



# ARSD College, University of Delhi

## Model Course Handout/Lesson Plan

| <b>Course Name : B.Sc. (Hons) Mathematics</b> |             |                                |             |              |               |            |
|---|-------------|--------------------------------|-------------|--------------|---------------|------------|
| Semester                                      | Course Code | Course Title                   | Lecture (L) | Tutorial (T) | Practical (P) | Credit (C) |
| IV  | BMATH408    | Partial Differential Equations | 4x14=56     | 0            | 0             | 4          |
| Teacher/Instructor(s)                         |             | Chhatra Pal                    |             |              |               |            |
| Session                                       |             | (Jan- May) 2021-22             |             |              |               |            |

**Course Objective:** The main objectives of this course are to teach students to form and solve partial differential equations and use them in solving some physical problems.

### Course Learning Outcomes:

The course will enable the students to:

- i) Formulate, classify, and transform first order PDEs into canonical form.
- ii) Learn about method of characteristics and separation of variables to solve first order PDE's.
- iii) Classify and solve second order linear PDEs.
- iv) Learn about Cauchy problem for second order PDE and homogeneous and nonhomogeneous wave equations.
- v) Apply the method of separation of variables for solving many well-known second order PDEs.

### Lesson Plan:

| Unit No. | Learning Objective   | Lecture No. | Topics to be covered   |
|----------|--|-------------|--|
| 1.       | <b>First Order PDE and Method of Characteristics</b>                     | 1-2         | Introduction of 1 <sup>st</sup> order partial differential equations (PDE) |
|          |  | 3           | Classification of 1 <sup>st</sup> order PDE                                |
|          |  | 4-5         | Construction and geometrical interpretation of 1 <sup>st</sup> order PDE   |
|          |  | 6-7         | Method of characteristic of 1 <sup>st</sup> order PDE                      |
|          |  | 8-9         | General solution of 1 <sup>st</sup> order PDE                              |
|          |  | 10-11       | Canonical form of 1 <sup>st</sup> order PDE                                |
|          |  | 12          | Method of separation of variables for 1 <sup>st</sup> order PDE.           |
| 2.       | <b>Mathematical Models and Classification of Second Order Linear PDE</b> | 13-14       | Vibrating String and Vibrating Membrane                                    |
|          |  | 15-16       | Gravitational potential, Conservation laws and Burger's equations          |
|          |  | 17-18       | Classification of second order PDE,  |
|          |  | 19-20       | Reduction to canonical forms,  |

|    |  |        |   |
|----|--|--------|---|
|    |  | 21-24  | Equations with constant coefficients, General solution.   |
| 3. | <b>The Cauchy Problem and Wave Equations</b> | 25- 28 | Cauchy problem for second order PDE,  |
|    |  | 29-30  | Homogeneous wave equation   |
|    |  | 31-32  | Initial boundary value problems,  |
|    |  | 33-34  | Nonhomogeneous boundary conditions,   |
|    |  | 35-36  | Finite strings with fixed ends  |
|    |  | 37-38  | Non-homogeneous wave equation   |
|    |  | 39-40  | Goursat problem.  |
| 4. | <b>Method of Separation of Variables</b>     | 41-44  | Method of separation of variables for second order PDE,   |
|    |  | 45-48  | Vibrating string problem using method of separation of variables                                |
|    |  | 49-50  | Existence (without discussing proof) and uniqueness of vibrating string problem                 |
|    |  | 51     | Heat conduction problem   |
|    |  | 52- 54 | Existence (without discussing proof) and uniqueness of the solution of heat conduction problem. |
|    |  | 55-56  | Non-homogeneous problem.  |
|    |  |        |   |

