

## Syllabus template

| <b>Semester: 1</b>  |                  |   |                       |                            |
|---|------------------|---|-----------------------|----------------------------|
| <b>Programme: Mathematics</b>   |                  |   |                       |                            |
| <b>Course: Differential Equations-1</b>   |                  |   |                       |                            |
| <b>Paper code: C1MT230111T</b>  |                  |   | <b>Credits: 4</b>     |                            |
| <b>Hours/week: 4 hours</b>  |                  |   |                       |                            |
| <b>Category: Core/MDC/SEC/VAC : Core</b>  |                  |   |                       |                            |
| <b>Theory / Practical / Composite : Theory</b>  |                  |   |                       |                            |
| <b>No of Modules : Nil</b>  |                  |   |                       |                            |
| <b>Course Overview: Differential Equations-1</b>  |                  |   |                       |                            |
| <p>This course provides a comprehensive introduction to the theory, solution techniques, and applications of ordinary differential equations (ODEs). It aims to develop students' ability to model real-world phenomena mathematically and solve differential equations arising in science, engineering, and other fields. Emphasis is placed on both analytical methods and the interpretation of solutions. The course is structured into three major modules: First Order ODEs, Higher Order ODEs, and Systems of ODEs, each progressing in conceptual depth and problem-solving sophistication.</p> |                  |   |                       |                            |
| <b>Course Outcome: Differential Equations-1</b>   |                  |   |                       |                            |
| 1. Understand the genesis of ordinary differential equations; explain the origin, formation, and classification of ordinary differential equations arising from geometry, physics, and other applied fields.  |                  |   |                       |                            |
| 2. Apply in solving first-order differential equations, including exact, non-exact, linear, and Bernoulli equations, using appropriate analytical techniques and integrating factors.   |                  |   |                       |                            |
| 3. Analyze higher-degree first-order differential equations such as Clairaut's and equations solvable for $x$ , $y$ , or $p$ , and determine singular solutions where applicable.   |                  |   |                       |                            |
| 4. Determine the general and particular solutions of higher-order linear homogeneous and inhomogeneous differential equations using methods such as undetermined coefficients and variation of parameters.  |                  |   |                       |                            |
| 5. Analyze and examine the linear independence of solutions using the Wronskian and apply the principle of superposition.   |                  |   |                       |                            |
| 6. Formulate, analyze and solve systems of first-order differential equations using matrix methods, eigenvalues, and eigenvectors, including generalized eigenvectors where necessary.  |                  |   |                       |                            |
| 7. Evaluate and interpret the physical meaning and behaviour of solutions to differential equations and systems in applied mathematical contexts.   |                  |   |                       |                            |
| <b>Prerequisites: <i>Basic knowledge about any prior course: Differentiation and Integration in plus-2 level</i></b>  |                  |   |                       |                            |
| <b>SYLLABUS</b>   |                  |   |                       |                            |
| <b>UNIT/Module</b>  | <b>CONTENT</b>   | <b>HOURS<br/>or<br/>NUMBER<br/>OF<br/>CLASSES</b> | <b>CO<br/>Mapping</b> | <b>COGNITIVE<br/>LEVEL</b> |
| I.  | First Order ODE: | 13 hours  | CO1,                  | K2, K3, K4                 |

|      |  |          |          |                |
|------|--|----------|----------|----------------|
|      | <p>Genesis of Ordinary differential equations from geometry and other fields [2]. Exact differential equations of first order [2]. Non exact differential equations of first order and integrating factors, linear equation and Bernoulli equations, special integrating factors and transformations.[5] First order ode of higher degree: equations solvable for x, y and p. Clairaut's equations and differential equations transformable into Clairaut's form. Singular solutions. [4]</p>  |          | CO2, CO3 |                |
| II.  | <p>Higher Order ODE:<br/>General solution of linear homogeneous differential equation of second and higher order, principle of superposition. Wronskian to check independency of functions.[4] Linear inhomogeneous equations of higher order with constant coefficients [5] Cauchy-Euler's equation [2] Method of undetermined coefficients [2] Second order differential equations with variable coefficients — finding complementary function in terms of a known integral. Method of variation of parameters to solve inhomogeneous equations [6] Exact higher order ode [3]</p> | 22 hours | CO4, CO5 | K2, K3, K4, K6 |
| III. | <p>System of ODE<br/>Reduction of higher order linear differential equations into a system of first order linear differential equations [2] Differential operators, solving a system of homogeneous and non-homogeneous linear ODE's of two variables by operator method [5] Expressing a system of homogeneous linear ODE into</p>  | 17 hours | CO6, CO7 | K2, K3, K4, K5 |

