NATIONAL UNIVERSITY

BANGLADESH

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Syllabus
Bachelor of Science (Honours) Second Year
Department of Mathematics

Effective from the Academic Year: 2024-2025 and onward

Vision of the University: We expect that the hundredth anniversary of the National University, our commitment to "Progress for Everyone" will be evident in all areas of our operations and stakeholder engagements.
We leverage our core strength in education, research, and community engagement to address pressing global issues and foster sustainable development.
By 2042, National University aims to strengthen its position as Bangladesh's top academic institution and rank among the world's leading universities. Our focus will be on expanding expertise, building strategic partnerships, and increasing our global influence. Our services will be measured by the achievements of the individuals and communities we serve.

Mission of the University: To promote "Progress for Everyone" by fostering transformative education, conducting pioneering research, and encouraging meaningful collaboration with individuals, communities, and partners both in Bangladesh and around the world.

Name of the Program: B.Sc. (Honours) in Mathematics

Vision of the Program: To be a recognized mathematics program of excellence in education, research, and innovation, producing graduates who contribute to scientific advancement, sustainable development, and the well-being of society.

Mission of the Program: The B.Sc. (Honours) in Mathematics program is committed to advancing quality mathematics education and promoting research, innovation, and community engagement. The program aims to:

1. Support the vision, mission, and strategic goals of National University through excellence in mathematics education, research, and outreach.
2. Provide a strong academic foundation in pure and applied mathematics and foster intellectual curiosity, critical thinking, and innovation.
3. Promote quality teaching, research, and the effective use of modern computational tools in mathematics.
4. Create an academic environment that encourages lifelong learning, interdisciplinary collaboration, and professional growth.
5. Contribute to national development and global sustainability through the advancement and application of mathematical knowledge.

Program Educational Objectives (PEOs): After graduation, our students will be able to

PEO 1: Help others understand basic concepts of mathematics and science, and support learning at the school and college levels.

PEO 2: Work together with teachers, students, and others to understand how mathematics builds thinking and problem-solving skills.

PEO 3: Use mathematical and scientific knowledge in study and work, and develop leadership, communication, and teamwork abilities.

PEO 4: Contribute to making the Department of Mathematics a centre of quality education and research.

Program Learning Outcomes (PLOs): At the time of graduation, B.Sc. (Honours) in Mathematics students will have achieved the ability to

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PLO 1: Mathematical Knowledge: Understand and use basic to advanced mathematics, and apply this acquired knowledge to solve real-life, academic, and professional problems.

PLO 2: Problem-Solving Ability: Recognize, formulate, and solve mathematical problems using logic, formulas, and mathematical techniques, and draw accurate conclusions in both pure and applied mathematics.

PLO 3: Designing Solutions: Design and conduct individual research or develop models and solutions in areas such as human welfare, technology, environmental issues, pollution, water use, climate change, and sustainable living.

PLO 4: Research Skills: Collect, analyze, and interpret data using mathematical methods; perform calculations, draw graphs, and present results confidently with logical conclusions.

PLO 5: Use of Modern Tools: Utilize modern tools, including scientific calculators, computers, and standard mathematical software (e.g., Mathematica, FORTRAN, MATLAB, Python, C, C++), to solve mathematical problems effectively.

PLO 6: Health and Society: Apply mathematical knowledge to practical activities, societal functions, health, and overall development.

PLO 7: Career and Academic Readiness: Demonstrate readiness for careers in industry, teaching, or government, and qualify for admission to advanced studies in mathematics and related fields such as engineering, medical sciences, statistics, physics, economics, and education.

PLO 8: Ethics and Responsibility: Follow moral values in learning and research, be an honest professional, and avoid copying or using incorrect information.

PLO 9: Teamwork and Leadership: Function effectively as an individual and also as a member or leader in teams. Be able to lead a group when needed in academic, research, or job settings.

PLO 10: Communication Skills: Share mathematical ideas clearly through writing, speaking, and presenting. Be able to write reports, give presentations, and explain concepts.

PLO 11: Project and Time Management: Plan and manage time, tasks, and projects well. Use mathematics in real situations while working alone or in a team.

PLO 12: Lifelong Learning: Keep learning new mathematics, tools, and skills beyond graduation for personal and professional growth in an ever-evolving technological world.

Mapping PEOs with PLOs

	PEO 1	PEO 2	PEO 3	PEO 4
PLO 1	√		√	
PLO 2	√	√		
PLO 3		√		√
PLO 4		√	√	√
PLO 5			√	
PLO 6			√	
PLO 7	√			√
PLO 8	√			√
PLO 9		√	√	
PLO 10	√	√	√	
PLO 11			√	
PLO 12			√	√

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Second Year Courses, Marks and Credit Distribution

Course Code	Course Title	Marks	Credits
8223751	Advanced Calculus	100	4
8223753	Ordinary Differential Equations	100	4
8223755	Programming Fundamentals (FORTRAN)	100	4
8223756	Math Lab-Practical II (Mathematica and FORTRAN)	100	4
Any Two of the following:			
8222757	Physics-III (Electricity and Modern Physics)	100	4
8222758	Physics-IV (Physics Practical)	50	2
8223659	Methods of Statistics	100	4
8223660	Lab: Methods of Statistics	50	2
8222259	Bangladesh Economy	100	4
8222267	Mathematical Economics	50	2
8222859	General Chemistry-II	100	4
8222861	Environmental Chemistry	50	2
Compulsory			
8221171	Functional English	100	4
8226601	Applied Information and Communication Technology (Applied ICT)	75	3
8226602	Practical: Applied ICT	25	1
8223760	Viva-Voce (Mathematics)	50	2
	Total	**950**	**38**

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Matrix of Courses with Program Learning Outcomes (Curriculum map):

	PLO 1	PLO 2	PLO 3	PLO 4	PLO 5	PLO 6	PLO 7	PLO 8	PLO9	PLO10	PLO11	PLO12
8223751	√	√		√								
8223753	√	√										
8223755	√	√			√							
8223756	√	√		√	√					√		
8222757	√	√										
8222758	√	√		√				√		√		
8223659	√	√	√	√	√					√	√	
8223660	√	√	√	√	√					√	√	
8222259	√	√	√	√		√				√		√
8222267	√	√	√		√							
8222859	√	√	√	√	√	√	√					√
8222861	√	√	√	√	√	√	√	√		√		√
8221171							√			√		
8226601				√	√		√	√	√	√	√	√
8226602				√	√		√	√	√	√	√	
8223760	√	√		√	√		√			√		

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Detailed Syllabus of All Courses

Course Code	8223751	Marks: 100	Credits: 4	Class Hours: 56
Course Title:	Advanced Calculus			

Course Description: This course develops advanced concepts and techniques of calculus, including vector-valued functions, functions of several variables, partial and higher-order derivatives, gradients, directional derivatives, tangent planes, maxima and minima, optimization, double and triple integrals, change of variables and Jacobians, and vector calculus. It emphasizes conceptual understanding, analytical reasoning, problem-solving skills, and applications of advanced calculus to mathematical and real-world problems.

Course Objectives (COs)

This course aims to

- introduce advanced concepts of multivariable and vector calculus.
- develop a sound understanding of vector-valued functions, functions of several variables, partial differentiation, and optimization techniques.
- develop analytical and computational skills for evaluating multiple integrals and performing coordinate transformations.
- introduce the fundamental concepts and applications of vector calculus, including line and surface integrals and the integral theorems of Green, Gauss, and Stokes.
- enable students to apply multivariable and vector calculus to solve mathematical, scientific, engineering, and real-life problems.

Course Learning Outcomes (CLOs)

After completing this course, students will be able to

CLO#	Course Learning Outcomes	Bloom's Level
CLO1	**Explain** the fundamental concepts and techniques of vector-valued functions, including limits, derivatives, integrals, tangent lines, arc length, and curvature of plane curves.	Level 2 – Understand
CLO2	**Determine** partial derivatives, gradients, directional derivatives, tangent planes, and extreme values of functions of several variables using appropriate methods, including Lagrange multipliers.	Level 3 –Apply
CLO3	**Set up and evaluate** double, triple, and multiple integrals in rectangular, polar, cylindrical, and spherical coordinate systems, including change of variables and Jacobians.	Level 3 –Apply
CLO4	**Apply** partial derivatives and multiple integrals to solve real-	Level 3 –Apply

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	life problems involving surface areas, volumes, and other physical applications.	
CLO5	**Apply** the fundamental concepts of vector calculus, including line and surface integrals, and the integral theorems of Green, Stokes, and Gauss (Divergence), to solve mathematical and physical problems.	Level 3 –Apply

Mapping of CLOs with PLOs

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12
CLO1	√											
CLO2	√	√										
CLO3	√	√		√								
CLO4	√	√										
CLO5	√	√										

Course Contents — 28 weeks, 2 contact hours per week

Week	Topics	Teaching-Learning Strategy	Assessment Strategy	CLOs
1-4 (4 weeks)	**Vector-valued functions of a single variable:** Limits, derivatives, and integrals of vector-valued functions; Tangent lines to graphs of vector-valued functions; Arc length from a vector viewpoint; Arc length parametrization.	Lecture; Whiteboard Teaching; Problem Solving	Written Quiz; Tutorial Exercise; Class Test	CLO1
5-7 (3 weeks)	**Curvature of plane curves:** Definition, Curvature from intrinsic equations, Cartesian equations and parametric equations, Radius of curvature, Centre of curvature.	Lecture; Worked Examples; Tutorial	Tutorial; Problem Solving; Class Test	CLO1
8-14 (7 weeks)	**Functions of several variables:** Graphs of functions of two variables; limits and continuity; partial derivatives, Differentiability, linearization, and differentials; the chain rule; partial derivatives with constrained variables; directional	Lecture; Whiteboard Teaching; Problem Solving	Assignment; Problem Solving; Class Test	CLO2

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	derivatives and tangent planes; extrema of functions of several variables; Lagrange multipliers; Taylor's formula.			
15-18 (4 weeks)	**Multiple Integration:** Double integrals and iterated integrals, Double integrals over nonrectangular regions, Double integrals in polar coordinates, Area by double integrals.	Lecture; Worked Examples; Tutorial	Tutorial Exercise; Problem Solving; Class Test	CLO3, CLO4
19-21 (3 weeks)	**Triple integrals and iterated integrals:** Volume as a triple integral, Triple integral in cylindrical and spherical coordinates.	Lecture; Problem Solving; Tutorial	Assignment; Problem Solving; Class Test	CLO3, CLO4
22-23 (2 weeks)	**General multiple integrals:** Change of variables in multiple integrals; Jacobians.	Lecture; Worked Examples; Problem Solving	Tutorial Exercise; Problem Solving; Written Quiz	CLO3
24-28 (5 weeks)	**Vector Calculus:** Scalar and vector fields; gradient, divergence, and curl and their properties; line and surface integrals; Green's theorem, Gauss's theorem, and Stokes' theorem.	Lecture; Interactive Discussion; Problem Solving	Assignment; Problem Solving; Class Test	CLO5

Course Assessment Framework

Total Course Marks: 100

Assessment Category	Assessment Component	Weightage
Formative Assessment (20%)	Attendance & Class Participation	5%
	In-course Examination	10%
	Quiz / Assignment Presentation	5%
Summative Assessment (80%)	Final Examination • Students will have to answer 8 questions out of 12 • 10 marks per question ($8 \times 10 = 80$ marks) • Each question may contain a maximum of 3 sub-sections (e.g., a, b, c) • Duration of Examination: 4 Hours	80%

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List of Books

Anton, H., Bivens, I., & Davis, S. (2012). *Calculus* (10th ed.). John Wiley & Sons.

Bers, L., & Karal, P. (1976). *Calculus with analytic geometry*. Holt, Rinehart and Winston.

