Curriculum

for the degree of

B.S. (Hon's) in Mathematics

Faculty of Science

Session: 2022-2023

Department of Mathematics

Bangamata Sheikh Fojilatunnesa Mujib Science & Technology University

Jamalpur-2012, Bangladesh.

Contents

Program Name

Bachelor of Science (Honors) in Mathematics.

Description of the Program

The Department of Mathematics is one of the most active departments within the Faculty of Science. It provides courses that are pertinent to the field in order to generate graduates who are highly trained and have both theoretical and well-equipped practical knowledge. Specifically, it focuses on offering sufficient opportunities to work with relevant instruments, to learn how to design experiments, execute experiments, analyze experiments and troubleshoot problems in the context of solving practical problems. Our students are provided with the background information that is necessary to make educated decisions concerning mathematical and socio-economic challenges in this complicated existence by integrating the themes across the pure and applied mathematics courses, lab experiences and the courses in fields that are not related to science.

Vision

The Mathematics Department at Bangamata Sheikh Fojilatunnesa Mujib Science & Technology University envisions becoming a premier hub for excellence in mathematics education and research. We are committed to cultivating an environment encouraging critical thinking, innovation, and knowledge advancement. Our objective is to equip students to tackle the challenges of a swiftly changing world, contributing to the development of Smart Bangladesh through their mathematical expertise and leadership.

Mission

The Department of Mathematics is determined to fulfill the above vision in the following ways:

1. Offering comprehensive and diverse programs that foster a deep understanding of mathematical principles and applications.
2. Conducting innovative research across multiple mathematical disciplines, contributing to the advancement of pure and applied mathematics, as well as interdisciplinary fields.
3. Providing opportunities for students to engage in theoretical and experiential learning, and research projects to apply mathematical concepts to real-world problems.
4. Fostering a supportive and inclusive learning environment that encourages curiosity, collaboration and critical thinking among students and teachers.
5. Supporting professional development and mentoring programs for students and faculty to enhance teaching effectiveness, research productivity and career opportunities.

Course Structure

1. Program duration: 4 Years
2. Numbers of Semester: 8
3. Semester Duration: 6 Months
4. Earn a minimum CGPA: 2.25
5. Complete the program within six academic years of his/her 1st admission year into the program.

Marks and Credits Distribution

Summary of the total available credits

Departmental Courses		**121 credits**
Non-Departmental Courses		**33 credits**
Theory Courses	128 credits	
Lab Courses	14 credits	
Project and Presentation	4 credits	
Viva Voce	8 credits	
Total		**154 credits**

Distribution of credits in different areas of study

Areas of study	**Theory**	**Lab**	**Viva-voce**	**Total**
Mathematics	105	8	8	121
English	3	---	---	3
Computer Science	6	6	---	12
Physics	9	---	---	9
Statistics	6	---	---	6
Humanities	3	---	---	3
Total	132	14	8	154

Distribution of Marks (as per course types)

Theoretical courses

	Marks (%)
Class Attendance	10%
Internal Evaluation	20%
Semester Final Examination	70%
Total	100%

Continuous Assessment

Continuous assessment includes class attendance, quizzes, class test, tutorial, in-course exam, presentation, assignment or any other form of formative examination.

Lab Courses

	Marks (%)
Class Attendance (CA)	10%
Internal Evaluation	40%
Semester Final Examination	50%
Total	100%

Project Work/ Field Work/ Professional Training

	Marks (%)
Report Evaluation	50%
Presentation & Viva-voce	30%
Assessment of Supervisor	20%
Total	100%

Grading System Calculation

Grade Point Average (GPA): A Grade Point Average (GPA) shall be calculated for each semester as follows:

$$GPA = \frac{\sum_{i=1}^{n} C_i G_i}{\sum_{i=1}^{n} C_i}$$

Where, n is the number of courses offered during the semester, C_i is the number of credits allotted to a particular course and G_i is the grade point earned the for that course.

Yearly Grade Point Average (YGPA): A Yearly Grade Point Average (YGPA) shall be calculated for each academic year as follows:

$$YGPA = \frac{\sum_{j=1}^{2} C_j G_j}{\sum_{j=1}^{2} C_j}$$

Where, C_j is the number of credits allotted to a semester and G_j is the GPA earned for that semester.

Cumulative Grade Point Average (CGPA): The Cumulative Grade Point Average (CGPA) gives the cumulative performance of the students from the 1st year up to the end of the year to which it refers and will be calculated as follows:

$$CGPA = \frac{\sum_{k=1}^{m} C_k G_k}{\sum_{k=1}^{m} C_k}$$

Where, m is the total number of years being considered, C_k is the total number of credits registered during a year and G_k is the YGPA of that particular year.

- A Cumulative Grade Point Average (CGPA) shall be calculated at the end of each academic year and to be communicated to the students along with the YGPAs. The individual grades of courses obtained by them for the semesters of the academic year will, however, be communicated at the end of individual semester by the Chairman of the Examination Committee.

Course outline

Course Title and Numbering System

Each course is designated by a two to four letter word usually identifying the course offering department followed by a three digits number with the following criteria without any space between letters and numerical.

(a) The first digit will correspond to the year in which the course is normally taken by the students.
(b) The second digit will correspond the semester (1 for January-June and 2 for July-December) in which the course is normally taken by the students.

(c) The third digit will be reserved for departmental use for such things as to identify different areas within a department.
(d) The fourth digit will be '0' for viva-voce, '1' for theoretical courses, '2' for laboratory/sessional courses and '3' for project /field work/thesis.

Semester-wise course outline for the entire program

1st Year 1st Semester

Course Code	Course Title	Credits
MAT 1111	Fundamentals of Mathematics	3
MAT 1121	Two Dimensional Geometry	3
MAT 1131	Differential Calculus	3
STA 1141	Introduction to Statistics and Probability	3
GED 1151	Bangladesh Studies	3
CSE 1161	Fundamentals of Computer Science	2
CSE 1162	Computer Fundamentals Lab	2
MAT 1170	Viva-Voce	1
	Total Credits	20

1st Year 2nd Semester

Course Code	Course Title	Credits
MAT 1211	Theory of Matrices	3
MAT 1221	Three Dimensional Geometry	3
MAT 1231	Integral Calculus	3
STA 1241	Mathematical Statistics	3
PHY 1251	Mechanics and Properties of Matter	3
ENG 1261	Functional English	3
MAT 1272	Mathematica Lab	2
MAT 1280	Viva-Voce	1
	Total Credits	21

2nd Year 1st Semester

Course Code	Course Title	Credits
MAT 2111	Linear Algebra	2
MAT 2121	Algebra and Trigonometry	3
MAT 2131	Advanced Calculus	3
MAT 2141	Ordinary Differential Equation I	3
PHY 2151	Heat, Thermodynamics and Optics	3
CSE 2161	Structured Programming Language	2
CSE 2162	Structured Programming Language Lab	2
MAT 2170	Viva-Voce	1
	Total Credits	19

2nd Year 2nd Semester

Course Code	Course Title	Credits
MAT 2211	Real Analysis I	3
MAT 2221	Numerical Analysis I	3
MAT 2231	Vector Calculus	3
MAT 2241	Ordinary Differential Equation II	3
PHY 2251	Electricity and Magnetism	3
CSE 2261	Data Structure	2
CSE 2262	Data Structure Lab	2
MAT 2270	Viva-Voce	1
	Total Credits	20

3rd Year 1st Semester

Course Code	Course Title	Credits
MAT 3111	Real Analysis II	3
MAT 3121	Numerical Analysis II	3
MAT 3131	Mechanics I	3
MAT 3141	Partial Differential Equation	3
MAT 3151	Mathematical Methods I	3
MAT 3162	FORTRAN/ Python Programing Lab	2
MAT 3170	Viva-Voce	1
	Total Credits	18

3rd Year 2nd Semester

Course Code	Course Title	Credits
MAT 3211	Abstract Algebra	3
MAT 3221	Complex Analysis	3
MAT 3231	Mechanics II	3
MAT 3241	Tensor Analysis	3
MAT 3251	Mathematical Methods II	3
MAT 3261	Linear Programming	3
MAT 3262	MATLAB I	2
MAT 3270	Viva-Voce	1
	Total Credits	21

4th Year 1st Semester

Course Code	Course Title	Credits
MAT 4111	Topology	3
MAT 4121	Differential Geometry	3
MAT 4131	Hydrodynamics	3
MAT 4141	Integral Equation	3
MAT 4151	Discrete Mathematics	3
MAT 4162	MATLAB II	2
MAT 4170	Viva-Voce	1
	Total Credits	18

4th Year 2nd Semester

Course Code	Course Title	Credits
MAT 4211	Functional Analysis	3
MAT 4221	Theory of Numbers	3
MAT 4231*	Classical Mechanics	3
MAT 4241*	Astronomy	3
MAT 4251*	Fuzzy Mathematics	3
MAT 4261*	Mathematical Modelling in Biology	3
MAT 4271*	Rings and Modules	3
MAT 4281*	Graph Theory	3
MAT 4291*	Mathematical Finance	3
MAT 4294*	Actuarial Mathematics	3
MAT 4293	Project and Presentation	4
MAT 4290	Viva-Voce	1
	Total Credits	17

*** Two courses from MAT 4231 to MAT 4294 will be offered as per the decision of the academic committee.**

Courses for 1st Year 1st Semester

Sl. No.	Course Code	Course Title	Credits
1	MAT 1111	Fundamentals of Mathematics	3
2	MAT 1121	Two Dimensional Geometry	3
3	MAT 1131	Differential Calculus	3
4	STA 1141	Introduction to Statistics and Probability	3
5	GED 1151	Bangladesh Studies	3
6	CSE 1161	Fundamentals of Computer Science	2
7	CSE 1162	Computer Fundamentals Lab	2
8	MAT 1170	Viva-Voce	1
		Total Credits:	20

MAT 1111: Fundamentals of Mathematics

Conduct hours per week: 3.0 Credits: 3.0

SI. No.	Course Contents
1	**Elements of Logic:** Mathematical statements; Logical connectives; Conditional and biconditional statements; Truth tables and tautologies; Quantifications; Logical implication and equivalence.
2	**Set Theory:** Sets and subsets; Set operations; Family of Sets; Cardinality of sets; De Morgan's laws; Applications of Set Theory.
3	**Relations and Functions:** Cartesian product of sets, Relations, Order relation, Equivalence of sets, Equivalence relations, Partially and totally ordered sets, Functions, Injective, Surjective and Bijective functions, Inverse functions, Images and inverse images of sets.
4	**Real Number System:** Field and order properties; Natural numbers, integers and rational numbers; Absolute value; Basic inequalities including inequalities involving means, powers inequalities of Weierstrass, Cauchy, Chebyshev.
5	**Complex number system:** Field of complex numbers; Geometrical representations; Polar form; De Moivre's theorem and its applications.
6	**Algebra of vectors:** Scalar and vector products; Coplanar vectors; Scalar triple product; Vector triple product. Applications.

Evaluation: Continuous Assessment: 30 marks (Class attendance: 10 marks, Class Test/ Assignment/ Presentation/ Quizzes: 20 marks).
Semester Final (3 hours) Examination: 70 marks. Seven questions of equal value will be set, of which any five are to be answered.

References:

1. S. Lipschutz, Set Theory, Schaum's Outline Series.
2. P.R. Halmos, Naive Set Theory.
3. Murray R Spiegel, Vector Analysis, Schaum's Outline Series.

MAT 1121: Two Dimensional Geometry

Conduct hours per week: 3.0 Credits: 3.0

Sl. No.	Course Contents
1	**Transformation of coordinates:** Coordinate and origin, Different type of coordinates, Axes of coordinates, Rectangular System/Axes, Oblique System/Axes, Relation among/between coordinates, Rotation of rectangular Axes, Transformation of origin, Removal of first-degree terms, Removal of xy (Product of x and y) terms, Theory of invariant, some applications of coordinate transformation.
2	**Pair of Straight lines:** Homogeneous and non-homogeneous equations, Equation of pair of straight lines, General equation of second degree, General condition, Condition of parallel lines, Condition of perpendicular lines, Equation of bisectors, Straight lines under different conditions.
3	**Circles**: Definition of Circle, General equation of circle, Condition of tangency, Pole and polar, Chord of contact, Conjugate points and lines, Common tangents, Equation of chord, Equation of chord in terms of its middle point, some applications.
4	**System of Circles:** Angle of intersection of two circles, Radial axes and properties of radical axes, Co-axial circles, Point circles, Limiting points and properties of limiting point, some examples.
5	**Conic Sections:** Parabola, Ellipse, Hyperbola, Standard Equation, Equation of tangent, normal and their properties, Condition of tangency, Direct circle, Focal distance, Eccentric angle, Conjugate diameters and properties, some examples.
6	**The General equations of second degree:** Reduction to standard forms, identifications, properties and tracing of conics, Polar equation of conic with applications.

Evaluation: Continuous Assessment: 30 marks (Class attendance: 10 marks, Class Test/ Assignment/ Presentation/ Quizzes: 20 marks).
Semester Final (3 hours) Examination: 70 marks. Seven questions of equal value will be set, of which any five are to be answered.

References:

1. Calculus 9/E – Howard Anton.
2. Analytic Geometry and Vector Analysis – A. F. M. Abdur Rahman & P.K. Bhattacharjee.
3. Analytic Geometry – J.M. Kar.
4. Analytic Geometry and Vector Analysis – Khosh Mohammad.
5. Analytic Geometry – S. Loney.

MAT 1131: Differential Calculus

Conduct hours per week: 3.0 Credits: 3.0

Sl. No.	Course Contents
1	**Functions and their graphs:** Notion, representation and transformation of graphs of functions; Different kinds of functions (polynomial, rational, logarithmic, exponential, trigonometric, hyperbolic functions), their inverses and graphs; Combination of functions; Even and odd functions.
2	**Limit and Continuity:** Limit of a function; Basic limit theorems with proofs; Limit at infinity and infinite limit; Sandwich (Squeezing) theorem (without proof); Continuous and discontinuous functions; Algebra of continuous functions; Properties of continuous functions on closed and bounded intervals; Horizontal and vertical asymptotes; Intermediate Value Theorem (statement and illustration with applications).
3	**Differentiation:** Tangent lines and rates of change; Derivative of a function, One sided derivatives; Techniques of differentiation; Chain rule theorem; Successive differentiation; Leibnitz theorem; Rates of change in Natural and Social Sciences; Related rates; Indeterminate forms; L'Hospital's rules.
4	**Applications of Differentiation:** Increasing and decreasing functions; Rolle's theorem; Mean value theorem; Taylor's theorem; Maclaurin's theorem; Concavity and point of inflection of functions; Relative maximum and minimum values of functions, Absolute maximum and minimum values of functions.
5	**Partial differentiation:** Techniques of partial differentiation, Euler's theorem for homogeneous function and it's application.