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|--|--|--|--|--|
|  | $d\vec{X}/dt = AX$ form where $X$ has three or more components and solving them using eigenvalues[5]. Introduction to generalised eigenvectors |  |  |  |
| <b>Text Books</b>  |  |  |  |  |
| 1. Ghosh & Chakraborty: Ordinary Differential Equations.   |  |  |  |  |
| 2. S.L. Ross: Differential Equations, 3rd Ed., John Wiley and Sons, India, 2004.   |  |  |  |  |
| 3. G.F. Simmons: Differential Equations with Historical Notes.   |  |  |  |  |
| <b>Suggested readings</b>  |  |  |  |  |
| 1. Martha L Abell, James P Braselton: Differential Equations with MATHEMATICA, 3rd Ed., Elsevier Academic Press, 2004. • R. Kent Nagle, Edward B. Saff, Arthur David Snider: --Fundamentals of Differential Equations (8 th Ed.), Pearson. |  |  |  |  |
| 2. R. Kent Nagle, Edward B. Saff, Arthur David Snider: Fundamentals of Differential Equations (8 th Ed.), Pearson  |  |  |  |  |
| 3. D.A. Murray: Differential Equations [Orient Longmann].  |  |  |  |  |
| <b>Web Resources</b>   |  |  |  |  |
| 1. <a href="https://youtu.be/_LX1p0VFkp4">https://youtu.be/_LX1p0VFkp4</a>   |  |  |  |  |
| 2. <a href="https://ocw.mit.edu/courses/18-03-differential-equations-spring-2010/">https://ocw.mit.edu/courses/18-03-differential-equations-spring-2010/</a>   |  |  |  |  |
| <b>Evaluation:</b> Theory CIA: 20+5+5=30 Semester Exam: 70   |  |  |  |  |
| <b>Paper Structure for Theory Semester Exam:</b> 7 questions each carrying 10 marks out of 12/13 questions.  |  |  |  |  |

### Course outcomes (COs) and Cognitive Level Mapping

| COs | CO Description  | Cognitive levels |
|-----|---|------------------|
| CO1 | Understand the genesis of ordinary differential equations; explain the origin, formation, and classification of ordinary differential equations arising from geometry, physics, and other applied fields. | K2               |
| CO2 | Apply in solving first-order differential equations, including exact, non-exact, linear, and Bernoulli equations, using appropriate analytical techniques and integrating factors.                        | K3               |
| CO3 | Analyze higher-degree first-order differential equations such as Clairaut's and equations solvable for $x$ , $y$ , or $p$ , and determine singular solutions where applicable.                            | K4               |
| CO4 | Determine the general and particular solutions of higher-order linear homogeneous and inhomogeneous differential equations using methods such as undetermined coefficients and variation of parameters.   | K3               |
| CO5 | Analyze and examine the linear independence of solutions using the Wronskian and apply the principle of superposition.  | K4               |

|     |   |        |
|-----|---|--------|
| CO6 | Formulate, analyze and solve systems of first-order differential equations using matrix methods, eigenvalues, and eigenvectors, including generalized eigenvectors where necessary. | K3, K4 |
| CO7 | Evaluate and interpret the physical meaning and behaviour of solutions to differential equations and systems in applied mathematical contexts.                                      | K6     |