Course No	Course Name	L-T-P-Credits
MA 544	**Optimal Control Theory**	**3-0-0: 3**

Prerequisite: Ordinary Differential Equations

Course Objectives: The objective of this course is cover the basic concepts, theory, computational techniques, and tools related to optimal control for dynamical systems in continuous time. Particular consideration is given to applications of the computational technique to solve real world problems.

Course Outcomes: After successful completion of the course, students will be able to:

1. Solve some historical problems on calculus of variations.
2. Formulate first order optimality condition for calculus of variation and optimal control problem.
3. Find optimal control by solving for two-point boundary value problem.
4. Determine optimal control for linear time invariant systems by solving the corresponding Riccati equations.
5. Apply Pontryagin principle and identify bang-bang control situation for model problem.
6. Apply control tools to solve some engineering and biological problems.

SYLLABUS

Module	Contents	Hours
I	Introduction, some classic calculus of variations problems: the brachistochorone problem, Dido's problem, weak and strong extrema, first order necessary conditions for weak extrema, Euler-Lagrange equation, variable end points problems, Free-end points problems, broken extremal, Weierstrass-Erdmann condition, extremal conditions on the Hamiltonian, principle of least square, Legendre second order conditions, Jacobi and Riccati equations, isoperimetric problem, extremal for dual functional.	16
II	Pontryagin principle, additional necessary conditions, Principle of optimality, optimal control of continuous time systems, Hamiltonian-Bellman equation, bounded control, constrained time optimal problem, constrained state optimal problem, minimum time optimal problem, bang-bang principle.	14
III	Solving real world problems in engineering and biological science, discussions on recent research advances in this field.	6

Essential Readings:

1. A. S. Gupta, "Calculus of Variations with Applications", PHI Learning Pvt. Ltd., 2015
2. I. M. Gelfand and S. V. Fomin, "Calculus of Variations", Dover, 2000

Supplementary Readings:

1. B. Dacorogna, "Introduction to the Calculus of Variations", Imperial College Press, 3rd edition, 2014
2. D. Krik, "Optimal Control Theory: An Introduction", Dover, 1st edition, 2004
3. Leslie M. Hocking, "Optimal Control: An Introduction to the Theory with Applications", Clarendon Press, Oxford, 1st edition, 1991