Lang, S. (1987). *Calculus of several variables* (3rd ed.). Springer-Verlag.

Marsden, J. E., & Tromba, A. J. (2012). *Vector calculus* (6th ed.). W. H. Freeman and Company.

Stewart, J., Clegg, D., & Watson, S. (2020). *Calculus: Early transcendentals* (9th ed.). Cengage Learning.

Swokowski, E. W. (1983). *Calculus with analytic geometry* (5th ed.). Brooks/Cole Publishing Company.

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Course Code	8223753	Marks: 100	Credits: 4	Class Hours: 56
Course Title:	Ordinary Differential Equations			

Course Description: This course provides an introduction to ordinary differential equations with applications. Topics include classification of differential equations and what is meant by the solution of a differential equation; first-order equations for which exact solutions are obtainable; solution of initial value problems; explicit methods for solving higher-order linear differential equations; an introduction to systems of differential equations. Solutions of second- and higher-order linear differential equations with constant and variable coefficients. Students will acquire basic knowledge of the applications of differential equations and the formulation of models for real-world problems.

Course Objectives (COs)

The objectives of this course are to

- develop a sound understanding of the fundamental concepts, classifications, and solution techniques of ordinary differential equations.
- develop analytical and problem-solving skills for solving first-order and higher-order ordinary differential equations using appropriate mathematical methods.
- enable students to formulate and analyze mathematical models of real-world problems using ordinary differential equations.
- introduce series methods for solving second-order linear differential equations and special differential equations arising in mathematics, science, and engineering.

Course Learning Outcomes (CLOs)

After completing this course, students will be able to

CLO#	Course Learning Outcomes	Bloom's Level
CLO1	**Explain** the concepts, classifications, solution types, existence and uniqueness theorems, direction fields, and phase plane of ordinary differential equations.	Level 2 – Understand
CLO2	**Solve** first-order and higher-order ordinary differential equations using appropriate analytical methods, including separable, linear, exact, homogeneous, Bernoulli, Riccati, Clairaut, Euler–Cauchy, undetermined coefficients, and variation of parameters.	Level 3 – Apply
CLO3	**Analyze** mathematical models involving ordinary differential equations, interpret their solutions, and apply them to real-world problems in science, engineering, and related fields.	Level 4 – Analyze
CLO4	**Analyze and solve** second-order linear differential equations using Taylor and Frobenius series methods, and determine series solutions of Legendre, Bessel, Laguerre, and Hermite differential equations.	Level 4 – Analyze

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Mapping of CLOs with PLOs

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12
CLO1	√											
CLO2	√	√										
CLO3	√	√										
CLO4	√	√										

Course Contents — 28 weeks, 2 contact hours per week

Week	Topics	Teaching-Learning Strategy	Assessment Strategy	CLOs
1-3 (3 weeks)	**Ordinary differential equations and their solutions:** Classification of differential equations. Solutions. Implicit solutions. Singular solutions. Initial value problems. Boundary value problems. Basic existence and uniqueness theorems (statement and illustration only). Direction fields. Phase plane.	Lecture; Whiteboard Teaching; Interactive Discussion	Written Quiz; Tutorial Exercise; Class Test	CLO1
4-9 (6 weeks)	**Solution of first-order differential equations:** Separable equations. Linear equations. Exact equations. Special integrating factors. Substitutions and transformations. Homogeneous equations. Bernoulli equation. Riccati equation. First-order, higher-degree equation solvable for *x*, *y*, and *p*. Clairaut's equation.	Lecture; Worked Examples; Problem Solving	Problem Solving; Assignment; Class Test	CLO2
10-14 (5 weeks)	**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	Lecture; Problem-Based Learning; Case Study	Assignment; Problem Solving; Presentation	CLO3

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	and oblique trajectories.			
15–21 (7 weeks)	**Solution of higher-order linear 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 linear equations with constant coefficients. Non-homogeneous equation. Method of undetermined coefficients. Variation of parameters. Euler-Cauchy differential equation.	Lecture; Worked Examples; Problem Solving	Problem Solving; Tutorial Exercise; Class Test	CLO2
22–28 (7 weeks)	**Series solutions of second-order linear equations:** Taylor series solutions about an ordinary point. Frobenius series solutions about regular singular points. Series solutions of Legendre, Bessel, Laguerre, and Hermite equations.	Lecture; Worked Examples; Tutorial	Tutorial Exercise; Assignment; Class Test	CLO4

Course Assessment Framework

Total Course Marks: 100

Assessment Category	Assessment Component	Weightage
Formative Assessment (20%)	Attendance & Class Participation	5%
	In-course Examination	10%
	Quiz / Assignment Presentation	5%
Summative Assessment (80%)	Final Examination • Students will have to answer 8 questions out of 12 • 10 marks per question ($8 \times 10 = 80$ marks) • Each question may contain a maximum of 3 sub-sections (e.g., a, b, c) • Duration of Examination: 4 Hours	80%

List of Books

Ayres, F., Jr. (1972). *Schaum's outline of theory and problems of differential equations*. McGraw-Hill.

Braun, M. (1993). *Differential equations and their applications* (4th ed.). Springer-Verlag.

Gill, D. (1986). *Introduction to differential equations*. Prentice Hall.

Ross, S. L. (1984). *Differential equations* (3rd ed.). John Wiley & Sons.

Zill, D. G. (2018). *A first course in differential equations with modeling applications* (11th ed.). Cengage Learning.

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Course Code	8223755	Marks: 100	Credits: 4	Class Hours: 56
Course Title:	Programming Fundamentals (FORTRAN)			

Course Description: This course is designed to help students develop foundational knowledge of computer programming and gain hands-on experience with developer tools. By focusing on the syntax, semantics, and data types of the FORTRAN programming language, students will gain the skills needed to write efficient, portable code. The course emphasizes practical application and problem-solving, enabling students to develop programs that function across various hardware and software platforms. Upon completion, students will be able to apply programming principles to real-world tasks, aligning with specific course learning outcomes.

Course Objectives (COs)

This course aims to

- introduce the fundamental concepts of computers, information processing, and FORTRAN programming.
- develop algorithmic thinking and problem-solving skills through flowcharts, algorithms, and structured programming techniques.
- develop programming skills for designing, coding, testing, and debugging FORTRAN programs using appropriate programming constructs and subprograms.
- enable students to apply FORTRAN programming to solve mathematical and scientific problems through computational methods.

Course Learning Outcomes (CLOs)

After completing this course, students will be able to

CLO#	Course Learning Outcomes	Bloom's Level
CLO1	**Explain** the fundamental concepts of computer systems, information processing, data representation, and the basic features and evolution of the FORTRAN programming language.	Level 2 – Understand
CLO2	**Develop** algorithms, flowcharts, and structured FORTRAN programs using appropriate programming constructs, data types, input/output operations, decision structures, loops, arrays, functions, subroutines, and recursion.	Level 3 – Apply
CLO3	**Implement and debug** FORTRAN programs to solve mathematical and scientific problems using appropriate programming techniques.	Level 3–Apply
CLO4	**Analyze** computational problems, select appropriate programming approaches, and interpret program outputs to solve mathematical and scientific problems, including root-finding and initial-value problems.	Level 4 – Analyze

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Mapping of CLOs with PLOs

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12
CLO1					√							
CLO2	√	√			√							
CLO3		√			√							
CLO4		√			√							

Course Contents — 28 weeks, 2 contact hours per week

Week	Topics	Teaching-Learning Strategy	Assessment Strategy	CLOs
1–2 (2 weeks)	**Brief Introduction to Computers:** Computer system, Information processing cycle, Operating System, Data representation in a computer.	Lecture; Interactive Discussion; Demonstration	Written Quiz; Tutorial Exercise; Class Test	CLO1
3–4 (2 weeks)	**Problem-solving techniques using computers:** Flowcharts, Algorithms.	Lecture; Problem Solving; Hands-on Practice	Assignment; Coding Exercise; Class Test	CLO2
5 (1 week)	**Programming Language:** FORTRAN and its History, Evolution of FORTRAN.	Lecture; Interactive Discussion; Demonstration	Written Quiz; Tutorial Exercise	CLO1
6–8 (3 weeks)	**Basic Elements of FORTRAN:** Character set, Structure of Fortran statements, Constants, Variables, Operators and Operations, Intrinsic Functions.	Lecture; Worked Examples; Hands-on Practice	Written Quiz; Coding Exercise; Class Test	CLO1, CLO2
9–18 (10 weeks)	**Programming in Fortran:** Syntax and semantics, Data types and program structure, Formatted input/output concepts, Loops, Decision statements, One- and two-dimensional arrays, User-defined functions, Recursion, Pseudocode and Control	Lecture; Coding Practice; Problem Solving	Coding Exercise; Assignment; Class Test	CLO2, CLO3

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	structures.			
19–21 (3 weeks)	**Subprogram:** Function subprogram and subroutine.	Lecture; Coding Practice; Worked Examples	Coding Exercise; Assignment; Class Test	CLO2, CLO3
22–28 (7 weeks)	**Computing using FORTRAN:** Construction and implementation of FORTRAN programs for solving problems in mathematics and the sciences, including the root-finding problem for equations of one variable and IVPs.	Hands-on Practice; Problem-Based Learning; Computer Lab	Programming Project; Practical Test; Viva Voce	CLO3, CLO4

Course Assessment Framework

Total Course Marks: 100

Assessment Category	Assessment Component	Weightage
Formative Assessment (20%)	Attendance & Class Participation	5%
	In-course Examination	10%
	Quiz / Assignment Presentation	5%
Summative Assessment (80%)	Final Examination • Students will have to answer 8 questions out of 12 • 10 marks per question ($8 \times 10 = 80$ marks) • Each question may contain a maximum of 3 sub-sections (e.g., a, b, c) • Duration of Examination: 4 Hours	80%

List of Books

Brainerd, W. S., Goldberg, C. H., & Adams, J. C. (1996). *Programmer's guide to Fortran 90* (3rd ed.). Springer.

Chapman, S. J. (2008). *Fortran 95/2003 for scientists and engineers* (3rd ed.). McGraw-Hill.

Chivers, I., & Sleightholme, J. (2015). *Introduction to programming with Fortran* (4th ed.). Springer.

Metcalf, M., Reid, J., & Cohen, M. (2018). *Modern Fortran explained: Incorporating Fortran 2018* (5th ed.). Oxford University Press.

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Course Code	8223756	Marks: 100	Credits: 4	Class Hours: 84
Course Title:	Math Lab-Practical II (Mathematica and FORTRAN)			

Course Description: This course provides hands-on training in solving mathematical problems using Mathematica and FORTRAN. It emphasizes computationally implementing and visualizing concepts from Advanced Calculus, Ordinary Differential Equations, and Programming Fundamentals (FORTRAN) through algorithm development, programming, symbolic computation, numerical computation, and graphical analysis. The course develops practical skills in mathematical computing, problem-solving, program implementation, and interpretation of computational results for applications in mathematics, science, and engineering.

Course Objectives (COs)

This course aims to

- apply practical skills in using Mathematica and FORTRAN for mathematical computation and problem-solving.
- enable students to integrate concepts from Advanced Calculus, Ordinary Differential Equations, and Programming Fundamentals (FORTRAN) for computational modelling and problem-solving using Mathematica and FORTRAN.
- develop programming and algorithmic skills for mathematical and scientific computing using FORTRAN.
- enhance students' ability to visualize, analyze, and interpret mathematical problems through symbolic, numerical, and graphical computations using Mathematica.
- strengthen computational thinking and technical skills required for advanced study, research, and applications in mathematics, science, and engineering.