Evaluation: Continuous Assessment: 30 marks (Class attendance: 10 marks, Class Test/ Assignment/ Presentation/ Quizzes: 20 marks).
Semester Final (3 hours) Examination: 70 marks. Seven questions of equal value will be set, of which any five are to be answered.

References:

1. H. Anton, I. C. Bivens and S. Davis, Calculus: Early Transcendentals, Wiley.
2. E.W. Swokowski, Calculus with Analytic Geometry, Brooks/Cole.
3. G. B. Thomas and R. L. Finney, Calculus and Analytic Geometry.
4. J. Stewart, Calculus: Early Transcendentals.
5. Differential Calculus – Das and Mukherjee.

STA 1141: Introduction to Statistics and Probability

Conduct hours per week: 3.0 Credits: 3.0

Sl. No.	Course Contents
1	**Fundamental Statistics:** Definition, nature and scope of statistics, population and sample, variables, qualitative and quantitative variables, data and collection of data.
2	**Frequency Distribution:** Frequency distributions for qualitative and quantitative data, graphical representations of data: graphical representations of qualitative data- bar chart and pie chart, graphical representation of quantitative data- histogram, frequency polygon, frequency curve, ogive and stem-and-leaf plot with interpretations.
3	**Measures of Central Tendency:** Arithmetic mean, geometric mean, harmonic mean, median and mode and their interpretations, quartiles, percentiles and its uses.
4	**Measures of Dispersion/variation:** Absolute measures of dispersion range, interquartile range, mean deviation, standard deviation and variance. Relative measures of dispersion– coefficient of variation.
5	**Shape characteristics of distribution:** Moments, skewness and kurtosis, Box and whisker's plot.
6	**Correlation and regression analysis:** Simple linear correlation and its properties, rank correlation, simple linear regression model and its fitting by the method of least squares.
7	**Probability:** Random experiment, sample space, event, complementary of an event, mutually exclusive and non-mutually exclusive events. The classical, empirical and axiomatic approach of probability. Conditional probability, additive and multiplicative laws of probability. Bayes' theorem. Random variable, probability function and probability density function, joint probability function, marginal and conditional probability functions. Mathematical expectation and its properties, the variance of a random variable and its properties, moment generating function, characteristic function and cumulative generating function, common probability distribution: binomial distribution-definition, derivation, mean and variance, characteristic function and applications. Poisson distribution-definition, derivation, mean and variance, characteristic function and applications. Normal distribution definition and its applications.

Evaluation: Continuous Assessment: 30 marks (Class attendance: 10 marks, Class Test/ Assignment/ Presentation/ Quizzes: 20 marks).
Semester Final (3 hours) Examination: 70 marks. Seven questions of equal value will be set, of which any five are to be answered.

References:

1. Basic Statistics – Simpson and Kafka, W. W. Norton & Co. Inc. New York, London.
2. Introductory Statistics – John Wiley, NY- Hoel P G.
3. Methods of Statistics – Mostofa M G. Bangladesh.
4. An Introduction to Statistics and Probability – M Nurul Islam, Book World, Dhaka.
5. Introduction to Probability – Vol-1, 3rd Ed, John Wiley, NY- Fellor W.

GED 1151: Bangladesh Studies

Conduct hours per week: 3.0 Credits: 3.0

Sl. No.	Course Contents
1	**Geography and Demographic features of Bangladesh:** Geography of Bangladesh: Origin of the name of Bangladesh, Geographical location and area, river, weather, culture, Flora and Fauna. Demographic features: Ethnic and cultural diversity, population by age group, economic dividend, society, religions and believes, arts, literature and culture of Bangladesh.
2	**The Liberation War of Bangladesh and its Background:** Participation of Indian subcontinent, Two nation theory, Language Movement 1952, 1954 Election, Education movement 1962, Six-Point Movement, 1966, Mass Upsurge 1968-69, General Elections 1970, Non- cooperation Movement, 1971, Bangabandhu's Historic Speech of 7th March and declaration of independence of Bangladesh. Formation and Functions of Mujibnagar government, Role of Major Powers and of the UN, Surrender of Pakistani Army, Bangabandhu's return to liberated Bangladesh. Withdrawal of Indian armed forces from Bangladesh.
3	**Economy of Bangladesh:** Economy with particular emphasis on developments including Poverty Alleviation, GNP, NNP, GDP, SDG, etc. after the emergence of the country.
4	**The Constitution of the People's Republic of Bangladesh:** Preamble, Features, Directive Principles of State Policy, Constitutional Amendments.
5	**Foreign Policy and External Relations of Bangladesh:** Goals, Determinants and policy formulation process; Factors of National Power; Security Strategies; Geo-Politics and Environment Issues; Economic Diplomacy; Man-power exploitation, Participation in International Organizations; UNO and UN Peace Keeping Missions, NAM, SAARC, OIC, BIMSTEC,D-8 etc. and International Economic Institutions, Foreign Aid, International Trade.

Evaluation: Continuous Assessment: 30 marks (Class attendance: 10 marks, Class Test/ Assignment/ Presentation/ Quizzes: 20 marks).
Semester Final (3 hours) Examination: 70 marks. Seven questions of equal value will be set, of which any five are to be answered.

References:

1. A History of Bangladesh- William Van Schendel, Cambridge University Press 2009.
2. History of Bangladesh (1704-1971), Vol-1, Sirajul Islam (Edited), Asiatic Society of Bangladesh.
3. Social History of the Muslims of Bengal (English & Bangla Version)-Abdul Karim.
4. Bangladesh National Culture and Heritage- A F Salahuddin Ahmed, Bazlul Mobin Chowdhury (Edited), An Introductory Reader, Independent University Bangladesh.
5. Social & Cultural History of Bengal, Vol-2 (English & Bangla Version)- M.A. Rahim.

CSE 1161: Fundamentals of Computer Science

Conduct hours per week: 3.0 Credits: 2.0

SI. No.	Course Contents
1	**Computer Basics:** History, Computer Generation, Classification of computer-based on configuration, operation and capacity, characteristics of a computer, Impact of computers on society and technology. Number system.
2	**Specification of Computers:** CPU types, Speed variation, Memory, type size Cache, Storage Media, Hard disk. Floppy disk, CD ROM, DVD. Printer: Dot Matrix Printer/ Laser Printer, Inkjet Printer. Computer Hardware: Digital electronics, CPU. Memory: RAM, ROM, DRAM, SRAM, PROM, EPROM, EFROM, Mass storage devices.
3	**Number System of Computers:** Binary, decimal, Octal, Hexadecimal number format, conversion from one number system to another.
4	**Computer Arithmetic and Logic:** Binary Addition, Binary subtraction, Binary Multiplication and Division. Boolean logic, Basic logic gate: AND, OR, NOT XOR gate, universal gate: NOR, NAND gate, minimization of Boolean algebra k-map minimization.
5	**The idea of System Software and Application Software:** Function of Operating System, Discussion on different types of Operating Systems: DOS/Window, Mac UNIX/LINUX, etc.
6	**Concept of formal Languages:** Different types of Computer Languages, Assembly, FORTRAN, Pascal C and C++, Artificial Language, etc.
7	**Purpose and Scope of Application Packages:** Essential general purpose packages, Word Processing, Spreadsheet analysis, database latex, etc.

Evaluation: Continuous Assessment: 30 marks (Class attendance: 10 marks, Class Test/ Assignment/ Presentation/ Quizzes: 20 marks).
Semester Final (3 hours) Examination: 70 marks. Seven questions of equal value will be set, of which any five are to be answered.

References:

1. Introduction to Computers – Peter Norton.
2. Fundamentals of Computer – P.K. Sinha.
3. Fundamentals of Computers – E. Balagurusamy.
4. Computer Fundamentals – Dr. Lutfur Rahman.
5. Computer Fundamentals – Goel.

CSE 1162: Computer Fundamentals Lab

Conduct hours per week: 4.0 Credits: 2.0

SI. No.	Course Contents
1	**Operating Systems: Windows:** Students will learn the basics of computers, how to operate them in two basic environments, Dos and Windows.
2	**Word Processor:** Students will learn to use a popular word processor to create a camera-ready test file complete with figures, columns and tables, **Spread Sheet:** Students will learn to use a popular Spread Sheet to maintain a small database, minor book keeping and statistical and graphical analysis of data. **Presentation package:** Students will learn how to create multimedia slides and animation.
3	**Bangla Typing:** As a mother language student will learn how to write anything using Bijoy and Avro Bangla font.
4	**Mathematical Equation Typing:** Students will learn how to write any mathematical equation using Math Type Equation Editor.
5	**Internet:** Student will learn how to use a search engine, web browser, mail basic, upload and download concepts, internet download manager (IDM) installation, Google drive, Google class room, Dropbox, LAN connection, broadband connection, internet connection through a modem, switch, hub, router introduction, basic of an internet interface card, enable or disable of internet connection, IP address concept.

Evaluation: Continuous Assessment: 50 marks (Class attendance: 10 marks, Lab Report/ Assignment: 20 marks, Lab test: 20 marks). Semester Final (Lab: 4 hours) Examination: 50 marks.

MAT 1170: Viva-Voce

Credits: 1.0

Viva-Voce on courses taught in the 1st year 1st semester.

Courses for 1st Year 2nd Semester

Sl. No.	Course Code	Course Title	Credits
1	MAT 1211	Theory of Matrices	3
2	MAT 1221	Three-Dimensional Geometry	3
3	MAT 1231	Integral Calculus	3
4	STA 1241	Mathematical Statistics	3
5	PHY 1251	Mechanics and Properties of Matter	3
6	ENG 1261	Functional English	3
7	MAT 1272	Mathematica Lab	2
8	MAT 1280	Viva-Voce	1
		Total Credits:	21

MAT 1211: Theory of Matrices

Conduct hours per week: 3.0 Credits: 3.0

Sl. No.	Course Contents
1	**Matrices:** Different types and kinds of matrices, examples, theories, properties and verification.
2	**Adjoint and Inverse Matrices:** Theories and properties of determinant, adjoint and inverse matrices; Higher order determinant, solution of system of equation by determinant.
3	**Elementary Transformations:** Ranks of the matrices, Echelon, Minor, Canonical or normal forms.
4	**System of Linear Equations:** Consistency, Solution of homogeneous and non-homogeneous system by Matrix Method and reduction to equivalent system. Cayley-Hamilton theorem and its application.
5	**Eigen value and Eigen vectors:** Polynomial, Eigen value, Eigen vector and their applications; Matrix diagonalization.

Evaluation: Continuous Assessment: 30 marks (Class attendance: 10 marks, Class Test/ Assignment/ Presentation/ Quizzes: 20 marks).
Semester Final (3 hours) Examination: 70 marks. Seven questions of equal value will be set, of which any five are to be answered.

References:

1 P. N Chatterjee : Matrices.
2 F. Ayres : Theory of Matrices.
3 C. C. Mcduffe : Theory of Matrices.
4 S. Lipschutz : Linear Algebra.
5 S. L. Croasman : Elementary Linear Algebra.
6 M. L. Khanna : Matrices.

MAT 1221: Three Dimensional Geometry

Conduct hours per week: 3.0 Credits: 3.0

Sl. No.	Course Contents
1	**Coordinates:** Direction-cosine and direction-ratio: Direction-cosine of a line joining two points, The angle between two directed lines, Projection of the joining of two points on a line.
2	**The plane:** Derivation of the general equation of a plane, Different forms of the equation of plane, Angle between two planes, Bisecting plane, Combined equation of two planes, Projection on a plane.
3	**Straight line:** The equation of a line, Symmetrical form of equation, Condition for a line to lie in a plane, Plane through a given line, Foot of perpendicular from a point to a line, Projection of a line on a plane, Coplanar line, Line intersecting two given lines, Distance of a point from a line, Intersection of three planes.
4	**Shortest distance:** The derivation of shortest distance between two given lines and also the equation of shortest distance, The coplanar condition and related problems.
5	**Sphere:** Various forms of the equation of a sphere, Plane section of a sphere, Tangent plane of a sphere, Polar plane, Orthogonal intersection of two spheres, Radical plane and Coaxial sphere.
6	**Cone and cylinder:** The general equation of cone, Condition of tangency, Cone with vertex at origin, Tangent plane, Angle between the lines of section, Three mutually perpendicular generators
7	**The general equation of second degree:** Centre of the surface, Discriminating cubic, Nature of the conicoid, Elliptic or hyperbolic paraboloid, Elliptic or hyperbolic cylinder, Pair of planes, Ellipsoid, hyperboloid or paraboloid of revolution, Parabolic cylinder or pair of parallel planes.

Evaluation: Continuous Assessment: 30 marks (Class attendance: 10 marks, Class Test/ Assignment/ Presentation/ Quizzes: 20 marks).
Semester Final (3 hours) Examination: 70 marks. Seven questions of equal value will be set, of which any five are to be answered.

References:

1. J.M. Kar: Analytic Geometry of Conic Section.
2. H. H. Askwith: Analytic Geometry of Conic Section.
3. Rahman & Bhattacharjee: Coordinate Geometry with vector Analysis.
4. J.T.Bell.: A Treatise on Three Dimensional Geometry.
5. Bell, J. T : A Treatise on Three dimensional Geometry.
6. Loney S. L. : Analytic Coordinate Geometry.
7. Smith, C : An Elementary Trealises on Solid Geometry.
8. B. D. Sharma : Solid Geometry.
9. M. L. Khanna : Solid Geometry.

MAT 1231: Integral Calculus

Conduct hours per week: 3.0 Credits: 3.0

Sl. No.	Course Contents
1	**Indefinite Integrals:** Fundamental properties, Method of substitution, Integration by parts, Special trigonometric functions and rational functions.
2	**Definite Integrals:** Fundamental theorem of integral calculus, Evaluation of definite integrals, Summation of Series by definite integrals.
3	**Properties of Integration:** Fundamental properties of definite integrals, Reduction formulae, Walli's formulae.
4	**Infinite or Improper Integrals:** Different types of improper integrals and their applications, Gamma and Beta function.
5	**Applications of Integration:** Plane area; Arc length and surface area by revolution; Area and arc length in polar coordinates; Solids of revolution; Volume by cross-section and cylindrical shell.

