Department of Mathematics Central University of Kashmir

Revised Structure and Syllabi of first six (06) semesters of Integrated B. Sc.-M. Sc. Programme in Mathematics

In operation w.e.f March 2018

Course structure for the B. Sc.-M. Sc. (Integrated) Mathematics

Semester - I

Subject Code	Subject	Contact Hours per Week (Theory+Tutorials+Presentation)	Credits	Marks	
				CIA	ESE
MTH-101A	Mathematics-IA	[3+2+1]	4	40	60
MTH-101B	Mathematics-IB	[3+2+1]	4	40	60
PHY-101T	Physics-I	[4+0+1]	4	40	60
CHM-101T	Chemistry-I	[4+0+1]	4	40	60
CSC-101T	Computer Science-I	[4+0+1]	4	40	60
GEC-101	Communication Skills	[2+0+1]	2	20	30
Laboratory (Experiments)					
PHY-101L	Physics-I Laboratory	[4+0+0]	2	20	30
CHM-101L	Chemistry-I Laboratory	[4+0+0]	2	20	30
CSC-101L	Computer Science-I Laboratory	**[4+0+0]**	**2**	20	30
	Semester Credits/Marks	**[29+2+5]**	**28**	**280**	**420**
				700	
	Subtotal		**28 of 242**	**700 of 6050**	

Semester-II

Subject Code	Subject	Contact Hours per Week (Theory+Tutorials+Presentations)	Credits	Marks	
				CIA	ESE
MTH-201A	Mathematics-IIA	[3+2+1]	4	40	60
PHY-201T	Physics-II	[4+0+1]	4	40	60
CHM-201T	Chemistry-II	[4+0+1]	4	40	60
MTH-201B	Mathematics-II B	[3+2+1]	4	40	60
GEC-201	Environmental Science	[2+0+1]	2	20	30
Laboratory (Experiments)					
PHY-201L	Physics-II Laboratory	[4+0+0]	2	20	30
CHM-201L	Chemistry-II Laboratory	[4+0+0]	2	20	30
	Semester Credits/Marks	**[24+4+5]**	**22**	**220**	**330**
				550	
	Subtotal		**50 of 242**	**1250 of 6050**	

Semester-III

Subject Code	Subject	Contact Hours per Week (Theory+Tutorials+Presentations)	Credits	Marks	
				CIA	ESE
MTH-301	Plane and Solid Geometry	[3+2+1]	4	40	60
MTH-302	Analysis-I	[3+2+1]	4	40	60
MTH-303	Algebra-I	[3+2+1]	4	40	60
MTH-304	Mathematical statistics-I	[3+2+1]	4	40	60
MTH-305	Methods of Applied Mathematics	[3+2+1]	4	40	60
CSC-301T	Computer Science-II	[3+2+1]	4	40	60
CSC-301L	Computer Science-II lab	[4+0+0]	2	20	30
	Semester Credits/Marks	**[22+12+6]**	**26**	**260**	**390**
				650	
	Subtotal		76 of 242	**1900 of 6050**	

Semester-IV

Subject Code	Subject	Contact Hours per Week (Theory+Tutorials+Presentations)	Credits	Marks	
				CIA	ESE
MTH-401	Analysis-II	[3+2+1]	4	40	60
MTH-402	Algebra-II	[3+2+1]	4	40	60
MTH-403T	Computational Mathematics	[3+2+1]	2	20	30
MTH-404T	Ordinary and Partial Differential Equations	[3+2+1]	4	40	60
MTH-405	Mathematical Statistics-II	[3+2+1]	4	40	60
GEC-401	History of Mathematics	[2+0+1]	2	20	30
Laboratory					
MTH-403L	Computational Mathematics Lab	[4+0+0]	2	20	30
	Semester Credits/Marks	**[25+10+6]**	**22**	**280**	**360**
				550	
	Subtotal		**98 of 242**	**2450 of 6050**	

Semester-V

Subject Code	Subject	Contact Hours per Week (Theory+Tutorials+Presentations)	Credits	Marks	
				CIA	ESE
MTH-501	Analysis-III	[3+2+1]	4	40	60
MTH-502	Algebra-III	[3+2+1]	4	40	60
MTH-503	Numerical Analysis	[3+2+1]	3	30	45
MTH-504	Operations Research I	[3+2+1]	4	40	60
MTH-505	Topology-I	[3+2+1]	4	40	60
MTH-506	Discrete Mathematics	[3+2+1]	4	40	60
		LABORATORY			
MTH-503L	Numerical Analysis Lab	[4+0+0]	1	10	15
	Semester Credits/Marks	**[22+12+6]**	**24**	**240**	**360**
				600	
	Subtotal		**122 of 242**	**3050 of 6050**	

Semester-VI

Subject Code	Subject	Contact Hours per Week (Theory+Tutorials+Presentations)	Credits	Marks	
				CIA/Viva	ESE/Dissertation
MTH-601	Analysis-IV	[3+2+1]	4	40	60
MTH-602	Algebra-IV	[3+2+1]	4	40	60
MTH-603	Functional Analysis-I	[3+2+1]	4	40	60
MTH-604	Differential Geometry	[3+2+1]	4	40	60
MTH-605	Elementary Number Theory	[3+2+1]	4	40	60
MTH-606	Minor Project	[3+0+2]	4	30	70
	Semester Credits/Marks	**[18+10+7]**	**24**	**230**	**370**
				600	
	Subtotal		**146 of 242**	**3650 of 6050**	

Semester-VII

Subject Code	Subject	Contact Hours per Week (Theory+Tutorials+Presentations)	Credits	Marks	
				CIA	ESE
MTH-701	Analysis –V	[3+2+1]	4	40	60
MTH-702	Algebra –V	[3+2+1]	4	40	60
MTH-703.	Advanced Complex Analysis	[3+2+1]	4	40	60
MTH-704	Advanced Number Theory	[3+2+1]	4	40	60
SEC-701 SEC-705	Subject Elective	[3+2+1]	4	40	60
OEC-701	Open Elective	[4+0+0]	4	40	60
	Semester Credits	**[19+10+5]**	**24**	**240**	**360**
				600	
	Subtotal		**170 of 242**	**4250 of 6050**	

Course Code	Choices for Subject Elective & Open Elective
SEC-701	Theory of Semi-Groups
SEC-702	Lattices and ordered Algebras
SEC-703	Calculus of Variations and integral equations
SEC-704	Complex Dynamics
SEC-705	Operation Research –II
OEC-701	Any one out of the Pool of open electives for Master Programs

Semester-VIII

Subject Code	Subject	Contact Hours per Week (Theory+Tutorials+Presentations)	Credits	Marks	
				CIA	ESE
MTH-801	Topology- II	[3+2+1]	4	40	60
MTH-802	Commutative Algebra	[3+2+1]	4	40	60
MTH-803	Statistical Inference	[3+2+1]	4	40	60
MTH-804	Fourier Analysis	[3+2+1]	4	40	60
SEC-801 to 805	Subject Elective	[3+2+1]	4	40	60
OEC-801	Open Elective	[4+0+0]	4	40	60
	Semester Credits/Marks	**[19+10+5]**	**24**	**240**	**360**
				600	
	Subtotal		**194 of 242**	**4850 of 6050**	

Course Code	Choices for Subject Elective & Open Elective
SEC-801	Topics in Ring Theory
SEC-802	Category Theory
SEC-803	Advanced Numerical Methods
SEC-804	Fluid Dynamics
SEC-805	Computational Mathematics-II
OEC-801	Any one from the Pool of Open Electives of the University

Semester-IX

Subject Code	Subject	Contact Hours per Week (Theory+Tutorials+Presentations)	Credits	Marks	
				CIA	ESE
MTH-901	Advanced Functional Analysis	[3+2+1]	4	40	60
MTH-902	Partial Differential Equations	[3+2+1]	4	40	60
MTH-903	Representation Theory of Finite Groups	[3+2+1]	4	40	60
SEC	Elective I	[3+2+1]	4	40	60
SEC	Elective-II	[3+2+1]	4	40	60
SEC	Elective-III	[3+2+1]	4	40	60
	Semester Credits/Marks	**[18+12+6]**	**24**	**240**	**360**
				600	
	Subtotal		**218 of 242**	**5450 of 6050**	

Semester-X

Subject Code	Subject	Contact Hours per Week (Theory+Tutorials+Presentation) (Disscussion+Presentations)	Credits	Marks	
				CIA/Viva	ESE/Dissertation
SEC	Elective-I	[3+2]	**4**	40	60
SEC	Elective-II	[3+2]	**4**	40	60
SEC	Project work	[12+8]	**16**	100	300
	Semester Credits		**24**	**180**	**420**
				600	
	Subtotal		**242 of 242**	**6050 of 6050**	

S. No.	Subject Electives for Semester IX and X
SEC-901	Stochastic Analysis
SEC-902	Topics in Graph Theory
SEC-903	Probability Measure
SEC-904	Algebraic Topology
SEC-905	Wavelet Analysis
SEC-906	Universal Algebra
SEC-1001	Advanced Commutative Algebra
SEC-1002	Advanced topics in Theory of Analytic Polynomials
SEC-1003	Advanced Semi Group Theory
SEC-1004	Banach Algebras
SEC-1005	Differential Topology
SEC-1006	Coding Theory

Total Credits = 240, Total Marks = 6000

S. NO	Symbol	Meaning	S. No	Symbol	Meaning
1	MTH	Mathematics	6	GEC	General Elective Course
2	PHY	Physics	7	SEC	Subject Elective Course
3	CHM	Chemistry	8	OEC	Open Elective Course
4	CSC	Computer Science	9	T	Theory
5	STS	Statistics	10	L	Laboratory

Semester - I

MTH-101A: Mathematics – IA

Unit I

Limit of a function, basic properties of limits, continuous functions and attainment of bounds of continuous functions on close interval. Differentiable function, higher order derivatives and Leibnitz rule, Rolle's Theorem, Langrage's Mean Value Theorem, Cauchy's Mean Value Theorem and their applications.

