

**Syllabus for APMA0340**  
**Summary of the topics to be covered in APMA0340**

Part I Systems of First Order Ordinary Differential Equations (ODE)

1. Where does a system of first-order ODE come from?
  - (a) From higher-order ODEs
  - (b) Mechanical problems
  - (c) Electrical circuits
  - (d) Chemical mixing problems
  - (e) Ecological (population) problems
2. Linear Systems of ODEs
  - (a) Linear system of ODE in matrix form
  - (b) Algebra of matrices
    - Multiplication of matrices
    - Inverse matrices
    - Determinants
    - Systems of linear algebraic equations
    - Linearly independent set of vectors
    - Exponential of a square matrix
  - (c) Homogeneous linear systems of ODEs with constant coefficients
  - (d) Homogeneous linear systems with variable coefficients

Part II Nonlinear Systems of ODEs

1. Simple pendulum
2. Autonomous systems
3. Critical (equilibrium) points
4. Linearization around a critical point
5. Stability and instability around a critical point
6. Phase portraits of non-linear systems
7. Competing species: equilibrium population
8. Predator-prey: periodic variations of species
9. Lyapunov's second method

10. Limit cycles

11. Chaos and Lorenz equations

Part III Partial Differential Equations (PDE)

1. Sturm–Liouville problems

2. Fourier series

3. Heat conduction problems

(a) Separation of variables

(b) Homogeneous boundary value problems

(c) Non-homogeneous boundary value problems

4. Wave equations

5. Laplace equations