Evaluation: Continuous Assessment: 30 marks (Class attendance: 10 marks, Class Test/ Assignment/ Presentation/ Quizzes: 20 marks).
Semester Final (3 hours) Examination: 70 marks. Seven questions of equal value will be set, of which any five are to be answered.

References:

1 Howard Anton : Calculus.
2 G. B. Topmas and R. L. Finny : Calculus and Analytical Geometry.
3 S.K.Stein and A.Barcellos : Calculus and Analytical Geometry.
4 F. Ayres : Calculus.
5 Das and Mukherjee : Integral Calculus.
6 M. R. Spigel : Advanced Calculus.
7 Williamson : Integral Calculus.

STA 1241: Mathematical Statistics

Conduct hours per week: 3.0 Credits: 3.0

Sl. No.	Course Contents
1	**Estimation:** Concept of estimation; Point estimation and its method; Characteristics of a good point estimator; Interval estimation and its method; Interval estimation of mean and variance of normal distribution.
2	**Hypothesis Testing:** Preliminaries of hypothesis and their types; Procedures and significance of testing hypothesis; Level of significance; One-tailed and two-tailed tests; Test statistics; Testing the significance of single mean and variance; Difference of two means; Ratio of two variances and their confidence intervals; Paired t-test; Simple correlation coefficient and regression coefficient tests; Testing the homogeneity of several population means and variances; Test of goodness of fit.
3	**Multivariate Analysis:** Meaning and application of multivariate analysis.
4	**Multivariate Normal Distributions:** Meaning, forms and properties of Multivariate Normal Distribution; Maximum Likelihood Estimator of Mean Vector and Variance Covariance Matrix and their properties; Multivariate Sampling Distributions: The distributions of Hotelling's T2, D2 and their properties; General Linear Regression Model: Meaning, Functional form and underlying assumptions; Estimation of parameter with its mean and variance.
5	**Principal Component Analysis:** Introduction to the Principal Component Analysis, ML Estimator of the Principal Components and their variances; Sampling properties of the Sample Principal Components, Statistical Inference.
6	**Factor Analysis:** Preliminaries of Factor Analysis; Mathematical Model for Factor Structure; ML Estimators for Random Orthogonal Factors; Estimation for Fixed Factors, Factor rotation; Testing the goodness of fit of the Factor Model.

Evaluation: Continuous Assessment: 30 marks (Class attendance: 10 marks, Class Test/ Assignment/ Presentation/ Quizzes: 20 marks).
Semester Final (3 hours) Examination: 70 marks. Seven questions of equal value will be set, of which any five are to be answered.

References:

1. Hoel P G : Introduction to Mathematical Statistics
2. Hogg and Craig : Introduction to Mathematical Statistics
3. Mood, Graybill and Boes : Introduction to the Theory of Statistics
4. Mostafa M G : Methods of Statistics

PHY 1251: Mechanics and Properties of Matter

Conduct hours per week: 3.0 Credits: 3.0

Sl. No.	Course Contents
1	**Vector Analysis:** Scalar product, Vector product, Triple vector products, Derivatives of vectors; Gradient, Divergence and Curl: Physical significance and their applications.
2	**Rotational Kinematics:** Rotational motion, Rotation with constant angular acceleration, Rotational quantities as a vector, Relation between kinematics for a particle in linear and circular motion (vector form).
3	**Elasticity:** Hook's law; Classification of modulus of elasticity; Poisson's ratio; Relation between elastic constants.
4	**Gravitation:** Newton's law; Gravitational field and potential and also their calculation in simple cases; Escape velocity; compound and Kater's pendulum.
5	**Fluid Dynamics:** Streamline flow; Turbulent flow; Poiseulli's equation, Reynolds number; Bernoulli's theorems and its applications.

Evaluation: Continuous Assessment: 30 marks (Class attendance: 10 marks, Class Test/ Assignment/ Presentation/ Quizzes: 20 marks).
Semester Final (3 hours) Examination: 70 marks. Seven questions of equal value will be set, of which any five are to be answered.

References:

1 Ahmed and Nath : Mechanics properties of Matter
2 Bandopadhya and Ghose : Padartha Bidya (Bengali)
3 Emran, *et. al.* : General Properties of Matter
4 Halliday and Resnick : Physics (1 and 2)

ENG 1261: Functional English

Conduct hours per week: 3.0 Credits: 3.0

SI. No.	Course Contents
1	**Grammar:** Parts of Speech, sentence, appropriate preposition, tenses, use of voice, phrase, conditionals, infinitive, participle, gerunds, right forms of verb, correction of sentences.
2	**Reading:** Reading strategies, paraphrasing and summarizing, effective reading, practicing comprehension.
3	**Writing:** **(a)** Situational Writing: Resume or Curriculum Vitae, paragraph writing, composition or essay writing, press releases, advertisements, thematic writing. **(b)** Scientific Writing: Distinctive features of scientific writing and research report writing.
4	**Speaking and Listening:** Correctly use of phonetic symbols, dialogue, responding to a particular situation, presentation.
5	**Developing vocabularies:** Suffixes, prefixes, synonyms and antonyms, conversion of words.
6	**Translation:** Process of translation, strategies, methods and procedures, types of translation, translation from English to Bengali and Bengali to English.

Evaluation: Continuous Assessment: 30 marks (Class attendance: 10 marks, Class Test/ Assignment/ Presentation/ Quizzes: 20 marks).
Semester Final (3 hours) Examination: 70 marks. Seven questions of equal value will be set, of which any five are to be answered.

References:

1 Allen, WS : Living English Structure
2 Fitikides, TJ : Common Mistakes in English
3 Ahmed, S : Learning English Grammar
4 Thomson, AJ and Martinet, AV : A Practical English Grammar
5 Swales, J : Writing Scientific English
6 Wren and Martin : English Grammar and composition
7 Vallins, GH : Good English
8 Hornby, As : The Teaching of Structural Words and Sentence Patterns (stages 1&2), (stages)
9 Sindair, J (Editor-in- Chief) : Collins Cobuild English Grammar

MAT 1272: Mathematica Lab

Conduct hours per week: 4.0 Credits: 2.0

SI. No.	Course Contents
1	**Basic Concepts:** Constants, 'Built-in' functions, basic arithmetic operations, strings, assignment and replacement, Logical Relations, sums and products, Loops, User-defined functions, Operations on functions.
2	**Lists:** Generating lists, list manipulation, set theory, tables and matrices.
3	**Two- and Three-Dimensional Graphics:** Plotting functions of single and two variables, Graphics commands, Special two and three-dimensional plots, Animation.
4	**Equations:** Solving algebraic and transcendental equations.
5	**Algebra and Trigonometry:** Polynomials, Rational and Algebraic functions, Trigonometric functions.
6	**Differential and Integral Calculus:** Limits, Derivatives, Maximum and minimum values, Power series, Anti-derivatives, Definite integrals, Riemann sums.

Evaluation: Continuous Assessment: 50 marks (Class attendance: 10 marks, Lab Report/ Assignment: 20 marks, Lab test: 20 marks). Semester Final (Lab: 4 hours) Examination: 50 marks.

MAT 1280: Viva-Voce

Credits: 1.0

Viva-Voce on courses taught in the 1st year 2nd semester.

Courses for 2nd Year 1st Semester

Sl. No.	Course Code	Course Title	Credits
1	MAT 2111	Linear Algebra	2
2	MAT 2121	Algebra and Trigonometry	3
3	MAT 2131	Advanced Calculus	3
4	MAT 2141	Ordinary Differential Equation I	3
5	PHY 2151	Heat, Thermodynamics and Optics	3
6	CSE 2161	Structured Programming Language	2
7	CSE 2162	Structured Programming Language Lab	2
8	MAT 2170	Viva-Voce	1
		Total Credits:	19

MAT 2111: Linear Algebra

Conduct hours per week: 2.0 Credits: 2.0

SI. No.	Course Contents
1	**Vector spaces and subspaces:** Vector space and subspace of a vector space, Linear combinations, Linear spans, sums and direct sums.
2	**Basis and Dimension:** Linear dependence and independence, Basis and dimension of a vector space, Rank and nullity of a matrix, Applications to linear equations.
3	**Linear Transformations:** Range, kernel, singular and nonsingular transformations, Operations with linear mappings, Algebra of linear operators, Invertible operator.
4	M**atrices of Linear Mappings/Operators:** Linear operators, matrix representation of a linear operator, change of basis, similarity, matrices and general linear mappings.
5	**Linear Functional and the Dual space:** Linear functional and the dual space of a vector space, Dual basis, Annihilators.
6	**Inner Products:** Norms and inner products. Orthogonal complements, orthonormal sets, Gram Schmidt orthogonalization process, Adjoint operators, Hermitian, Unitary, Orthogonal and Normal operators.
7	**Bilinear, Quadratic & Hermitian forms:** Matrix form; transformations; canonical forms; reduction form; definite and semi-definite forms; principal minors; and factorable forms.

Evaluation: Continuous Assessment: 30 marks (Class attendance: 10 marks, Class Test/ Assignment/ Presentation/ Quizzes: 20 marks).
Semester Final (3 hours) Examination: 70 marks. Seven questions of equal value will be set, of which any five are to be answered.

References:

1. S. Lipshutz, Linear Algebra, Schaum's Outline Series.
2. A.H. David: Matrix Algebra from a statistician perspective, Springer-Verlag, New York, Inc
3. L.N. Herstein: Topics in Algebra
4. S. Lipschutz: Theory and Problems of Linear Algebra, McGraw-Hill, New York.

MAT 2121: Algebra and Trigonometry

Conduct hours per week: 3.0 Credits: 3.0

SI. No.	Course Contents
1	**Inequalities:** Arithmetic, Geometric and Harmonic Means with examples. Weierstrass, Cauchy's and Chebyshev's inequalities.
2	**Summation of Series:** Summation of Algebraic and Trigonometric Series, Sum of sines and cosines of n angles in Arithmetic progression.
3	**Theory of Equations:** Fundamental theorem of algebra, Relation between roots and coefficients, Descartes rule of sign, Nature of the roots, Solution of cubic and biquadratic equation.
4	**Cubic and Biquadratic Equations:** Solution of cubic and biquadratic equations and their applications.
5	**Complex number system:** Complex number, Functions of complex arguments, Periodicity of circular and exponential functions, Logarithm of complex quantity, Inverse circular functions of complex arguments, De-Moivre's theorem and it's application.
6	**Hyperbolic Functions:** Hyperbolic functions and their solutions, Formulae of Hyperbolic functions, Expansions of sinhx and coshx, Periodicity of Hyperbolic functions.

Evaluation: Continuous Assessment: 30 marks (Class attendance: 10 marks, Class Test/ Assignment/ Presentation/ Quizzes: 20 marks).
Semester Final (3 hours) Examination: 70 marks. Seven questions of equal value will be set, of which any five are to be answered.

References:

1. Bernard and Child : Higher Algebra.
2. Burnside and Panton : Theory of equations.
3. Hall and Knight : Higher Algebra.
4. Das and Mukherjee : Higher Trigonometry.
5. Sattar, M.A. : Higher Trigonometry.

MAT 2131: Advanced Calculus

Conduct hours per week: 3.0 Credits: 3.0

Sl. No.	Course Contents
1	**Function of several variables:** Partial differentiation, total differentiation, differentials, Euler's theorem of homogeneous function, Taylor's series for function of several variables, Jacobian, Heissen matrix.
2	**Extrema of functions of several variables:** Maxima and Minima of function of several variables and applications, Lagrange's undetermined multiplier.
3	**Curvature of plane curve:** Concave and convex curve, Node, cusp, conjugate point, the point of inflexion, curve tracing.
4	**Definite integral:** Integration under the sign of differentiation and integration, Improper integral, Theorem of Frullani, Applications of definite integral.
5	**Multiple integral:** Double integration, triple integration, Diritchlet's Theorem, Change of order of integration, Determination of arc length, areas and volume using multiple integral.

Evaluation: Continuous Assessment: 30 marks (Class attendance: 10 marks, Class Test/ Assignment/ Presentation/ Quizzes: 20 marks).
Semester Final (3 hours) Examination: 70 marks. Seven questions of equal value will be set, of which any five are to be answered.

References:

1. M. R. Spiegel : Advanced Calculus.
2. Williamson : Integral Calculus.
3. Edwards J. : Dierential Calculus.
4. Wider : Advanced Calculus.

MAT 2141: Ordinary Differential Equation I

Conduct hours per week: 3.0 Credits: 3.0

Sl. No.	Course Contents
1	**Ordinary differential equations and their solutions:** Classification of differential equations. Solutions. Implicit solutions. Singular solutions. Initial and Boundary value problems. Basic existence and uniqueness theorems (statement and illustration only). Direction fields and Phase plane.
2	**Solution of first order equations:** Separable equations. Linear equations, Exact equations, Integrating factors, Substitutions and transformations.
3	**Modelling with first order differential equations:** Construction of differential equations as mathematical models (exponential growth and decay, heating and cooling, mixture of solutions, series circuit, logistic growth, chemical reaction, falling bodies). Model solutions and interpretation of results. Orthogonal and oblique trajectories.
4	**Solution of higher order linear differential equations:** Linear differential operators. Basic theory of linear differential equations. Solution space of homogeneous linear equations. Fundamental solutions of homogeneous equations. Reduction of order. Homogeneous and Non-homogeneous linear equations with constant coefficients. Method of undetermined coefficients and variation of parameters. Inverse operators. Cauchy-Euler differential equations.
5	**Modelling with second-order equations:** Vibration of a mass on a spring, free and undamped motion; free and damped motion; forced motion; resonance phenomena; electric circuit problems, motion of a rocket.

Evaluation: Continuous Assessment: 30 marks (Class attendance: 10 marks, Class Test/ Assignment/ Presentation/ Quizzes: 20 marks).
Semester Final (3 hours) Examination: 70 marks. Seven questions of equal value will be set, of which any five are to be answered.

References:

1. S. L. Ross, Differential Equations, John Wiley and Sons 19.
2. D. G. Zill, A First Course in Differential Equations with Applications, Brooks Cole.
3. Earl D Rainville and Phillip E Bedient, Elementary Differential equations, Macmillan.
4. F. Brauer & J. A. Nohel, Ordinary Differential Equations: A First Course, W. A. Benjamin.
5. Erwin Kreyszig, Advanced engineering mathematics, John Wiley.