Course Learning Outcomes (CLOs)

After completing this course, students will be able to

CLO#	Course Learning Outcomes	Bloom's Level
CLO1	**Apply** Mathematica and Fortran to solve mathematical and scientific problems.	Level 3 – Apply
CLO2	**Develop and implement** Fortran programs to solve problems related to Advanced Calculus and Ordinary Differential Equations.	Level 3 – Apply
CLO3	**Analyze and visualize** mathematical functions, vector fields, multiple integrals, and differential equation models using Mathematica.	Level 4 – Analyze
CLO4	**Evaluate and validate** computational results obtained using Mathematica and Fortran and present solutions using appropriate numerical, graphical, and computational techniques.	Level 5 – Evaluate

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Mapping of CLOs with PLOs

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12
CLO1	✓				✓							
CLO2	✓	✓			✓							
CLO3	✓	✓		✓	✓							
CLO4		✓		✓	✓					✓		

Course Contents — 28 weeks, 3 contact hours per week

Week	Topics	Teaching-Learning Strategy	Assessment Strategy	CLOs
1–2 (2 weeks)	**Introduction to Mathematical Computing** • Mathematica environment • FORTRAN environment • Basic commands and programming interface • File handling and program execution	Demonstration; Hands-on Practice; Interactive Discussion	Practical Exercise; Written Quiz; Viva Voce	CLO1
3–8 (6 weeks)	**Mathematica Applications in Advanced Calculus** • Vector-valued functions, derivatives, and integrals • Arc length and curvature of curves • Partial and directional derivatives, gradients, and tangent planes • Optimization of multivariable functions and Lagrange multipliers • Double and triple integrals • Jacobians and vector calculus	Demonstration; Hands-on Practice; Problem Solving	Practical Exercise; Assignment; Practical Test	CLO1, CLO3
9–13 (5 weeks)	**Fortran Applications in Advanced Calculus** • Computational solutions to problems involving vector-valued functions and curvature • Numerical differentiation and integration • Numerical evaluation of multiple integrals	Coding Practice; Hands-on Practice; Problem Solving	Coding Exercise; Practical Test; Viva Voce	CLO2

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	• Computational applications of partial derivatives and optimization			
14–19 (6 weeks)	**Mathematica Applications in Ordinary Differential Equations** • Symbolic and numerical solutions of first- and higher-order ODEs • Initial-value problems and direction fields • Phase-plane analysis • Mathematical modelling using first-order ODEs • Taylor and Frobenius series solutions	Demonstration; Hands-on Practice; Problem Solving	Practical Exercise; Assignment; Practical Test	CLO3, CLO4
20–24 (5 weeks)	**FORTRAN Applications in Advanced Calculus and ODEs** • Numerical optimization and mathematical computation • Numerical methods for multiple integrals • Root-finding methods for nonlinear equations in one variable • Numerical solutions of initial-value problems (IVPs)	Coding Practice; Hands-on Practice; Problem Solving	Coding Exercise; Practical Test; Viva Voce	CLO2, CLO4
25–28 (4 weeks)	**Computational Projects and Practical Problem Solving** • Development and implementation of computational solutions using Mathematica and Fortran • Testing, verification, and interpretation of computational results • Applications drawn from Advanced Calculus and Ordinary Differential Equations • Presentation of computational projects	Project-Based Learning; Hands-on Practice; Presentation	Project Report; Practical Test; Presentation	CLO2, CLO3, CLO4

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Teaching Learning Activities

Laboratory Classes: 28 (Each 3-hour laboratory session covers computational problems from the second-year core mathematics courses.)
Class Test: 01
Lab Notebook: 01 (Instructors will assign at least 28 lab tasks)

Assessment Scheme
Continuous Assessment: 30 Marks + **Final Exam:** 70 Marks

Type of evaluation	Time	Marks	Guideline
Final Exam	3 hours	70	The examination shall consist of 10 questions, divided into Group A (Mathematica) and Group B (FORTRAN), with 5 questions in each group. Students shall answer 7 questions, selecting at least 3 questions from each group.
Class Test	1 hour	20	Internal Assessment: Two questions have to be answered out of the three questions
Lab Notebook	-----	5	Internal Assessment: Throughout the whole course content (at least 28 lab tasks)
Class attendance	-----	5	Internal Assessment
Total		**100**	

Problem Selection: Select practical problems, assignments, and examination tasks from the courses Advanced Calculus, Ordinary Differential Equations, and Programming Fundamentals (FORTRAN) offered in the second year of the B.Sc. (Honours) Mathematics programme.

List of Books

Chapman, S. J. (1998). *Fortran 90/95 for scientists and engineers*. McGraw-Hill.

Lipschutz, S. (1990). *Schaum's outline of Mathematica*. McGraw-Hill.

Metcalf, M., Reid, J., & Cohen, M. (2018). *Modern Fortran explained: Incorporating Fortran 2018* (5th ed.). Oxford University Press.

Smith, G. D. (1985). *Fortran 77 and numerical methods for scientists and engineers*. Ellis Horwood.

Wolfram Research, Inc. (2024). *Mathematica* (Student Edition). Wolfram Research.

Wolfram, S. (2003). *The Mathematica book* (5th ed.). Wolfram Media.

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Allied Courses

Course Code	8222757	Marks: 100	Credits: 4	Class Hours: 56
Course Title:	Physics-III (Electricity and Modern Physics)			

Course Description

This course develops fundamental knowledge of electricity, magnetism, electronics, electromagnetism, special relativity, quantum physics, atomic physics, and nuclear physics. Students learn to apply physical principles to solve theoretical and practical problems, analyze electromagnetic phenomena, explain quantum behavior of matter, and understand nuclear processes and their applications.

Course Objectives

Upon successful completion of this course, students will be able to:

1. Develop a sound understanding of electricity and modern physics.
2. Explain the phenomenon laws of electricity and modern physics.
3. Apply knowledge of electricity, magnetism, and modern physics to analyze the theory of relativity and quantum concepts of physical phenomena.
4. Understand the physical principles underlying modern technologies.
5. Solve practical problems involving circuits, nuclear physics, and real-life applications of modern physics.

Course Learning Outcomes (CLOs)

Upon successful completion of this course, students will be able to:

CLO-1	Explain the concepts of electrostatics, electric fields, electric potential, capacitance, and dielectric materials using appropriate physical laws.
CLO-2	Analyze DC and AC electric circuits, electromagnetic induction and magnetic phenomena using mathematical techniques and circuit laws.
CLO-3	Apply the principles of electronics, semiconductors, and transistor circuits in explaining the operation of electronic devices.
CLO-4	Interpret the principles of special relativity and quantum mechanics in explaining microscopic physical phenomena.
CLO-5	Explain atomic structure, nuclear properties, radioactivity, nuclear reactions and their technological applications.
CLO-6	Solve numerical and analytical problems involving electricity, magnetism, relativity, quantum physics and nuclear physics using appropriate mathematical and computational methods.

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Mapping of CLOs with Program Learning Outcomes

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12
CLO1	✓											
CLO2	✓	✓										
CLO3	✓	✓										
CLO4	✓											
CLO5	✓											
CLO6	✓	✓										

Course Contents — 28 weeks, 2 contact hours per week

Week	Topics	Teaching-Learning Strategy	Assessment Strategy	CLO
1-2	**Electrostatic Field**: Electric field, Electric field due to point charge, dipole and continuous charge distribution	Interactive lectures, Problem-solving sessions	Quiz test, In-course and Final Examination	CLO1
3-4	**Electrostatic potential**: Electric potential and potential energy, Relation between electric field and potential, Van de Graaff generator	Interactive lectures, Group discussions	Quiz test, In-course and Final Examination	CLO1
5	**Flux of electrostatic field**: Electric flux, Gauss's law, Solid angle, Applications of Gauss's law	Interactive lectures, Problem-solving sessions,	Quiz test, In-course and Final Examination	CLO1
6	**Capacitors and Dielectrics:** Capacitors, Parallel-plate and cylindrical capacitors, Dielectrics, Energy stored in electric field	Interactive lectures, Problem-solving sessions,	Quiz test, In-course and Final Examination	CLO1
7-8	**Electric Current (D.C):** Current and current density. Resistance, Resistivity and conductivity, Atomic view of resistivity, Energy transfer in an electric circuit, Kirchhoff's laws and their applications. Potentiometer. Meter bridge and Post office box.	Interactive lectures, Problem-solving sessions,	Quiz test, In - course and Final Examination	CLO2
9-10	**Magnetic Properties of matter:** Magnetic dipole, Gauss's Law for magnetism, Paramagnetism, Diamagnetism and ferromagnetism, Nuclear magnetism, Energy in a magnetic field, Hysteresis.	Interactive lectures, Problem-solving sessions	Quiz test, In-course and Final Examination	

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10-13	**The Magnetic field and Electromagnetic induction:** Motion of a charge in a magnetic field. Magnetic force on a current, Torque on a current loop, the Hall effect, Circulating charges. Thomson`s experiment, Ampere's law, B near a long wire, Ampere's circuital law, B due to a solenoid, the Biot-Savart law and its applications. Time-varying magnetic fields, Energy density in a magnetic field.	Interactive lectures, Problem-solving sessions,	Quiz test, In-course and Final Examination	CLO2
14-16	**Alternating Currents:** Alternating current, Concept of r.m.s and average values of current and voltage, Resistive circuit, CR, LR and LCR circuits in series and parallel, Resonance, Phase and Power transformer.	Interactive lectures, Problem-solving sessions,	In- course and Final Examination	CLO2
17-18	**Electronics:** Vacuum diodes and triodes, P-type, n-type semiconductors, p-n junctions, Transistors, Transistor biasing, Transistor amplifiers, Transmitters and Receivers.	Interactive lectures, Problem-solving sessions,	In- course and Final Examination	CLO3
19-21	**Special Theory of Relativity:** Inertial frame, Galilean transformation, Michelson-Morley experiment, Postulates of special theory of relativity, Lorentz transformation equations, space contraction, Time dilation, Relativity of mass, Mass and energy.	Interactive lectures, Problem-solving sessions,	Quiz test, In-course and Final Examination	CLO4
22-23	**Light and Quantum Physics:** Planck's radiation formula, Photoelectric effect, Einstein's Photon theory, The Compton effect, The hydrogen atom and The correspondence principle	Interactive lectures, Problem-solving sessions, Group discussions	Presentation, In- course and Final Examination	CLO4
24-25	**Waves and particles:** Matter waves, atomic structure and standing waves, Mechanics, Uncertainty principle.	Interactive lectures,	In- course and Final Examination	CLO4

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26	**The atomic nucleus:** The nuclear force, Nuclear radius, Stable nuclei, The binding energy of stable nuclei mass defect, and Packing fraction.	Interactive lectures, Group discussions	Quiz test, In-course and Final Examination	CLO5
27-28	**Radioactivity:** Meaning of radioactivity, Unstable nuclei, Exponential decay law, Half-life, Mean life and units of radioactivity, Basic ideas of nuclear reactor, Nuclear fission and Nuclear fusion.	Interactive lectures, Problem-solving sessions,	Quiz test, In-course and Final Examination	CLO5

Course Assessment Framework

Total Course Marks: 100

Assessment Category	Assessment Component	Weightage
Formative Assessment (20%)	Attendance & Class Participation	5%
	In-course Examination	10%
	Quiz / Assignment Presentation	5%
Summative Assessment (80%)	Final Examination • Students will have to answer 8 questions out of 12 • 10 marks per question ($8 \times 10 = 80$ marks) • Each question may contain a maximum of 3 sub-sections (e.g., a, b, c) • Duration of Examination: 4 Hours	80%

Mapping of Course Contents with CLOs

Module	CLO1	CLO2	CLO3	CLO4	CLO5	CLO6
Electrostatics	✓	✓				✓
Electric Current & Magnetism		✓				✓
AC & Electronics		✓	✓			✓
Relativity & Quantum Physics				✓		✓
Nuclear Physics				✓	✓	✓

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List of Books

Beiser, A. (2003). *Concepts of Modern Physics* (6th ed.). McGraw-Hill Higher Education

Goldstein, H., Poole, C. P., & Safko, J. L. (2002). *Classical mechanics* (3rd ed.). Addison-Wesley.