Unit II

Taylor's Theorem, Maclurin's Theorem with applications, Indeterminate forms and L-hospital's rule, Intermediate Value Property for continuous functions. Darboux Intermediate Theorem for derivatives, tangents and normals in polar coordinates, Pedal Equations and length of arcs.

Unit III

Partial differentiation of functions of two and three variables, Euler's theorem on homogeneous functions, Curvature, Asymptotes, Envelopes, Involute, Evolutes, Double points and Tracing of curves.

Unit IV

Review of complex numbers, Triangle inequality, De Moivre's theorem for rational index and its applications, nth root of unity. Functions of complex variable, Exponential function, Circular functions, Hyperbolic functions, Logarithm functions of complex variables, Summation of trigonometric series, Difference method and C+iS Method.

Text books: -

1. Thom's calculus, Maurice D. Weir, Joel Hass, Pearson.
2. Complex Trigonometry by M.R. Puri, Kapoor Publications.
3. Differential Calculus by M. L. Kochar and S. D. Chopra, Kapoor Publications.

References:

4. Calculus I, T.M. Apostal, Wiley.
5. Calculus II, T.M. Apostal, Wiley
6. Complex trigonometry by S.P. GILL.
7. Mathematical Methods for Scientists and Engineers, Donald A McQuarrie

MTH-101B: MATHEMATICS IB

Unit I

Integration of irrational functions, Reduction formulae, Theorems on Definite integrals and their applications, Summation of series with the help of definite integrals.

Unit II

Quadrature, Area of a region bounded by a curve, Sectorial Areas bounded by a closed curve, length of plane curves, Volume and Surface of Revolution, Pappus theorem.

Unit III

Multiple Integrals: Integrals over plane areas in xy-plane, Double integrals, Evaluation, change of order of integration for two variables, Double integral in Polar co-ordinates, Integrals over regions in xyz-space, Triple integrals, Evaluation, Triple Integrals in cylindrical and spherical Polar co-ordinates, Change of variables, Beta and Gamma functions and their properties, Relation between Beta and Gamma functions.

Unit IV

Differential equations: Linear differential equations, Bernoulli's differential equations, Exact differential equations, Symbolic Operators, linear differential equations with constant coefficients. Homogeneous linear equations.

Text Books: -

1. Thom's calculus, Maurice D. Weir, Joel Hass, Pearson.
2. Ordinary and partial Differential equations , H T H Piaggo, Narosa.
3. Integral calculus by Kochhar Chopra, Kapoor Publications.
4. Mathematical Methods for Scientists and Engineers, Donald A McQuarrie.

PHY-101T: PHYSICS-I

Unit I

Review of basic vector algebra, scalar and vector product and related vector identities. Differentiation of vectors, time-derivative, velocity and acceleration, Vector differential operators (del-operator and Laplacian operator), Scalar field, Gradient of scalar field with geometrical interpretation, Vector field, Divergence and curl of vector field, their physical interpretation, Conservative fields. Line, surface and Volume integral of vector fields.

Unit II

Fundamentals of Dynamics: Reference frames. Inertial frames, Review of Newton's Laws of Motion. Dynamics of a system of particles. Centre of Mass. Principle of conservation of momentum. Impulse.

Work and Energy: Work and Kinetic Energy Theorem. Conservative and non- conservative forces. Potential Energy. Energy diagram. Stable and unstable equilibrium. Elastic potential energy. Force as gradient of potential energy. Work & Potential energy. Work done by non-conservative forces. Law of conservation of Energy.

Unit III

Rotational Dynamics: Angular Momentum of a particle and system of particles. Torque. Principle of conservation of angular momentum. Rotation about a fixed axis. Moment of Inertia. Calculation of moment of inertia for rectangular, cylindrical and spherical bodies. Kinetic energy of rotation. Motion involving both translation and rotation.

Elasticity: Relation between Elastic constants. Twisting torque on a Cylinder or Wire.

Unit-IV

Gravitation and Central Force Motion: Law of gravitation. Gravitational potential energy. Inertial and gravitational mass. Potential and field due to spherical shell and solid sphere. Motion of a particle under a central force field. Two-body problem and its reduction to one-body problem and its solution. The energy equation and energy diagram. Kepler's Laws. Satellite in circular orbit applications. **Collisions:** Elastic and inelastic collisions between particles.

Text Books:

1. *An introduction to mechanics*, D. Kleppner, R.J. Kolenkow, McGraw-Hill.
2. *Mechanics, Berkeley Physics, vol.1*, C.Kittel, W.Knight, et.al. Tata McGraw-Hill.

References:

1. *Mechanics*, D.S. Mathur, S. Chand and Company Limited, 2000
2. *University Physics*. F.W Sears, M.W Zemansky, H.D Young , 1986, Addison Wesley
3. *Physics*, Resnik,Halliday and Walker, Wiley.
4. *Analytical Mechanics*, G.R.Fowle and G.L. Cassiday. 2005, Cengage Learning.
5. *Feynman Lectures*, Vol. I, R. P. Feynman, R. B. Leighton, M. Sands, Pearson Education
6. *University Physics*, Ronald Lane Reese, 2003, Thomson Brooks/Cole.

CHM-101T: Chemistry-I

Unit 1: States of Matter

Solids: Introduction, Types of crystal systems in 3D, Crystal planes, Weiss and Miller indices, crystallographic laws, structures of some solids (Rock salt, Zinc Blend and Fluorite), Defects and dislocation (line and screw) in solids, properties of solids. Metallic bonding.
Liquids: Introduction, Properties of liquids: Surface tension, Viscosity, Evaporation; Vapour pressure of liquid and factors affecting vapour pressure.
Gases: Introduction, Kinetic theory of gasses, Ideal gas equation & its derivation, Real gasses, Deviation of gasses from ideal behaviour (effect of Temperature and Pressure), Compressibility factor.

Unit 2: Atomic structure, periodic properties and Chemical bonding

Introduction, Somerfield's and Wave mechanical model of atom, Quantum numbers, Wave Function-Radial and Angular wave functions, Shape of orbitals, Electronic configuration-principles involved, Stability of half-filled and completely filled subshells.
Periodic properties: Periodic and non-periodic properties, Trends in periodic properties: Atomic and Ionic radii, Ionization enthalpy, Electron gain enthalpy, Electronegativity-Factors affecting in each case, Scales of measuring Electronegativity.
Types of Bonds, VBT-Hybridization involving s, p and d orbitals, Resonance, VSEPR theory for shapes of molecules, Fajan's rules-polarization effect,

Unit 3: Basic principles of Organic Chemistry

Introduction, Electron displacements in covalent bonds-Factors affecting, Reaction intermediates: Carbocation, Carbanion, Free radicals, Carbenes, Nitrenes, Benzynes; Types of organic reactions; Purification of Organic compounds.
Benzene: Preparation and properties, Evidence in favour of Ring structure, Mechanism of electrophilic substitution reactions, Aromaticity, Anti and non-aromatic systems.SN^1 and SN^2 reactions in Haloalkanes, Acidity of Alcohols and Phenols.

Unit 4: Analytical Chemistry

Significant Figures; Precision, Accuracy and errors; Standard and Mean deviation, Analysis-Principles of Gravimetric and Volumetric analysis; Basic requirements of a titration reaction, Standard solutions-Primary and Secondary standard, Types of Titrations, Indicators, Dosometry.

Text Books:

1. *Principles of Physical Chemistry*, Puri, Sharma and Pathania, Vishal Publishing Co
2. *Principles of Inorganic Chemistry*, Puri, Sharma and Kalia, Milestone publishers& distributors.
3. *Concise Inorganic Chemistry* J. D Lee, 4^{th} edition, ELBS, 1991.
4. *Organic Chemistry*, R. T Morrison and R. N Boyd, Prentice Hall of India.

CSC-101T: Computer Science I

Unit-I

Computer Fundamentals: Notion and definition of computer, Basic architecture and working of a computer, characteristics & classification of computers, concept of hardware& software, types of software, Fundamentals of digital logic and Boolean algebra.

UNIT II

Data Representation: Representation of characters, Integers, fractions. Hexadecimal representation of numbers, decimal –to- binary conversion. Binary Arithmetic, Binary addition, subtraction, two's complement, representation of numbers, addition/ subtraction of numbers in two's complement, binary multiplication and division.

Unit-III

Introduction to DOS, concepts of drives, directories and files, basic DOS commands, Microsoft Windows- An overview, Basic Windows elements, basics of MS-Word, MS-Excel, MS-Access and MS- PowerPoint.