PHY 2151: Heat, Thermodynamics and Optics

Conduct hours per week: 3.0 Credits: 3.0

Sl. No.	Course Contents
1	**Thermometry:** Gas thermometers and their corrections; measurement of low and high temperatures; platinum resistance thermometer; thermocouple.
2	**Kinetic Theory of Gases:** Kinetic theory of gas, deduction of Boyle's; Charles' and Avogadro's laws, determination of gas constants; mean free path.
3	**Liquefaction of gases:** Different methods of liquefaction of air and nitrogen; refrigeration.
4	**Thermal conduction:** Thermal conductivity; Fourier's equations of heat flow; thermal conductivities of good and bad conductors.
5	**First law of Thermodynamics:** Internal energy; work done by expanding fluid'; specific heats of perfect gases; ratio of Cp to C, isothermal and adiabatic expansions.
6	**Second law of Thermodynamics and Entropy:** Reversible and irreversible processes; Carnot's cycle; efficiency of heat engines; absolute scale of temperature; Clausius and Clapeyron's theorem; entropy; change of entropy in reversible and irreversible processes.
7	**Geometrical optics:** Fermat's principle, theory of equivalent lenses; defect of images; optical instruments, dispersion; rainbow.

Evaluation: Continuous Assessment: 30 marks (Class attendance: 10 marks, Class Test/ Assignment/ Presentation/ Quizzes: 20 marks).
Semester Final (3 hours) Examination: 70 marks. Seven questions of equal value will be set, of which any five are to be answered.

References:

1. Bhulyah and Rahnift : Text Book of Heat, Thermodynamics and Radiation.
2. Hallidary and Rasnlak : Physics (I and II).
3. Sahel and Srivastava : A treatise on Heat.
5. Zeman6ky : Heat and Thermodynamics.
6. Sears : Optics.

CSE 2161: Structured Programming Language

Conduct hours per week: 2.0 Credits: 2.0

SI. No.	Course Contents
1	**Program and software:** Overview of programming language, programming language generation, structural programming language, Functional programming language, Compiler and interpreter basic, software concepts and its classification.
2	**C-Language:** Preliminaries, Program constructions, variables and data types in C. Input and output. Character and formatted I/O; Arithmetic Expressions and Assignment statements; Branching Loops and Nested loops; Decision making; Arrays, Functions; Arguments and local variables, Calling Functions and arrays. Recursion and Recursive functions; Structures within a structure, union Pointers; Pointers and structures; Pointer and functions; Pointer and arrays; Operation and Pointer; Pointer and memory addresses; Files; File functions for sequential and Random (I/O). Operations on Bits; Bit Operation; Bit field; Advanced features; Standard and library.

Evaluation: Continuous Assessment: 30 marks (Class attendance: 10 marks, Class Test/ Assignment/ Presentation/ Quizzes: 20 marks).
Semester Final (3 hours) Examination: 70 marks. Seven questions of equal value will be set, of which any five are to be answered.

References:

1. Programming in C – Stephen G. Kochan.
2. Teach Yourself C – Herbert Schildt.
3. The Ultimate Reference for C contestant – Herbert Schildt.

CSE 2162: Structured Programming Language Lab

Conduct hours per week: 4.0 Credits: 2.0

SI. No.	Course Contents
1	**Introduction to Programming Tools:** environmental setup for programming; installation of IDEs; compilation and execution programs,
2	**Syntax and semantics of C programs:** introducing syntax and semantics of C programs; designing modular C programs; introducing different header files; how to use comments or documentation in programs.
3	**Variables and data types:** scope of variables; defining and initialize of variables; use case and types of variables; different data types, including built-in and user-defined.
4	**Operators and expressions:** introducing different types of operators in C programs; implementing various kinds of expressions, including mathematical, logical or any business-oriented (e.g., balance sheet calculation or payroll calculation) and scientific expression.
5	**Conditions and looping:** introducing different types of conditional statements such as *if, if-else, else-if ladder*, and switch case statement; use case and structure of looping statement, including *for*, *while*, *do-while* and nested loops.
6	**Arrays and matrix:** initializing and defining arrays; use case of arrays; matrix operations: addition, subtraction, and multiplication.
7	**Functions and procedures:** introducing user-defined and built-in functions (e.g., mathematical, or timer function); designing user-defined functional program.

Evaluation: Continuous Assessment: 50 marks (Class attendance: 10 marks, Lab Report/ Assignment: 20 marks, Lab test: 20 marks). Semester Final (Lab: 4 hours) Examination: 50 marks.

MAT 2170: Viva-Voce

Credits: 1.0

Viva-Voce on courses taught in the 2nd year 1st semester.

Courses for 2nd Year 2nd Semester

Sl. No.	Course Code	Course Title	Credits
1	MAT 2211	Real Analysis I	3
2	MAT 2221	Numerical Analysis I	3
3	MAT 2231	Vector Calculus	3
4	MAT 2241	Ordinary Differential Equation II	3
5	PHY 2251	Electricity and Magnetism	3
6	CSE 2261	Data Structure	2
7	CSE 2262	Data Structure Lab	2
8	MAT 2270	Viva-Voce	1
		Total Credits:	20

MAT 2211: Real Analysis I

Conduct hours per week: 3.0 Credits: 3.0

SI. No.	Course Contents
1	**Real number systems:** Natural and integer numbers, rational and irrational numbers, real numbers, algebraic and order properties of real numbers, consequences of the algebraic and order axioms, absolute value and real line, properties of absolute value, upper and lower bounds of a set and function.
2	**Completeness Property of Real Numbers:** Maximum and minimum of a set, least upper bound and greatest lower bound, axiom of completeness, Archimedean property, density of the set of rational and irrational, applications of the supremum property.
3	**Metric spaces:** Metric on real numbers**,** open and closed sets, compact sets, perfect sets, cantor sets.
4	**Sequences:** Concept of sequence, convergence and divergence of sequence, approximating supremum and infimum by sequence, Cauchy sequence, bounded sequence, monotonically increasing and decreasing sequence, monotone convergence theorem, subsequences, Bolzano-Weierstrass theorem, completeness of the set of rational, irrationals and real numbers, Cauchy's criterion for convergent sequence.
5	**Series:** Concept of series, relation between sequence and series, Cauchy's criterion of convergent series, comparison test, integral test, root and ratio test, absolutely and conditionally convergent.
6	**Continuity:** Limits and continuity of functions, sequential criterion of limits and continuity, intermediate value theorem, extreme value theorem, uniform continuity, sequential criterion of uniform continuity, uniform continuity on compact set Lipschitz's continuity.
7	**Differentiability:** Differentiability of functions, intermediate value theorem for derivatives, Rolle's theorem, mean value theorem, inverse functions theorem.

Evaluation: Continuous Assessment: 30 marks (Class attendance: 10 marks, Class Test/ Assignment/ Presentation/ Quizzes: 20 marks).
Semester Final (3 hours) Examination: 70 marks. Seven questions of equal value will be set, of which any five are to be answered.

References:

1. Stephen Abbott, Understanding Analysis.
2. K. A. Ross, Elementary Analysis: The Theory of Calculus.
3. R. G. Bartle, & D. R. Sherbert, Introduction to Real Analysis.
4. W. Rudin, Principles of Mathematical Analysis.
5. M. Ramzan Ali Sarder, Elements of Real Analysis.

MAT 2221: Numerical Analysis I

Conduct hours per week: 3.0 Credits: 3.0

Sl. No.	Course Contents
1	**Preliminaries of Computing:** Basic concepts, Floating point arithmetic, Types of errors and their computation, Convergence.
2	**Numerical solution of non-linear and transcendental equations:** Bisection method, Method of false position. Fixed point iteration, Newton-Raphson method, Iterative method and Error Analysis.
3	**Interpolation and polynomial approximation:** Taylor polynomials, Interpolation and Lagrange polynomial, Iterated interpolation, Richardson's extrapolation.
4	**Numerical Differentiation and Integration:** Numerical differentiation, Richardson's extrapolation, Elements of Numerical Integration, Trapezoidal, Simpson's, Weddle's etc., Adaptive quadrature method, Romberg's integration.
5	**Numerical Solutions of linear systems:** Direct methods for solving linear systems, Gaussian elimination and backward substitution, pivoting strategies, numerical factorizations.

Evaluation: Continuous Assessment: 30 marks (Class attendance: 10 marks, Class Test/ Assignment/ Presentation/ Quizzes: 20 marks).
Semester Final (3 hours) Examination: 70 marks. Seven questions of equal value will be set, of which any five are to be answered.

References:

1. Numerical Analysis–Richard L. Burden and, J. Douglas Faires.
2. Introduction to Numerical Analysis–S.S. Sastry.
3. E.W. Swokowski, Calculus with Analytic Geometry, Brooks/Cole.
4. G.B. Thomas and R. L. Finney, Calculus and Analytic Geometry, Addison Wesley.
5. J. Stewart, Multi Variable Calculus: Early Transcendentals, Cengage Learning.
6. W. Rudin, Principle of Mathematical Analysis.

MAT 2231: Vector Calculus

Conduct hours per week: 3.0 Credits: 3.0

Sl. No.	Course Contents
1	**Vectors and Scalars:** Definitions and fundamental laws, Dot product, Cross product, Box product, Reciprocal vectors, Equation of planes, Straight lines, Spheres, Vector triple product and their applications.
2	**Vector differentiation:** Ordinary derivatives of vector-valued functions, Continuity, Differentiability, Partial derivatives of vectors.
3	**Vector differential operators:** Gradient, Divergence, Curl and their related problems.
4	**Vector integration:** Line integration, Surface integration, Volume integration and their applications.
5	**Integral theorems:** Green's theorem, Gauss's divergence theorem, Stoke's theorem and their applications.
6	**Coordinates:** Curvilinear coordinates, Transformation of coordinates, Special orthogonal coordinates system.

Evaluation: Continuous Assessment: 30 marks (Class attendance: 10 marks, Class Test/ Assignment/ Presentation/ Quizzes: 20 marks).
Semester Final (3 hours) Examination: 70 marks. Seven questions of equal value will be set, of which any five are to be answered.

References:

1. M. R. Spiegel : Vector and Tensor Analysis.
2. M.A. Sattar : Vector Analysis.
3. Khosh Mohammad, Analytic Geometry and Vector Analysis.
4. J. A. Hummel, Vector Geometry.

MAT 2241: Ordinary Differential Equation II

Conduct hours per week: 3.0 Credits: 3.0

Sl. No.	Course Contents
1	**Existence and uniqueness theory:** Fundamental existence and uniqueness theorem. Dependence of solutions on initial conditions and equation parameters. Existence and uniqueness theorems for systems of equations and higher-order equations.
2	**Series solutions of second order linear equations:** Taylor series solutions about an ordinary point. Frobenius series solutions about regular singular points.
3	**Legendre functions**: Generating function, recurrence relations and other properties of Legendre polynomials, Expansion theorem, Legendre differential equation, Legendre function of first kind, Legendre function of second kind, associated Legendre functions.
4	**Bessel functions**: Generating function, recurrence relations, Bessel differential equation, Integral representations Orthogonality relations, Modified Bessel functions.
5	**Hermite & Laguerre polynomials:** Generating function, Rodrigues' formula, orthogonal properties, Hermite and Laguerre differential equation, recurrence relations, expansion theorems.
6	**Special functions:** Gamma function. Error function. Hyper geometric equation, special hyper geometric function, Generalized hyper geometric function, special confluent hyperbolic functions.
7	**Systems of linear first order differential equations:** Elimination method. Matrix method for homogeneous linear systems with constant coefficients. Variation of parameters. Matrix exponential.

Evaluation: Continuous Assessment: 30 marks (Class attendance: 10 marks, Class Test/ Assignment/ Presentation/ Quizzes: 20 marks).
Semester Final (3 hours) Examination: 70 marks. Seven questions of equal value will be set, of which any five are to be answered.

References:

1. S. L. Ross, Differential Equations.
2. D. G. Zill, A First Course in Differential Equations with Applications.
3. F. Brauer & J. A. Nohel, Differential Equations.
4. H.J.H. Piaggio, An Elementary Treatise on Differential Equations.
5. W.N. Lebedev & R.A. Silverman, Special Functions and their Applications.

PHY 2251: Electricity and Magnetism

Conduct hours per week: 3.0 Credits: 3.0

Sl. No.	Course Contents
1	**Electrostatistics:** Electric dipole, electric field due to a dipole, dipole on external electric field, Gauss's law and its applications.
2	**Capacitor:** parallel plate capacitors with dielectrics, dielectric constant; energy stored in an electric field.
3	**Electric Current:** Electron theory of conductivity: conductor, semiconductors and insulators, superconductors, current and current density, current and current density, Kirchhoff's Law and its applications.
4	**Thermoelectricity:** Thermal e.m.f. Seebeck, Peltier and Thomson Effects, laws of thermal e.m.f.s thermoelectric power.
5	**DC and AC circuits:** DC circuits with LR, RC, LC and LCR in series, AC circuits with LR, RC, LC and LCR in series.
6	**Magnetism:** Magnetic dipole, mutual potential energy of two small magnets: magnetic shell, energy in a magnetic field, magnetometers.
7	**Electromagnetic Induction:** Faraday's experiment; Faraday's law Ampere's law, Biot-Savart law, Derivatives of Maxwell's_Equation, motional e.m.f. self and mutual inductance; galvanometers-moving cell ballistic and deadbeat types.

Evaluation: Continuous Assessment: 30 marks (Class attendance: 10 marks, Class Test/ Assignment/ Presentation/ Quizzes: 20 marks).
Semester Final (3 hours) Examination: 70 marks. Seven questions of equal value will be set, of which any five are to be answered.

References:

1. Electricity and Magnetism with Electronics – K. K. Tewari.
2. Electricity Magnetism and Electronics – B. L. Theraja,
3. Physics – R. Resnick, D. Halliday, and Krane.
4. Electricity Magnetism and Electronics – Duckworth, H.E.

CSE 2261: Data Structure

Conduct hours per week: 2.0 Credits: 2.0

SI. No.	Course Contents
1	**Introduction:** concept and importance of data, data structure, the relation between the data structure and algorithm (program), major operations on the data structure.
2	**Array:** Definition of one-dimensional and two-dimensional arrays and their representations, different operations using an array.
3	**Linked List:** Concept of pointers, linearly linked list, doubly linked list, circular linked list. Operation on each type of liked list.
4	**Stack:** Definition of the stack, its implementation using an array and linked list. Prefix to postfix conversion using the stack. Evaluation of mathematical expression using the stack.
5	**Queue:** Concept of the queue, representation of queue using an array and linked list with implementation. Drawbacks for array-based queue and application of queue in the network, the internet, etc.
6	**Tree:** Definition of different types of trees. Representation of binary tree using an array. Binary tree traversal methods using recursive functions. Binary search tree and different operations on it, The concept of the heap, and different operations on the heap.
7	**Graph:** The concept of different types of graphs. Representation of graphs using an array. Graph traversal methods. Definition of spanning tree and minimum cost spanning tree. Single source shortest path problem and related algorithm.
8	**Searching and Sorting:** Definition of searching and algorithms related to searching. The concept of internal and external sorts. Some elementary sorting algorithms (bubble sort, selection sort, insertion sort).

