# MA6002E MATHEMATICAL METHODS FOR THERMAL AND ENERGY SYSTEMS

Pre-requisites: NIL

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**Total Lecture Sessions: 39**

**Course Outcomes:**

CO1: Apply the concepts of vector calculus
CO2: Develop the analytic approach for solving differential equations for thermal and energy systems
CO3: Apply the finite difference and finite volume methods for differential equations
CO4: Implement the analytical and computational techniques in thermal and energy systems

**Vector Calculus**
Gradient, Divergence, Curl operators and their interpretation, Line Integrals, Surface Integrals, Volume Integral, Gauss-Divergence theorem, Green's Theorem, and Stokes' theorem with applications.

**ODE and PDE-Analytical solutions to ordinary and partial differential equations**
First-order differential equations: Initial value problem, Solution techniques and applications, Second-order differential equations: homogeneous and nonhomogeneous cases. Boundary value problem: Shooting methods, Applications of second-order differential equations, series solutions, Frobenius method, Sturm-Liouville problems, Bessel and Legendre equations; Systems of first-order differential equations, Partial differential equations: Cauchy problem, Method of characteristics, classification of second-order PDEs, Solution to one-dimensional unsteady heat conduction equation, Solution to one-dimensional wave equation using variable separable methods, d'Alembert's solution, Solution to two-dimensional Laplace equation

**Numerical solutions to ordinary and partial differential equations**
First and higher-order numerical methods for solving first-order differential equations, Implementation of higher-order ordinary differential equations: boundary value problem: Finite difference and shooting method, Data-fitting, Interpolation, Least-squares, Numerical methods for scalar transport equation, Finite difference methods for heat, wave, and Laplace equations. Introduction of finite volume method.

**Case studies:** Solution for liquid flat plate collector with steady or variable heat flux, Solution for liquid parabolic collector with steady or variable heat flux, Energy storage system, Wind energy system, Fuel cell, Droplet combustion, Application of Bessel function for 2-D heat conduction problem

**References:**

[1] Kreyszig, E, 2011, *Advanced Engineering Mathematics*, Wiley.

[2] Simmons, G.F., 2017, *Differential Equations with Applications and Historical Notes*, McGraw Hill.

[3] Ross, S. L., 2004, *Differential Equations*, John Wiley & Sons, Inc.

[4] Buchanan, J R and Shoude, Z, 2017, *A First Course in Partial Differential Equations*, World Scientific.

[5] Butcher, J C, 2003, *Numerical Methods for Ordinary Differential Equations*, Wiley.

[6] Thomas, J W, 2013, *Numerical Partial Differential Equations: Finite Difference Methods*, Springer.

[7] Versteeg, H K and Malalasekera, W, 2007, *An Introduction to Computational Fluid Dynamics: The Finite Volume Method*, Pearson Ed. Ltd.