UNIT IV

Linux- An overview of Linux, Basic Linux elements: System Features, Software Features, File Structure, File handling in Linux: H/W, S/W requirements, Preliminary steps before installation, specifics on Hard drive repartitioning and booting a Linux system. Basic shell commands

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Text Books:

1. *Fundamentals of Computers*, V. Rajaraman, Prentice-Hall, 2006 edition.
2. *Introduction to computers*, Peter Norton, Tata McGraw Hill, Sixth Edition.
3. *Boolean Algebra and Switching Circuits*, Elliot Mendelson: *Schaum's Outline Series.*
4. How Linux Works, *Brain Ward: No Starch Press.*
5. Exploring Computer Fundamentals MS Office, *Anupam Jain,* Vitasta Publishing PVT. LTD.
6. Microsoft Office 2010, Law Point Publications.

GEC-101: Communication skills

Unit-I

Human Communication (Theoretical perspective): Its uniqueness, its nature, models of communication. Language, non-verbal communication, logic and reasoning, lateral thinking. Self communication, interpersonal communication, dyadic communication. Small group communication. Public communication. Mass Communication. Reliability of communication.

Unit-II

Input and Evaluation Processes (Practice): Listening (process, comprehension, evaluation). Reading (process, comprehension, evaluation). Watching (process, comprehension, evaluation).

Unit-III Output and Interaction Processes (Practice): Speech (conversation, interview, group discussion, public speech). Writing (spontaneous writing, guided writing, and creative writing). Organizing ideas (noting, summary, flow charts, and concept maps). Correspondence (personal, business).

Unit-IV

Science / Scientific Writing (Theory and practice): Goals and Objectives. Ethics in writing. Structure of documents. Language and grammar. Illustrations and aids. Writing proposals and instructions. Making presentations. Formatting documents. Drafts and revisions. Editing. Writing popular science / journal article.

Text Books:

1. *Communicating a social and career focus*, K. M. Berko, Andrew D. Welwyn and Darlyn R. Welwyn, Houghton Mifflin Co., Boston, 1977.

2. *The Craft of Scientific Writing* (3rd Edition), Michael Alley, Springer, New York, 1996.

3. *Science and Technical Writing* – A Manual of Style (2nd Edition), Philip Reubens (General Editor), Rutledge, New York, 2001.

4. *Writing Remedies* – Practical Exercises for Technical Writing Edmond H. Weiss, Universities Press (India) Ltd., Hyderabad, 2000.

CSC-101L: Computer science-I Lab

(Experiments in the lab are based on the contents of CSC-101T)

PHY-101L: Physics-I Laboratory

List of experiments* (At least five to be performed in one semester)*:

- Measurements of length (or diameter) using vernier caliper, screw gauge and travelling microscope.
- To determine the Height of a Building using a Sextant.
- To determine the Moment of Inertia of a Flywheel.
- To determine the Young's Modulus of a Wire by Optical Lever Method.
- To determine the Modulus of Rigidity of a Wire by Maxwell's needle.
- To determine the Elastic Constants of a Wire by Searle's method.
- To determine g by Bar Pendulum.
- To determine g by Katter's Pendulum.
- To determine g and velocity for a freely falling body using Digital Timing
- Technique
- To study the Motion of a Spring and calculate (a) Spring Constant (b) Value of g

Reference Books (for practicals):

- Advanced Practical Physics for students, B. L. Flint and H. T. Worsnop, 1971, Asia Publishing House.
- Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4 th Edition, 1985, Heinemann Educational Publishers.
- Engineering Practical Physics, S.Panigrahi & B.Mallick,2015, Cengage Learning India Pvt. Ltd.
- A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11 th Edition, 2011, Kitab Mahal, New Delhi.

CHM-101L: Chemistry I Laboratory

Experiments:

1. Determination of λ_{max} for methyl orange and methylene blue using spectrophotometer.
2. Determination of hardness of water by EDTA titration.
3. Preparation of Sodium trioxalatoferrate(III)
4. Separation and identification of various amino acids by paper chromatography.
5. Identification organic functional groups (Aldehydic, Ketonic and Carboxylic acid functional groups)

Semester-II

MTH-201A: Mathematics – IIA

UNIT I

General Properties of Equations, Synthetic Division, Relation between the roots and the coefficients of an equation, Transformation of equation, Diminishing the roots of an equation by a given number, Removal of terms of an equation, Formation of equation whose roots are functions of the roots of a given equation, Equation of square differences

UNIT II

Symmetric functions, Newtons Method of finding the sum of powers of the roots of the equation, Cardan's Method for finding the roots of the cubic equation, Nature of roots of a cubic equation, Descart's Method for finding the roots of Biquadratic equation, Descart's rule of signs, Rational roots and integral roots of a polynomial, Location of roots of an equation (simple cases)

UNIT III

Review of 3-dimentional coordinate systems, vectors and their properties, lines and planes, cylinders and quadric surfaces. Curves in space and their tangents, integrals of vector functions, projectile motion, arc length in space curvature and normal vectors of a curve, tangential and normal components of acceleration, velocity and acceleration in polar coordinates.

UNIT IV

Line integrals: Vector fields and line integrals. Work, Circulation and Flux, Path independence, Conservative fields and Potential functions, Greens Theorem in the plane, Surfaces and areas, Surface integrals, Stoke's Theorem, Gauss Divergence Theorem.

TEXTBOOKS: -

1. Thom's calculus, Maurice D. weir, Joel Hass, Pearson.
2. Theory of equation, W.S. Burnside and A.W. Panton
3. Mathematical Methods for Scientists and Engineers, Donald A McQuarrie.

MTH- 201B: MATHEMATICS-IIB

Unit I

Composition and resolution of forces acting at a point. Resultant forces, Parallelogram law of forces, Resolved parts of forces, $\lambda - \mu$ Theorem and its applications. Triangle law of forces, Lami's Theorem and its converse parts with generalization, Equilibrium of forces.

Unit II

Parallel forces, Resultant of two parallel forces acting in a rigid body and its generalization. Moment of a force about a point, Coplanar forces acting on a rigid body, Moment of a force about a line, Varignor's Theorem, Couple, Moment of a couple, Equivalent couples, Composition of couple's, Resultant of a single force and a couple.

Unit III

Motion of a particle, Velocity and Acceleration of a moving particle, Rectangular motion under uniform acceleration, Recti-linear motion, Relation between u, v, f, s and t Vertical motion under gravity. Newtons law of motion, Matter Mass momentum, the relation p = mf Simple applications. Motion of a mas on a horizontal table and other hanging bodies.

Unit IV

Simple Harmonic motion, Projectiles, Velocity and Acceleration of a particle moving in a curved path. Motion of particle, Path, Time of flight range etc. Velocity at any point, Direction to hit a given point.

TEXTBOOKS: -

1. Statics by G. N. Hafiz and K.L. Gupta, Sultan Chand.
2 Elements of Dynamics K.L Gupta and K.C Pant, S Chand and Sons.
3. Dynamics S.R. Gupta, S Chand and Sons.
4 Engineering Mechanics, Statics and Dynamics, Russell C. Hobbler.
5.Statics and Dynamics, David M.C. Mahon, Publisher, McGraw-Hill Education.

PHY-201T PHYSICS-II

Unit I

Electric Field and Electric Potential:

Electric field: Electric field lines. Electric flux. Gauss' Law with applications to charge distributions with spherical, cylindrical and planar symmetry. Conservative nature of Electrostatic Field. Electrostatic Potential. Laplace's and Poisson equations. The Uniqueness Theorem. Potential and Electric Field of a dipole. Force and Torque on a dipole. 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.

Unit II

Dielectric Properties of Matter: Electric Field in matter. Polarization, Polarization Charges. Electrical Susceptibility and Dielectric Constant. Capacitor (parallel plate, spherical, cylindrical) filled with dielectric. Displacement vector **D**. Relations between **E**, **P** and **D**. Gauss' Law in dielectrics.

Magnetic Field: Magnetic force between current elements and definition of Magnetic Field **B**. Biot-Savart's Law and its simple applications: straight wire and circular loop. Current Loop as a Magnetic Dipole and its Dipole Moment (Analogy with Electric Dipole). Ampere's Circuital Law and its application to (i) Solenoid and (ii) Toroid. Properties of **B**: curl and divergence.

Vector Potential. Magnetic Force on (i) point charge (ii) current carrying wire (iii) between current elements. Torque on a current loop in a uniform Magnetic Field.

Unit III

Magnetic Properties of Matter: Magnetization vector (**M).** Magnetic Intensity (**H).** Magnetic Susceptibility and permeability. Relation between **B, H** and **M**. Ferromagnetism. B-H curve and hysteresis.

Electromagnetic Induction: Faraday's Law. Lenz's Law. Self Inductance and Mutual Inductance. Reciprocity Theorem. Energy stored in a Magnetic Field. Introduction to Maxwell's Equations. Charge Conservation and Displacement current.

Unit IV

Electric Circuits: AC Circuits: Kirchhoff's laws for AC circuits. Complex Reactance and Impedance. Series LCR Circuit: (i) Resonance, (ii) Power Dissipation and (iii) Quality Factor, and (iv) Band Width. Parallel LCR Circuit.

Network theorem: Ideal Constant-voltage and Constant-current Sources. Network Theorems: Thevenin theorem, Norton theorem, Superposition theorem, Reciprocity theorem, Maximum Power Transfer theorem. Applications to dc circuits.

Text Books:

1. *Electricity, Magnetism & Electromagnetic Theory*, S. Mahajan and Choudhury 2012, Tata McGraw.
2. *Electricity and Magnetism*, Edward M. Purcell, 1986, McGraw-Hill Education.