Evaluation: Continuous Assessment: 30 marks (Class attendance: 10 marks, Class Test/ Assignment/ Presentation/ Quizzes: 20 marks).
Semester Final (3 hours) Examination: 70 marks. Seven questions of equal value will be set, of which any five are to be answered.

References:

1. Data Structure Schaum Series – Seymour Lipschutz, Seymour Lipschutz Manual, 5thEdition, 2019.
2. Data Structures and Algorithms Made Easy – Narasimha Karumanchi, Paperback, 3rdEdition, 2018.
3. Algorithm Design – Jon Kleinberg, Eva Tardos, Kindle Edition, 1stEdition, 2019.
4. Fundamentals of Data Structure – Ellis Horowitz, Sartaj Sahni, computer science Press.
5. Data Structures – Richard F, Gilberg, Forouzan, Cengage, 2/e, 2005.

CSE 2262: Data Structure Lab

Conduct hours per week: 4.0 Credits: 2.0

SI. No.	Course Contents
1	**Introduction:** Implementation of some elementary programs where different types of data are used. **Array:** Implementation of searching, insertion, merging operations using a one-dimensional array. Implementation of some algorithms where two-dimensional arrays are used.
2	**Linked List:** Implementation of algorithms to add a node to a different place of linear linked and doubly linked list. Similarly, development of programs to delete a node from different places of linear and doubly-linked lists.
3	**Stack:** Development of programs to evaluate a mathematical expression using the stack, to convert prefix to postfix expression and evaluate the expression using the stack. **Queue:** Do practical using array-based and linked list-based queues.
4	**Tree:** Development of programs to represent binary trees using an array and linked list. Implementation of Binary tree traversal methods using recursive functions. Create a Binary search tree and perform different operations on it. Create heap and perform different operations such as the addition of a node and deletion of root node from the heap. **Graph:** Develop a program to store data of the graph and implement BFS and DFS traversal methods.
5	**Searching and Sorting:** Implementation of searching and sorting algorithms. **Hashing:** Development of the program to create a hash table to store data in it and implementation of some hash collision resolution schemes.

Evaluation: Continuous Assessment: 50 marks (Class attendance: 10 marks, Lab Report/ Assignment: 20 marks, Lab test: 20 marks). Semester Final (Lab: 4 hours) Examination: 50 marks.

MAT 2270: Viva-Voce

Credits: 1.0

Viva-Voce on courses taught in the 2nd year 2nd semester.

Courses for 3rd Year 1st Semester

Sl. No.	Course Code	Course Title	Credits
1	MAT 3111	Real Analysis II	3
2	MAT 3121	Numerical Analysis II	3
3	MAT 3131	Mechanics I	3
4	MAT 3141	Partial Differential Equation	3
5	MAT 3151	Mathematical Methods I	3
6	MAT 3162	FORTRAN/ Python Programing Lab	2
7	MAT 3170	Viva-Voce	1
		Total Credits: 18	

MAT 3111: Real Analysis II

Conduct hours per week: 3.0 Credits: 3.0

SI. No.	Course Contents
1	**Euclidean Space:** Definition and properties, k-cell, Relationship among metric space, perfect set and uncountable set in $\mathbb{R}^k$, Heine-Borel theorem, Weierstrass theorem, Cantor set.
2	**Functions of Several Variables:** Level curves and level surfaces, open and closed sets, Limit and continuity of two variables, Partial differentiation, Schwarz's theorem and Young's theorem, Directional derivative, Total derivative, Contraction principle, Banach's fixed point theorem and its applications in differential equations, The inverse and implicit function theorem.
3	**The Riemann Integral:** Definition and existence of the integrals, Properties of the integrals, Mean-value theorem, Indefinite-integral theorem, fundamental theorem of calculus, The Riemann-Stieltjes integral.
4	**Sequences of Functions:** Basic concept, Point wise convergence, uniform convergence and continuity, importance of uniform convergence.
5	**Series of Functions:** Fundamental concept, Point wise and uniform convergence of series of functions, uniform convergence and integration, uniform convergence and differentiation, geometric series, power series and Taylor series.
6	**Metric on Function spaces:** Definition and examples, open and closed sets, topology, completeness and compactness, pre-compactness, uniform boundless and equicontinuity, Stone-Weierstrass's theorem, Arzela-Ascoli's theorem, Peano's existence theorem.

Evaluation: Continuous Assessment: 30 marks (Class attendance: 10 marks, Class Test/ Assignment/ Presentation/ Quizzes: 20 marks).
Semester Final (3 hours) Examination: 70 marks. Seven questions of equal value will be set, of which any five are to be answered.

References:

1 W. Rudin : Principles of Mathematical Analysis
2 M.H. Proter & C.B. Morey : Modern Mathematical Analysis
3 Bortle : Real Analysis
4 Royden : Mathematical Analysis
5 Apostal : Mathematical Analysis

MAT 3121: Numerical Analysis II

Conduct hours per week: 3.0 Credits: 3.0

SI. No.	Course Contents
1	**Iterative Techniques in Matrix Algebra:** Jacobi method, Gauss-Seidel Method, SOR method, Eigenvalues and eigenvectors, the power method, Householder's method, Q-R method.
2	**Nonlinear System of Equations:** Fixed point for functions of several variables, Newton's method, Quasi-Newton's method, Steepest Descent techniques.
3	**Initial value problems for ODE:** Euler's and modified Euler's method, Higher order Taylor's method, Single-step methods (Runge-Kutta methods, extrapolation methods, higher order differential equations and systems of differential equations), Multi-step methods (Adams-Bashforth, Adams-Moulton, Predictor-Corrector), error and stability analysis. Numerical solutions of Systems of Differential Equations (IVP).
4	**Boundary Value Problem for ODE:** Shooting method for linear and nonlinear problems, Finite difference methods for linear and nonlinear problems, the Rayleigh-Ritz Method (Piecewise Linear, and cubic splines).

Evaluation: Continuous Assessment: 30 marks (Class attendance: 10 marks, Class Test/ Assignment/ Presentation/ Quizzes: 20 marks).
Semester Final (3 hours) Examination: 70 marks. Seven questions of equal value will be set, of which any five are to be answered.

References:

1. Sastry, S.S.: Introductory Methods of Numerical Analysis
2. Henrici, P.: Elements of Numerical Analysis
3. Burden, Faires and Reynolds: Numerical Analysis
4. Bashishthe, A. R.: Numerical Analysis
5. Steven C. Chapra, Raymond P. Canale: Numerical Methods for Engineers.

MAT 3131: Mechanics I

Conduct hours per week: 3.0 Credits: 3.0

Sl. No.	Course Contents
1	**General conditions of equilibrium:** The reduction of coplanar forces; Equilibrium of coplanar forces; Astatic equilibrium and its conditions; General conditions of equilibrium forces.
2	**Principal of Virtual Work:** Work; Virtual displacement; Virtual work and its theorem; Miscellaneous problems on virtual work
3	**Stable and Unstable Equilibrium:** Stable, unstable and neutral equilibrium; Theorems and miscellaneous problems on stable, unstable and neutral equilibrium.
4	**Centre of Gravity:** Centre of gravity of an arc, a plane area, a solid and surface of revolution; Miscellaneous problems on centre of gravity.
5	**Equilibrium of flexible strings and Chains:** The common catenary; General condition of equilibrium of string; Catenary of a uniform strength; String under central forces; Miscellaneous problems.

Evaluation: Continuous Assessment: 30 marks (Class attendance: 10 marks, Class Test/ Assignment/ Presentation/ Quizzes: 20 marks).
Semester Final (3 hours) Examination: 70 marks. Seven questions of equal value will be set, of which any five are to be answered.

References:

1. S. L. Loney : An Elementary treatise on the dynamic of a particle and of Rigid Bodies
2. S. L. Loney : An Elementary treatise on statics
3. A. S. Ramsey : Dynamics
4. P. P. Gupta : Statics
5. G. S. Malik : Dynamics

MAT 3141: Partial Differential Equation

Conduct hours per week: 3.0 Credits: 3.0

SI. No.	Course Contents
1	**Total Differential Equations: C**ondition of Integrability; Solution of exact, homogeneous, non-homogeneous and special form partial differential equations. Application of partial differential equations.
2	**i) Formation of partial differential equations**: Elimination of arbitrary constant functions. **ii) First Order linear PDEs:** General Solution, Lagrange form, Complete Solution.
3	**First Order quasilinear PDEs:** First Order non-linear PDEs, General Solution for four types form, Charpit's method, Jacobi method.
4	**(i) Second Order homogeneous PDEs with Constant Coefficients.** **(ii) Second order non- homogeneous PDEs with Constant Coefficients:** Reducible forms, Irreducible form.
5	**Non-homogeneous PDEs with constant Coefficients:** PDEs of order two with variable coefficients; Laplace transformation; Monge's Method.
6	**Classification of general second order PDEs and Canonical forms.**
7	**Laplace's equation in Cartesian, cylindrical, and Spherical coordinates in two and three-dimension.**
8	**Boundary value problem:** Method of Separation of variables; Solution of wave and heat equations; D' Alembert's method.

Evaluation: Continuous Assessment: 30 marks (Class attendance: 10 marks, Class Test/ Assignment/ Presentation/ Quizzes: 20 marks).
Semester Final (3 hours) Examination: 70 marks. Seven questions of equal value will be set, of which any five are to be answered.

References:

1. Ayres, F. : Differential Equations.
2. Sneddon, I.N. : Elements of Partial Differential Equations
3. Dennemeyer, R. : Introduction to Partial Differential Equations
4. Myint, U.T. : Partial Differential Equations
5. Sharma, B.D. : Partial Differential Equations

MAT 3151: Mathematical Methods I

Conduct hours per week: 2.0 Credits: 3.0

SI. No.	Course Contents
1	**Fourier series:** Fourier series and its convergence, Fourier sine and cosine series, properties of Fourier series, Operations on Fourier series, Complex form, Applications of Fourier series, Such as Steady Periodic solution of 2^{nd} order ODE and solution of PDE (Heat and Wave equation).
2	**Fourier transforms:** Fourier transforms, Inversion theorem, sine and cosine transforms, Transform of derivatives, Transforms of a rational function, Convolution theorem, Parseval's theorem, Applications to boundary value problems and integral equation.
3	**Laplace transforms:** Laplace transforms and application to initial value problems, Application to solve ordinary differential equations, Laplace transforms, Review of basic definitions and properties, Existence theorem, Transform of derivatives, Relations involving integrals, Transforms of periodic functions, Transforms of convolutions, Inverse transform, Calculation of inverse transforms, Use of contour integration, Applications.
4	**Z-transformation:** Definition, Expansion, Relation between Fourier Series and Z-transformation.

Evaluation: Continuous Assessment: 30 marks (Class attendance: 10 marks, Class Test/ Assignment/ Presentation/ Quizzes: 20 marks).
Semester Final (3 hours) Examination: 70 marks. Seven questions of equal value will be set, of which any five are to be answered.

References:

1. Jeffreys and Jeffreys : Methods of Mathematical Physics
2. Courant and Hilbert : Methods of Mathematical Physics
3. B.S. Rajput : Mathematical Physics
4. M R Spiezel : Laplace Transforms
5. B.D. Sharma and R.K. Gupta : Mathematical Method
6. M J Lighthill : Asymptotic Expansion
7. L Apipes : Applied Mathematics for Engg. & Scientist

MAT 3162: FORTRAN/ Python Programing Lab

Conduct hours per week: 4.0 Credits: 2.0

SI. No.	Course Contents
1	**Elementary programs using conditionals:** Solving quadratic equations, Finding areas and circumferences of circles, triangles etc. Determination of center and radius of the circumcircle of a triangle.
2	**Programs using do loops:** Summation of series, product of factors, testing of prime numbers.
3	**Programs using select case:** Finding number of days if the year and month is given, tabulating results of students from the marks of different courses, printing salary sheet of employees of an organization.
4	**Programs of arrays:** Printing Fibonacci numbers, sorting in ascending / descending order of a given array, searching the highest and lowest number in a given array, addition and multiplication of matrices, transposing of matrices.
5	**Using Functions and subroutine:** Defining factorial of a non-negative integer, defining a given function and printing its values at a set of equally spaced points. Calculation of A.M., G.M, H.M, S.D., M.D etc. of an array of numbers. Elementary row operations of matrices, solving a system of linear equations.
6	**File processing:** Printing an array of numbers in a file, reading two matrices from a file and printing the addition/ subtraction / multiplication in another file. Creating, editing, appending files of student's records.

Evaluation: Continuous Assessment: 50 marks (Class attendance: 10 marks, Lab Report/ Assignment: 20 marks, Lab test: 20 marks). Semester Final (Lab: 4 hours) Examination: 50 marks.

MAT 3170: Viva-Voce

Credits: 1.0

Viva-Voce on courses taught in the 3rd year 1st semester.

Courses for 3rd Year 2nd Semester

Sl. No.	Course Code	Course Title	Credits
1	MAT 3211	Abstract Algebra	3
2	MAT 3221	Complex Analysis	3
3	MAT 3231	Mechanics II	3
4	MAT 3241	Tensor Analysis	3
5	MAT 3251	Mathematical Methods II	3
6	MAT 3261	Linear Programming	3
7	MAT 3262	MATLAB I	2
8	MAT 3270	Viva-Voce	1
		Total Credits: 21	

MAT 3211: Abstract Algebra

Conduct hours per week: 3.0 Credits: 3.0

Sl. No.	Course Contents
1	**Groups:** Binary operations, concept of group, groupoid, semi-group, order of a group, order of an element, Abelian group.
2	**Subgroups:** Subgroups, characteristics of subgroup, criteria of a subgroup, union of a subgroup and related theorems, co-sets, Lagrange's theorem, cyclic groups.
	Normal subgroups: Definition of normal subgroup, proper and improper normal subgroup, simple and Hamiltonian group, normal subgroup related theorems, quotient groups.
3	**Permutation groups:** Transformation, symmetric group of permutations, inverse and identity permutations, cyclic permutations, transposition, Alternative groups, orbit of a permutation.
4	**Homomorphism and isomorphism of groups:** Homomorphism, isomorphism, monomorphism and epimorphism, the isomorphism theorems, automorphism.
5	**Rings:** Concept of ring, various types of rings, properties of rings, characteristics of a ring, subrings, ideals, quotient rings, principal ideal, principal ideal ring, prime and maximal ideals.
6	**Integral domains and fields:** Characteristic of a ring, characteristic zero, characteristic of a ring, ordered integral domains, homomorphism and isomorphism of rings, factorization in integral domain.

