General Aims:

The module covers 12 topics.

1: Algebra and geometry of 2x2 matrices: Addition, multiplication, determinants and inverses of 2x2 matrices. Linear transformations of the plane and the geometric interpretation of these concepts. Examples of linear phenomena in science.

2: Eigenvalues and eigenvectors of 2x2 matrices: Definition of eigenvalues and eigenvectors; geometric interpretation; stochastic matrices; applications to practical recurrence problems in biology, chemistry and physics; Principle of Induction.

3: Systems of equations and matrices: Systems of n equations in n unknowns. Multiplication, determinants, adjoints, inverses of nxn matrices. Applications to practical problems in biology, chemistry and physics.

4: Continuous functions: Basic functions and their graphs; inverse functions; limits; Intermediate Value Theorem; roots of equations;

5: Rates of change and optimization: Definition of derivative and its physical interpretation; techniques of differentiation; differentiability implies continuity; Mean Value Theorem; roots of equations.; detecting maxima/minima; monotonicity, concavity; application to graph sketching; optimisation problems.

Sem I

6: Anti-derivatives: Exponentials and logarithms; anti-derivatives; real-world problems involving anti-derivatives.

7: Complex numbers: Cartesian and polar coordinates; geometric interpretation using Argand diagrams; roots of unity; roots of polynomials; complex conjugates.

8: Probability: Probability of events; conditional probability and independence of events; Bayes' Theorem; expected values.

9: Descriptive statistics: Histograms; mode, median, mean, quartile; standard deviation. Population, samples and estimators; applications to practical problems in biology, chemistry and physics.

10: Integral Calculus: Definite integrals and the Fundamental Theorem of Calculus; applications of integration to real-world problems.

11: Techniques of integration: A range of techniques for calculating definite and indefinite integrals; further applications to real-world problems.

12. Differential equations: separable differential equations; logistic equation; applications to radioactive decay and biological population models.

Sem II

Learning Outcomes:

On successful completion of this module:

1: You will be able to perform algebraic operations with 2x2 matrices, and translate some geometric problems into the language of 2x2 matrices. You will be able to identify some commonly occurring linear scientific phenomena.

2: You will be able to calculate the eigenvalues and eigenvectors of a 2x2 matrix and use these calculations to solve some recurrence problems occurring in science.

3: You will be able to solve a system of n equations in n unknowns (for low values of n) and, in particular, decide when such a system has no solution, a unique solution or infinitely many solutions.

4: You will be able to: sketch the graph of a number of basic functions; calculate the limit of a function at a point or at infinity; decide whether a given function has an inverse and, if it does, calculate it; use the Intermediate Value Theorem to find roots of equations. You will be able to apply the material learned to a variety of problems coming from physics and earth sciences.

5: You will be able to: use the definition of derivative to compute the derivative of simple functions; apply different techniques of differentiation to calculate derivatives; apply the Mean Value Theorem to finding roots of equations; find maxima/minima/inflection points, and use these to sketch graphs of functions; apply differentiation techniques to solve optimisation problems.

6: You will be able to perform calculations with logarithms and the exponential function. You will be able to use anti-derivatives to solve some basic problems in biology, chemistry and physics.

7: You will be able to perform basic arithmetic operations with complex numbers, and factorize polynomial as a product of linear factors.

8: You will be able to quantify the likelihood of some simple events, and calculate the expected value of some simple random variables.

9: You will be able to describe data using the notions of median, mode, percentile, mean, standard deviation; you will be able to make inferences based on the estimated mean and standard deviation of a population.

10: You will be able to explain the connection between differential and integral calculus using the Fundamental Theorem of Calculus, and you will be able to apply this connection to some practical scientific problems.

11. You will be able to evaluate definite and indefinite integrals using a variety of techniques.

12. You will be able to solve separable differential equations and apply this skill to study population models in biology and physics.