References:

1. *Introduction to Electrodynamics*, D. J. Griffiths, 3rd Edn. 1998, Benjamin Cummings.
2. *Feynman Lectures Vol. 2*, R. P. Feynman, R. B. Leighton, M. Sands, 2008, Pearson Education.
3. *Elements of Electromagnetism*, M. N. O. Sadiku, 2010, Oxford University Press.
4. *Electricity and Magnetism*, J. H. Fewkes & J. Yarwood. Vol. I, 1991, Oxford Univ. Press.

CHM-202T Chemistry-II

Unit 1: Chemical Thermodynamics and Electrochemistry

Introduction, Laws of thermodynamics, State functions-Exact and Inexact Differentials, Joule-Thomson effect, Joule-Thomson coefficient for Ideal and Real gasses, Enthalpy variation with Temperature-Kirchhoff's Laws, Hess's Law and its applications.

Concept of Free energy, Gibb's Helmholtz equation, Partial Molar quantities-Chemical potential, Gibb's Duhem equation, Clausius Clapeyron equation and its applications.

Electrolytic Conduction-Electrodes and electrolytes, Kholrausch's law and its applications, Transport Number and its determination, Galvanic Cells-Nernst equation, Electrolytic Cells.

Unit 2: Symmetry and Group Theory

Introduction, Symmetry elements and Symmetry operations, Molecular Point groups and their representations (Reducible and Irreducible), Great Orthogonality Theorem (GOT) and its use to construct Character tables for some simple molecules (H_2O and NH_3).

Unit 3: Carbonyls and Diazonium Salts

Introduction, Preparation and properties of Aldehydes and Ketones, Mechanism of chemical reactions: Aldol condensation, Cannizero reaction, Perkins & Benzoic condensation, Meerwein-ponndrof Verley reduction, Reaction of carbonyls with Tollen's reagent, Felling solution, Benedicts solution-Popoff's rule.Acidity of carboxylic acids and its comparison with alcohols.

Amines, Basicity of amines, Hinsberg's Test for distinguishing 1°, 2° and 3° amines.

Diazonium Salts, Mechanism of Diazotization, Physical and Chemical properties, Synthetic application of Diazonium salts.

Unit 4: Spectroscopic Techniques

Introduction, General Principles of UV-Visible, FTIR and X-ray Diffraction, Wood-word Fieser Rules, Bear-lambert law, FTIR for the identification & assignment of functional groups, Bragg's Law of diffraction, Electron and Neutron diffraction (Qualitative Idea only).

Text Books:

1. *Principles of Physical Chemistry,* Puri, Sharma and Pathania, 46th edition.
2. *Principles of Inorganic Chemistry,* Puri, Sharma and Kalia, year-2012-13.

References:

1. *Symmetry and Group theory*, Veera Reddy
2. *Organic Chemistry,* R. T Morroson and R. N Boyd, Prentice Hall of India.
3. *Text book of Organic Chemistry,* Peter Sykes
4. *Spectroscopic methods,* C N Benwell

GEC-201: Environmental Science

Unit I

Definition of Environment and Environmental Science, its scope and importance Concept of components of environment. Ecological Balance in Nature. Origin of the earth; Evolution of life. Biosphere: a brief account.

Unit-II

Ecosystem: Definition and types of ecosystems. Structure and Function. Food chains, Food webs and Ecological pyramids. Energy flow in an Ecosystem. Abiotic and biotic components of an aquatic and terrestrial ecosystem. Primary and secondary productivity: a brief account. Biotic interaction in ecosystem. Ecological Succession.

Unit III

Biodiversity basic concept. India as mega biodiversity nation. Values of biodiversity. Threats to biodiversity. Hot spots of biodiversity. Conservation of biodiversity- in-situ and ex-situ. Concept of extinction threshold and extinction debt.

Unit-IV

Environmental Pollution. Definition, Causes, consequences and control of. Air pollution. Water pollution. Soil pollution. Noise pollution. Solid waste management. Wasteland reclamation. Sustainable development and causes of unsustainability. Environmental ethics. Global Warming, Climate Change, Acid rain and Ozone layer Depletion.

Text Books:

1. *Text Book of Environmental Studies*, Bharucha, Erach, Universities Press (India), Hyderabad, 2005.
2. *Environmental Sciences,* Y. K. Singh, New Age International (P) Limited, Publishers, 2006.
3. *Environmental Studies*. Joseph, Benny, McGraw Hill Companies, 2005.

References:

1. *Environmental Engineering*, De, Anil Kumar and De, Arnab Kumar, 2nd edition. New Age International Publishers.
2. *Textbook on Environmental Studies*, Kanagasabai, S, PHI Learning , 2010.
4. *Environmental Studies* Chauhan, B.S. 2008..University Science Press.

PHY-201L: PHYSICS-II Laboratory

List of experiments **(At least five to be performed in one semester):**

1. To use a Multimeter for measuring (a) Resistances, (b) AC and DC Voltages, (c)DC Current, and (d) checking electrical fuses.
2. Ballistic Galvanometer:
   (i) Measurement of charge and current sensitivity
   (ii) Measurement of CDR
   (iii) Determine a high resistance by Leakage Method
   (iv) To determine Self Inductance of a Coil by Rayleigh's Method.
3. To compare capacitances using De'Sauty's bridge.
4. Measurement of field strength B and its variation in a Solenoid (Determined B/dx).
5. To study the Characteristics of a Series RC Circuit.
6. To study a series LCR circuit and determine its (a) Resonant Frequency, (b) Quality Factor
7. To study a parallel LCR circuit and determine its (a) Anti-resonant frequency and (b) Quality factor Q
8. To determine a Low Resistance by Carey Foster's Bridge.
9. To verify the Thevenin and Norton theorems.
10. To verify the Superposition, and Maximum Power Transfer Theorem.

Reference Books (for Practical):

- Advanced Practical Physics for students, B. L. Flint & H. T. Worsnop, 1971, Asia Publishing House.
- A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition, 2011, Kitab Mahal, New Delhi.
- Engineering Practical Physics, S. Panigrahi & B. Mallick,2015, Cengage Learning India Pvt. Ltd.
- Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, Heinemann Educational Publishers
- Laboratory Manual of Physics for undergraduate classes, D. P. Khandelwal, 1985, Vani Pub.

CHM-202L Chemistry II Laboratory

Experiments:

1. Determination of Viscosity of Sucrose solution by Ostwald's Viscometer.

2. Conductometric Titration of NaOH solution against standard HCl.

3. Semimicro technique for the identification of metal ions (Ag, Fe, As, Pb).

4. Preparation of Nickel DMG complex.

5. Synthesis of Asprin.

Semester-III

MTH-301: Plane and Solid Geometry

Unit-I

Parabola: Equation of parabola, equation of tangents and normals, Pole and Polar, equation of chord in terms of middle point, parametric equation of parabola.

Ellipse: Equation of Ellipse, equations of tangents and normals, Pole and polar, parametric equation of ellipse, diameter and conjugate diameter.

Unit-II

Hyperbola: Equation of hyperbola, equations of tangents and normals, equation of hyperbola referred to asymptotes as axes, rectangular and conjugate diameter, general second-degree equation in x and y, tracing of conics

Unit-III

Plane: Equation of plane, Bisectors of angle between two planes, joint equation of planes, volume of tetrahedron.

Sphere: Equation of sphere, Condition for two spheres to be orthogonal.

Cone: Definition of cone, Equation of cone, Condition for general second-degree equation represents a cone, Necessary and sufficient conditions for a cone to have three mutual perpendicular generators.

Unit-IV

Cylinder: Equation of cylinder, Enveloping cylinder of a sphere.

Central Conicoids. Tangent lines and tangent planes, Normal to conicoid at a point on it, Normal from a point to conicoid, Shapes and features of the three central coincides.

Text Books:

1. *Coordinate Geometry of Conics*, M. R. Puri. Kapoor publications
2. *Solid Geometry*, M R Puri. Kapoor publications
3. *Coordinate Geometry*, Ram Ballabh, Malhotra Publications.

References:

4. *Coordinate Geometry of two and three-dimension*, P Balasubramanian, G.R Venkataraman.
5. *Analytical Solid Geometry*, Shanti Narayan. S Chand and Sons.

MTH-302: Analysis-I

Unit-I:

Sets and Functions, Countable and uncountable sets with examples. Real numbers, Q is countable and R is uncountable, Least upper bound and greatest lower bound, Dedekind's cut of reals. Incompleteness of Q and completeness of R, Nested Interval Theorem, Bolzano Weirestrass's Theorem. Sequences Bounded and monotone sequences, The limit superior and limit inferior of a sequence, Cauchy sequence, The necessary and Sufficient condition for a sequence to be convergent.

Unit-II

Series: Convergence and Divergence of series, Tests for convergences: Comparison test, p-test Cauchy's root test, Ratio test, Raabe's test, Integral tests, logarithm test, Gauss test. Absolute convergence and conditional convergence, Leibnitz test. Uniform continuity: Uniform continuity of continuous function on closed interval.

Unit-III

Riemann Integration: Definition and existence of Riemann integral, Necessary and Sufficient conditions for existence of Riemann integral, Algebra of Riemann integrable functions, integrability of |f|. Fundamental Theorem of integral calculus and Mean Value Theorem for integrals.

Unit-IV

Improper integral: Integration of unbounded function with finite limit of integration, comparison tests for convergence of improper integrals, Cauchy's test for convergence, infinite range of integration of bounded functions, convergence of integrals of unbounded functions with infinite limits of integration, Abel's and Dritchelet's tests of convergence.

