***Mathematical methods, models and modelling* (MST210)** content listing

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 coeficients 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*	Newton's laws of motion. Sliding friction. Models of air resistance. Application to single particle dynamics problems. Projectile motion.
Unit 4 *Matrices and determinants*	Solving systems of linear equations using Gaussian elimination. Matrices as linear transformations. Matrix algebra and matrix inversion. Evaluating 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*	Visualising functions of several variables, contour maps and gradient along a path. Partial derivatives. The gradient vector. Taylor polynomials. Classifying stationary points.
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*	Modelling interacting populations using non-linear differential equations. Qualitative solutions via phase plane portraits. Equilibrium points. Using linearization to classify equilibrium points.
Unit 13 *Fourier series*	Periodic functions. Representing periodic functions as Fourier series of sines and cosines. Pointwise convergence theorem.
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).