Evaluation: Continuous Assessment: 30 marks (Class attendance: 10 marks, Class Test/ Assignment/ Presentation/ Quizzes: 20 marks).
Semester Final (3 hours) Examination: 70 marks. Seven questions of equal value will be set, of which any five are to be answered.

References:

1. P.B. Bhattarcharya, S.K. Jain & S.R. Nagpaul, Basic Abstract Algebra.
2. W.K. Nicholson, Introduction to Abstract Algebra.
3. J.B. Fraleigh, Introduction to Abstract Algebra.
4. M. Artin, Algebra.
5. R S Aggarwal, A Text Book on Modern Algebra.

MAT 3221: Complex Analysis

Conduct hours per week: 3.0 Credits: 3.0

Sl. No.	Course Contents
1	**Complex Plane:** Complex number and its properties with proof, polar form of a complex number, geometric representation of complex number.
2	**Complex Function:** Single and many valued functions; Limit, continuity and differentiability of a complex function; Analytic function and their properties; Singularity and its types; Harmonic function and its applications.
3	**Complex Integration:** Line integration over rectifiable curves; Winding number; Cauchy's theorem; Cauchy's integral formula; Liouville's theorem; Argument theorem; Fundamental theorem of algebra; Rouche's theorem; The maximum and the minimum modulus theorem.
4	**Infinite Series:** Power series of a complex terms; Taylor's theorem and its application; Laurent's theorem and its application; Entire and meromorphic functions.
5	**Calculation of Residues:** Residues; Cauchy's residues theorem; contour integration; Branch point and cuts.
6	**Bilinear Transformations and Mappings:** Conformal mappings and its applications; Bilinear transformations; Analytic continuation.

Evaluation: Continuous Assessment: 30 marks (Class attendance: 10 marks, Class Test/ Assignment/ Presentation/ Quizzes: 20 marks).
Semester Final (3 hours) Examination: 70 marks. Seven questions of equal value will be set, of which any five are to be answered.

References:

1 M. R. Spigel : Complex Variable
2 M. L. Khanna : Complex Analysis
3 J. B. Conway : Functions of complex variables
4 L. V. : Complex Analysis
5 D. Sarason : Notes on complex function theory

MAT 3231: Mechanics II

Conduct hours per week: 3.0 Credits: 3.0

Sl. No.	Course Contents
1	**Motion of a Particle in a Straight line:** Some Important theorems related to Simple Harmonic Motion (Periodic time, Amplitude and Frequency), Motion of a particle towards the earth from a point outside of it.
2	**Motion of a Particle in a Plane:** Motion where the accelerations are parallel to fixed axe, Motion in a plane referred to polar coordinates, Velocities and accelerations of a particle along and perpendicular to the radius vector to it from a fixed origin, Tangential and normal accelerations.
3	**Central Forces:** Definitions of central force and central orbit, Apse, Apsidal distance and apsidal angle, some important theorems related to the central force, Kepler's Laws.
4	**Dynamics of a rigid body:** a) **Moments and products of inertia**: The momental Ellipsoid, Equi-momental systems, principal axes. b) **D' Alembert's Principle:** The general equations of motion, Independence of the motions of translation and rotation, Impulsive force.

Evaluation: Continuous Assessment: 30 marks (Class attendance: 10 marks, Class Test/ Assignment/ Presentation/ Quizzes: 20 marks).
Semester Final (3 hours) Examination: 70 marks. Seven questions of equal value will be set, of which any five are to be answered.

References:

1. S. L. Loney : Statics and Analytical Dynamics of a Particle, Publisher Arihant Publications.
2. L.A. Pars: Introduction to Dynamics, Publisher, New Age International.
3. G.S. Malik: Dynamics.

MAT 3241: Tensor Analysis

Conduct hours per week: 3.0 Credits: 3.0

Sl. No.	Course Contents
1	**Co-ordinates, vector and tensor:** Curvilinear coordinates, Kronecker delta, Summation convention, Space of n-dimensions, Euclidean and Riemannian space, Co-ordinate transformation, Contravariant and covariant vector.
2	**Riemannian metric and metric tensors:** Basis and reciprocal basis vectors, Euclidean metric in three dimensions, Reciprocal or conjugate tensors, Conjugate metric tensor, Associated vectors and tensor's length and angle between two vectors, The Christoffel symbols (1^{st} and 2^{nd} order).
3	**Covariant Differentiation of tensors and applications:** Covariant derivatives and its higher rank tensor and covariant curvature tensor.

Evaluation: Continuous Assessment: 30 marks (Class attendance: 10 marks, Class Test/ Assignment/ Presentation/ Quizzes: 20 marks).
Semester Final (3 hours) Examination: 70 marks. Seven questions of equal value will be set, of which any five are to be answered.

References:

1. Tensor Analysis – L.S. Sokolnikoss.
2. Theory and Problems of Tensor Analysis – Murray R. Spiegel, SI (Metric) Edition.
3. Applications of Tensor Analysis – A. J. McConnell.

MAT 3251: Mathematical Methods II

Conduct hours per week: 2.0 Credits: 3.0

Sl. No.	Course Contents
1	**Bessel's Equation:** Solution, Generating function, Recurrence relation, values of Bessel function, Orthogonality, Neuman, and Hankel function, Modified Bessel function.
2	**Legendre's Equation:** Solution, Generating function, Recurrence relation, Rodrigues' formula and orthogonality of Legendre polynomial.
3	**Hermite's Equation:** Solution, Integral and Recurrence formula, Orthogonality, Differential formula.
4	**Laguerre's Equation:** Solution, Integral and Recurrence formula, Differential form, Orthogonality.
5	**Hypergeometric Equation:** Solution, Hypergeometric function and its properties, Integral formula and linear transformation of hypergeometric function.

Evaluation: Continuous Assessment: 30 marks (Class attendance: 10 marks, Class Test/ Assignment/ Presentation/ Quizzes: 20 marks).
Semester Final (3 hours) Examination: 70 marks. Seven questions of equal value will be set, of which any five are to be answered.

References:

1. D. A. Kuddus : Mathematical Methods.
2. Jeffreys and Jeffreys : Methods of Mathematical Physics.
3. Courant and Hilbert : Methods of Mathematical Physics.
4. B.S. Rajput : Mathematical Physics.
5. M R Spiezel : Laplace Transforms.
6. B.D. Sharma and R.K. Gupta : Mathematical Method.
7 M J Lighthill : Asymptotic Expansion.
8. L A Pipes : Applied Mathematics for Engg. & Physicists.

MAT 3261: Linear Programming

Conduct hours per week: 3.0 Credits: 3.0

SI. No.	Course Contents
1	**Introduction to Linear Programming:** Basic definitions, Formulation of linear programming problems, Graphical solutions.
2	**Simplex Method:** Simplex method, Setting up the Simplex Method, The Algebra of the Simplex Method, The Simplex Method in Tabular Form, Solution and Convergence: Two phase method, Big-M simplex method.
3	**Duality Theory:** The Essence of Duality Theory and Primal-Dual Relationships, Economic Interpretation of Duality, Duality of linear programming and related theorems (No Proof), Dual simplex method.
4	**Sensitivity Analysis:** Analysis of the effect of changing various parameters in linear programming problems such as right-hand side of the constraints, cost coefficients, addition of a new constraint, deletion of a constraint etc.
5	**Transportation and Assignment Problem:** Introduction, Formulation, Solution procedure, applications.

Evaluation: Continuous Assessment: 30 marks (Class attendance: 10 marks, Class Test/ Assignment/ Presentation/ Quizzes: 20 marks).
Semester Final (3 hours) Examination: 70 marks. Seven questions of equal value will be set, of which any five are to be answered.

References:

1. The Wayne L Winston, Operations Research: Applications and Algorithms, Indiana University.
2. Sharma J K, Operations Research: Theory and Applications, (2013), Macmillan Pub India.
3. Taha H A, Operations Research: An Introduction, (2009), Prentice-Hall of India.
4. Hillier, F.S. and G.J. Lieberman, 'Introduction to Operations Research', 9th Ed., 2010, McGraw Hill, New York.

MAT 3262: MATLAB I

Conduct hours per week: 4.0 Credits: 2.0

SI. No.	Course Contents
1	**Matrix manipulation:** Construction of matrices, linear combination of matrices, multiplication of matrices, inversion of nonsingular matrices, solving system of linear equations and polynomial equations. Find out the determinant, inverse, eigenvalues and eigenvectors etc. of a square.
2	**Graphs:** Plotting a set of points, line drawing joining consecutive points, Plotting of curves of some well-known functions in Cartesian and polar coordinates, Circle and system of circles. Roots of algebraic and transcendental equations using graphs. Testing the continuity and differentiability of a function only by the observation of the graphs.
3	**Conics:** Identification and trace of conics, tangent and normal of conics (parabola and ellipse).
4	**Programming:** (i) Area and perimeter of triangles, square, rectangles, rhombus, circles etc. (ii) Summation of finite series and product of a finite number of factors. Integration.
5	**Symbolic operation:** Tangent and normal of explicit and implicit function, maxima and minima of a function.

Evaluation: Continuous Assessment: 50 marks (Class attendance: 10 marks, Lab Report/ Assignment: 20 marks, Lab test: 20 marks). Semester Final (Lab: 4 hours) Examination: 50 marks.

MAT 3270: Viva-Voce

Credits: 1.0

Viva-Voce on courses taught in the 3rd year 2nd semester.

Courses for 4th Year 1st Semester

Sl. No.	Course Code	Course Title	Credits
1	MAT 4111	Topology	3
2	MAT 4121	Differential Geometry	3
3	MAT 4131	Hydrodynamics	3
4	MAT 4141	Integral Equation	3
5	MAT 4151	Discrete Mathematics	3
6	MAT 4162	MATLAB II	2
7	MAT 4170	Viva-Voce	1
		Total Credits:	18

MAT 4111: Topology

Conduct hours per week: 3.0 Credits: 3.0

Sl. No.	Course Contents
1	**Topological Spaces:** Definitions and examples (discrete, indiscrete, co-finite, co-countable topologies), Metric topology, Cluster point of a set, Neighborhood system, Base and subbase, Subspace, Topological properties.
2	**Continuous functions in topological spaces:** Continuity, Sequential continuity, Uniform continuity, Homeomorphisms.
3	**Creating New Topological Spaces:** The Subspace Topology, coarser and finer topologies, The Product Topology, The Quotient Topology, More Examples of Quotient Spaces.
4	**Separation axioms:** Properties of $T0$, $T1$, $T2$, $T3$, $T4$ spaces, Some related theorems, Completely regular spaces, Completely normal spaces.
5	**Compactness:** Compact spaces, Concept of product spaces, Tychonoff's theorem, Locally compact spaces, Compactness in metric spaces, Totally boundedness, Lebesgue number, Equivalence of compactness, sequential compactness and Bolzano-Weierstrass property.
6	**Connectedness:** Connected spaces, totally disconnected spaces, components of space, locally and path-wise connected spaces.

Evaluation: Continuous Assessment: 30 marks (Class attendance: 10 marks, Class Test/ Assignment/ Presentation/ Quizzes: 20 marks).
Semester Final (3 hours) Examination: 70 marks. Seven questions of equal value will be set, of which any five are to be answered.

References:

1. G.F. Simmons, Introduction to Topology and Modern Analysis, Krieger Publishing Company.
2. S.Lipschutz, General Topology, McGraw-Hill.
3. J. Kelly, General Topology, Springer-Verlag.
4. J. Munkres, Topology, Prentice Hall, Inc.

MAT 4121: Differential Geometry

Conduct hours per week: 3.0 Credits: 3.0

Sl. No.	Course Contents
1	**Fundamental Properties of Curves:** Parametric representation, arc length, tangent, osculating plane, normal, principal normal, binormal and fundamental planes.
2	**Curves:** Curvature and torsion, Serret-Frenet formula, Helices, Osculation circle, osculating sphere, involute and evolute.
3	**Surface:** Parametric equation, parametric curves, tangent plane, normal and envelope, two and three parameter family of surfaces.
4	**Fundamental Forms:** First and second fundamental forms, fundamental coefficients, direction coefficients, orthogonal trajectories, double family of curves.
5	**Non-intrinsic properties of surface:** Normal curvature and section, Meusnier's theorem, principal sections, curvature and directions, Rodrigues' formula, Euler's theorem, minimal surface.
6	**Developable Surface:** Developable surface and its equation, Monge's theorem, conjugate direction, asymptotic lines, theorem of Beltrami and Enneper.
7	**Ruled and Parallel Surface:** Ruled and skew surfaces, parallel surfaces and Bonnet's theorem, isometric lines.

Evaluation: Continuous Assessment: 30 marks (Class attendance: 10 marks, Class Test/ Assignment/ Presentation/ Quizzes: 20 marks).
Semester Final (3 hours) Examination: 70 marks. Seven questions of equal value will be set, of which any five are to be answered.

References:

1. An Introduction to Differential Geometry – L.P. Eisenhart.
2. Differential Geometry – Schaum'sOutline Series.
3. An Introduction to Differential Geometry – T.J.Willmore.
4. Differential Geometry S. Stamike.
5. Theory and Problems of Differential Geometry – M.M. Lipschutz.
6. Differential Geometry – C. Weatherburn.
7. An Introduction to Differential Geometry – T. J. Willmore, Courier Corporation, 2012.
8. A course in Differential Geometry – W. Klingenberg, Springer-Verlag New York.

MAT 4131: Hydrodynamics

Conduct hours per week: 3.0 Credits: 3.0

SI. No.	Course Contents
1	**Preliminaries:** Velocity and acceleration of fluid particles, relation between local and individual rates; steady and unsteady flows, uniform and non-uniform flows, stream lines, path lines, vortex lines, velocity potential.
2	**Kinematics:** Rotational and irrotational flows, equations of continuity, equation of continuity in spherical and cylindrical polar coordinates, boundary surface.
3	**Equations of motion:** Euler's equation of motion, conservative forces, Lamb's hydrodynamical equations of motion, Bernoulli equation, motion under conservative body force, Energy equation, vorticity equations.
4	**Two-dimensional motion:** Motion in two dimensions, stream function, physical meaning of stream function, velocity in polar-coordinates, relation between stream function and velocity, stagnation points, pressure equation.
5	**Sources and sinks:** Source, Sink and Doublet, complex potential and complex velocity, complex potential due to a source and a doublet, image in two and three dimensions, Stoke's stream function.
6	**Streaming motions:** Circulation and vorticity, relation between circulation and vorticity, Kelvin's circulation theorem, permanence of irrotational motion, impulsive motion, Kelvin's minimum energy theorem.
7	**Motion of cylinders:** Circle theorem, Blasius theorem, motion of a circular cylinder, coaxial cylinders, pressure at points on a circular cylinder, application of circle theorem.

