real world problems
CO-4	Formulate and solve recurrence relations
CO-5	Determine whether a given relation is an equivalence relation/poset and will be able to draw a Hasse diagram

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	2	2	–	–	–	–	–	–	–	–	–	–	–	–	–
CO-2	3	2	2	2	1	–	–	–	–	–	–	–	–	–	–	–
CO-3	2	2	2	–	–	–	–	–	–	–	–	–	–	–	–	–
CO-4	2	2	2	–	–	1	–	–	–	–	–	–	–	–	–	–
CO-5	2	2	2	–	–	–	–	–	–	–	–	–	–	–	–	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Mathematical Logic: Connectives, Tautologies, Equivalence of formulas, Duality law, Tautological implications, Normal forms, Theory of inference for statement calculus, Methods of proof.

Predicates: Predicative logic, Statement functions, Variables and quantifiers, Free and bound variables, Inference theory for predicate calculus.

Counting: Basics of counting, Permutations and combinations - Generalized Permutations and combinations; Pascal's identity, Vandermonde's identity, the Principles of inclusion-exclusion, Pigeonhole principle and its application.

Recurrence relations: Generating functions, Generating functions of permutations and combinations, Formulation as recurrence relations, Solving recurrence relations by substitution and generating functions, Method of characteristic roots, Solving inhomogeneous recurrence relations, Applications of recurrence relations.

Relations: Binary relations - Properties of binary relations, Equivalence relations and partitions, Matrix representation of relations, Adjacency matrices, Incidence matrices, Transitive closure and Warshal's algorithm, Partial and total ordering relations, Lattices.

Boolean Algebra: Chains, Lattices, principle of duality, basic properties of lattices, distributive and complemented lattices, Boolean lattices and algebras, uniqueness of finite Boolean algebras, Boolean expressions and functions - Representation and Minimizations of Boolean functions.

Learning Resources:

Text Books:

1. J. R. Mott, A. Kandel and Baker, Discrete Mathematics for Computer Scientists, PHI, 2006, Second Edition
2. C. L. Liu, and O. P. Mohapatra Elements of Discrete Mathematics, McGraw Hill, 2017, Fourth Edition

Reference Books:

1. K. H. Rosen, Discrete Mathematics and its Applications with Combinatorics and Graph Theory, Tata McGraw Hill, 2015, Seventh Edition.
2. Bernand Kolman, Robert C. Busby and Sharon Cutler Ross, Discrete Mathematical Structures, PHI, 2009, Sixth Edition.

MA17023 **3-0-0 (3)**

Distribution Theory

Pre-Requisites: None

Course Outcomes:

CO-1	Identify the weak solutions for differential equations
CO-2	Understand support and singular support of distributions
CO-3	Derive fundamental solutions of partial differential equations
CO-4	Prove approximations theorems

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	2	1	2	–	–	–	–	–	–	–	–	–	–	–	–	–
CO-2	2	1	1	-	-	1	–	–	–	–	–	–	–	–	–	–
CO-3	3	2	1	–	–	–	–	–	–	–	–	–	–	–	–	–
CO-4	3	2	2	–	–	2	–	–	–	–	–	–	–	–	–	–

Syllabus:

The calculus of distributions: Test functions and distributions, Some operations with distributions, Adjoint identities, Consistency of derivatives, Distributional solutions of differential equations. Support and singular support of distributions, Convolution of functions, Convolution of distributions, Fundamental solutions.

The Fourier transforms: From Fourier series to Fourier integrals, The Schwartz space, The Fourier inversion formula, Tempered distributions. Convolution with tempered distributions.

Solving partial differential equations: The Laplace equation, The heat equation, The wave equation.

The structure of distributions: Structure theorems, Distributions with point support, Positive distributions, Continuity of distributions, Approximation theory of distributions, Local theory of distributions, Distributions on spheres.