Halliday, D., Resnick, R., & Walker, J. (2018). *Fundamentals of physics* (11th ed.). Wiley.

Marion, J. B., & Thornton, S. T. (2003). *Classical dynamics of particles and systems* (5th ed.). Brooks/Cole.

Purcell, E. M., & Morin, D. J. (2013). *Electricity and magnetism* (3rd ed.). Cambridge University Press.

Reitz, J. R., Milford, F. J., & Christy, R. W. (2008). *Foundations of electromagnetic theory* (4th ed.). Pearson.

Tarrant, G. T. P. (1949). *Electricity, Magnetism and Modern Physics.* Dent, UK

Taylor, J. R. (2005). *Classical mechanics*. University Science Books.

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Course Code	**8222758**
Course Title	Physics-IV (Physics Practical)
Credits	2
Marks	50
Practical Hours	42
Examination Duration	6 Hours

Course Description

This laboratory course is designed to provide students with practical knowledge and experimental skills in mechanics, thermal physics, electricity, magnetism, and optics. The course enables students to verify fundamental physical laws experimentally, acquire competence in handling laboratory instruments, analyze experimental data using graphical and statistical methods, estimate experimental errors, and prepare scientific laboratory reports. The laboratory activities strengthen the theoretical concepts learned in Physics courses and develop professional laboratory practices.

Course Objectives (COs)

After successful completion of this course, students will be able to

CO1.	Develop proficiency in handling standard laboratory instruments used in mechanics, thermal physics, electricity, magnetism, and optics.
CO2.	Perform physics experiments systematically by following standard laboratory procedures and safety protocols.
CO3.	Analyze experimental observations using appropriate mathematical and graphical techniques.
CO4.	Estimate experimental uncertainties and interpret results using error analysis.
CO5.	Prepare scientific laboratory reports and communicate experimental findings effectively.

Course Learning Outcomes (CLOs)

Upon successful completion of the course, students will be able to:

CLO	Learning Outcome	Bloom's Level
CLO1	Explain the theoretical principles underlying laboratory experiments in mechanics, thermal physics, electricity, magnetism, and optics.	Understand
CLO2	Conduct laboratory experiments related to Mechanics and Thermal Physics using appropriate apparatus while following laboratory safety and ethical practices.	Apply
CLO3	Conduct laboratory experiments related to Electricity and Optics using appropriate apparatus while following laboratory safety and ethical practices.	Apply
CLO4	Analyze experimental data through calculations, graphs, and error	Analyze

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	estimation to obtain reliable physical parameters.	
CLO5	Evaluate experimental results by comparing them with theoretical predictions and identifying possible sources of error.	Evaluate
CLO6	Prepare well-organized laboratory reports and effectively communicate experimental findings during viva-voce examinations.	Create

Mapping of CLOs with Program Learning Outcomes (PLOs)

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12
CLO1	✓											
CLO2	✓	✓						✓				
CLO3	✓	✓						✓				
CLO4		✓		✓								
CLO5	✓	✓		✓								
CLO6										✓		

Course Contents

Group A: Mechanics and Thermal Physics Laboratory

Students will perform **one experiment** from the following list.

Expt. No.	Experiment	Teaching Learning Weeks
	Safety in laboratory	1
	Lab report writing	2
1	Determination of acceleration due to gravity (g) by compound pendulum	3
2	Determination of Young's and rigidity modulus by Searle's dynamic method	4
3	Determination of Rigidity modulus by static method	5
4	Determination of Surface tension of water by capillary tube method	6
5	Determination of Spring constant, effective mass and rigidity modulus of a spiral spring	7
6	Determination of Young's modulus by bending (flexure) method	8
7	Determination of Moment of inertia of a flywheel	9
8	Determination of Surface tension of mercury by Quincke's method	10
9	Determination of Specific heat of a solid by the method of mixtures	11
10	Determination of Specific heat of a liquid by cooling method	12
11	Determination of Thermal conductivity of a bad conductor by Lee's method	13
12	Determination of Mechanical equivalent of heat (J) with radiation	14

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	correction	
13	Verification of laws of transverse vibration using a sonometer (frequency against length and frequency against tension curves)	15
14	Frequency determination by Melde's experiment	16

Group B: Electricity and Optics Laboratory

Students will perform **one experiment** from the following list.

Expt. No.	Experiment	Practical Hours
15	Comparison of EMFs using potentiometer	17
16	Determination of Galvanometer resistance by half-deflection method	18
17	Determination of Low resistance by fall of potential method	19
18	Determination of Electrochemical equivalent of copper/silver	20
19	Determination of Refractive index of prism using spectrometer	21
20	Determination of Cauchy's constants and resolving power of prism	22
21	Determination of Wavelength determination using Newton's rings	23
22	Determination of Wavelength determination using Fresnel biprism	24
23	Investigation of Specific rotation using polarimeter	25
	Practice: Experiment and Viva	26-28

Teaching-Learning Strategies

- Laboratory demonstrations
- Hands-on experiments
- Guided laboratory sessions
- Problem-solving during experiments
- Data analysis using graphical methods
- Laboratory discussions
- Viva-voce
- Scientific report writing

Laboratory Safety Practices

Students shall

- Follow laboratory safety regulations.
- Handle fragile optical and electrical instruments carefully.
- Maintain laboratory discipline.

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- Record observations honestly.
- Report equipment malfunction immediately.
- Dispose of laboratory materials properly.

Assessment Strategy

Examination duration: 6 hours

To perform two experiments (one from each group), each of three hours' duration.

i) Experiments (3 hours each)	2 x 17=	34
ii) Laboratory note book		6
iii) Class attendance		5
iv) Experimental Viva-voce		5

Marks for each experiment shall be distributed as follows:

a) Theory	4
b) Data collection and Tabulation	6
c) Calculation, graphs and result	4
d) Discussion	3
Total marks =	17

Assessment Component	CLOs Assessed
Experiment-1-14	CLO1,2,3 and 5
Experiment-15-23	CLO1,2,4 and 5
Laboratory Notebook	CLO4 and 5
Experimental Viva-Voce	CLO1 to CLO6
Total	

CLO–Assessment Mapping

Assessment Tool	CLO1	CLO2	CLO3	CLO4	CLO5
Experiment Performance	✓	✓	✓	✓	
Data Analysis		✓	✓	✓	
Laboratory Notebook			✓		✓
Viva-Voce	✓	✓	✓	✓	✓

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Graduate Attributes Developed

Upon completion of the course, students will develop:

- Practical laboratory skills
- Experimental design and execution
- Critical thinking
- Scientific reasoning
- Quantitative data analysis
- Technical communication
- Professional ethics
- Teamwork
- Lifelong learning attitude

List of Books:

Ahmed, G. U., & Uddin, M. S. (1992). *Practical physics for degree students* (3rd ed.). Hafiz Book House

Cerny, E. J. (1976). *Introduction to experimental physics*. McGraw-Hill.

Halliday, D., Resnick, R., & Walker, J. (2018). *Fundamentals of physics* (11th ed.). Wiley.

Nelkon, M., & Parker, P. (1978). *Advanced level physics*. Heinemann.

Singh, S. P. (2011). *Advanced practical physics* (18th ed.). Pragati Prakashan.

Squires, G. L. (2001). *Practical physics* (4th ed.). Cambridge University Press.

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Course Code: 8223659	Marks: 100	Credits:4	Class Hours: 56
Course Title: Methods of Statistics			Exam Duration: 4 hours

I. COURSE DESCRIPTION

This course provides a rigorous mathematical and applied introduction to the core pillars of statistical inference. Students will explore the theoretical foundations of sampling distributions (Normal, χ^2, t, and F), the logic of experimental design and ANOVA (CRD, RBD, LSD, and Factorials), probabilistic survey sampling techniques (SRS, Stratified, Systematic, Cluster, and Multistage), and the Neyman-Pearson paradigm of hypothesis testing. The curriculum culminates in the practical application of parametric and non-parametric tests for means, variances, proportions, correlation, regression, and goodness-of-fit, equipping students to design studies, analyze data critically, and communicate findings effectively.

II. COURSE LEARNING OUTCOMES (CLOs)

CLO #	Course Learning Outcomes	Bloom's Level
CLO-1	**Define** sampling distributions, mathematically derive the standard error of statistics, and differentiate the properties, assumptions, and appropriate applications of the Normal, χ^2, t, and F distributions.	Level 1, 4: Understand, Analyze
CLO-2	**Apply** the principles of Randomization, Replication, and Local Control to construct complete ANOVA tables, estimate parameters, and perform missing plot analysis for CRD, RBD, and LSD.	Level 3, 4: Apply, Analyze
CLO-3	Design, analyze, and interpret main and interaction effects for $\mathbf{2^2}$ and $\mathbf{2^3}$ factorial experiments, utilizing interaction plots to draw valid conclusions.	Level 4, 5: Analyze, Evaluate
CLO-4	Distinguish between censuses and sample surveys, identify sampling and non-sampling errors, and execute parameter estimation (means, totals, proportions) using SRS, Stratified, Systematic, Cluster, and Multistage sampling designs.	Level 3, 4: Apply, Analyze
CLO-5	Critically **evaluate** the statistical and logistical trade-offs between probability sampling methods and non-probability quota sampling in real-world survey contexts.	Level 5: Evaluate

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CLO-6	Explain the Neyman-Pearson logic of hypothesis testing, formulate null/alternative (simple/composite) hypotheses, and correctly compute Type I/II errors, power, significance levels, and p-values for one- and two-tailed tests.	Level 1, 3: Understand, Apply
CLO-7	Execute significance tests and construct confidence intervals for single/double means, variances, proportions, correlation coefficients, and regression coefficients (including paired t-tests).	Level 3, 4: Apply, Analyze
CLO-8	Apply χ^2 tests of homogeneity to compare several population means, variances, and proportions, and perform χ^2 goodness-of-fit tests for theoretical distributions.	Level 3, 5: Apply, Evaluate
CLO-9	Synthesize sampling, experimental design, and hypothesis testing methods to design a complete statistical investigation, analyze data using appropriate tools, and communicate evidence-based conclusions effectively.	Level 5, 6: Evaluate, Synthesize

III. MAPPING OF COURSE LEARNING OUTCOMES (CLOs) WITH PROGRAM LEARNING OUTCOMES (PLOs)

This table demonstrates how each CLO contributes to achieving the broader Program Learning Outcomes.