Evaluation: Continuous Assessment: 30 marks (Class attendance: 10 marks, Class Test/ Assignment/ Presentation/ Quizzes: 20 marks).
Semester Final (3 hours) Examination: 70 marks. Seven questions of equal value will be set, of which any five are to be answered.

References:

1. Theoretical Hydrodynamics – L.M. Milne Thomson.
2. Fluid Mechanics: Fundamentals and Applications –Yunus Cengel, John Cimbala.
3. Fluid Dynamics – M. D. Raisinghania.
4. Fluid Mechanics – Frank M. White.
5. Fluid Mechanics – Pijush K. Kundu, Ira M. Cohen, David R Dowlin.
6. Fundamentals of Fluid Mechanics – Bruce R. Munson, Donald F. Young, Theodore H. Okiishi.

MAT 4141: Integral Equation

Conduct hours per week: 3.0 Credits: 3.0

Sl. No.	Course Contents
1	**Basic Concepts:** Introduction, Types of Integral Equations (IEs), Differentiation under an integral sign, Relation between differential and integral equations.
2	**Solution of the Integral Equations:** Solution of the Volterra Integral Equation (VIEs) and Fredholm Integral Equations (FIEs) of the first and second kinds.
3	**Fredholm's Integral Equations:** Fredholm's First, Second and Third fundamental theorems, Integral Equations (IEs) with degenerate kernels, Eigen values & Eigen functions.
4	**Applications of the Fredholm's theory:** Applications of the Fredholm's theorems, Fundamental function, Green's Function, Determination of the Green's Function.
5	**Hilbert Schmidt Theory:** Symmetric kernel, Orthogonal & Normalized systems, Schmidt's solution of non-homogeneous IEs, Hilbert Schmidt theorem.

Evaluation: Continuous Assessment: 30 marks (Class attendance: 10 marks, Class Test/ Assignment/ Presentation/ Quizzes: 20 marks).
Semester Final (3 hours) Examination: 70 marks. Seven questions of equal value will be set, of which any five are to be answered.

References:

1. Shanti Swarup : Integral Equations.
2. M.D. Raishinghania: Linear Integral Equations.
3. R.P. Kanwal : Linear Integral Equations.
4. T.G. Tricomi : Integral Equations.
5. A.R. Vashishtha : Integral Equations.

MAT 4151: Discrete Mathematics

Conduct hours per week: 3.0 Credits: 3.0

Sl. No.	Course Contents
1	**Logic and Mathematical Proofs:** Propositional logic and Equivalences; Rules of Inferences and Quantifiers; Various Quantified Statements; Methods of proof.
2	**Graphs and planar Graphs:** Introduction, Basic terminology, Multi-graph and weighted graph, Path and circuit, Shortest Path in weighted graph, Rulerian Path and circuit, Hamiltonian Path and circuit.
3	**Trees and Cuts Set:** Tree, Rooted tree, Path length in rooted tree, Binary search tree, spanning tree and cuts set, Minimum spanning tree.
4	**Lattice:** Lattice and Algebraic system, Principle of duality, Basic Properties of Algebraic system defined by lattices, Distributive and complemented lattices, Boolean lattices and Boolean algebra.
5	**Boolean Algebra:** Boolean function and Boolean expression Prepositional calculus, Design and implementation of digital Network,Switching circuit. Boolean lattice.
6	**Basic application of graph theory:** In switching and coding theory, Electrical network analysis by graph theory, graph theory inoperation research.

Evaluation: Continuous Assessment: 30 marks (Class attendance: 10 marks, Class Test/ Assignment/ Presentation/ Quizzes: 20 marks).
Semester Final (3 hours) Examination: 70 marks. Seven questions of equal value will be set, of which any five are to be answered.

References:

1. K. H. Rosen, An Introduction to Discrete Mathematics and Its Applications.
2. C. L Liu, Elements of Discrete Mathematics.
3. R. Kolman, R. C. Bushy, S. Ross, Discrete Mathematical Strictures.
4. R. P. Grimaldi and B. V. Ramana, Discrete and Combinatorial Mathematics: An Applied Introduction.

MAT 4162: MATLAB II

Conduct hours per week: 4.0 Credits: 2.0

SI. No.	Course Contents
1	**Solution of algebraic equations in single variables:** Bisection method, method of false position, fixed-point iteration, Newton-Raphson method.
2	**Interpolation and polynomial approximation:** Taylor polynomials, Interpolation (Newtons forward, backward & general interpolation, divided difference interpolation and Lagrange's interpolations, Central difference interpolation formula) and extrapolation.
3	**Differentiation and Integration:** Numerical differentiation, Richardson's extrapolation, Numerical integration, Trapezoidal rule, Simpson's rules, Weddle's rule, Adaptive quadrature method, Gaussian quadrature.
4	**Solutions of linear systems:** Gaussian elimination and backward substitution, Pivoting strategies, Direct factorization of matrices, Iterative technique for solving linear systems (Jacobi, Gauss-Seidel, SOR methods).
5	**Solutions of nonlinear systems:** Fixed point method for functions of several variables, Newton's method, Quasi-Newton's method.
6	**Initial value problem for ODE:** Picard's method, Euler's method, Higher-order Taylor's method, Runge-Kutta methods (Order two and four), Multi-step method, variable step-size multistep methods, extrapolation method.
7	**Boundary Value problem:** Linear shooting method, shooting method for nonlinear BVP.

Evaluation: Continuous Assessment: 50 marks (Class attendance: 10 marks, Lab Report/ Assignment: 20 marks, Lab test: 20 marks). Semester Final (Lab: 4 hours) Examination: 50 marks.

MAT 4170: Viva-Voce

Credits: 1.0

Viva-Voce on courses taught in the 4^{th} year 1^{st} semester.

Courses for 4th Year 2nd Semester

Sl. No.	Course Code	Course Title	Credits
1	MAT 4211	Functional Analysis	3
2	MAT 4221	Theory of Numbers	3
3	MAT 4231*	Classical Mechanics	3
4	MAT 4241*	Astronomy	3
5	MAT 4251*	Fuzzy Mathematics	3
6	MAT 4261*	Mathematical Modelling in Biology	3
7	MAT 4271*	Rings and Modules	3
8	MAT 4281*	Graph Theory	3
9	MAT 4291*	Mathematical Finance	3
10	MAT 4294*	Actuarial Mathematics	3
11	MAT 4293	Project and Presentation	4
11	MAT 4290	Viva-Voce	1
			Total Credits: 17

*** Two courses from MAT 4231 to MAT 4294 will be offered as per the decision of the academic committee.**

MAT 4211: Functional Analysis

Conduct hours per week: 3.0 Credits: 3.0

Sl. No.	Course Contents
1	**Review of General Linear (Vector) spaces:** Linear mappings, linear operators, elementary properties of linear operators, linear operators in finite dimensional spaces, linear functional, basis and its dual on finite dimensional space, Zorn's lemma, extension of linear functions, sublinear functional.
2	**Inner product and norm (on a vector space over $\mathbb{R}$):** Definitions and examples, Cauchy-Schwarz inequality, norm derived from inner product, Parallelogram law, metric derived from a norm, inner product space, orthogonality, Bessel's inequality.
3	**Normed linear spaces:** Sequence space, separability, Riesz's lemma, boundedness and continuity, Quotient space, spaces of bounded linear operators.
4	**Banach spaces:** Open mapping theorem, closed graph theorem, and their applications, Baire's category theorem, Uniform boundedness principle, normed conjugate of a NLS (Hahn-Banach theorem). Fixed point theorems: Contraction mapping, Banach fixed point theorem, Schauder fixed point theorem and applications of fixed-point theorems.
5	**Hilbert spaces:** Basic properties, Riesz representation theorem, adjoint of a linear operator.

Evaluation: Continuous Assessment: 30 marks (Class attendance: 10 marks, Class Test/ Assignment/ Presentation/ Quizzes: 20 marks).
Semester Final (3 hours) Examination: 70 marks. Seven questions of equal value will be set, of which any five are to be answered.

References:

1. E. Taylor: Introduction to Functional Analysis, Wiley.
2. E. Kreyszig: Introduction to Functional Analysis with Applications, Wiley.
3. J. Maddox: Elements of Functional Analysis, Cambridge University Press.
4. B, Rynne, M. A. Youngson: Linear Functional Analysis, Springer.
5. M. Schechter: Principles of Functional Analysis, American Mathematical Society.

MAT 4221: Theory of Numbers

Conduct hours per week: 3.0 Credits: 3.0

SI. No.	Course Contents
1	**Some Preliminary Considerations and Divisibility Theory in the integers:** Mathematical induction, Binomial Theorem, The number system, Division Algorithm, Greatest Common Divisor, Euclidean Algorithm, Diophantine equations.
2	**The Distribution of Prime Numbers:** The Fundamental Theorem of Arithmetic, The Exclusion-Inclusion Principle, Abundance and Scarcity of Prime Numbers, The Prime Number Theorems.
3	**Congruences:** The congruence concept and its basic properties, Residue systems, Residue classes, Prime Residue classes modulo n, Linear Congruences, Chinese Remainder Theorem.
4	**Fermat's Theorem:** Fermat's Factorization method, Fermat's Little Theorem, Pseudoprime, Absolute Pseudoprime, Wilson's Theorem.
5	**Arithmetic Functions and Euler's Generalization of Fermat's Theorem:** Mobius Inversion Formula, Euler's phi-function, Multiplication of phi-functions, Euler's Theorem, Some properties of the phi-function.
6	**Primitive Roots and Indices:** The order of an Integer Modulo n, Primitive roots for primes, Composite numbers having primitive roots, The Theory of indices.
7	**The Quadratic Reciprocity Low:** Quadratic residues and nonresidues, Euler's Criterion, The Legendre Symbol and its properties, Gauss' Lemma.
8	**Fibonacci Numbers and Continued Fractions:** The Fibonacci Sequence, Certain Identities, Involuting Fibonacci Numbers, Continued Fractions Perfect Numbers.

Evaluation: Continuous Assessment: 30 marks (Class attendance: 10 marks, Class Test/ Assignment/ Presentation/ Quizzes: 20 marks).
Semester Final (3 hours) Examination: 70 marks. Seven questions of equal value will be set, of which any five are to be answered.

References:

1. D.M. Burton: Elementary Number Theory, Wm C. Brown Company Publisher, 1989.
2. G.H. Hardly and W.J. Leveque: Fundamental of Number Theory, Oxford University Press, London.
3. W.J. Leveque: Topics in Number Theory Vol 1 Addiso Wesley Co. New York.

MAT 4231: Classical Mechanics

Conduct hours per week: 3.0 Credits: 3.0

SI. No.	Course Contents
1	**Generalized Coordinates:** Holonomic and non-holonomic systems. Lagrange's equation for holonomic and non-holonomic dynamical systems.
2	**Elementary principles:** Mechanics of a particle and system of particles, constraints, D-Alembert's principle and Lagrange's equation. Simple application of Lagrange's equation.
3	**Applications of Euler- Lagrange differential equation:** Introduction to calculus of variation, Euler- Lagrange differential equation, applications.
4	**Hamiltonian Dynamics:** Phase space, Hamilton's equations, and Hamilton's principle, principle of least action, Hamilton's function and Hamilton-Jacoby equation.
5	**Canonical Transformations:** Canonical transformation, contact transformation, commentator, Definition and properties of Lagrange's and poison brackets, Equations of motions, Constant of motion.
6	**Motion:** Motion in rotating frame, motion relative to earth, Foucault's pendulum.

Evaluation: Continuous Assessment: 30 marks (Class attendance: 10 marks, Class Test/ Assignment/ Presentation/ Quizzes: 20 marks).
Semester Final (3 hours) Examination: 70 marks. Seven questions of equal value will be set, of which any five are to be answered.

References:

1. H. Goldstein : Classical Mechanics.
2. Rutherford : Classical Mechanics.
3. Gupta, Kumar : Classical Mechanics.
4. B.D. Gupta and S. Saha : Classical Mechanics.

MAT 4241: Astronomy

Conduct hours per week: 3.0 Credits: 3.0

SI. No.	Course Contents
1	**Elements of Spherical trigonometry:** Spherical and polar triangles; Properties of spherical and polar triangles; Cosine, sine and cotangent formulas, Analogues of cosine formula; Napier's rules.
2	**Celestial coordinate system:** Celestial sphere; Celestial system of coordinates and its transformation; Relation between different coordinate systems; Midnight sun; Circumpolar stars; twilight and its causes and measurement; twilight at different places on the earth surface.
3	**Refraction:** Astronomical refraction, laws of refraction, effect of refraction on celestial bodies, coefficient of refraction and its determination, Cassini's hypothesis, Bradley's formula; Effect of refraction on sunrise and sunset; Effect of refraction on right ascension and declination of a heavenly body.
4	**Planetary motion:** Different kind of times, conversion of times, year, mean sun, apparent sun, the equation of time and its measurement, equation of centre, reduction to the equator, astronomical seasons and their causes, lengths of different seasons.
5	**Time, seasons:** Main feature of the solar system, solar planet, sidereal and synodic periods of solar planet, direct and retrograde motions, elongation phase of the moon. Bode law, Kepler's laws of planetary motion, Anomalies.
6	**Aberration:** Aberration, aberrational error, apex, effect of aberration on celestial bodies, longitude and latitude of a star, aberrational ellipse, planetary aberration, precession and nutation of equinoxes and their causes, planetary precession, effect of precession and nutation on right ascension and declination of a star.

Evaluation: Continuous Assessment: 30 marks (Class attendance: 10 marks, Class Test/ Assignment/ Presentation/ Quizzes: 20 marks).
Semester Final (3 hours) Examination: 70 marks. Seven questions of equal value will be set, of which any five are to be answered.

References:

1. Smart : Spherical Trigonometry.
2. Godtrey : Spherical Trigonometry.
3. Kar, J.M. : Astronomy.
4. Datta and Choudhary : Astronomy.
5. Todhunter : Spherical Trigonometry.
6. Khan and Sikder : Astronomy.
7. Dey, A.K. : Astronomy.
8. S. K. Bhattacharjee : A text book on Spherical Astronomy.