**Evaluation Scheme:**

| No. | Component                | Duration | Marks |
|-----|--------------------------|----------|-------|
| 1.  | Internal Assessment      |          | 25    |
|     | • Quiz                   |          |       |
|     | • Class Test             |          |       |
|     | • Attendance             |          |       |
|     | • Assignment             |          |       |
| 2.  | End Semester Examination | 3 hr     | 75    |

| <b>Details of the Course</b> |  |               |
|------------------------------|--|---------------|
| Unit                         | Contents   | Contact Hours |
| 1                            | Introduction, Classification, Construction and geometrical interpretation of first order partial differential equations (PDE), Method of characteristic and general solution of first order PDE, Canonical form of first order PDE, Method of separation of variables for first order PDE. | 12            |
| 2                            | Gravitational potential, Conservation laws and Burger's equations, Classification of second order PDE, Reduction to canonical forms, Equations with constant coefficients, General solution.   | 12            |
| 3                            | Mathematical modeling of vibrating string and vibrating membrane, Cauchy problem for second order PDE, Homogeneous wave equation,  | 16            |

|   |  |           |
|---|--|-----------|
|   | Initial boundary value problems, Nonhomogeneous boundary conditions, Finite strings with fixed ends, Non-homogeneous wave equation, Goursat problem.   |           |
| 4 | Method of separation of variables for second order PDE, Vibrating string problem, Existence and uniqueness of solution of vibrating string problem, Heat conduction problem, Existence and uniqueness of solution of heat conduction problem, Non-homogeneous problem. | 16        |
|   | <b>Total</b>   | <b>56</b> |

**Suggested Books:**

| Sl. No. | Name of Authors/Books/Publishers  | Year of Publication/Reprint |
|---------|---|-----------------------------|
| 1       | Myint-U, Tyn and Debnath, Lokenath- Linear Partial Differential Equation for scientist and engineers -Birkauser Boston, Indian Reprint                      | 2007                        |
| 2       | Sneddon, I. N. <i>Elements of Partial Differential Equations</i> , Dover Publications. Indian Reprint.  | 2006                        |
| 3       | Stavroulakis, Ioannis P & Tersian, Stepan A. <i>Partial Differential Equations: An Introduction with Mathematica and MAPLE</i> (2nd ed.). World Scientific. | 2004                        |

**Mode of Evaluation:**

Internal Assessment / End Semester Exam

**Progress Report:**

| Unit No. | Learning Objective   | Date | Topics to be covered  |
|----------|--|------|---|
| 1.       | <b>First Order PDE and Method of Characteristics<br/>Mathematical Models and Classification of Second Order Linear PDE</b> |      | Introduction of first order partial differential equations (PDE)                                |
|          |  |      | Classification of PDE   |
|          |  |      | Construction and geometrical interpretation of first order PDE                                  |
|          |  |      | Method of characteristic of first order PDE   |
|          |  |      | General solution of first order PDE   |
|          |  |      | Canonical form of first order PDE   |
|          |  |      | Method of separation of variables for first order PDE.  |
|          |  |      | Vibrating String and Vibrating Membrane   |
|          |  |      | Gravitational potential, Conservation laws and Burger's equations                               |
|          |  |      | Classification of second order PDE,   |
|          |  |      | Reduction to canonical forms,   |
|          |  |      | Equations with constant coefficients, General solution.   |
| 2.       | <b>The Cauchy Problem and Wave Equations</b>   |      | Cauchy problem for second order PDE,  |
|          |  |      | Homogeneous wave equation   |
|          |  |      | Initial boundary value problems,  |
|          |  |      | Nonhomogeneous boundary conditions,   |
|          |  |      | Finite strings with fixed ends  |
| 3.       | <b>Method of Separation of Variables</b>   |      | Goursat problem.  |
|          |  |      | Method of separation of variables for second order PDE,   |
|          |  |      | Vibrating string problem using method of separation of variables                                |
|          |  |      | Existence (without discussing proof) and uniqueness of vibrating string problem                 |
|          |  |      | Heat conduction problem   |
|          |  |      | Existence (without discussing proof) and uniqueness of the solution of heat conduction problem. |
|          |  |      | Non-homogeneous problem.  |