Indication: ✓ = Mapped / Aligned

CLOs	**PLO 1**	**PLO 2**	**PLO 3**	**PLO 4**	**PLO 5**	**PLO 6**	**PLO 7**	**PLO 8**	**PLO 9**	**PLO 10**	**PLO 11**	**PLO 12**
CLO 1	✓											
CLO 2	✓	✓										
CLO 3	✓	✓	✓	✓								
CLO 4	✓	✓		✓								
CLO 5		✓	✓									
CLO 6	✓	✓										
CLO 7	✓	✓		✓								
CLO 8	✓	✓		✓								
CLO 9	✓	✓	✓	✓	✓					✓	✓	

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IV. DETAILED SYLLABUS (MODULE-WISE WITH TEACHING-LEARNING APPROACH & ASSESSMENT)

Module & Class Hours	Contents	Teaching-Learning Approach	Module Assessment	CLOs Mapped
Module 1 (Class Hours 10)	**Sampling Distributions** • Concept of sampling distribution of a statistic. • Derivation of Standard Error (SE) for sample means and proportions. • χ^2 distribution: properties, degrees of freedom, and uses. • t-distribution: properties, relationship to Normal, and uses. • F-distribution: properties, ratio of variances, and uses.	• Lectures: Interactive chalk-and-talk for derivations. • Collaborative Learning: Group problem-solving sessions on deriving SE. • Inquiry-Based: Students compare the shapes of t, χ^2, and F curves for different df using software.	• Quiz 1 • Assignment 1 • Class Test 1	CLO 1
Module 2 (Class Hours 10)	**Design of Experiments (Part A: Basic Designs)** •Principles: Randomization, Replication, Local Control. •ANOVA logic and construction of analysis tables. •Completely Randomized Design (CRD): Analysis & parameter estimation. •Randomized Block Design (RBD): Analysis & parameter estimation. •Latin Square Design (LSD): Analysis & parameter estimation. •Missing plot estimation techniques and adjusted analysis.	• Lectures: Step-by-step construction of ANOVA tables. • Flipped Classroom: Students watch a video on missing-plot estimation before class and practice in class. • Hands-on Lab: Use R/Minitab to analyze RBD and validate manual calculations.	• Lab Assignment 1 • Assignment 2 • Class Test 2	CLO 2

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Module & Class Hours	Contents	Teaching-Learning Approach	Module Assessment	CLOs Mapped
Module 2 (Class Hours 8)	**Design of Experiments (Part B: Factorial Designs)** • Introduction to factorial experiments. • 2^2 Factorial design: Main effects, interaction effects, and analysis. • 2^3 Factorial design: Main effects, two-way and three-way interactions. • Interpretation of results and interaction plots. • Choosing the appropriate design based on experimental constraints.	• Lectures: Demonstrate effect calculation using contrast coefficients. • Visual Learning: Construct interaction plots using data from case studies. • Case-Based Learning: Real-world factorial experiments (e.g., agriculture, manufacturing).	• Assignment 3 • Lab Assignment 2 • Class Test 3	CLO 3
Module 3 (Class Hours 10)	**Survey Methods & Sampling Techniques** • Population, sample, census vs. surveys; Sampling frame. • Sampling vs. Non-sampling errors. • Simple Random Sampling (SRS): Estimation of mean, total, proportion, and SE. • Stratified Random Sampling: Proportional & Optimal (Neyman) allocation. • Systematic Sampling: Selection methods and variance estimation. • Cluster Sampling (equal & unequal clusters). • Quota Sampling and Multistage Sampling: Concepts and practical trade-offs.	• Lectures: Derive estimators for each sampling method. • Problem-Based Learning: Real-world survey data (e.g., national census, health surveys). • Comparative Analysis: Compare variance reduction across SRS, Stratified, and Cluster using simulated data.	• Assignment 4 • Quiz 2 • Class Test 4	CLO 4, CLO 5

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Module & Class Hours	Contents	Teaching-Learning Approach	Module Assessment	CLOs Mapped
Module 4 (Class Hours 8)	**Introduction to the Test of Hypothesis** • Concept and logic of hypothesis testing. • Neyman-Pearson approach to testing. • Null (H_0) and Alternative (H_1) hypotheses; Simple and Composite hypotheses. • Hypothesis testing procedures. • Type I error, Type II error, and Statistical Power. • Level of significance • One-tailed and Two-tailed tests. • Critical value and P-value: interpretation and decision-making. • Overview of test statistics: Z, χ^2, t, F and their applications.	• Lectures: Build the Neyman-Pearson framework step-by-step. • Interactive Discussion: Real-world analogies (e.g., medical trials, court trials) to explain Type I/II errors. • Peer Instruction: Students formulate H_0 and H_1 for given scenarios and share with peers.	• Quiz 3 • Assignment 5 • In-course Exam 1	CLO 6

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Module & Class Hours	Contents	Teaching-Learning Approach	Module Assessment	CLOs Mapped
Module 5 (Class Hours 10)	**Statistical Tests** • Single mean, single variance, single proportion (tests & CIs). • Difference of two means (independent) and two proportions. • Ratio of two variances (F-test) and confidence intervals. • Confidence intervals for simple correlation coefficient (ρ). • Confidence intervals for regression coefficients (single & double sample). • Paired t-test (dependent samples). • χ^2 test of Homogeneity for several population means, variances, and proportions. • χ^2 Test of Goodness of Fit. **Non**-parametric tests: Sign test, Wilcoxon signed-rank test, Mann-Whitney U test, Kruskal-Wallis H test, K-S test, Test of randomness.	• Lectures: Derive test statistics for each test type. • Demonstration: Use software to run tests and compare with manual calculations. • Capstone Project: Students design a mini-study, collect data, and apply appropriate tests. • Case Studies: Real datasets from public health, economics, and education.	• Lab Assignment 3 • Assignment 6 • In-course Exam 2	CLO 7, CL 8, CLO 9

V. COURSE EVALUATION

Evaluation will be done using the grading system, as per the university guidelines.

A. Continuous Assessment

i. In-course – 10 Marks
ii. Assignments/quiz – 5 Marks
iii. Class attendance – 5 Marks

B. Final Examination: 80 Marks.

The question paper should contain 12 (twelve) theoretical questions, and students have to answer 08 (eight) questions. Each question carries 10 marks and may contain a maximum of 3 sub-sections (e.g., a, b, c).

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V. REFERENCES

Agresti, A. (2018). *Statistical Methods for the Social Sciences* (5th Edition, Pearson).

Ali, A. (1973). Theory of Statistics, Vol. II. Dhaka Book Mart.

Bhuiyan, M. R. (1977). Fundamentals of Experimental Design. Dhaka – Shakil Prokashoni.

Casella, G., & Berger, R. L. (2024). *Statistical Inference* (2nd Edition, Cengage Learning).

Cochran, W. G. (1977; Re-printed 2022). *Sampling Techniques* (3rd Edition, Wiley Classics Library).

Islam, M. N. (2014). An introduction to sampling methods: Theory and Applications. Dhaka: Mullick & Brothers.

Montgomery, D. C. (2023). *Design and Analysis of Experiments* (10th Edition, Wiley).

Mostafa, M. G. (1972). Methods of Statistics. Dhaka: Karim Press.

Peck, R., Olsen, C., & Devore, J. L. (2020). *Introduction to Statistics and Data Analysis* (6th Edition, Cengage).

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Course Code: 8223660	Marks: 50	Credits:2	Class Hours: 42
Course Title: Lab: Methods of Statistics			Exam Duration: 5 hours

I. COURSE DESCRIPTION

This lab-oriented practical course is designed to provide hands-on experience with advanced statistical methods, including design of experiments, sampling techniques, and hypothesis testing. Students will learn to analyze basic and factorial designs, handle missing plot estimation, and compute measures of relative efficiency. The course covers various sampling methods such as Simple Random Sampling (SRS), Stratified, Cluster, and Systematic sampling, along with estimation of population parameters. Additionally, students will gain proficiency in conducting common tests of significance for means, variances, proportions, correlation, and regression coefficients, fitting theoretical distributions, testing goodness-of-fit, and constructing confidence intervals. The course emphasizes practical problem-solving, data analysis using statistical software, report writing, and teamwork through a mini-project, preparing students for careers in research, data management, and academia.

II. COURSE LEARNING OUTCOMES (CLOs)

CLO #	Course Learning Outcomes	Bloom's Level
CLO-1	**Remember** the fundamental concepts and formulas related to the design of experiments (basic and factorial designs), missing plot estimation, and relative efficiency.	Level 1: Remembering
CLO-2	**Understand** and explain the principles and assumptions underlying various sampling techniques (SRS, Stratified, Cluster, Systematic) and hypothesis testing procedures.	Level 2: Understand
CLO-3	**Apply** appropriate statistical methods to analyze basic and factorial designs, estimate missing plot values, compute relative efficiency, draw various types of samples, and estimate population parameters with standard errors.	Level 3: Apply
CLO-4	**Analyze** and interpret statistical outputs from hypothesis tests (means, variances, proportions, correlation, regression), goodness-of-fit tests, and tests of homogeneity to draw valid conclusions.	Level 4: Analyze
CLO-5	**Evaluate** the appropriateness of different statistical techniques for given research problems and justify the selection of specific sampling designs or hypothesis tests based on data characteristics.	Level 5: Evaluate
CLO-6	**Create** comprehensive statistical reports and deliver effective presentations based on practical projects, demonstrating the ability to synthesize statistical findings and communicate them clearly to diverse audiences.	Level 6: Create

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III. MAPPING OF COURSE LEARNING OUTCOMES (CLOs) WITH PROGRAM LEARNING OUTCOMES (PLOs)

This table demonstrates how each CLO contributes to achieving the broader Program Learning Outcomes.

Indication: ✓ = Mapped / Aligned

CLOs	PLO-1	PLO-2	PLO-3	PLO-4	PLO-5	PLO-6	PLO-7	PLO-8	PLO-9	PLO-10	PLO-11	PLO-12
CLO-1	✓											
CLO-2	✓	✓										
CLO-3	✓	✓		✓	✓							
CLO-4	✓	✓		✓	✓							
CLO-5		✓	✓									
CLO-6				✓	✓					✓	✓	

IV. DETAILED SYLLABUS (MODULE-WISE WITH TEACHING-LEARNING APPROACH & ASSESSMENT)

Module & Class Hours	Contents	Teaching-Learning Approach	Module Assessmen	CLOs Mapped
Module 1: Design of Experiments (*Hours)*	Introduction to basic experimental designs: CRD, RCBD, and LSD. - Analysis of variance (ANOVA) for CRD, RCBD, and LSD. - Missing plot estimation techniques for RCBD and LSD. - Measures of relative efficiency of designs. - Introduction to factorial designs (2^2 and 2^3). - Analysis of factorial designs: main effects and interactions.	- **Lectures:** Conceptual explanation and derivation of formulas. - **Demonstrations:** Step-by-step problem-solving on the board. - **Practical Sessions:** Hands-on lab work using manual calculations.	- Practical Assignments: - Viva Voce:, - Quiz:	CLO 1, CLO 2, CLO 3

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Module & Class Hours	Contents	Teaching-Learning Approach	Module Assessmen	CLOs Mapped
Module 2: Sampling Techniques *(10 Hours)*	- Simple Random Sampling (SRS) with and without replacement. - Estimation of population mean, total, and proportion with standard errors in SRS. - Stratified Random Sampling: proportional and Neyman allocation. - Estimation of population mean and variance from stratified samples. - Cluster Sampling: introduction and estimation procedures. - Systematic Sampling: introduction and estimation procedures. - Determination and interpretation of the relative efficiency of different sampling designs. - Practical exercises comparing sampling methods using simulated data.	- **Lectures:** Conceptual framework and formulas for each sampling method. - **Demonstrations:** Selecting samples using random number tables and software. - **Practical Sessions:** Simulating different sampling designs and comparing estimates. - **Case Studies:** Real-world applications.	- Practical Report, - Problem-Solving Exercises: - Group Activity:	CLO 1, CLO 2, CLO 3, CLO 5

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Module & Class Hours	Contents	Teaching-Learning Approach	Module Assessmen	CLOs Mapped
Module 3: Hypothesis Testing and Confidence Intervals *(8 Hours)*	- Tests of significance for a single mean (z-test, t-test). - Tests for difference of two means (independent and paired samples). - Tests for variances (Chi-square test). - Tests for proportions (z-test). - Tests for correlation coefficient (t-test). - Tests for regression coefficient (t-test). - Construction of confidence intervals for means, proportions, and variances. - Fitting of theoretical distributions (Binomial, Poisson, Normal). - Testing goodness-of-fit using the Chi-square test. - Large sample tests (z-tests). - Tests of homogeneity (Chi-square test for contingency tables). - Practical exercises using real-world datasets.	- **Lectures:** Step-by-step guide to hypothesis testing procedures and assumptions. - **Practical Sessions:** Performing tests on real-world datasets using software and manual calculations. - **Case Studies:** Applying tests to problems in public health, business, and social sciences. - **Peer Teaching:** Students explain concepts to each other.	- Practical Assignments, - Quiz: - Viva Voce:, - Problem-Solving:	CLO 2, CLO 3, CLO 4, CLO 5

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Module & Class Hours	Contents	Teaching-Learning Approach	Module Assessmen	CLOs Mapped
Module 4: Project Work and Communication Skills *(4 Hours)*	- Identification of a real-world research problem. - Data collection and management. - Application of appropriate statistical techniques (designs, sampling, hypothesis tests). - Analysis using statistical software. - Interpretation of results and drawing logical conclusions. - Report writing: structure, content, and formatting. - Presentation of findings using tables, graphs, and oral communication. - Peer review and feedback.	- **Project-Based Learning:** Students work in teams on a mini-project.	- Mini-Project Report - Oral Presentation: - Peer Evaluation - Project Viva	CLO 1, CLO 2, CLO 3, CLO 4, CLO 5, CLO 6

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V. COURSE EVALUATION

Evaluation will be done in the grading system as per university guidelines.