Learning Resources:

Text Books:

1. S. Kesavan, Topics in Functional Analysis and Applications, , New Age International Publishers, 2015.
2. R. S. Strichartz, A Guide to Distribution Theory and Fourier Transforms, World Scientific, 2008, Third Edition

Reference Books:

1. I. M. Gelfand and G. E. Shilov, Generalized Functions, Academic Press, 1964, Vol.1.
2. Gerald B. Folland, Introduction to Partial Differential Equations, Princeton University Press, 1995

MA17025 **3-0-0 (3)**

Multivariate Data Analysis

Pre-Requisites: **None**

Course Outcomes:

CO-1	Analyze Multivariate Distributions and their characteristics
CO-2	Perform Multivariate Analysis of variance
CO-3	Perform Conjoint analysis
CO-4	Analyze Cluster analysis and canonical correlation
CO-5	Interpret Multidimensional scaling

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	2	1	2	1	–	1	–	–	–	–	–	–	–	–	–	–
CO-2	3	2	1	–	–	–	–	–	–	–	–	–	–	–	–	–
CO-3	2	2	1	–	–	–	–	–	–	–	–	–	–	–	–	–
CO-4	3	2	3	–	–	2	–	–	–	–	–	–	–	–	–	–
CO-5	2	2	2	–	–	1	–	–	–	–	–	–	–	–	–	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Multivariate analysis of variance: Introduction -- Differences between MANOVA and discriminant analysis – A hypothetical illustration of MANOVA – A decision process for MANOVA

Conjoint analysis: Comparing conjoint analysis with other multivariate methods – Designing a conjoint analysis experiment – Managerial applications of conjoint analysis – Alternate conjoint methodologies – An illustration of conjoint analysis

Canonical correlation analysis: Analysing relationships with canonical correlation – interpreting the canonical variate – Validation and diagnosis

Cluster analysis: Cluster analysis decision process – Multidimensional scaling – Comparing MDS to other interdependence techniques – A decision framework for perceptual mapping – Correspondence analysis.

Learning Resources:

Text Books:

1. Joseph F. Hair, Multivariate Data Analysis, CENGAGE, 2018, Eighth Edition.
2. M. G. Kendall, Charles Griffith, A Course in Multivariate Analysis, 1968, First Edition.

Reference Books:

1. Trever Cox, An Introduction of Multivariate Data Analysis, Holder Education, 2005, First Edition.
2. Kohei Adachi, Matrix Based Introduction to Multivariate Data Analysis, Springer, 2021, Second Edition.

Professional Elective – V

MA17027 **3-0-0 (3)**

Numerical Solutions of Differential Equations

Pre-Requisites: **MA16007**

Course Outcomes:

CO-1	Apply the explicit and implicit multistep methods to solve the linear and non-linear initial value problems in ordinary differential equations
CO-2	Apply the cubic splines method to solve the two-point boundary value problems in ordinary differential equations
CO-3	Apply the iterative schemes to finite difference equations.
CO-4	Find the numerical solution of the heat equation, wave equation and the Laplace equation in one dimensional and 2-dimensional space using the finite difference
CO-5	Analyse the stability, convergence and the error analysis of the finite difference methods

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	2	3	–	–	1	–	–	–	–	–	–	–	–	–	–
CO-2	3	2	3	–	–	2	–	–	–	–	–	–	–	–	–	–
CO-3	3	2	3	–	–	3	–	–	–	–	–	–	–	–	–	–
CO-4	3	3	3	–	–	2	–	–	–	–	–	–	–	–	–	–
CO-5	3	3	3	–	–	2	–	–	–	–	–	–	–	–	–	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Ordinary Differential Equations: Multistep (explicit and implicit) methods for initial value problems, Linear and nonlinear boundary value problems, Quasi-linearization and Shooting methods.

Finite Difference Methods: Finite difference approximations for derivatives, Boundary value problems with explicit and implicit boundary conditions, Error analysis, Stability analysis, Convergence analysis.

