26MA802 Physics Informed Neural Networks for Solving differential equations 4-0-0 4

COURSE OUTCOMES

CO1	The learner will be able to understand the basics of artificial neural network (ANN) and its architecture along with the paradigms of learning, the activation functions, and leaning rules.
CO2	The learner will develop a clear understanding of differential equations along with the initial value problems and boundary value problems in detail.
CO3	The learner applies the concept of ANN and ODE in formulation of Multilayer ANN Model and General Formulation of ODE.
CO4	The learner can analyze the structure and formation of artificial neural networks (ANN) along with the formation of system of first order ODE.
CO5	The learner understands the concept of PINN and their real time applications and compares the results for PDE.

UNIT I **13 hours**

Artificial Neural Network : Architecture of ANN -- Paradigms of Learning -- Learning Rules or Learning Processes -- Activation Functions including Unipolar Sigmoid Function -- Bipolar Sigmoid Function --Tangent Hyperbolic Function.

UNIT II **12 hours**

Differential Equations : Order and Degree of Differential equations -- Linear and Nonlinear Differential Equations -- Partial Differential Equation -- Initial Value Problem -- Boundary Value Problem.

UNIT III **10 hours**

Formulation of ODE based on ANN : Structure of Multilayer ANN -- Formulations and Learning Algorithm of Multilayer ANN Model -- General Formulation of ODEs Based on ANN Model -- Formulation of nth-Order IVPs -- Formulation of BVPs.

UNIT IV

10 hours

System of ODEs : Formulation of a System of First-Order ODEs -- Computation of Gradient of ODEs for Multilayer ANN Model -- First-Order Linear ODEs -- Higher-Order ODEs -- System of ODEs.

UNIT V

10 hours

System of PDEs : Physical Model of Heat conduction – Thermal Inversion -- Gradient Method -- 2D Heat Conduction Model – 3D Heat Conduction Model – Architecture of PINN and its Loss functions – Comparison.

REFERENCE BOOKS

1. Artificial Neural Networks for Engineers and Scientists Solving Ordinary Differential Equations, Snehashish Chakraverty and Susmita Mall, 2017.
2. Deep Learning-Based Forward Modeling and Inversion Techniques for Computational Physics Problems, Yinpeng Wang Qiang Ren, 2024.
3. Physics informed Neural Networks and Biologically inspired Machine Learning: Vikram Sankhala Lecture Notes, **2023**
4. Kun Zhou and Bo Liu. Chapter 1 - Fundamentals of classical molecular dynamics simulation. In Kun Zhou and Bo Liu, editors, Molecular Dynamics Simulation, Elsevier, Amsterdam, 2022.

Evaluation Pattern:

The weightage of the marks :

Midterm – 30 marks

Continuous Assessment - 30 marks (Quizzes/assignments)

At the end of the course, end-of-semester exam- 50 marks.

Skill Development:

To help the learners understand the system of Ordinary differential equations and Partial differential equations along with the ANN Model. To prepare the learners to understand the application of ANN in solving the ODEs and PDEs.

To prepare the learners to work with PINN model for their research problems. To analyze and compare the loss terms of the PINN Models to understand and apply them in solving the equations more efficiently .