# Discipline Specific Elective (DSE) Course-1

**Any *one* of the following :**

**DSE-1 (i): Differential Equations (with Practicals)**

**DSE-1 (ii): Mechanics and Discrete Mathematics**

## DSE-1 (i): Differential Equations (with Practicals)

**Total Marks: 150** (Theory: 75, Internal Assessment: 25, and Practical: 50)
**Workload:** 4 Lectures, 4 Practicals (per week) **Credits:** 6 (4+2)
**Duration:** 14 Weeks (56 Hrs. Theory + 56 Hrs. Practical) **Examination:** 3 Hrs.

**Course Objectives:** This course helps the students to develop skills and knowledge of standard concepts in ordinary and partial differential equations and also provide the standard methods for solving differential equations.

**Course Learning Outcomes:** The student will be able to:

i) Solve the exact, linear and Bernoulli equations and find orthogonal trajectories.
ii) Apply the method of variation of parameters to solve linear differential equations.
iii) Formulate and solve various types of first and second order partial differential equations.

**Unit 1: First Order Ordinary Differential Equations**

First order exact differential equations, Integrating factors, Rules to find an integrating factor; Linear equations and Bernoulli equations, Orthogonal trajectories and oblique trajectories; Basic theory of higher order linear differential equations, Wronskian, and its properties; Solving differential equation by reducing its order.

**Unit 2: Second Order Linear Differential Equations**

Linear homogenous equations with constant coefficients, Linear non-homogenous equations, The method of variation of parameters, The Cauchy–Euler equation; Simultaneous differential equations.

**Unit 3: Partial Differential Equations**

Partial differential equations**:** Basic concepts and definitions with mathematical problems; First order partial differential equations**:** Classification, Construction, Geometrical interpretation, Method of characteristics and general solutions, Canonical forms and method of separation of variables; Second order partial differential equations**:** Classification, Reduction to canonical forms; Linear second order partial differential equations with constant coefficients**:** Reduction to canonical forms with general solutions.

**References:**

1. Kreyszig, Erwin (2011). *Advanced Engineering Mathematics* (10th ed.). John Wiley & Sons, Inc. Wiley India Edition 2015.
2. Myint-U, Tyn & Debnath, Lokenath. (2007). *Linear Partial Differential Equation for Scientists and Engineers* (4th ed.). Springer, Third Indian Reprint, 2013.
3. Ross, Shepley L. (1984). *Differential Equations* (3rd ed.). John Wiley & Sons, Inc.

**Additional Readings:**

i. Ross, Clay C. (2004). *Differential Equations*: *An Introduction with Mathematica*® (2nd ed.). Springer.

ii. Sneddon, I. N. (2006). *Elements of Partial Differential Equations*, Dover Publications. Indian Reprint.

## Practical /Lab work to be performed in a Computer Lab:

Use of computer algebra systems (CAS), for example Mathematica/MATLAB/Maple/Maxima/ Scilab, etc., for developing the following programs:

1. Solution of first order differential equation.
2. Plotting of second order solution family of differential equation.
3. Plotting of third order solution family of differential equation.
4. Solution of differential equation by variation of parameter method.
5. Solution of systems of ordinary differential equations.
6. Solution of Cauchy problem for first order PDE.
7. Plotting the characteristics for the first order PDE.
8. Plot the integral surfaces of a given first order PDE with initial data.

**Teaching Plan (Theory Paper: DSE-1 (i): Differential Equations):**

**Week 1:** First order ordinary differential equations: Basic concepts and ideas.
[2] Chapter 1 (Section 1.1).
[3] Chapter 1 (Sections 1.1, and 1.2).

**Week 2:** First order exact differential equations. Integrating factors and rules to find integrating factors.
[2] Chapter 1 (Section 1.4).
[3] Chapter 2 (Sections 2.1, and 2.2).

**Weeks 3 and 4:** Linear equations and Bernoulli equations, Orthogonal trajectories and oblique trajectories; Basic theory of higher order linear differential equations, Wronskian, and its properties; Solving a differential equation by reducing its order.
[3] Chapter 2 (Sections 2.3, and 2.4), Chapter 3 (Section 3.1), and Chapter 4 (Section 4.1).

**Weeks 5 and 6:** Linear homogenous equations with constant coefficients. Linear non-homogenous equations.
[2] Chapter 2 (Section 2.2).
[3] Chapter 4 (Sections 4.2, 4.3, and 4.6).

**Week 7:** The method of variation of parameters, The Cauchy–Euler equation.
[3] Chapter 4 (Sections 4.4, and 4.5).

**Week 8:** Simultaneous differential equations.
[3] Chapter 7 (Sections 7.1, and 7.3).

**Week 9:** Partial differential equations: Basic concepts and definitions with mathematical problems. Classification of first order partial differential equations.
[1] Chapter 2 (Sections 2.1, and 2.2).

**Week 10:** Construction and Geometrical interpretation of first order partial differential equations.
[1] Chapter 2 (Sections 2.3, and 2.4).

**Week 11:** Method of characteristics, General solutions of first order partial differential equations.
[1] Chapter 2 (Section 2.5)

**Week 12:** Canonical forms and method of separation of variables for first order partial differential equations.
[1] Chapter 2 (Sections 2.6, and 2.7).

**Week 13:** Classification of second order partial differential equations, reduction to canonical forms.
[1] Chapter 4 (Sections 4.1, and 4.2).

**Week 14:** Second order partial differential equations with constant coefficients, General solutions.
[1] Chapter 4 (Sections 4.3, and 4.4).

**Facilitating the Achievement of Course Learning Outcomes**

| Unit No. | Course Learning Outcomes | Teaching and Learning Activity | Assessment Tasks |
|---|---|---|---|
| 1. | Solve the exact, linear and Bernoulli equations and find orthogonal trajectories. | (i) Each topic to be explained with illustrations.<br>(ii) Students to be encouraged to discover the relevant concepts.<br>(iii) Students to be given homework/assignments.<br>(iv) Discuss and solve the theoretical and practical problems in the class.<br>(v) Students to be encouraged to apply concepts to real world problems. | • Presentations and class discussions.<br>• Assignments and class tests.<br>• Student presentations.<br>• Mid-term examinations.<br>• Practical and viva-voce examinations.<br>• End-term examinations. |
| 2. | Apply the method of variation of parameters to solve linear differential equations. | | |
| 3. | Formulate and solve various types of first and second order partial differential equations. | | |

**Keywords:** Integrating factors, Bernoulli equations, Wronskian, Cauchy–Euler equation, First and second order PDE's.