Text Books:

1. *Mathematical Analysis,* S. C. Malik and Savita Arora, New Age International.

References:

1. *Mathematical Analysis,* Bernd S. W. Schroder, Wiley.

2. *Mathematical Analysis,* Tom M. Apostol; Narosa.

3. *Methods of Real Analysis*, R Goldberg, Oxford and IBH Publications.

MTH-303: Algebra-I

Unit-I

Recollection of equivalence relations and equivalence classes, congruence class of integers modulo n, Definition of binary operation and examples. Definition of group, examples including matrices, permutation groups, groups of symmetry, roots of unity. First properties of a group, laws of exponents, finite and infinite groups.

Unit-II

Subgroups and cosets, order of an element, Lagrange's theorem. Normal subgroups, quotient groups. homomorphisms, kernel and image, isomorphism, homomorphism theorems. Cyclic groups, Subgroups and quotients of cyclic groups. Finite and infinite cyclic groups.

Unit-III

Definition of ring, examples including congruence classes mod n, integral domains division rings and fields with examples subrings and ideals prime and maximal ideals of a ring. Principal ideals, Algebra of ideals. Nilpotent and nil ideals, fields of quotients and Embedding Theorem.

Unit-IV

Ring of polynomial F[x] over a field F, F[x] is an integral domain. The division algorithm in F[x]. Factorization in integral domains. Divisibility, associates, prime and irreducible elements in a commutative ring. Principal ideal domains with related results.

Texts Books:

1. *Topics in Algebra,* I.N. Herstien, John Wiley.
2. *Basic Abstract Algebra,* P B Bhattacharya, S K Jain, S R Nagpaul: Cambridge.

References:

1. *Algebra,* M. Artin, Prentice Hall of India.
2. *Abstract Algebra,* D.S Dumit and R.M. Foote, John Wiley.
3. *Abstract Algebra,* Joseph Gallian Narosa.
4. *Basic Algebra* I, N. Jacboson, Hindustan Publishing Corporation.
5. *University Algebra,* N.S Gopal Krishnan, New Age Internationals.
6. *Modern algebra,* Surjeet Singh and Qazi Zameerudin, New Age Internationals.

MTH-304: MATHEMATICAL STATISTICS-I

UNIT-I

Correlation and Regression. Properties and uses of correlation coefficient. Methods of studying correlation, Scatter diagram. Karl-Pearson's correlation coefficients, Spearman's Rank correlation coefficient and concurrent deviation methods. Regression analysis, Properties and uses of regression analysis. Simple linear regression, Regression equations of X on Y and Y on X, Regression coefficients and properties of regression coefficients. To find the regression coefficients and the correlation coefficients from the two lines of regression.

UNIT-II

Probability, Basic definitions, Addition and multiplication theorems of probability with application. Point function and set function with examples. Properties of the probability set function. Boole's Inequality, conditional Probability Independence, Conditional probability, Bayes theorem with applications. Discrete and Continuous Random variables, Probability density function with applications. Distribution function, Properties of distribution function.

UNIT-III

Transformation of random variables, Mathematical expectation of random variable and some special mathematical expectations. Variance and its properties in terms of expectation. Moment generating function, Mean variance and Mgf of different distributions. Chebyshev's inequality, Markov's inequality.

UNIT-IV

Multivariate distribution: Distribution of two random variables with examples, Expectation, Transformation of random variables, Conditional distribution and expectations, Correlation coefficient, Independence random variables, Necessary and Sufficient condition for two random variables to be independent. If X_I and X_2 be stochastically independent random variables and $U(X_I)$ and $V(X_2)$ be a function of X_1 and X_2 alone then expectation of product is equal to the product of expectation. Some special distributions, Binomial distribution, The Poisson Distribution with applications.

Recommended Books

1. Introduction to mathematical statistics By Hogg McKean and Craig. Pearson Education.
2. Probability and statistics By Murray R Spiegel and John J Schiller, McGraw Hill Education.
3. Probability and statistics By Morris H. and Mark J. Addison-Wesley.
4. Fundamentals of mathematical statistics By S.C. Gupta. Himalaya Publishing House.

MTH-305: Methods of Applied mathematics

Unit I:
Introduction of Graphs, Paths and cycles, Operations on Graphs, Bipartite graphs and Konig's Theorem, Euler graphs and Euler's theorem, Konigsberg bridge problem, Hamiltonian graphs and Dirac's theorem, Degree sequences, Wang-Kleitman Theorem, Havel-Hakimi Theorem, Hakimi's Theorem, Erdos Gallai Theorem, Degree sets.

Unit II
Trees and their properties, Centres in trees, Binary and Spanning trees, Degree sequences in trees, Cayley's Theorem, Fundamental cycles, Generation of trees, Helly property, signed graphs, Balanced signed graphs and their characterizations.

UNIT III

Review of Matrices (Types, Algebra, Inverse of matrix, Representation of square matrix), Reversal law for the inverse of a product of two matrices and its generalization to several matrices, possesses an inverse if and only if it is non-singular. The operations of transposing and inverting are commutative, Trace of matrix, Tr(AB)=Tr(BA), Inverse of partitional matrices and lower triangular matrices, Elementary row and column transformation of a matrix, Finding the inverse and the rank of a matrix by elementary transformation

Unit IV

Reduction of matrix to normal form, Elementary matrices, every non-singular matrix is a product of elementary matrices, Employment of only row (column) transformation, The rank of a product of two matrices. Linear dependence and independence of column (row) vectors. Linear combination. The columns of a matrix A are linearly dependent iff there exist a vector $x \neq 0$ such that AX=0. The columns of a matrix A of order $m \times n$ are linearly dependent iff the rank of A is less than *n*. The matrix A has rank r iff it has r linearly independent columns where as any s columns s > r, are linearly dependent. Analogous results for rows, linear homogeneous and non-homogeneous equations. The equation AX=0 has a non-zero solution iff rank of A is less than *n*, the number of its columns. The number of linearly independent solutions of the equation AX=0 is (n-r) where r is rank of matrices the equation AX=B is consistent iff the two matrices A and [A: B] are of the same rank.

Text: -

1. Graph theory with applications, Narsing Deo, Prentice Hall India limited.
2. Theory of matrices shanti Narayana. S Chand and Sons.
3. M. Spiegel, Matrices (Schaum Series) PHI.
4. Matrix Theory, Robert Piziac, CRC.
5. The Theory of Matrices, F R Gantmacher, University Press.
6. Graphs and Application, John M Aldous, Springer.

CSC-301T: Computer Science –II

Unit-I

Programming Language Classification & Methodology: Introduction to Computer Languages, Generation of Languages, High-level languages, Translators Flow Charts, Introduction to C Programming: computer languages, History of C,. Data types, symbolic constants, operators, priority of operators ,C program Structure, Control Structures in C .

Unit-II

Functions: Program modules, Math library functions, Functions, Function definition, calling functions, random number generation, and recursion. Arrays, multi-dimensional arrays, application, Searching and Sorting Techniques.

UNIT III

Pointers: Declarations, Passing pointers to a function, Operations on pointers, Pointer Arithmetic, Pointers and arrays, Arrays of pointers and function pointers. Dynamic memory allocation function Union and structures in C.

UNIT IV

Data Analysis using SPSS: Data Entry In SPSS; Computing with SPSS; Preparation of Graphs with SPSS; Statistical Package Handling and command description for SPSS- reports; Descriptive Statistics, Compare means, time series analysis , correlation and regression models; correlation coefficients and their significance tests of significance(T, F and Chi square), Analysis of variance .

Text Books:

1. *Fundamentals of Computers*, V. Rajaraman, Prentice-Hall, 2006 edition.
2. *Introduction to computers*, Peter Norton, Tata McGraw Hill, Sixth Edition.
3. *Schaums outline of Theory and Problems of programming with C* : Gottfried
4. *Mastering C* by Venugopal, Prasad – TMH
5. *Programming in ANSI C*, Balaguruswamy

References:

1. *Engineering Problem Solving with ANSI C*, Delores M. Etter, Prentice Hall
2. *C Programming*, Ivor Horton, Wrox Press Limited
3. *The C programming language :* Kerninghan and Ritchie
4. *Statistics for social Sciences*, (with SPSS application), Asthana and Bra Bhushan.
5. *SPSS for Beginners*, Vijay Gupta, Published by VJ Books Inc.

CSC-301 L: Computer Science –II Lab

(Experiments in the lab are based on the contents of CSC-301T)

Semester-IV

MTH-401: Analysis-II

Unit-I

Inequalities: Arithmetic-Geometric mean inequality, Cauchy-Schwarz inequality, Holder's and Minkowski's Inequality, Jensen's inequality with applications and illustrative problems. Concave and Convex functions.

Unit-II

Functions of several variables. Limit, Continuity, Partial derivatives, directional derivative, total derivative, continuity and their relationships, necessary and sufficient condition for differentiability. Matrix of linear functions and Jacobian of differentiable function at a point, chain rule. Mean value Theorem for differentiable functions. Extreme values and Saddle points.

Unit-III

Partial derivatives of higher order, sufficient condition for equality of mixed partials, Taylor's Theorem for function form R^n to R. Implicit and Inverse function Theorem, Lagrange's Multipliers extremum problems for function on R^n.

Unit-IV

Definition and example of metric space, Sequence and Cauchy sequence and notion of completeness, open sets, closed sets, compact sets, connectedness, continuous and uniform continuous function on metric spaces, attainment of supremum and infimum of continuous functions on a compact set.