Final Examination: 50 Marks.

i. **Problem solving – 45 marks.** [There will be a hands-on problem-solving test in the computer lab. The question paper should contain 5 (five) practical problems, and students have to solve 3 (three) problems.]
ii. **Practical Notebook – 5 marks.**

VI. REFERENCES

Agresti, A. (2018). *Statistical Methods for the Social Sciences* (5th Edition, Pearson).

Ali, A. (1973). Theory of Statistics, Vol. II. Dhaka Book Mart.

Bhuiyan, M. R. (1977). Fundamentals of Experimental Design. Dhaka – Shakil Prokashoni.

Casella, G., & Berger, R. L. (2024). *Statistical Inference* (3rd ed.). Cengage Learning.

Cochran, W. G. (1977; Re-printed 2022). *Sampling Techniques* (3rd Edition, Wiley

Classics Library).

Devore, J. L., & Berk, K. N. (2021). *Modern Mathematical Statistics with Applications* (3rd ed.). Springer.

Islam, M. N. (2014). An introduction to sampling methods: Theory and Applications. Dhaka: Mullick & Brothers.

Montgomery, D. C. (2023). *Design and Analysis of Experiments* (10th Edition, Wiley).

Mostafa, M. G. (1972). Methods of Statistics. Dhaka: Karim Press.

Peck, R., Olsen, C., & Devore, J. L. (2020). *Introduction to Statistics and Data Analysis* (6th Edition, Cengage).

Singh, D., & Chaudhary, F.S. (1986). Theory and Analysis of Sample Survey Designs, Wiley.

Walpole, R. E., Myers, R. H., Myers, S. L., & Ye, K. (2021). *Probability & Statistics for Engineers & Scientists* (9th ed.). Pearson.

PROVISIONAL

Course Code:	8222259	Marks: 100	Credits: 4	Class Hours: 56
Course Title:	Bangladesh Economy			

Course Description: This course examines the structure, performance, and management of the Bangladesh economy from a political science perspective. It covers macroeconomic trends, national income, fiscal and monetary management, agriculture, industry, external trade, employment, poverty, human development, infrastructure, private-sector development, and environmental challenges. The course also highlights the relationship between economic policies, governance, public administration, and political decision-making in Bangladesh.

Course Objectives

1. To develop a fundamental understanding of Bangladesh's macroeconomic structure, economic performance, growth, savings, investment, and policy framework.
2. To examine the roles, performance, and challenges of the agriculture, industrial, external, and private sectors in Bangladesh's economic development.
3. To develop an understanding of fiscal and monetary management, including taxation, public expenditure, budgeting, banking, financial markets, and economic reforms.
4. To analyze trends in employment, wages, prices, poverty, human development, and social protection, and examine relevant government initiatives.
5. To evaluate the relationship between economic performance, governance, public policy, and political decision-making in Bangladesh.
6. To develop students' ability to interpret economic information and critically assess contemporary economic and development issues through a political science perspective.

Course Learning Outcomes (CLOs)

Upon successful completion of the course, students will be able to

CLO#	Course Learning Outcomes	Bloom's Level
CLO1	Explain Bangladesh's macroeconomic structure, growth performance, national income, savings, investment, and institutional policy framework.	Understand
CLO2	Analyze the contribution, performance, and challenges of the agriculture, industrial, external, infrastructure, and private sectors in Bangladesh's economic development.	Analyze
CLO3	Evaluate Bangladesh's fiscal and monetary management, including taxation, public expenditure, budgeting, banking, financial markets, and economic reforms.	Evaluate
CLO4	Analyze trends in employment, wages, prices, poverty, human development, and social protection, including relevant government programs.	Analyze
CLO5	Evaluate the political economy dimensions of Bangladesh's development by linking economic outcomes with governance, public policy, planning, and administration.	Evaluate

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CLO6	Critically interpret economic data, policy documents, and contemporary development issues and communicate evidence-based analyses effectively.	Evaluate

Mapping of CLOs with PLOs

CLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12
CLO1	✓											
CLO2	✓	✓		✓								
CLO3	✓	✓		✓								
CLO4	✓	✓		✓		✓						
CLO5		✓	✓			✓						
CLO6		✓		✓						✓		✓

Course Contents — 28 weeks, 2 contact hours per week

Week	Course Content	Teaching–Learning Strategy	Assessment Methods	Mapped CLOs
1-3	**Overview of the Bangladesh Economy:** growth performance, savings and investment trends, and the institutional and policy framework guiding macroeconomic management, including the medium-term macroeconomic framework and ongoing reform programs.	Interactive lectures, discussion on recent Bangladesh Economic Review data	Class participation, short quiz, written assignment	CLO1
4-7	**National Income and Price Trends:** sector-wise growth of GDP, savings and investment; consumer price index and inflation; wage trends, labor force, employment, overseas employment, and remittances.	Interactive lectures, data reading exercises, class discussion	Quiz, class test, data-analysis assignment	CLO1 CLO4 CLO6
8-10	**Fiscal Policy and Public Finance Management:** government receipts and tax management, revenue collection, public expenditure and the Annual Development Programme, budget balance and financing, and public debt management.	Interactive lectures, case-based discussion, budget document review	Class test, budget analysis assignment, written assignment	CLO1 CLO3 CLO6
11-14	**Monetary Management and Financial Market Development:** monetary policy, money and credit situation, the banking and non-	Interactive lectures, group discussion, guided reading	Quiz, analytical assignment, class	CLO3 CLO6

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	banking financial sector, interest rate movements, financing of agriculture, industry and SMEs, and capital market development.	assignments	presentation	
15-18	**The External Sector:** world trade scenario, export and import policy, tariff structure, Bangladesh's position in the WTO and regional trade arrangements, balance of payments, exchange rate policy, and foreign exchange reserves.	Interactive lectures, group discussion, thematic assignments	Class test, thematic assignment, presentation	CLO2 CLO5 CLO6
19-21	**Agriculture, Industry and State-Owned Enterprises:** management of food grain production and agricultural credit; growth and performance of the manufacturing sector and SMEs; the production, financial performance, and reform of state-owned enterprises.	Interactive lectures, sector case studies, group presentations	Case-study assignment, group presentation, class test	CLO2
22-24	**Power, Energy, Transport, Communication and Human Development:** power generation and transmission, transport and communication infrastructure, and human development outlays covering education, health, women and children's affairs, and social welfare.	Interactive lectures, documentary screening, group discussion	Short quiz, thematic assignment, group presentation	CLO2 CLO4
25-28	**Poverty Alleviation, Private Sector Development and Environment:** poverty trends and reduction strategies, employment generation programs, a private-investment-friendly environment, privatization and public-private partnership, and environmental and climate change challenges facing Bangladesh.	Interactive lectures, thematic assignments, policy debate	Policy analysis assignment, class presentation, final examination	CLO4 CLO5 CLO6

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Course Assessment Framework
Total Course Marks: 100

Assessment Category	Assessment Component	Weightage
Formative Assessment (20%)	Attendance & Class Participation	5%
	In-course Examination	10%
	Quiz / Assignment Presentation	5%
Summative Assessment (80%)	Final Examination • Students will have to answer 8 questions out of 12 • 10 marks per question ($8 \times 10 = 80$ marks) • Each question may contain a maximum of 3 sub-sections (e.g., a, b, c) • Duration of Examination: 4 Hours	80%

List of Books

Bangladesh Bank. (Current issue). Annual report. Dhaka, Bangladesh: Bangladesh Bank.

Islam, Nurul. (2003). Making of a nation, Bangladesh: An economist's tale. Dhaka, Bangladesh: University Press Limited.

Islam, S. M. Mujahidul. (Latest edition). Bangladesh economy. Dhaka, Bangladesh: Bangladesh Publishers.

Khan, Akbar Ali. (1996). Discovery of Bangladesh. Dhaka, Bangladesh: University Press Limited.

Mahmud, Wahiduddin (Ed.). (n.d.). Bangladesh's development experience: Some selected issues. Dhaka, Bangladesh: University Press Limited.

Ministry of Finance, Government of Bangladesh. (Latest edition). Bangladesh economic review. Dhaka, Bangladesh: Finance Division.

Sen, Binayak, & Ali, Zaidi. (Eds.). (n.d.). Bangladesh development studies (Journal, current issues). Dhaka, Bangladesh: Bangladesh Institute of Development Studies (BIDS).

Sobhan, Rehman. (2016). Untranquil recollections: Nation building in post-liberation Bangladesh. New Delhi, India: SAGE Publications.

অর্থ মন্ত্রণালয়, গণপ্রজাতন্ত্রী বাংলাদেশ সরকার। (২০২৫)। *বাংলাদেশ অর্থনৈতিক সমীক্ষা*। ঢাকা: অর্থ বিভাগ।

ইসলাম, রিজওয়ানুল। (২০১৫)। *উন্নয়ন ভাবনায় কর্মসংস্থান ও শ্রমবাজার*। ঢাকা: ইউনিভার্সিটি প্রেস লিমিটেড (ইউপিএল)।

ইসলাম, রিজওয়ানুল। (২০২৩)। *উন্নয়নের অর্থনীতি*। ঢাকা: ইউনিভার্সিটি প্রেস লিমিটেড (ইউপিএল)।

উল্লাহ, মাহবুব। (২০০৩)। *বাংলাদেশ অর্থনীতি*। ঢাকা: বাংলাদেশ।

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Course Title:	Mathematical Economics

Course Description: This course introduces the formulation, solution, and interpretation of selected economic models using mathematical methods. Emphasis is placed on functions, differential and partial differentiation, optimization, matrices and systems of linear equations, linear programming, and simple dynamic models. Economic concepts from Principles of Economics, Bangladesh Agricultural Economics, and Bangladesh Economy are used as contexts for applying mathematical methods; they are not retaught as separate economic theories.

Course Objectives

1. To develop students' ability to formulate simple economic relationships using mathematical functions, equations, and graphs.
2. To apply differential and partial calculus to marginal analysis, comparative statics, and economic optimization problems.
3. To apply optimization techniques to economic resource-allocation and decision-making problems.
4. To use matrices and systems of linear equations in input-output and interdependence models.
5. To formulate and solve selected economic decision problems using linear programming.
6. To introduce simple dynamic economic models and interpret equilibrium and stability using mathematical methods.

