Heat Conduction Course Description

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Chapter I: Heat Conduction Fundamentals

1.1 The Heat Flux
1.2 Thermal Conductivity
1.3 Differential Equation of Heat Conduction
1.4 Fourier's Law and the Heat Equation in Cylindrical and Spherical Coordinate Systems
1.5 General Boundary Conditions and Initial Condition for the Heat Equation
1.6 Nondimensional Analysis of the Heat Conduction Equation
1.7 Lumped and Partially Lumped Formulation

Chapter II: Separation of Variables in the Rectangular Coordinate System

2.1 Basic Concepts in the Separation of Variables Method
2.2 Generalization to Multidimensional Problems
2.3 Solution of Multidimensional Homogenous Problems
2.4 Multidimensional Nonhomogeneous Problems: Method of Superposition
2.5 Product Solution

Chapter III: Separation of Variables in the Cylindrical Coordinate System

3.1 Separation of Heat Conduction Equation in the Cylindrical Coordinate System
3.2 Solution of Steady-State Problems
3.3 Solution of Transient Problems

Chapter IV: Separation of Variables in the Spherical Coordinate System

4.1 Separation of Heat Conduction Equation in the Spherical Coordinate System
4.2 Solution of Steady-State Problems
4.3 Solution of Transient Problems

Chapter V: Solution of the Heat Equation for Semi-Infinite and Infinite Domains

5.1 One-Dimensional Homogeneous Problems in a Semi-Infinite Medium for the Cartesian Coordinate System
5.2 Multidimensional Homogeneous Problems in a Semi-Infinite Medium for the Cartesian Coordinate System

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5.3 One-Dimensional Homogeneous Problems in An Infinite Medium for the Cartesian Coordinate System
5.4 One-Dimensional homogeneous Problems in a Semi-Infinite Medium for the Cylindrical Coordinate System
5.5 Two-Dimensional Homogeneous Problems in a Semi-Infinite Medium for the Cylindrical Coordinate System
5.6 One-Dimensional Homogeneous Problems in a Semi-Infinite Medium for the Spherical Coordinate System

Chapter VI: Use of Duhamel's Theorem

6.1 Development of Duhamel's Theorem for Continuous Time-Dependent Boundary Conditions
6.2 Treatment of Discontinuities
6.3 General Statement of Duhamel's Theorem
6.4 Applications of Duhamel's Theorem
6.5 Applications of Duhamel's Theorem for Internal Energy Generation

Chapter VII: Green's Function Approach for Solving Nonhomogeneous Transient

7.1 Determination of Green's Functions
7.2 Representation of Point, Line, and Surface Heat Sources with Delta Functions
7.3 Applications of Green's Function in the Rectangular Coordinate System
7.4 Applications of Green's Function in the Cylindrical Coordinate System
7.5 Applications of Green's Function in the Spherical Coordinate System
7.6 Products of Green's Functions,

Chapter VIII: Use of the Laplace Transform

8.1 Definition of Laplace Transformation
8.2 Properties of Laplace Transform
8.3 Inversion of Laplace Transform Using the Inversion Tables
8.4 Application of the Laplace Transform in the Solution of Time-Dependent Heat Conduction Problems

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8.5 Approximations for Small Times

Chapter IX: Moving Heat Source Problems

9.1 Mathematical Modeling of Moving Heat Source Problems
9.2 One-Dimensional Quasi-Stationary Plane Heat Source Problem
9.3 Two-Dimensional Quasi-Stationary Line Heat Source Problem
9.4 Two-Dimensional Quasi-Stationary Ring Heat Source Problem

Chapter X: Phase-Change Problems

10.1 Mathematical Formulation of Phase-Change Problems
10.2 Exact Solution of Phase-Change Problems
10.3 Integral Method of Solution of Phase-Change Problems
10.4 Variable Time Step Method for Solving Phase-Change Problems: A Numerical Solution
10.5 Enthalpy Method for Solution of Phase-Change Problems: A Numerical Solution

Chapter XI: Approximate Analytic Methods

11.1 Integral Method: Basic Concepts
11.2 Integral Method: Application to Linear Transient Heat Conduction in a Semi-Infinite Medium
11.3 Integral Method: Application to Nonlinear Transient Heat Conduction
11.4 Integral Method: Application to a Finite Region
11.5 Approximate Analytic Methods of Residuals
11.6 The Galerkin Method
11.7 Partial Integration
11.8 Application to Transient Problems

Chapter XII: Integral Transform Technique

12.1 Use of Integral Transform in the Solution of Heat Conduction Problems
12.2 Applications in the Rectangular Coordinate System
12.3 Applications in the Cylindrical Coordinate System
12.4 Applications in the Spherical Coordinate System
12.5 Applications in the Solution of Steady-state problems

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Chapter XIII: Numerical Methods in Conduction Heat Transfer

13.1 Introduction
13.2 Finite Difference Method
13.3 Fundamental Concepts
13.4 Steady Two – Dimensional Problem
13.5 Transient Numerical Methods
13.6 Solution Techniques
13.7 Relaxation Method
13.8 Boundary Element Method

Grading: The Following Weights Will Be Used For Grading:

Homeworks and Projects	40%
Midterm Exam	20%
Final Exam	40%
Total	100%

List of References:

- Hahn, D. W., Ozicik, M. N., “Heat Conduction”, 3rd edition, John Willey and Sons, 2012.
- Arpaci, V. s., “Conduction Heat Transfer”, Addison-Wesley, 1966.
- KaKac, S., Yener, Y., Naveira-Cotta, C. P., “Heat Conduction”, 5rd edition, CRC Press, 2018.