Text Books:

1. *Principles of Mathematical Analysis*, W. Rudin, Tata McGraw Hill.

2. *Inequalities, An Approach through problems* Venkatachala, Hindustan Book Agency.

References:

1. *Principles of Real Analysis,* C. D. Aliprantis and O. Burkinshow; Academic Press, New York.

2. *Principles of Real Analysis*, H. L. Royden; PHI

3. *Infinite Dimensional Analysis,* C. D. Aliprantis and K C Border, Springer.

4. *Methods of Real Analysis;* R Goldberg; Oxford and IBH Publication.

MTH-402: Algebra-II

Unit-I

Systems, of linear equations: Basic definitions, equivalent systems, elementary operations, systems in triangular and echelon form. Gaussian elimination, echelon matrices, Row canonical form and row equivalence. Homogeneous systems of linear equations, elementary matrices, LU-decomposition.

Unit-II

Vector spaces: Definition and examples, linear combinations, spanning sets and subspaces, linear spans, Row space of a matrix and related results, linear dependence and independence, basis and dimension. Application to matrices: rank of a matrix. Sums and direct sums, coordinates.

Unit-III

Linear mappings (transformations), kernel and image of a linear mapping, rank and nullity of a linear mapping, singular and non-singular linear mappings, isomorphisms, operations with linear mappings. Algebra A (V) of linear mappings and related results.

Unit-IV

Matrix representation of a linear operator change of basis matrices and related results, similarity, matrices and general linear mappings, characteristic and minimal polynomial, Cayley-Hamilton Theorem, eigen values and eigen vectors.

Text Book:

1. *Linear Algebra,* K. Hoffman and R. Kunze, Pearson Education.

References:

1. *Linear Algebra,* Schaum's Outline Series, Tata McGraw-Hill.
2. *Introduction to Linear Algebra,* Gilbert Strang, Wellesley-Cambridge Press.
3. *Elementary Linear Algebra,* Howard Anton, Wiley.
4. *Linear Algebra,* Serge Lang, Springer.

MTH-403T: Computational Mathematics

Unit-I
Review of the basic concepts of a computer, main parts and its working, Computing in mathematics- need, domain and overview of the discipline of computational mathematics, problem solving and notion of algorithms: origin, definition and properties. Python programming for Mathematical computing: Data Types, control structures, Functions, Recursion, writing python functions for solving mathematical problems. Matplotlib for plotting and visualization.

Unit-II
Introduction to Mathematica. Detailed exploration of notions of calculus of one variable and simple multivariable calculus using Mathematics. Basic Linear Algebra using Mathematica.

Unit-III
Introduction to Scipy. Numerical solution of algebraic non-linear equations; iterative methods: Bisection method, Secant method, Newton-Raphson methods from scipy. Fixed point of iterations.

Unit-IV
Introduction to Numpy. Matrix algebra with Numpy. Solution of systems of equations;Guass Elimination. Introduction to Eigenvalue problem in Numpy. Introduction to Sage. Basic Group theory with Sage.

Text Books:

1. *CalcLabs with Mathematica for Single Variable Calculus*, Selwyn Hollis, Fifth Edition.
2. *Principles of Linear Algebra with Mathematica*, Kenneth Shiskowski, Karl Frinkle.
4. *Sage Math for Undergraduates*, Gregory V Bard, The American Mathematical Society,

MTH-403L: Computational Mathematics Lab

Experiments in the lab are based on the contents of MTH-403T: Computational Mathematics.

MTH-404: ORDINARY AND PARTIAL DIFFERENTIAL EQUATIONS

Unit I

First order and higher degree differential equations solvable for x, y, z, p. Clairaut's form, Equations reducible to Clairaut's form. Singular solutions, p-discriminant and c-discriminant, Initial value problems of first order ODE, General theory of Homogeneous and Non-homogeneous linear ODE, Factorization of Operator. Method of variation of parameters.

Unit II

Solution in Series: (i) Roots of an Indicial equation, un-equal and differing by a quantity not an integer. (ii) Roots of an Indicial equation, which are equal. (iii) Roots of an Indicial equation differing by an integer making a coefficient infinite. (iv) Roots of an Indicial equation differing by an integer making a coefficient indeterminate. Simultaneous equation $dx/P = dx/Q = dz/R$ and its solutions by use of multipliers and a second integral found by the help of first. Total differential equations $Pdx + Qdy + Rdz = 0$. Necessary and sufficient condition for integrability of an equation. Geometric interpretation of the $Pdx + Qdy + Rdz = 0$.

Unit III

Partial differential equation of first order, origin of first order partial differential equations, Cauchy's problem for first order PDEs, linear equations of first order, nonlinear PDEs of first order, Langrage's and Charpits methods for solving first order PDEs.

Unit-IV

Classification of second order partial differential equations (PDEs), general solution of higher order PDEs with constant coefficients, method of separation of variables for three basic equations: Laplace, Heat and Wave equations.

Text Books:

1. *Differential Equations,* H.T. H Piaggo,
2. *Theory of Ordinary Differential Equations,* E.A. Coddington and N. Levinson:
3. *Partial differential Equation,* Fritz John, Springer Verlag.
4. *Partial Differential Equation,* Ian Sneddon, McGraw Hill.

References:

1. *Differential Equations,* G.F. Simmons, Tata McGraw Hill.
2. *Ordinary Differential Equations* P. Hartmen.
3. *Ordinary Differential Equations,* D. Somasundaram, Narosa Publishers.
4. *Partial differential Equation,* Fritz John, Springer Verlag.
5. *Partial Differential Equation,* Ian Sneddon, McGraw Hill.

MTH-405: Mathematical Statistics-II

Unit 1

Some Special Distributions: The uniform distribution, Negative Binomial distribution trinomial distribution, Extension of Binomial Distribution and their moments. The Gamma distribution, β- distribution, χ- square distribution. The Normal Distribution, Bivariate Normal Distribution and their moments.

Unit II

The t-distribution, The F-distribution, Moments of F-distribution, students Theorem. Random sample, Expectations of functions, Convergence in probability, Convergence in distribution, Stirling's formula, Moment generating function technique, Central Limit Theorem.

UNIT-III

Sampling and statistics Ordered statistics. Quantiles, Confidence interval for Quantiles, Confidence interval for Median, Confidence interval for mean under Bernoulli and normality, Confidence interval for difference of means. Hypothesis testing. Chi-Square test and the method of Monte Carlo.

Unit IV

Maximum Likelihood Methods: Methods of maximum likelihood estimation with examples, Rao-Cramer's Lower bound and Efficiency with examples, Maximum Likelihood tests and related results. Multiparameter case, Estimation with examples and related results

Recommended Books

1. Introduction to Mathematical Statistics, Hogg McKean and Craig, Pearson Education.
2. Probability and statistics, Murray R Spiegel and John J Schiller, McGraw Hill Education.
3. Probability and statistics, Morris H. and Mark J. Addison-Wesley.

GEC-401: History of Mathematics

Unit-I

Mathematics in ancient times Babylonian and Egyptian contribution. Contribution of Greek Mathematics: Eudoxus, Euclid and Archimedes.

Unit-II

Indian contribution to Mathematics. Contribution of Brahmagupta, Bhaskara and Madhava. Kerela school of Mathematics.

Unit-III

Contribution of Islamic civilization to Mathematics. Works of AL-Khwarizmi, ALkindi,AL-Haytham and Omer Khayyam.

Unit-IV

Medieval European Mathematics to present times: the contribution of Fibonacci and adoption of decimal system contribution of Leibnitz, Newton and Euler.

Text Books:

1. *A History of Mathematics***,** Boyer, C.B.
2. *A History of mathematics: an introduction,* Katz, Victor J, Addision Wesley.
3. *Mathematics in india-500 BC-1800,* Plofker, Kim, Princeton University press.

Semester-V

MTH-501: Analysis III

UNIT-*I*:
Functions of a complex variable, Limits, Continuity, Differentiability, Cauchy-Riemann Equations and their applications, Analytic function, Harmonic function, The functions like $e^z, sin\ z, cos\ z$ and the complex logarithm. Contour integral, Cauchy's theorem, Cauchy-Goursat's theorem, Cauchy's integral formula, Higher order derivatives.

UNIT-II:
Bilinear transformations- Properties and Classification, Fixed Points, Cross ratios, Inverse points and Critical points. Conformal mapping, Mappings of: Upper half plan on to unit disc, Unit disc onto unit disc, left half plane on to unit disc, Circle onto circle. The transformations: $w = \sqrt{z}\ ,\ w = z^2, w = \frac{1}{2}(z + 1/z)$.

UNIT-III:
Morera's theorem, Cauchy's inequality, Liouville's theorem and its applications, Winding numbers-index of a point with respect to a closed curve. Power Series, Radius of convergence of a power series, Taylor theorem, Taylor's series, Expansion of analytic functions in a power series.

UNIT-IV:
Laurent's series, Singular Points, Isolated singularities, Poles and essential singular points, Behavior of functions at infinity, Casorati – Weirestrass's theorem.
Calculus of residues: Cauchy's residue theorem and its applications, Calculation of residues, Evaluation of definite integrals by the method of residues.