Course Learning Outcomes (CLOs)

CLO#	Course Learning Outcomes	Bloom's Level
CLO1	Formulate simple economic relationships using functions, equations, graphs, and equilibrium conditions.	Apply
CLO2	Apply differential and partial differentiation to determine and interpret marginal measures and comparative-static changes in economic models.	Apply
CLO3	Apply unconstrained and constrained optimization techniques to solve economic resource-allocation and decision problems and interpret the optimality conditions.	Apply
CLO4	Use matrices and systems of linear equations to formulate and solve simple input-output and interdependence models.	Apply / Analyze
CLO5	Formulate and solve linear programming models for selected economic resource-allocation problems and interpret the solutions.	Apply / Analyze
CLO6	Formulate and interpret simple dynamic economic models using difference or differential equations and analyze equilibrium and stability.	Analyze

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Mapping of CLOs with PLOs

CLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12
CLO1	✓	✓										
CLO2	✓	✓										
CLO3	✓	✓	✓									
CLO4	✓	✓	✓									
CLO5	✓	✓	✓		✓							
CLO6	✓	✓	✓									

Course Contents --- 28 weeks, 1 contact hour per week

Weeks	Detailed Content	Teaching–Learning Strategy	CLOs
1–3	**Mathematical Formulation of Economic Models:** Economic variables and parameters; constants and variables in economic models; functions and equations; linear and nonlinear relationships; graphical representation; equilibrium conditions; interpretation of mathematical relationships; formulation of simple economic models without repeating the economic theory of demand and supply.	Lecture, guided problem solving, discussion, mathematical modelling exercises	CLO1
4–7	**Differential Calculus in Economic Analysis:** Marginal functions; marginal cost, marginal revenue and marginal product as derivatives; average and marginal relationships; first and second derivatives; increasing/decreasing functions; optimization of single-variable economic functions; comparative-static interpretation of changes in parameters.	Lecture, worked examples, problem solving, assignment	CLO2
8–11	**Multivariable Calculus and Optimization**: Functions of several variables; partial derivatives; marginal effects of several variables; total differential; unconstrained optimization of functions of two variables; second-order conditions; constrained optimization; Lagrange multiplier method; interpretation of optimal allocation of limited resources.	Lecture, worked examples, problem solving, tutorial	CLO2, CLO3
12–15	**Matrices and Input–Output Analysis:** Matrices and systems of linear equations in economic models; matrix representation; inverse matrix; Leontief input–output model; technical coefficient matrix; final demand and total output; interpretation of interdependence	Lecture, matrix-based problem solving, tutorial, computer-assisted exercise	CLO4

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	among sectors; simple numerical applications.		
16–19	**Linear Programming in Economic Decision Making:** Formulation of objective functions and constraints; graphical interpretation of feasible region; optimal solution; resource-allocation and production-planning applications; interpretation of shadow/resource limitations at an introductory level; application of previously learned linear programming methods rather than reteaching the full mathematical procedure.	Lecture, problem solving, graphical exercises, assignment	CLO5
20–23	**Dynamic Economic Models**: Introduction to economic dynamics; sequences and first-order difference equations; equilibrium and stability of simple discrete models; formulation and interpretation of simple adjustment models; introductory use of first-order differential equations for continuous-time economic change; interpretation of equilibrium paths.	Lecture, worked examples, problem solving, discussion	CLO6
24–27	**Integrated Mathematical Economic Modelling:** Formulation of a complete small-scale economic model; selection of an appropriate mathematical method; solution and interpretation; sensitivity/comparative-static interpretation; use of Mathematica or another suitable mathematical tool for selected calculations and graphs; presentation of results in economic language.	Modelling exercise, computer-assisted learning, group work, presentation	CLO1–CLO6
28	**Review and Problem-Solving:** Integrated review; model formulation and solution practice; examination-oriented problem solving.	Revision, tutorial and problem-solving session	CLO1–CLO6

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Course Assessment Framework
Total Course Marks: 50

Assessment Category	Assessment Component	Weightage
Formative Assessment (10%)	Attendance & Class Participation	2%
	In-course Examination	5%
	Quiz / Assignment Presentation	3%
Summative Assessment (40%)	Final Examination • Students will have to answer 4 questions out of 6 • 10 marks per question ($4 \times 10 = 40$ marks) • Each question may contain a maximum of 3 sub-sections (e.g., a, b, c) • Duration of Examination: 2 Hours	40%

List of Books

Chiang, A. C. & Wainwright, K. (2005). Fundamental Methods of Mathematical Economics (4th ed.). McGraw-Hill/Irwin.

Hoy, M., Livernois, J., McKenna, C., Rees, R. & Stengos, T. (2011). Mathematics for Economics (3rd ed.). MIT Press.

Simon, C. P. & Blume, L. (1994). Mathematics for Economists. W. W. Norton & Company.

Sydsæter, K., Hammond, P., Seierstad, A. & Strøm, A. (2008). Further Mathematics for Economic Analysis (2nd ed.). Pearson Education.

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Course Code	8222859	Marks: 100	Credits: 4	Class Durations: 28 Weeks
Course Title:	General Chemistry-II			

Course Description

This course provides students with a comprehensive understanding of fundamental concepts and principles of general chemistry, including the chemistry of nonmetals and metals, thermodynamics, chemical kinetics, electrochemistry, catalysis, solid-state chemistry, coordination chemistry, aromatic and organic reactions, carbohydrates, amino acids, and polymers. The course emphasizes the understanding of chemical principles, structures, reactions, mechanisms, properties, and applications across inorganic, physical, organic, and coordination chemistry.

Course Objectives

Upon completion of this course, students will be able to:

1. Understand the fundamental properties and chemical behaviour of nonmetals, metals, transition metals, and inner transition metals.
2. Explain the principles of thermodynamics, energy changes, chemical kinetics, electrochemistry, and catalysis.
3. Describe the structures, properties, and characteristics of crystalline and amorphous solids and coordination compounds.
4. Explain aromaticity, heterocyclic compounds, major organic reactions, and their mechanisms and applications.
5. Understand the structures, classification, properties, and reactions of carbohydrates, amino acids, and polymers.
6. Apply fundamental chemical concepts to explain chemical properties, reactions, mechanisms, and related phenomena.

Course Learning Outcomes (CLOs)

CLO#	Course Learning Outcome	Bloom's Level
CLO1	Explain the general properties, structures, bonding, electronic characteristics, and chemical behaviour of nonmetals, metals, transition metals, and inner transition metals.	Understand
CLO2	Explain and apply fundamental principles of thermodynamics, energy changes in chemical reactions, chemical kinetics, electrochemistry, and catalysis.	Apply

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CLO3	Describe the properties and structures of solids and explain fundamental concepts of coordination chemistry, including coordination compounds, ligands, nomenclature, bonding, and stability.	Understand
CLO4	Explain aromaticity, aromatic electrophilic substitution reactions, heterocyclic compounds, and major organic reactions with their mechanisms and applications.	Analyze
CLO5	Describe the definition, classification, structures, properties, and reactions of carbohydrates and amino acids, and explain the basic concepts and classifications of polymers.	Understand
CLO6	Analyze chemical concepts, reactions, structures, mechanisms, and properties across inorganic, physical, organic, and coordination chemistry.	Analyze

Mapping CLOs with PLOs

CLO / PLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12
CLO1	✓	✓				✓	✓					
CLO2	✓	✓		✓	✓	✓						
CLO3	✓	✓				✓	✓					
CLO4	✓	✓		✓			✓					
CLO5	✓	✓				✓	✓					
CLO6	✓	✓	✓	✓	✓	✓	✓					✓

Course Content — 28 weeks, 2 contact hours per week

Module No.	Contents	Teaching–Learning Strategies	Assessment Methods	CLOs
1	**Nonmetals:** General properties of nonmetals, ortho and para hydrogen molecules, allotropy of carbon, catenation, halogens and their basic properties, chemistry of noble gases.	Lecture, interactive discussion, concept explanation, molecular representation	Written examination, class test, short questions	CLO1
2	**Metals:** Metallic bond, electron sea theory of metallic bond, characteristics of metals, band theory of conductivity, conductors, semiconductors and insulators,	Lecture, discussion, diagrams, conceptual	Written examination, class test, short questions	CLO1, CLO6

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	transition metals and inner transition metals colour and magnetism in transition metal chemistry.	problem-solving		
3	**Energy changes in chemical Reactions:** System and surroundings, open system and closed system, thermodynamics, state functions, the first law of thermodynamics, the concept of internal energy and enthalpy, measurement of enthalpy changes, enthalpy of formation, Hess's law, lattice enthalpy, Born-Haber cycle, second law of thermodynamics, entropy and free energy.	Lecture, numerical problem-solving, board work, discussion	Numerical problems, written examination, class test	CLO2, CLO6
4	**Rates of chemical Reactions:** Reaction rate, rate constant, rate law, order of reactions, first-order reaction, half-life, order and molecularity, effect of temperature on the rate of reaction, collision theory and reaction rates, activation energy, Arrhenius equation.	Lecture, numerical exercises, graphical explanation, problem-solving	Numerical problems, written examination, class test	CLO2, CLO6
5	**Electrochemistry:** Redox reactions, electrolytic and galvanic cells, cell notation, standard reduction potentials, emf of cells, the effect of concentration on cell emf, batteries, corrosion.	Lecture, cell-diagram demonstration, problem-solving, discussion	Written examination, numerical problems, class test	CLO2, CLO6
6	**Catalysis:** Catalyst, homogeneous catalysis, enzyme catalysis, autocatalysis.	Lecture, discussion, examples, conceptual explanation	Written examination, short questions, class test	CLO2
7	**Solids:** Properties of solids, crystalline and amorphous solids, distinction between crystalline and amorphous solids, isomorphism, polymorphism and allotropy, crystal lattice, unit cell, crystal systems, Bragg's law.	Lecture, diagrams, model/visual demonstration, discussion	Written examination, short questions, problem-solving	CLO3, CLO6

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8	**Coordination Chemistry:** Coordination compounds, ligands, coordination number, nomenclature, structures of complex compounds, Werner's primary and secondary valency concept, Sidgwick's electronic concept, valence bond theory, stability of coordination compounds.	Lecture, structural representation, nomenclature exercises, discussion	Written examination, nomenclature exercises, class test	CLO3, CLO6
9	**Aromatic Compounds:** Aromaticity of benzene, Electrophilic aromatic substitution reactions with reference to nitration, halogenation, sulphonation and alkylation. Heterocyclic compounds: Pyrrole, furan, thiophene, pyridine.	Lecture, structural representation, reaction mechanism discussion, problem-solving	Written examination, reaction-based questions, class test	CLO4
10	**Organic reactions:** Brief study of electrophilic addition, Nucleophilic addition, Elimination reaction, condensation reaction, oxidation, and reduction reactions and organic compounds. Mechanism and application of the following reactions: Friedel-Crafts reaction, Clemmensen reduction, Wolf-Kishner reduction, Perkin reaction, Claisen reaction, Cannizzaro reaction, and Aldol condensation.	Lecture, reaction mechanism demonstration, structural representation, problem-solving	Written examination, reaction mechanisms, class test	CLO4, CLO6
11	**Carbohydrates:** Definition, classification, structure and reactions of monosaccharides. Polysaccharides: cellulose and starch.	Lecture, structural representation, discussion, reaction-based learning	Written examination, short questions, class test	CLO5
12	**Amino Acids:** Structures, classification, synthesis, physical and chemical properties of amino acids.	Lecture, structural representation, discussion, problem-solving	Written examination, short questions, class test	CLO5
13	**Polymer Chemistry:** Polymers: homopolymer, heteropolymer, low-	Lecture, classification	Written examination,	CLO5

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	density and high-density polymer, copolymers, studies of some polymers- polyvinyl chloride, nylon 66, silk and wool.	charts, discussion, examples	short questions, class test	

Course Assessment Framework

Total Course Marks: 100

Assessment Category	Assessment Component	Weightage
Formative Assessment (20%)	Attendance & Class Participation	5%
	In-course Examination	10%
	Quiz / Assignment Presentation	5%
Summative Assessment (80%)	Final Examination • Students will have to answer 8 questions out of 12 • 10 marks per question ($8 \times 10 = 80$ marks) • Each question may contain a maximum of 3 sub-sections (e.g., a, b, c) • Duration of Examination: 4 Hours	80%

List of Books

Cotton, F. A., Wilkinson, G., & Gaus, P. L. (1987). *Basic inorganic chemistry*. John Wiley & Sons.