Partial Differential Equations: Finite difference approximations for partial derivatives and finite difference schemes for parabolic equations: Schmidt's two level, Multi-level explicit methods, Crank-Nicolson's two level, Multi-level implicit methods, Dirichlet's problem, Neumann problem, Mixed boundary value problem. Hyperbolic Equations: Explicit methods, Implicit methods, One space dimension. Elliptic equations: Laplace equation, Poisson equation, Iterative schemes, Dirichlet's problem, Neumann problem, Mixed boundary value problem, ADI methods.

Learning Resources:

Text Books:

1. M. K. Jain, Numerical Solution of Differential Equations, Wiley Eastern, Delhi, 2018, Fourth Edition.
2. M. K. Jain, S. R. K. Iyengar and R. K. Jain, Computational Methods for Partial Differential Equations, Wiley Eastern, 2016, Second Edition.

Reference Books:

1. G. D. Smith, Numerical Solution of Partial Differential Equations, Oxford University Press, 2004, Reprint of Third Edition.
2. S. S. Sastry**,** Introductory Methods of Numerical Analysis, PHI, 2012, Fifth Edition.

MA17029 **3-0-0 (3)**

Dynamical Systems

Pre-Requisites: **MA16003 & MA16004**

Course Outcomes:

CO-1	Identify Autonomous and Nonautonomous Systems
CO-2	Understand Limit Cycle Motion and Periodic Attractor
CO-3	Differentiate Dissipative and Conservative Systems
CO-4	Understand different types of bifurcations
CO-5	Apply Poincare Bendixson Theory.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	1	2	3	2	1	1	–	–	–	–	–	–	–	–	–	–
CO-2	2	2	2	1	1	1	–	–	–	–	–	–	–	–	–	–
CO-3	2	1	2	–	–	–	–	–	–	–	–	–	–	–	–	–
CO-4	2	2	1	–	–	–	–	–	–	–	–	–	–	–	–	–
CO-5	3	2	-	–	–	–	–	–	–	–	–	–	–	–	–	–

Syllabus:

Qualitative Features: Autonomous and nonautonomous Systems- Equilibrium Points - Phase space/phase plane and phase trajectories: Stability, Attractors and Repellers; Classification of equilibrium points- Limit cycle motion - Periodic attractor – Poincare - Bendixson theorem - Higher dimensional systems: Lorenz equations - Quasiperiodic attractor- Poincare map - Chaotic attractor - Dissipative and conservative systems - Hamiltonian systems.

Bifurcations and Onset of Chaos in Dissipative Systems: Saddle-node bifurcation - Pitchfork bifurcation - Transcritical bifurcation - Hopf bifurcation - Discrete dynamical systems - Logistic map - Equilibrium points and their stability- Periodic solutions or cycles - Period doubling phenomenon- Onset of chaos: Sensitive dependence on initial conditions - Lyapunov exponent- Bifurcation diagram - Logistic map- Strange attractor in the Henon map - The period doubling phenomenon - Self-similar structure - Route to chaos.

Chaos in Conservative Systems: Poincare cross section - Orbits in conservative systems - Regular and irregular trajectories - Canonical perturbation theory: Overlapping resonances and chaos - Periodically driven undamped duffing oscillator - The standard map - Linear stability and invariant curves - Numerical analysis: Regular and chaotic motions.

Characterization of Regular and Chaotic Motions: Lyapunov exponents - Numerical computation of Lyapunov exponents - One-dimensional map - Computation of Lyapunov exponents for continuous time dynamical systems- Power spectrum and dynamical motion - Autocorrelation - Criteria for chaotic motion.

Learning Resources:

Text Books:

1. M. Lakshmanan, S. Rajasekar, Nonlinear Dynamics: Integrability, Chaos and Patterns, Springer, First edition, 2010.
2. George F. Simmons, Differential Equations with Applications and Historical Notes, McGraw-Hill, Second Edition, 2003.

Reference Books:

1. Hirsch, Smale and Devaney, Differential Equations, Dynamical Systems, and an Introduction to Chaos, , Elsevier Academic Press, USA, 2004.
2. Lawrence Perko, Differential Equations and Dynamical Systems, Third Edition, Springer-Verlag, 2010.