Recommended Books:

1. L. Ahlfors, Complex analysis
2. Richard Silverman, Complex Analysis
3. S. Ponnusamy, Foundations of Complex analysis
4. J.B. Conway, Functions of a complex variable-I

References:

1.Z. Nihari, Conformal mapping.
2. E.C. Titchmarsh, Theory of functions

MTH-502: Algebra-III

Unit-I

Detailed look at the group S_n of permutations, cycles and transpositions even and odd permutations, the alternating group A_n. Group actions, kernel and stabilizer of actions normalizes and centralizers, groups acting on themselves by conjugation, class equation, conjugacy in S_n. Simple groups and simplicity of A_n for n>5.

Unit-II

Cauchy's Theorem, Sylow's Theorem and its applications, automorphisms. Direct products and The Fundamental Theorem of Finitely generated abelian groups. Solvable groups, nilpotent groups composition series, Jordan holder Theorem, Scherier's refinement Theorem.

Unit-III

Euclidean domains, principal ideal domains and unique factorization domains, irreducibility criteria for polynomials. Primitive polynomials, Gauss Theorem, symmetric and elementary symmetric polynomials.

Unit-IV

Fields: prime fields and their structure, extension of fields. Finite and Algebraic extensions of a field Roots of a polynomial, remainder and factor Theorems, splitting field of a polynomial. Existence and uniqueness of splitting fields. Simple extension of a field.

Text Books:

1. *Abstract Algebra,* D.S Dumit and R.M. Foote, John Wiley.

2. *University Algebra,* N.S Gopal Krishnan. New Age International

References:

1. *Algebra,* M. Artin, Prentice Hall of India.

2. *Topics in Algebra,* I. N. Herstien, John Wiley.

3. *Abstract Algebra,* Joseph Gallian, Narosa.

4. *Basic Algebra I, II*, N. Jacobson, Hindustan Publishing Corporation.

5. *Abstract Algebra,* S. Sing and Qazi Zameerudin New Age International

MTH-503: Numerical Analysis

Unit I

Finite difference and Interpolation: Error estimation, Forward, Backward and Central difference Operator, and Relation between them. Newton's Difference formulas, Newton's divided difference formula, Gauss forward and backward formulae, Sterling, Bessel's and Everett's formulae, Lagrange's interpolation formula.

Unit II

Numerical solution of Algebraic and Transcendental equations: Basic concepts on polynomial equations, Roots of equations by Bisection method, iterative method, Regula-falsi method, Newton-Raphson method, Secant method.

Unit III

Numerical differentiation and integration: Numerical differentiation, errors in numerical differentiation, Numerical integration Trapezoidal, Simpson's 1/3 and 3/8 rules, Romberg integration-recursive formulae, Evaluation of double integrals by Trapezoidal and Simpson's rules.

Unit-IV

Numerical solution of ordinary differential equations: Initial value problems- Picard's and Taylor series methods – Euler's Method- Higher order Taylor methods - Modified Euler's method - Runge Kutta methods of second and fourth order – Multistep method - The Adams - Moulton method.

Text Books

1. *Introductory Numerical Analysis*, S.S Sastary, Narosa.

References:

1. *Numerical methods for scientific and engineering computation*, M. K. Jain, S. R. K. Iyengar and R.K. Jain, Wiley Eastern Ltd.
2. *Applied Numerical Methods*, C.F. Gerald and P.O. Wheatley, Pearson Education Asia.

MTH-503L- Numerical Analysis Lab

Experiments in the lab are based on the contents of MTH-503T: Numerical Analysis.

MTH-504: Operations Research

Unit I:

Definition of Operation Research. Features of OR modelling in OR and classification. Methodology of operation research. Opportunities and short comings of operation research, applications of operation research. Applications in business, technology, warfare, education and career, counselling, Operations Research Models.

Unit II:

Linear Programming Problem (LPP): General LPP models, Formulation of LPP models, Graphical solution of LPP. Convex sets, Convex hull, Convex and concave functions, Extreme point theorems and development of Simplex Method, Artificial Variable Technique-Big M-Method and Two-Phase Method.

Unit III:

Formulation of Transportation Problem, Finding of Basic Feasible solution (BFS) using North-West Corner Rule, Matrix Minima and Vogel's Approximation Method, Testing for optimality of the basic feasible solution– MODI and Stepping Stone Methods, Assignment Problem and its formulation, finding an optimal assignment using Hungarian Method.

Unit IV:

Project scheduling: Network representation of a Project, Rules for construction of a Network. Use of Dummy activity. The Critical Path Method (CPM) for constructing the time schedule for the project. Various Float times of activities. Programme Evaluation and Review Technique (PERT). Probability considerations in PERT. Probability of meeting the scheduled time. PERT Calculation, Distinctions between CPM and PERT.

Text Books:

1. *Linear Programming*, Problem, Gauss S.I, John Wiley
2. *Linear Programming*, Hadley, G, Narosa Publishing House.

References:

1. *Operations Research-Principles and Practice*, Ravindran ,A. Phillips Don T.and Solberg James J.

2. *Operations Research: An Introduction* H. A. Taha, 7th edition Prentice Hall of India Pvt. Ltd. New Delhi.
3. *Introduction to Operations Research*, Hillier F. S. and Lieberman G. J, McGraw Hill International Edition.

MTH-505: Topology I

UNIT-I

Review of countable and uncountable sets, Schroeder-Bernstein theorem, axiom of choice and its various equivalent forms, definition and examples of metric spaces, open and closed sets, completeness in metric spaces, Baire's category theorem, and applications to the (1) non-existence of a function which is continuous precisely at irrationals (ii) impossibility of approximating the characteristic of rationals on [0, 1] by a sequence of continuous functions.

UNIT-II

Completion of a metric space, Cantor's intersection theorem with examples to demonstrate that each of the conditions in the theorem is essential, uniformly continuous mappings with examples and counter examples, extending uniformity continuous maps, Banach's contraction principle with applications to the inverse function Theorem in R.

UNIT-III

Topological spaces; definition and examples, elementary properties, Kuratowski's axioms, continuous mappings and their characterizations, pasting lemma, convergence of nets and continuity in terms of nets, bases and sub bases for a topology, lower limit topology, concepts of first countability, second countability, separability and their relationships, counter examples and behaviour under subspaces, weak topology generated by a family of mappings, product topology

UNIT-IV

Compactness and its various characterizations, Heine-Borel theorem, compactness, sequential compactness and total boundedness in metric spaces, Lebesgue's covering lemma, continuous maps on a compact space, Tychnoff's theorem, ,separation axioms T_i (i=1,2,3,1\2,4) and their permanence properties, connectedness, local connectedness, their relationship and basic properties, connected sets in R, Urysohn's lemma, Urysohn's metrization theorem, Tietize's extension theorem, one point compactification.

Suggested Texts:

1. G.F. Simmons, Introduction to Topology and Modern Analysis, Tata McGraw Hill.
2. J. Munkres, Topology, Pearson India.

References:

1. K.D. Joshi, Introduction to General Topology.
2. J. L. Kelley, General Topology.
3. Murdeshwar, General Topology.
4. S.T. Hu, Introduction to General Topology.
5. Dugundji J, Topology Prentice Hall of India.
6. Willard, "General Topology" Addison-Wesley
7. I.M. Singer & J.A. Thorpe, "Lecture Notes on Elementary Topology and Geometry".

MTH-506: Discrete Mathematics

Unit 1:
Counting principle, counting set of pairs two way counting. Stirling numbers of 2nd kind, simple recursion formula satisfied by S(n, k) and direct formula for S(n, k) for k =1,2,….,n-1,n. Pigeonhole principle and its strong form, its application to geometry.

Unit-II
Principle of Inclusion and Exclusion, its applications, de arrangements, explicit formula for dn, various identities involving dn, deriving formula for Euler's phi function $\phi(n)$

Unit III
Recurrence relations, definition of homogeneous, non-homogeneous, linear and non- linear recurrence relations, obtaining recurrence relation in counting problems, solve (homogeneous as well as non- homogeneous) recurrence relation of 2nd degree using algebraic method.

Unit-IV

Partially Ordered Sets: (i) Concept of partial order, total order, and examples. (ii) Chains, Zorn's Lemma. (i) Peano's Axioms. (ii) Well-Ordering Principle. (iii) Weak and Strong Principles of Mathematical Induction. (iv) Transfinite Induction. (v) Axiom of Choice, product of an arbitrary family of sets. (vi) Equivalence of Axiom of Choice, Zorn's Lemma and Well-ordering principle.

Text Books:

1. *Norman Biggs/ discrete Math's*, oxford University Press.
2. *Combinations theory and applications,* V. Krishnamurthy, Affiliated East –West Press.

References:

1. *Introductory combinations,* Richard Brualdi, John Wiley and sons.
2. *Discrete mathematics,* Schaum's Outline series:
3. *Applied Combinations,* Allen Tucker, John Wiley and sons.

Semester-VI

MTH-601: Analysis -IV

Unit-I

Uniform convergence of sequence and series of functions point wise convergence, uniform convergence on an interval. Cauchy's criterion for uniform convergence, Weirestrass's M-test, Abel's and Dirichlet's tests for uniform convergence of series, uniform convergence and continuity, uniform convergence and integration, uniform convergence and differentiation, Weirestrass's Approximation Theorem.

Unit-II

Semi ring, algebras and σ -algebras of sets, Borel σ -algebra of metric space, measure on semirings and examples. Outer measure and measurable sets, collection of measurable sets as σ -algebra λ, σ -additivity of an outer measure on λ, Caratheodory extension of an outer measure, length function of an interval as an outer measure on a semi ring of finite intervals, Lebesgue measurable sets and existence of non-Lebesgue measurable set.