Ebbing, D. D., & Wrighton, M. S. (1996). *General chemistry*. Houghton Mifflin.

Finar, I. L. (1973). *Organic chemistry: Volume I: The fundamental principles*. Longmans.

Haider, S. Z. (n.d.-a). *Introduction to modern inorganic chemistry*. Friends International.

Haider, S. Z. (n.d.-b). *Selected topics on advanced inorganic chemistry*. Students' Publication.

Huque, M. M., & Nawab, M. A. (n.d.). *Principles of physical chemistry*. Students' Publications.

Madan, R. D. (n.d.). *Modern inorganic chemistry*. S. Chand & Company Ltd.

Malik, W. U., Tuli, G. D., & Madan, R. D. (n.d.). *Selected topics in inorganic chemistry*. S. Chand & Company Ltd.

Morrison, R. T., & Boyd, R. N. (n.d.). *Organic chemistry*.

Silberberg, M. (2009). *Chemistry: The molecular nature of matter and change*. McGraw-Hill Higher Education.

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Course Code	8222861	Marks: 50	Credits: 2	Class Hours: 28
Course Title:	Environmental Chemistry			

Course Description

This course provides a comprehensive introduction to the chemical principles governing the natural environment and the impact of anthropogenic activities on Earth systems. It encompasses a detailed study of the structural segments of the environment: atmosphere, hydrosphere, lithosphere, and biosphere, and focuses on the chemical pathways, transport dynamics, and transformations of pollutants. Students will explore the mechanisms behind critical global phenomena, including acid rain, the greenhouse effect, ozone depletion, and biomagnification. The curriculum emphasizes quantitative water quality metrics (pH, DO, BOD, COD), modern wastewater treatment processes, soil degradation vectors, and the biochemical toxicology of toxic persistent compounds like PCBs and heavy metals. Through theoretical frameworks, case studies, and numerical assessments, this course equips students with the essential analytical tools needed to evaluate environmental degradation and formulate sustainable mitigation strategies.

Course Objectives

Upon successful completion of this course, students will be able to:

1. Develop a fundamental understanding of the chemical composition, interactions, and structural layers defining environmental segments.
2. Analyze the chemical reactions, source identification methods, and transport pathways of hazardous air, water, and soil pollutants.
3. Evaluate industrial and municipal water contamination by measuring key water quality parameters and understanding standard purification technologies.
4. Explain the biochemical mechanisms of toxicity, bioaccumulation, and environmental hazards associated with heavy metals and persistent organic compounds.
5. Apply physical and chemical principles to design sustainable control mechanisms for industrial effluents, urban waste management, and soil remediation.
6. Cultivate scientific reasoning, problem-solving abilities, and an ethical foundation required to address domestic and global environmental challenges.

Course Learning Outcomes (CLOs)

By the end of this course, students will be able to:

CLO	Course Learning Outcome	Bloom's Level
CLO 1	Define and explain the fundamental components of the environment and their systemic interactions.	Understand
CLO 2	Analyze the sources, chemical behavior, transport, and environmental consequences of air, water, and soil pollutants.	Analyze
CLO 3	Evaluate key water and wastewater quality parameters, including pH, DO, BOD, and COD, and interpret their environmental significance.	Evaluate
CLO 4	Assess the biochemical toxicity, environmental impacts, and control methods of heavy metals and hazardous compounds such as PCBs.	Evaluate

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Mapping CLOs to PLO Matrix

CLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12
CLO1	✓					✓	✓			✓		
CLO2	✓	✓	✓	✓		✓	✓					✓
CLO3	✓	✓		✓	✓	✓						
CLO4	✓		✓			✓	✓	✓				✓

Course Contents

The original topics have been chronologically balanced across the 28 class hours within 28 weeks using the layout patterns validated in the curriculum text:

Week	Topics	Teaching-Learning Strategy	Assessment Strategy	CLO
Week 1-3	**1. Environment:** Introduction to components of environment, factors affecting environment, environmental management, environment and health, environmental chemistry, segments of environment – atmosphere, hydrosphere, lithosphere and biosphere, structure of atmosphere.	Interactive Lecture, Group Discussion, Concept Mapping	Quiz, Class Test, Short Assignment	CLO1
Week 4-7	**2. Pollution and Pollutants:** Pollution, environmental pollution, pollutant, classification of pollutants, types of pollution. PCBs and their sources and hazards, Detection & estimation of PCBs. Bio-magnification/Biomultification.	Lecture, Case Study Analysis, Group Discussion	Class Test, Assignment, Viva-voce	CLO2 CLO4
Week 8-14	**3. Air Pollution:** Introduction, air quality, major sources of air pollution, gaseous pollutants. Acid rain-how acid rain is formed, adverse effects of acid rain. Greenhouse effect- how the greenhouse effect is produced, consequences of the greenhouse effect and global warming. El Niño phenomenon and its effects. Ozone depletion, mechanism of ozone depletion, effects of ozone depletion.	Lecture, Multimedia Presentation, Problem-Based Learning	Quiz, Mid-Term Exam, Assignment	CLO2
Week 15-19	**4. Water Pollution:** Introduction, classification of water pollutants. Physical, chemical, and biological characteristics of wastewater. Industrial wastewater	Interactive Lecture, Numerical Exercises,	Class Test, BOD/COD Problems, Report	CLO3

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	treatment, municipal water treatment. Water quality parameters and standards, measurements of important parameters such as pH, DO, BOD, COD, and temperature for water quality assessments.	Laboratory Demonstration	Writing	
Week 20-24	**5. Soil Pollution:** Composition of soil, importance of soil to the biosphere, sources of soil pollution. Effects of soil pollution: synthetic fertilizers and pesticides, effects of industrial effluents, effects of urban wastes, control of soil pollution.	Lecture, Case Study Analysis, Group Discussion	Quiz, Assignment	CLO2
Week 25-28	**6. Heavy metals in the Environment:** Trace metals, light metals and heavy metals, deadly heavy metals, sources of heavy metals, biochemical effects, toxicity, toxicology, control and treatment of mercury, chromium, arsenic and lead.	Lecture, Problem-Based Learning, Course Revision	Final Assessment, Viva-voce	CLO4

Course Assessment Framework

Total Course Marks: 50

Assessment Category	Assessment Component	Weightage
Formative Assessment (10%)	Attendance & Class Participation	2%
	In-course Examination	5%
	Quiz / Assignment Presentation	3%
Summative Assessment (40%)	Final Examination • Students will have to answer 4 questions out of 6 • 10 marks per question ($4 \times 10 = 40$ marks) • Each question may contain a maximum of 3 sub-sections (e.g., a, b, c)	40%

List of Books

Dara, S. S., & Mishra, D. D. (2006). *A textbook of environmental chemistry and pollution control*. S. Chand Publishing.

De, A. K. (2017). *Environmental chemistry* (8th ed.). New Age International Publishers.

Manahan, S. E. (2010). *Environmental chemistry* (9th ed.). CRC Press.

Sharma, B. K., & Kaur, H. (2018). *Environmental chemistry* (16th ed.). Goel Publishing House.

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Course Code	8223760	Marks: 50	Credits: 2
Course Title:	Viva-Voce (Mathematics)		
Assessment	Oral Examination		

Course Description: This course assesses students' comprehensive understanding of mathematical concepts, analytical reasoning, problem-solving methods, and computational skills acquired through the prescribed second-year Mathematics Honours courses. The viva voce covers Advanced Calculus, Ordinary Differential Equations (ODE), Programming Fundamentals (FORTRAN), and Math Lab - Practical II (Mathematica and FORTRAN). It emphasizes conceptual clarity, mathematical reasoning, algorithmic understanding, interpretation of computational results, and effective oral communication.

Course Objectives

The objectives of this course are to:

1. Assess fundamental mathematical knowledge acquired through the prescribed theoretical courses.
2. Evaluate students' ability to explain mathematical methods and solve problems using logical reasoning.
3. Assess understanding of programming principles, algorithms, and computational techniques.
4. Evaluate the use of Mathematica and FORTRAN in mathematical computation and problem-solving.
5. Assess students' ability to communicate mathematical concepts clearly and logically during an oral examination.

Course Learning Outcomes (CLOs)

Upon successful completion of the viva voce examination, students will be able to:

CLO #	Course Learning Outcome	Bloom's Level
CLO 1	Explain fundamental concepts, definitions, theorems, and methods from Advanced Calculus and Ordinary Differential Equations.	Understand
CLO 2	Apply appropriate mathematical techniques and logical reasoning to solve problems in calculus and differential equations.	Apply
CLO 3	Explain programming concepts, algorithms, control structures, and program logic in FORTRAN.	Understand
CLO 4	Explain and interpret mathematical computations and results obtained using Mathematica and FORTRAN.	Analyze
CLO 5	Communicate mathematical concepts, solution methods, and computational procedures clearly and accurately during an oral examination.	Understand

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Mapping of CLOs with PLOs

CLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12
CLO1	✓	✓					✓					
CLO2	✓	✓		✓								
CLO3	✓	✓			✓		✓					
CLO4	✓	✓		✓	✓							
CLO5	✓	✓								✓		

Course Contents

The viva voce covers the following prescribed courses and their relevant topics. It is a comprehensive oral assessment.

SL. No.	Course / Content	Assessment Focus	CLOs
1	**Advanced Calculus:** Definitions, fundamental concepts, theorems, differentiation, integration, and relevant applications included in the prescribed syllabus.	Conceptual understanding and mathematical reasoning	CLO1, CLO2
2	**Ordinary Differential Equations:** Order and degree, formation of differential equations, methods of solution, higher-order equations, and applications covered in the prescribed syllabus.	Explanation of methods and problem-solving	CLO1, CLO2
3	**Programming Fundamentals (FORTRAN):** Data types, variables, operators, input/output, conditional statements, loops, arrays, functions, subprograms, and program logic covered in the prescribed syllabus.	Programming concepts and code interpretation	CLO3
4	**Mathematics Lab Practical II (Mathematica and FORTRAN):** Relevant commands, symbolic and numerical computation, implementation of mathematical algorithms, verification of results, and interpretation of computational output.	Computational understanding and interpretation	CLO3, CLO4
5	**Integrated Questions:** Related mathematical concepts and computational methods from the prescribed courses.	Conceptual understanding and logical reasoning	CLO1–CLO5

Assessment Strategy and Marks Distribution

The course will be assessed through an individual oral examination conducted by the appointed examiner(s) or examination committee. Students will be evaluated on conceptual understanding, mathematical accuracy, logical reasoning, understanding of computational methods, and clarity of oral responses. All questions will be answered orally; no separate written examination, practical test, or presentation will be conducted. Internal and external

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examiners should independently assess each student. The final mark is to be calculated from the arithmetic mean of the internal and external examiner marks.

Assessment Component	**Marks**
Advanced Calculus	10
Ordinary Differential Equations	10
Programming Fundamentals (FORTRAN)	10
Mathematics Lab Practical II (Mathematica and FORTRAN)	10
Integrated understanding of mathematical concepts from the prescribed courses	10
Total	**50**

References: Textbooks, lecture notes, and laboratory manuals prescribed for Advanced Calculus, Ordinary Differential Equations, Programming Fundamentals (FORTRAN), and Math Lab Practical II (Mathematica and FORTRAN).

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