Deterministic and stochastic dynamics **(MS327)** content listing

Unit 1 *Introduction and differential equations*	Logistic equation, phase space, stability of fixed points, constants of motion, solving differential equations, separation of variables, complementary functions and particular integrals, integrating factor method
Unit 2 *Oscillations of linear systems*	Harmonic oscillator, coupled oscillators, normal modes, Lissajous curves, Fourier series, damped oscillators
Unit 3 *Nonlinear dynamics*	Phase flow, Lotka-Volterra equations, classification of equilibrium points, periodic solutions and limit cycles, Poincaré-Bendixson theorem, chaotic orbits, Lyapunov exponents
Unit 4 *Random motion and probability*	Random walk, probability density, uniform, normal and exponential distribution, mean value, variance, moments
Unit 5 *Introduction to the calculus of variations*	Functionals, stationary paths, Euler-Lagrange equations, first integral, Fermat's principle
Unit 6 *Lagrangian mechanics*	Kinetic and potential energy, Hamilton's principle, generalised coordinates, Lagrangian, action
Unit 7 *Exploring dynamics using maps*	Poincaré sections and return map, classification of fixed points, periodic orbits, logistic map, Hénon map
Unit 8 *Quantifying chaotic dynamics*	Lyapunov exponents, chaotic orbits, tent map, box-counting dimension, skinny baker's map, Kaplan-Yorke dimension
Unit 9 *Random walks and diffusion*	Concentration, flux, continuity equation, diffusion equation, Fick's law, advection-diffusion equation, Gauss's theorem, heat equation
Unit 10 *Fourier transforms*	Fourier transform, inverse Fourier transform, Fourier transform pairs, Fourier transform rules, convolution theorem
Unit 11 *Solving the diffusion equation*	Non-transform derivative rule, propagator, solving partial differential equations, Dirichlet and Neumann boundary conditions, eigenvalues and eigenfunctions, generalised Fourier series, Bessel functions
Unit 12 *Case studies in stochastic processes*	Absorbing and reflecting boundary conditions, survival probability, first passage probability, generalised random walks, Fokker-Planck equation, stationary probability density, Ornstein-Uhlenbeck process, applications in finance, Black-Scholes formulas