MA17031 **3-0-0 (3)**

Analysis of Differential Equations

Pre-Requisites: **None**

Course Outcomes:

CO-1	Understand the Poincare inequality
CO-2	Understand the concepts of approximation
CO-3	Utilization of weak derivatives
CO-4	Apply the Galerkin's method
CO-5	Study the canonical forms of partial differential equations

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO-1	1	1	2	1	–	–	–	–	–	–	–	–	–	–
CO-2	1	1	3	1	–	–	–	–	–	–	–	–	–	–
CO-3	1	1	2	2	–	–	–	–	–	–	–	–	–	–
CO-4	1	1	2	1	–	–	–	–	–	–	–	–	–	–
CO-5	1	1	2	1	–	–	–	–	–	–	–	–	–	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Semigroups: Semigroups of operators, Examples, basic properties, Hille-Yosida theorem, Maximl dissipative operators, regularity, Heat equation, wave equation, Schrodinger equation, Inhomogeneous equations.

Sobolev spaces: Definition of Sobolev spaces, approximation by smooth functions, Extension theorems, Poincare inequality, Imbedding theorems, Compactness theorems, trace theory.

Boundary value problems: Variational problems in Hilbert spaces and Lax-Milgram lemma. Examples of weak formulations of elliptic boundary value problems, Regularity, Galerkin's method, Maximum principles, Eigenvalue problems, introduction to the finite element method,

Learning Resources:

Text Books:

1. S. Kesavan, Topics in Functional Analysis and Applications, John Wiley & Sons, 1989, First Edition.
2. L.C. Evans, Partial differential equations, American Mathematical Society, 2022, Second Edition.

Reference Books:

1. Walter Rudin, Real and complex analysis, McGraw-Hill, New York, 2003, Third Edition.
2. H. L. Royden, Real Analysis, Pearson, 2003, Third Edition.

Professional Elective – VI

MA17022 **3-0-0 (3)**

Measure and Integration

Pre-Requisites: **None**

Course Outcomes:

CO-1	Identify the class of measurable sets
CO-2	Derive properties of Lebesgue measurable sets and functions
CO-3	Determine whether the given function is Lebesgue integrable or not
CO-4	Prove Fatou's Lemma, Lebesgue's Monotone convergence theorem and Lebesgue dominated convergence theorem
CO-5	Understand and apply product measures and Fubini's theorem to perform integration on Cartesian products.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	1	2	–	–	–	–	–	–	–	–	–	–	–	–	–
CO-2	2	1	2	–	–	–	–	–	–	–	–	–	–	–	–	–
CO-3	3	1	2	–	–	–	–	–	–	–	–	–	–	–	–	–
CO-4	3	1	1	–	–	–	–	–	–	–	–	–	–	–	–	–
CO-5	3	2	1	–	–	–	–	–	–	–	–	–	–	–	–	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Lebesgue Measure: Outer measure, Measurable sets, A non-measurable set, Example of measurable set which is not a Borel set, Lebesgue measure and its properties, Measurable functions.

Abstract Integration: The concept of measurability, Simple functions, Elementary properties of measures, Arithmetic in [0, ∞], integration of positive functions, Lebesgue's monotone convergence theorem, Fatou's lemma, Lebesgue's dominated convergence theorem, Integration of complex functions, the role played by sets of measure zero.

Product measures: Integration on Cartesian products, Product measures, The Fubini's theorem.

Learning Resources:

Text Books:

1. H. L. Royden, Real Analysis, Pearson, 2003, Third Edition.
2. W. Rudin, Real and Complex Analysis, Tata McGraw-Hill Edition, 2006, Third edition

Reference Books:

1. G. de Barra, Measure and Integration, New Age International Pvt. Ltd, 2013, First Edition.
2. Terence Tao, An Introduction to Measure Theory, Graduate Studies in Mathematics, AMS, 2011.

