



FIRST/SECOND SEMESTER

Course Handout (Part II)

Date:.....

In addition to the part I (General Handout for all courses appended to the time table), this portion gives further specific details regarding the course.

**Course No.** : MATH G515  
**Course Title** : Topics in Differential Equations  
**Instructor-in-charge** :  
**Instructors** :

1. **Course Description:** In this course, students will learn the linear system of ordinary differential equations (ODEs), local existence and uniqueness theorems, stability of nonlinear ODE, Regular Sturm-Liouville Theory; method of characteristics for the first order hyperbolic partial differential equations (PDEs), classification of linear second order PDEs, Laplace equation, heat equation, wave equation, separation of variables, Fourier transform and application to heat and wave initial boundary value problems (IBVPs).

2. **Scope and Objective of the Course:** This course is meant for Ph.D. scholars before they embark on research in a specific area. This course covers basic concepts and basic theorems with a special thrust on problem solving and applications. Its link to other branches of Mathematics especially with Analysis, Topology, Linear Algebra, etc. will be explored in the course of lectures.

3. **Text Books:**

- 1) L. Perko, Differential Equations and Dynamical Systems; Text in Applied Mathematics Vol 7, Springer Verlag, NY (2004).
- 2) A. K. Nandakumaran, P.S. Datti and Raju K. George, Ordinary Differential Equations: Principles and Applications, Cambridge University Press, New Delhi (2017).
- 3) Fritz John, Partial differential Equations, Applied Mathematical Sciences Vol. 1, NY (1982).
- 4) L. C. Evans, Partial differential Equations, Graduate Studies in Mathematics Vol 19, AMS, Providence, Rhode Island (2002).

4. **Reference Books:**

- 1) M. C. Joshi, Ordinary Differential Equations: Modern Perspective, Narosa Publishing House, New Delhi (2006).
- 2) P.C. Das, Fun with Partial Differential Equations: Theories applied for all levels of curious learners of Mathematics, Amazon, India, 2022.
- 3) A. K. Nandakumaran and P.S. Datti, Partial Differential Equations: Classical Theory with a Modern Touch, Cambridge University Press, New Delhi (2020).
- 4) S. Salsa, Partial differential Equations in Action: From Modelling to Theory, Springer Verlag Italia (2009).

## 5. Lecture Plan:

Lecture numbers	Module	Topics to be covered
Lectures: 1-4 (TB-1: Ch.1.2-1.4, 1.6-1.7)	Ordinary Differential Equations (ODE): (i). Linear System of ODEs	Review of Exponential operators and Fundamental Theorem; Solution process ( Complex eigenvalues, multiple eigenvalues, Jordan forms), Stability theory; Nonhomogeneous linear systems.
Lectures: 5-8 (TB-2: Ch. 4.3-4.6)	(ii). Local existence and uniqueness Theorems	Review of Local existence theory: Picard's and Peano's theorems, Gronwall Lemma, continuation of solution and maximal interval of existence.
Lectures: 9-14 (TB-2: Ch.8.1-8.6)	(iii). Stability of nonlinear ODE	Linearised stability; Lyapunov Stability; nonlinear system in $R^2$ with phase portraits; Gradient and Hamiltonian systems.
Lectures: 15-18 (TB-2: Ch. 7.1-7.4, 9.2-9.3)	(iv). Two Point BVP and Sturm-Liouville Theory	BVP for linear problems, Green's functions; Sturm's comparison theorem and existence of eigenfunctions.
Lectures: 19-23 (TB-3: Ch. 1.4-1.9), (2.1,2.3)	Partial Differential Equations (PDEs): (i). Review of first order PDEs	Method of characteristics with geometric interpretation; Cauchy Problems; Monge cone and characteristic strips. Classification of linear second order PDEs.
Lectures: 24-27 (TB-4: Ch. 2.2)	(ii). Laplace equation	Fundamental solution; Poisson's equation; Green's identity; Maximum principle; Green's Function and Poisson's formula; Linear Elliptic PDE: boundary conditions; uniqueness by energy arguments.
Lectures:28-32 (TB-4: Ch. 2.3)	(iii). Heat equation	Fundamental Solutions with properties; Initial and boundary value problems (IBVPs) with uniqueness by energy arguments; Maximum principle with applications.
Lectures:33-37 (TB-4: Ch. 2.4)	(iv). Wave equation	d'Alembert formula; Fundamental solution; uniqueness by energy method.
Lectures:39-41 (TB-4: Ch. 4.1- 4.3)	(v). Solution Process	Separation of variables, Fourier Transform (Definition, Plancherel's Theorem, Properties, Inversion) with applications.

## 6. Evaluation Scheme:

EC No.	Evaluation Component	Duration	Weightage (%)	Date, Time	Remarks
1	Midsem	90 Min.	30	***	***
2	Tutorial Test/Quiz/ Assignments/Seminars	***	30	***	***
3	Comprehensive Exam	3 Hours	40	***	***

\*\*\* To be announced later.

**7. Problems:** Students are strongly advised to work out the problems in the textbook and do similar problems from the reference books.

**8. Chamber Consultation Hour:**

**9. Notices:**

**10. Make-up Policy:**

**Instructor-In-Charge**

