### Unit 1
**First- and second-order differential equations**
Analytic solution of first-order differential equations using either separation of variables or the integrating factor method. Direction fields and numerical solution by Euler’s method. Solution of linear constant-coefficient second-order differential equations. Using the method of undetermined coefficients to find particular integrals for simple inhomogeneous differential equations.

### Unit 2
**Vector algebra and statics**
Vectors both geometrically and algebraically. Scalar and vector products. Modelling forces (weight, normal reaction, tension, friction) as vectors. Calculating torques. Application to static equilibrium problems.

### Unit 3
**Dynamics**

### Unit 4
**Matrices and determinants**

### Unit 5
**Eigenvalues and eigenvectors**
Finding eigenvalues and eigenvectors by hand for simple cases. Iterative methods for finding eigenvalues of large matrices.

### Unit 6
**Systems of linear differential equations**
Solving first-order and second-order systems of linear differential equations by using the eigenvalue and eigenvectors of the coefficient matrix.

### Unit 7
**Functions of several variables**

### Unit 8
**Mathematical modelling**
Case study of pollution modelling in the Great Lakes. Overview of the modelling process. Dimensional consistency.

### Unit 9
**Oscillations and energy**
Modelling forces due to a spring (Hooke’s law). Motion of a single particle under influence springs. Potential energy. Principle of conservation of mechanical energy and equivalence with Newton’s laws. Application of energy conservation to mechanical systems.

### Unit 10
**Forcing, damping and resonance**
Modelling dampers. Single particle systems with springs and dampers. Forced oscillations and resonance.

### Unit 11
**Normal modes**
Analysing mechanical systems with two or more particles with springs.

### Unit 12
**Systems of differential equations**

### Unit 13
**Fourier series**

### Unit 14
**Partial differential equations**
Separation of variables applied to partial differential equations. Application to the wave equation and also to the heat equation.

### Unit 15
**Vector calculus**
Scalar and vector fields. Gradient of a scalar field. Cylindrical and spherical coordinates.

### Unit 16
**Further vector calculus**
Divergence and curl of a vector field. Line integrals of scalar and vector fields. Conservative fields and the curl test.

### Unit 17
**Multiple integrals**
Area and volume integrals in Cartesian coordinates. Area integrals in polar coordinates. Volume integrals in cylindrical and spherical coordinates.

### Unit 18
**Reviewing the model**
Dimensional analysis. Evaluating mathematical models. Case study on Great Lakes revisited.

### Unit 19
**Systems of particles**
Centres of mass of systems consisting of particles, simple geometric objects and laminas. Analysing collision problems using conservation of momentum and Newton’s law of restitution.

### Unit 20
**Circular motion**
Uniform and non-uniform motion in a circle. Defining angular velocity and angular momentum.

### Unit 21
**Rotating bodies and angular momentum**
Analysing the motion of mechanical systems that rotate about an axis that may accelerate (but has a fixed direction).