MA17024 **3-0-0 (3)**

Finite Element Method

Pre-Requisites: **None**

Course Outcomes:

CO-1	Determine an extremum by calculus of variations approach
CO-2	Formulate a variational problem for a boundary value problem
CO-3	Find the solution of solution of one-dimensional problems
CO-4	Find the solution of two-dimensional problems by rectangular elements
CO-5	Find the solution of two-dimensional problems by triangular elements

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	2	3	–	–	1	–	–	–	–	–	–	–	–	–	–
CO-2	3	2	2	–	–	2	–	–	–	–	–	–	–	–	–	–
CO-3	3	3	3	–	–	2	–	–	–	–	–	–	–	–	–	–
CO-4	3	2	3	–	–	2	–	–	–	–	–	–	–	–	–	–
CO-5	3	3	3	–	–	2	–	–	–	–	–	–	–	–	–	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Calculus of Variations: Introduction, Euler's Equation, Euler Lagrange Equations, Ostrogradsky equation.

Variational formulation: Variational Formulation for a boundary value problem with homogeneous and non-homogeneous boundary conditions, Rayleigh- Ritz minimization, Weighted residuals - Collocation, Least squares method, Galerkin, Petrov-Galerkin methods for boundary value problems.

One dimensional problem: Solution of one-dimensional boundary value problems by linear, quadratic and cubic shape functions.

Two dimensional problems: Solution of two-dimensional boundary value problems by linear, quadratic and cubic rectangular, serendipity and triangular shape functions.

Time Dependent Problems: One-dimensional heat and wave equations.

Learning Resources:

Text Books:

1. J. N. Reddy**,** An Introduction to the Finite Element Method, McGraw Hill, 2020, Fourth Edition.
2. I. J. Chung**,** Finite Element Analysis in Fluid Dynamics, McGraw-Hill International Book Company, 2007, Digitized Version, First Edition.

Reference Books:

1. O. C. Zienkiewiez and K. Morgan, Finite Elements and Approximation, John Wiley, 1983, First Edition.
2. P. E. Lewis and J. P. Ward, The Finite Element Method - Principles and Applications, Addison Wesley, 1991, First Edition.

MA17026 **3-0-0 (3)**

Inventory, Queuing Theory and Non-Linear Programming

Pre-Requisites: **None**

Course Outcomes:

CO-1	Determine the characteristics of a queuing model
CO-2	Determine the EOQ for a deterministic inventory model
CO-3	Determine the EOQ for a stochastic inventory model
CO-4	Determine the solution of a CNLPP
CO-5	Determine the solution of a QPP

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	2	2	2	–	–	1	–	–	–	–	–	–	–	–	–	–
CO-2	3	1	2	–	–	1	–	–	–	–	–	–	–	–	–	–
CO-3	2	1	2	–	–	1	–	–	–	–	–	–	–	–	–	–
CO-4	3	2	2	–	–	–	–	–	–	–	–	–	–	–	–	–
CO-5	3	1	2	–	–	–	–	–	–	–	–	–	–	–	–	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Queuing theory: Characteristics of queueing systems - The birth and death process - Steady state solutions - Single server model (finite and infinite capacities) - Single server model (with SIRO) - Models with state dependent arrival and service rates- Waiting time distributions.

Inventory control: Inventory control for single commodity - Deterministic inventory models (without and with shortages) - Probabilistic inventory (both discrete and continuous) control models.

Nonlinear programming problem: Unconstrained NLPP, Constrained NLPP - Lagrange's multipliers method - Convex NLPP, Kuhn-Tucker conditions (including the proof) - Quadratic programming problem (Wolfe's method).

Learning Resources:

Text Books:

1. H. A. Taha, Operations Research: An Introduction, PHI, Delhi, 2014, Tenth Edition.
2. H. M. Wagner, Principles of Operations Research, PHI, Delhi, 2010, Second Edition.

Reference Books:

1. J. C. Pant, Introduction to Optimization: Operations Research, Jain Brothers, Delhi, 2015, Seventh Edition.
2. Kanti Swarup, P.K. Gupta, Man Mohan, Operations Research - Introduction to Management Science, Sultan Chand and Sons, 2019, Thirteenth Edition.