MAT 4251: Fuzzy Mathematics

Conduct hours per week: 3.0 Credits: 3.0

SI. No.	Course Contents
1	**Fuzzy Set:** S Notion of fuzzy set, subset, empty set, equality of two fuzzy sets, complement of a fuzzy set, union and intersection of fuzzy sets, De Morgan's law. Product of fuzzy sets, Fuzzy point and fuzzy singleton. Function and basic results.
2	**Fuzzy sets operation**: Fuzzy set function, image and pre-image of fuzzy set under function and some of its basic results. Strong and weak α −cut, operations of $\alpha - cut$, and relation of strong and weak$\alpha - cut$ and some of their applications.
3	**Fuzzy Arithmetic:** What is interval, some type of interval operation? Fuzzy number, some type of fuzzy number, Triangular fuzzy number, addition, subtraction, multiplication and division of triangular fuzzy numbers. Fuzzy number defined on the set $\mathbb{Z}$, and in this domain their addition and subtraction. Use fuzzy number operation solve real life. Predict the mathematical model for washing mashing and air cooler.
4	**Fuzzy relations**: Notion of fuzzy relation, domain and range of fuzzy relation, union, intersection, max-min composition, min-max composition of fuzzy relations. Reflexive, symmetric, transitive and others type of fuzzy relation. α cut of a fuzzy relation, projection of fuzzy relation, cylindrical extension of fuzzy relation and some of their applications in real life problem.
5	**Fuzzy Logic:** Two valued logic, three valued logic, fuzzy logic, fuzzy propositions and their interpretations in terms of fuzzy sets. Linguistic variable, linguistic modifier, quantified, qualified and other type proposition, Composition rule for proposition, Quantification rule, qualification rule, semantic equivalence, semantic entailment and some of their daily life application.
6	**Fuzzy Algebra:** Fuzzy groupoid, intersection of fuzzy groupoid, fuzzy group, relation between classical group and fuzzy group. Homomorphism of fuzzy groups, normal fuzzy group, proper fuzzy group, characterization of some of their algebraic property. Fuzzy ring, fuzzy sub ring, fuzzy ideal, relation between ideal of a classical ring and ideal of a fuzzy ring. Some of their application.

Evaluation: Continuous Assessment: 30 marks (Class attendance: 10 marks, Class Test/ Assignment/ Presentation/ Quizzes: 20 marks).
Semester Final (3 hours) Examination: 70 marks. Seven questions of equal value will be set, of which any five are to be answered.

References:

1. A. Jones, A. Kaufmann and Zimmermann; Fuzzy Sets Theory and Applications. Riedel Pub. Co. (1986).
2. Georje J. Klin and Bo Yuan; Fuzzy Sets and Fuzzy Logic: Theory and Applications.
3. Masao Mukaidono; Fuzzy Logic for Beginners.

MAT 4261: Mathematical Modelling in Biology

Conduct hours per week: 3.0 Credits: 3.0

SI. No.	Course Contents
1	**Basic Concepts**: Population dynamics**,** phase space, phase portrait, discrete and continuous systems, conjugacy, fixed point, periodic points, hyperbolic point and stability.
2	**Dynamics of one-dimensional maps**: One parameter family of maps, contraction mapping, stability of fixed points and periodic points, family of logistic map, tent map, doubling map, linear maps, iterative map and quadratic family.
3	**Population Dynamics for Single Species**: Single species population model, growth models, Malthusian model, logistic model, migration model, Smith model, time-varying environment model, time-delay model, harvesting model.
4	**Continuous Models for Interacting Population**: Two species population model, Lotka-Volterra model, competition model, cooperation model, war model and multi-species population model.
5	**Discrete Population Models**: Simple discrete models, Malthusian discrete model, logistic discrete model, discrete growth models for interacting populations, discrete delay models.
6	**Disease Models**: Simple epidemic models - SI model, SIS model, SIR model, some infectious disease models (HIV/AIDS, TB model, etc.).

Evaluation: Continuous Assessment: 30 marks (Class attendance: 10 marks, Class Test/ Assignment/ Presentation/ Quizzes: 20 marks).
Semester Final (3 hours) Examination: 70 marks. Seven questions of equal value will be set, of which any five are to be answered.

References:

1. Steven H Strogatz, Nonlinear Dynamics and Chaos. CRC Press.
2. F Brauer, C Castillo-Chavez, Mathematical models in population biology and Epidemiology. Springer.
3. Leah Edelstein-Keshet, Mathematical Models in Biology. Siam.
4. J. D. Murray, Mathematical Biology, Springer.

MAT 4271: Rings and Modules

Conduct hours per week: 3.0 Credits: 3.0

Sl. No.	Course Contents
1	**Rings:** Ring, subring, ideal (principal, prime and maximal), factor ring, integral domain, fields, ring homomorphism and isomorphism with related theorems.
2	**Polynomial rings:** Polynomial rings and related theorems.
3	**Euclidean rings:** Euclidean rings and related theorems.
4	**Artinian, Noetherian:** Artinian, Noetherian and semi semi-simple rings and related theorems.
5	**Modules and exact sequences:** Modules, submodules, factor modules, module homomorphisms, exact and short exact sequences.
6	**Free modules:** Cartesian products, direct sums of free modules, projective and injective modules.
7	**Homomorphism and tensor product:** HomR (A, B) and its properties, tensor product, adjoint associativity.
8	**Some special lemmas:** Diagram lemmas, strong-four lemma, The five lemma, short five lemma.

Evaluation: Continuous Assessment: 30 marks (Class attendance: 10 marks, Class Test/ Assignment/ Presentation/ Quizzes: 20 marks).
Semester Final (3 hours) Examination: 70 marks. Seven questions of equal value will be set, of which any five are to be answered.

References:

1. Divinsky, N. J: Rings and Radicals, University of Toronto Press, 1965.
2. Herstein I.N.: Topics in Algebra.
3. Vander Warden B.L.: Modern Algebra, Vol.-1.
4. Curtis and Reiner: Representation Theory of finite groups and associative Algebra.
5. Lambek J.:Lectures on rings and Modules.
6. Jans J.P.: Rings and Homology.
7. Maclane: Homology.

MAT 4281: Graph Theory

Conduct hours per week: 3.0 Credits: 3.0

Sl. No.	Course Contents
1	**Introduce of graph theory:** Definition of a graph, finite and infinite graphs, incidence of vertices and edges, types of graphs, subgraphs, walks, trails, paths, cycles, connectivity, components of a graph, Eulerian and Hamiltonian graphs, travelling salesman problem, vertex and edge connectivity, matrix representation of graphs, incidence and adjacency matrices of graphs.
2	**Trees:** Definition and properties of trees, rooted and binary trees, counting trees, spanning trees, weighted graphs, minimum spanning tree.
3	**Planar graphs and graph coloring:** Planar graphs, Kuratowski's graphs, detection of planarity, Euler's formula for planar graphs, geometric and combinatorial duals of a planar graphs, coloring of graphs, chromatic numbers, chromatic polynomial, chromatic partitioning, four color theorems.
4	**Directed graphs:** Types of digraphs, digraphs and binary relations, directed paths and connectedness, Euler digraphs, de Brujin sequences, tournament.

Evaluation: Continuous Assessment: 30 marks (Class attendance: 10 marks, Class Test/ Assignment/ Presentation/ Quizzes: 20 marks).
Semester Final (3 hours) Examination: 70 marks. Seven questions of equal value will be set, of which any five are to be answered.

References:

1. Frank Harary: Graph Theory.
2. West: Graph Theory.
3. Parthasarathy: Graph Theory.
4. Calaude Berge: Introduction to Graph Theory.

MAT 4291: Mathematical Finance

Conduct hours per week: 3.0 Credits: 3.0

SI. No.	Course Contents
1	**Brownian Motion (BM)**: Random Walk to BM; construction of BM; BM in stock price dynamics; covariance and correlation of BMN; slope, non-differentiability and measurement of variability of BM paths. Selected intuitive examples.
2	**Martingale**: Filtration, sigma-algebra, conditional expectation and martingale; properties of conditional expectation and martingale; examples of martingale analysis; revisiting BM as martingale.
3	**Ito Stochastic Integral and Ito Calculus:** Stochastic for non-random step functions and for non-anticipating general random integrands; properties of Ito Stochastic integrals; Stochastic differential equations and Ito integrals: functions of BM and frequently used Ito integrals for BM.
4	**Stochastic Differential Equations (SDE):** Structure of SDE; SDE for arithmetic BM; SDE for geometric BM; Ornstein-Uhlenbeck SDE; mean reversion SDE; square root SDE; Diffusion SDE. Introductory solutions of SDE.
5	**Option Valuation:** PDE method; Martingale method in one period binomial framework; martingale method in continuous time framework; valuation of European options like digital call, Asset-or-noting call, standard European call.

Evaluation: Continuous Assessment: 30 marks (Class attendance: 10 marks, Class Test/ Assignment/ Presentation/ Quizzes: 20 marks).
Semester Final (3 hours) Examination: 70 marks. Seven questions of equal value will be set, of which any five are to be answered.

References:

1. Ubbo F. Wiersema, Brownian Motion Calculus, John Wiley and Sons.
2. Steven E Shreve, Lecture Notes:Stochastic Calculus for Finance-II.

MAT 4294: Actuarial Mathematics

Conduct hours per week: 3.0 Credits: 3.0

Sl. No.	Course Contents
1	**Theory of Interest:** Interest, Simple Interest, Compound Interest, Accumulated Value, Present Value, Rate of Discount: *d,* Constant Force of Interest: δ, Varying Force of Interest.
2	**Annuities and its Applications:** Annuity-Immediate, Annuity–Due, Deferred Annuities, Continuously Payable Annuities, Perpetuities, Equations of Value. Amortization of a Debt, Outstanding Principal, Mortgages, Refinancing a Loan, Sinking Funds, Comparison of Amortization and Sinking-Fund Methods.
3	**Individual Risk Models:** Models for Individual Claim Random Variables, Sums of Independent Random Variables, Approximations for the Distribution of the Sum, Applications to Insurance.
4	**Survival Distributions:** Probability for the Age-at-Death, The Survival Function, Time-Until-Death for a Person Aged *x*, Curtate-Future-Lifetime, Force of Mortality.
5	**Life Tables:** Relation of Life Table Functions to the Survival Function, Life Table Example, The Deterministic Survivorship Group, Other Life Table Functions, Assumptions for Fractional Ages, Some Analytical Laws of Mortality, Select and Ultimate Tables.
6	**Life Insurance:** Introduction, Insurance payable at the moment of death, Insurance payable at the end of the year of death, Recursion equations, Commutation Functions.
7	**Life Annuities:** Introduction, Mortality Tables, Pure Endowments, Continuous Life Annuities, Discrete Life Annuities, Life Annuities with mthly payments. Commutation Functions formula for annuities with level payments, Varying Annuities.
8	**Net Premium:** Fully continuous premiums, Fully discrete premiums, True monthly Payment Premiums, Commutation functions, Apportionable premiums.

Evaluation: Continuous Assessment: 30 marks (Class attendance: 10 marks, Class Test/ Assignment/ Presentation/ Quizzes: 20 marks).
Semester Final (3 hours) Examination: 70 marks. Seven questions of equal value will be set, of which any five are to be answered.

References:

1. Bowers, Gerber, Hickman, Jones Nesbitt: Actuarial Mathematics.
2. Petr Zima Robert L. Brown, Mathematics of Finance, Schaum's outlines.
3. Chris Ruckman, Joe Francis,Financial Mathematics: A Practical Guide for Actuaries and other Business Professionals.

MAT 4293: Project and Presentation

Conduct hours per week: 4.0 Credits: 4.0

Sl. No.	Course Contents
1	A particular topic in Mathematics is given by the concerned teacher.

Each student is required to work on a project and present a project report for evaluation. Such projects should be extensions or applications of materials included in different honours courses and may involve field work and use of technology. There may be group projects as well as individual projects.

Implementation:

The Academic Committee shall appoint a Project Implementation and Coordination Committee (PICC) well before the session begins. The PICC shall consist of a Project Coordinator (PC) and such other members as the Academic Committee considers appropriate. The PC shall invite projects from the teachers before the class started. Each teacher should submit three project proposals which should include a short description of the project. Such project should be an extension or application of materials included in different honours courses and may involve fieldwork and use of technology.

There may be group projects as well as individual projects. For group projects, students will sign up with the PICC in groups. These may not be changed later on without the approval of the PICC. The PICC shall assign each group a project. The members of each group shall work independently on the assigned project under the supervision of the concerned supervisors. The PICC shall monitor with the supervisors the progress of different projects and arrange weekly discussions on projects and materials.

Completion:

The project must be completed before the termination of the classes. Each student is required to prepare a separate report on the project. Each report should be of around 40 pages typed on one side of A4 size white paper preferably using word processors. Graphs and figures should be drawn preferably using a computer. Reports of different students working on the same group project should differ in some details and illustrations. The Academic Committee will fix a date for the submission of the project reports to the PICC. Each student must submit three typed copies of her/his project report to the PICC on or before the date fixed for such submission. Any student who fails to submit the report on the due date or to present the thesis on the fixed date will not get any credit for this course.

Evaluation:

The distribution of marks for each project shall be as follows:

Project Report	50 Marks
Project Presentation	30 Marks
Assessment of Supervisor	20 Marks

Each project report shall be examined by two examiners, one of whom shall be the project supervisor and the other appointed from amongst the teachers of the department on the recommendation of the PICC. The average of the marks given by two examiners (1st and 2nd) shall be taken as final. If the marks given by the 1st and 2nd examiners of a project report differ by 20% or more, the PICC shall recommend a "3rd examiner" to examine such report. In the case of the third examination, the average of the two nearest marks (in case of equal difference, highest two marks) shall be taken as final. Each student is required to present her/his work on the project before the PICC who will evaluate the presentation. The sum of the marks of the project report and project presentation is added and final marks are converted into grades.

The Academic Committee may prepare additional guidelines for the evaluation of the projects. All marks on the projects shall be submitted to the Examination Committee for tabulation with copies to the Controller of Examinations. The project reports shall be returned to the PICC for preservation.

References:

The list of references used in the project report contains books/thesis/journal papers/conference papers/web resources to be included at the end of the project report.

MAT 4290: Viva-Voce

Credits: 1.0

Viva-Voce on courses taught in the 4^{th} year 2^{nd} semester.