Unit-III

Measurable functions and their characterization, algebras of measurable functions, Stienhauss's Theorem on a set of positive measure, Ostroviski's Theorem on measurable solution of $f(x+y) = f(x) + f(y)$ for all x, y in R, convergence a.e., convergence in measure, almost uniform convergence and their relationships. Egoroff's Theorem.

Unit-IV

Simple and step functions, Integral of a step function, Linearity, monotonicity and order continuity of the integral of step function. Upper function, Integral of upper function, Lebesgue integrable functions: Lebesgue integral of a function in terms of upper functions, Levi's Theorem, Fatous Lemma, Monotone Convergence Theorem, The Lebesgue dominated Convergence Theorem. The Riemann integral as a Lebesgue integral, Fundamental Theorem of calculus.

Text Books:

1. *Principles of Real Analysis*, H. L. Royden, PHI.
2. *Measure and Integration*, G Debara, Woodhead Publishing;

References:

3. *Principles of Real Analysis,* C. D. Aliprantis and O. Burkinshow; Academic Press, New York.
4. *Measure and Integration*, I K Rana, Narosa.
5. *Infinite Dimensional Analysis,* C. D. Aliprantis and K.

MTH-602: Algebra IV

Unit-I

Review of Linear transformations and their properties, Linear functionals and dual space with examples and related results, transpose of linear transformation, characteristic values and diagonalizable linear operators with examples and related results. Invariant subspaces with examples and properties, simultaneous diagonalization of linear operators with related results and examples.

Unit-II

Inner products spaces with examples and properties, adjoint of linear operators on inner product spaces and related results. Self -Adjoint, Hermitian, unitary and normal operators on inner product spaces with examples and properties. Diagonalizability of normal operators on finite dimensional inner product spaces. Forms on inner product spaces (sesqui-linear, bilinear and quadratic).

Unit-III

Modules: basic properties, submodules, spanning sets, Linear independence, torsion elements and annihilators. Free modules, module homomorphisms and quotient modules, The Correspondence and Isomorphism Theorems. Direct sums, and extension of Isomorphisms. Rank of a free module, Noetherian modules. Modules over PIDs, decomposition of cyclic modules, Torsion free and free modules.

Unit-IV

The primary decomposition Theorem and the cyclic Decomposition Theorem of a primary module (proofs may be skipped). Elementary divisors and invariant factor decomposition, module associated with a linear operator, cyclic submodules and cyclic subspaces, indecomposable modules and companion matrices. Rational canonical form (elementary divisor and invariant factor version). Spectral mapping Theorem, Geometric and algebraic multiplicities of eigen values. The Jordan canonical form.

Text Book:

1. *Advanced Linear Algebra,* Steven Roman, Springer.
2. *Linear Algebra,* K. Hoffman and R. Kunze, Pearson Education.

References:

1. *Abstract Algebra,* D.S Dumit and R.M. Foote, John Wiley.
2. *University Algebra,* N.S Gopal Krishnan, New Age International.

MTH-603: Functional Analysis-I

Unit I

Banach Spaces: Definition and examples, subspaces, quotient spaces, continuous linear operators and their characterization, completeness of the space L(X,Y) of bounded linear operators (and its converse), incompleteness of C[a, b], under the integral norm, finite dimensional Banach spaces, Equivalence of norms on finite dimensional space and its consequences, dual of a normed linear space, Hahn Banach theorem (extension form) and its applications, complemented subspaces, duals of Co , lp ($p \geq 1$), C[a, b].

Unit II

Uniform boundedness principle and weak boundedness, dimension of an n –dimensional Banach space, conjugate of a continuous linear operator and its properties, Banach- Steinhauss Theorem, Open Mapping and Closed Graph Theorems, counterexamples to Banach-Steinhauss, Open Mapping Theorem and Closed Graph Theorems for incomplete domain and range spaces, separable Banach spaces and the separability of some concrete Banach spaces (Co, C[0,1], lp, $p \geq 1$), reflexive Banach Spaces, closed subspace and the dual of a reflexive Banach space, examples of reflexive and non-reflexive Banach spaces.

Unit III

Hilbert spaces: Definition and examples, Cauchy's Schwartz inequality, Parallelogram law, orthonormal (o.n) systems, Bessel's inequality and Parseval's Identity for complete orthonormal systems, Riesz-Fischer Theorem, Gram Schmidt process, o.n basis in separable Hilbert spaces.Fourier Series with respect to an orthonormal basis.

UNIT-IV

Projection Theorem, Riesz Representation Theorem. counterexample to the Projection theorem and Riesz Representation Theorem for incomplete spaces, Hilbert property of the dual of a Hilbert space and counterexamples for incomplete inner product spaces, reflexivity of Hilbert space, adjoint of a Hilbert space operator, weak convergence and Bolzano-Weirstrass property in Hilbert spaces, normal and unitary operators, finite dimensional spectral theorem for normal operators.

Text Books:

1. *Functional Analysis*, B.V.Limaya, Newage Internationals.
2. *A First Course in Functional Analysis*, C.Goffman G. Pedrick PHI

References:

1. *Elements of Functional Analysis*, L.A. Lusternick & V.J. Sobolov,
2. *A Course in Functional Analysis*, J.B. Conway Springer.

MTH-604: Differential Geometry

Unit I

Curves: Differentiable curves, Regular point, Parameterization of curves, arc-length, and arc-length is independent of parameterization, unit speed curves. Plane curves: Curvature of plane curves, osculating circle, centre of curvature. Computation of curvature of plane curves. Directed curvature, fundamental theorem for plane curves. Examples: Straight line, circle, ellipse, tractrix, evolutes and involutes. Space curves: Tangent vector, unit normal vector and unit binormal vector to a space curve. Curvature and torsion of a space curve. The Frenet-Serret Theorem. First Fundamental theorem of space curves. Intrinsic equation of a curve. Computation of curvature and torsion. Characterization of Helices and curves on sphere in terms of their curvature and torsion. Evolutes and involutes of space curves**.**

Unit II

Surfaces; Regular surfaces with examples, coordinate charts or curvilinear coordinates, change of coordinates, tangent plane at a regular point, normal to the surface, orient able surface, differentiable mapping between regular surfaces and their differential. Fundamental form or a metric of a surface, line element, invariance of a line element under change of coordinates, angle between two curves, condition of orthogonality of coordinate curves. Area of bounded region, invariance of area under change of coordinates.

Unit III

Curvature of a Surface: Normal curvature, Euler's work on principal curvature, Qualitative behaviour of a surface near a point with prescribed principal curvatures. The Gauss map and its differential. The differential of Gauss is self-adjoint. Second fundamental form. Normal curvature in terms of second fundamental form. Meunier theorem. Gaussian curvature, Weingarten equation. Gaussian curvature $K(p)= (eg-f^2)/EG-F^2$. surface of revolution. Surfaces with constant positive or negative Gaussian curvature. Gaussian curvature in terms of area. Line of curvature, Rodrigues's formula for line of curvature, Equivalence of Surfaces: Isometry between surfaces, local isometry, and characterization of local isometry.

Unit IV

Christoffel symbols. Expressing Christoffel symbols in terms of metric coefficients and their derivative. Theorema egregium (Gaussian curvature is intrinsic). Isometric surfaces have same Gaussian curvatures at corresponding points. Gauss equations and Manardi Codazzi equations

for surfaces. Fundamental Theorem for regular surface. (Statement only). Geodesics: Geodesic curvature, Geodesic curvature is intrinsic, Equations of Geodesic, Geodesic on sphere and pseudo sphere. Geodesic as distance minimizing curves. Gauss-Bonnet theorem (statement only). Geodesic triangle on sphere. Implication of Gauss- Bonnet theorem for Geodesic triangle.

Text Books

1. *Geometry from a differentiable Viewpoint*, John Mc Cleary, Cambridge Univ. Press.
2. *Elementary Differential Geometry*, Andrew Pressly, Springer.

References:

1. , *Elementary Differential Geometry*, Barret O'Neil, Academic Press.
2. *Elementary Differential Geometry*, C. Baer, Cambridge Univ. Press.
3. *A course in Differential Geometry*, W. Klingenberg, Springer.
4. *Riemannian Manifolds: An Introduction to Curvature*, J. M. Lee, Springer.

MTH-605: Elementary Number Theory

Unit I
Divisibility in integers, division algorithm, GCD, LCM, Fundamental theorem of arithmetic, infinitude of primes, Mersene numbers and Fermat numbers.

Unit II
Property of congruences, residue classes, complete and reduced residue system, their properties, Linear Diophantine equations. Fermat theorem, Euler's Theorem, Wilson Theorem. Linear congruence of degree 1, Chinese remainder Theorem.

Unit III
Greatest integer functions, arithmetic function, Euler ϕ function the number of divisors d (n), sum of divisors and similar functions. Greatest integer functions, Arithmetic functions, multiplicative functions, totally multiplicative functions, Mobius functions, Mobius inversion formula.

Unit IV: Farry series. Quadratic residue, Legendre symbols, its properties, law of quadratic reciprocity.

Text Books:
1. *An introduction to theory of numbers*, Niven & Zuckerman and H.L. Montgomery, John Wiley.
2. *Elementary Number theory*, David M. Burton, Universal book stalls.

MTH-606: Minor Project

Each Student will be assigned a topic on any one of the courses in Mathematics that he/she has studied in previous semesters. He/she will have to write a small dissertation on that topic (to be evaluated) and then has to defend it in a viva voce in front of panel of experts.