Professional Elective – VII

MA17028 **3-0-0 (3)**

Fluid Dynamics

Pre-Requisites: **None**

Course Outcomes:

CO-1	Draw stream lines and path lines of a velocity field of a fluid
CO-2	Find complex velocity potential for an incompressible and irrotational flow
CO-3	Set up equations of motion with boundary conditions for problems and solve them
CO-4	Analyze the flow in a tube of uniform cross section and find volumetric flow rate
CO-5	Draw streamlines and path lines of a velocity field of a fluid

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	3	2	3	2	3	–	–	–	–	–	–	–	–	–	–
CO-2	3	3	3	2	2	2	–	–	–	–	–	–	–	–	–	–
CO-3	3	2	3	2	3	3	–	–	–	–	–	–	–	–	–	–
CO-4	3	3	3	3	3	3	–	–	–	–	–	–	–	–	–	–
CO-5	3	3	2	3	2	3	–	–	–	–	–	–	–	–	–	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Kinematics of fluids in motion: Real fluids and ideal fluids – Velocity of a fluid at a point – Stream lines and path lines – Steady and unsteady flows – The velocity potential – The velocity vector – Local and particle rates of change – The equation of continuity – Acceleration of fluid – Conditions at a rigid boundary.

Equations of motion of fluid: Euler's equations of motion – Bernoulli's equation – Some flows involving axial symmetry – Some special two-dimensional flows. Some three-dimensional flows: Introduction – Sources, sinks and doublets – Axisymmetric flows – Stokes' stream function. The Milne-Thomson circle theorem – The theorem of Blasius – Applications.

Viscous flows: Stress analysis in fluid motion – Relations between stress and rate of strain – The coefficient of viscosity and laminar flow – the Navier-Stokes' equations of motion of viscous fluid – Steady motion between parallel planes, Through tube of uniform cross section and flow between concentric rotating cylinders. Steady viscous flow in tubes of uniform cross section – A uniqueness theorem – Tube having uniform elliptic cross section – Tube having equilateral triangular cross section – Steady flow past a fixed sphere.

Learning Resources:

Text Books:

1. Frank Chorlton, Fluid Dynamics, CBS Publishers, Delhi, 2004, Reprint of First Edition.
2. L. M. Milne Thomson, Theoretical Hydrodynamics, Macmillan Company, New York, 1960, First Edition.

Reference Books:

1. Franz Durst, Fluid Mechanics: An Introduction to the Theory of Fluid Flow, Springer Verlag Berlin Heidelberg, 2008, Second Edition
2. Stephen Whitaker, Introduction to Fluid Mechanics, Ed-Tech Press, 2018, Second Edition.

MA17030 **3-0-0 (3)**

Graph Theory and Algorithms

Pre-Requisites: **None**

Course Outcomes:

CO-1	Examine whether the graphs are isomorphic or not
CO-2	Determine whether graphs are Hamiltonian and/or Eulerian
CO-3	Construct minimal spanning trees and shortest paths
CO-4	Determine the matching in a graph and solve the assignment problem
CO-5	Construct planar graphs, coloring of graphs and their applications

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	1	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–
CO-2	1	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–
CO-3	3	2	2	3	–	1	–	–	–	–	–	–	–	–	–	–
CO-4	2	1	2	2	–	–	–	–	–	–	–	–	–	–	–	–
CO-5	3	2	3	3	2	1	–	–	–	–	–	–	–	–	–	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Preliminary Concepts: Graph definition, various kinds of graphs; Incidence matrix; Isomorphism; Decomposition; Special graphs; Paths, cycles and trails - connection in graphs, bipartite graphs, Eulerian Circuits, Fleury's algorithm; Vertex degree and counting, Havel-Hakimi criteria; Hamiltonian Cycles - necessary and sufficient conditions; Review of digraphs.

Trees: Trees and distance - properties; Spanning trees; Kruskal and Prim algorithms with proofs of correctness; Shortest paths - Dijkstra's algorithm, BFS and DFS algorithms, Application to Chinese postman problem; Trees in Computer science - rooted trees, binary trees, Huffman's Algorithm.

Matchings: Matching in a graph and maximum matchings; Hall's matching theorem; Maximum bipartite matching - Augmenting path algorithm; Weighted bipartite matching - Hungarian algorithm and solving the assignment problem; Tutte's theorem.

Connectivity: Connectivity; Characterizing 2-connected graphs; Menger's theorem; Network flow problems-Ford-Fulkerson labeling algorithm, Max-flow Min-cut Theorem.

Coloring: Chromatic number; Greedy coloring algorithm; Brooks' theorem; Graphs with large chromatic number; Turan's theorem.

Planar Graphs: Planar graphs; Euler's formula; Cycle method for planarity testing, dual of a plane graph; Kuratowski's Theorem; Five Color Theorem; Four Colour Problem.

Learning Resources:

Text Books:

1. Douglas B. West, Introduction to Graph Theory, Pearson, 2015, Second Edition
2. R. Diestel, Graph Theory, Springer, 2017, Fifth Edition

Reference Books:

1. Narsingh Deo, Graph Theory with Applications to Engineering and Computer Science, Prentice-Hall, 1979, First Edition.
2. J. A. Bondy and U. S. R. Murty, Graph Theory, Springer, 2010, First Edition.

MA17032 **3-0-0 (3)**

Finite Volume Method

Pre-Requisites: **None**

Course Outcomes:

CO-1	Discretize steady and unsteady convection-diffusion problem
CO-2	Identify the properties of discretisation schemes.
CO-3	Solve convective problems using upwind, QUICK and hybrid schemes
CO-4	Solve the velocity and pressure coupling
CO-5	Solve discretised equations using multigrid methods

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–
CO-2	–	–	–	–	–	2	–	–	–	–	–	–	–	–	–	–
CO-3	–	–	3	–	–	–	–	–	–	–	–	–	–	–	–	–
CO-4	–	2	3	–	–	–	–	–	–	–	–	–	–	–	–	–
CO-5	–	–	3	–	–	1	–	–	–	–	–	–	–	–	–	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Convection - Diffusion problems and discretization: Steady 1D, 2D and 3D convection and diffusion problems - Discretization schemes: Central differencing scheme, Upwind differencing scheme, Hybrid differencing scheme, Power-law scheme. Properties of discretization schemes: Conservativeness - Boundedness - Transportiveness.

Higher-order differencing schemes: Quadratic upwind differencing scheme: the QUICK scheme - Stability problems of the QUICK scheme and remedies - Generalization of upwind- biased discretization schemes - Total variation and TVD schemes - Criteria for TVD schemes - Flux limiter functions - Implementation and Evaluation of TVD schemes.

Solution algorithms for pressure—velocity coupling: The staggered grid – SIMPLE algorithm - SIMPLER algorithm.

Solution of discretized equations: Application of the TDMA to 2D and 3D problems - Point- iterative methods: Jacobi iteration method - Gauss-Seidel iteration method - Relaxation methods - Multigrid techniques: Multigrid cycles - Grid generation for the multigrid method.

Unsteady flows: Explicit scheme - Crank-Nicolson scheme - Fully implicit scheme - Transient SIMPLE.

Learning Resources:

Text Books:

1. H. Versteeg and W. Malalasekera, An introduction to CFD: The Finite Volume Method, Pearson, 2007, Second Edition.
2. S.V. Patankar, Numerical Heat Transfer and Fluid Flow, CRC Press, 2009, Reprint of First Edition.

Reference Books:

1. D.M. Causon, C.G. Mingham, and L. Own, Introductory Finite Volume Methods for Partial Differential Equations, Springer, 2009, Reprint of First Edition.
2. F. Moukalled, L. Mangani, M. Darwish, The Finite Volume Method in Computational Fluid Dynamics An Advanced Introduction with OpenFOAM® and Matlab, Springer, 2015, First Edition.