课程名称：电磁学理论与计算

教学目的与要求：

本课程为面向应用数学、物理学及相关专业高年级学生的强化课。课程主要分为三部分：第一部分介绍量纲分析和物理方程的建立，让学生深刻认识到物理量和数学量的关系，如何正确建立物理方程(应用数学的过程)。第二部分除了对麦氏方程组进行再讨论外(如初值表述、纳米尺度边界条件、含磁荷的方程组等)，增加了相对论电磁学、拓扑电磁学等前沿研究成果，让学生掌握电磁场现象、概念和核心数学方程，深刻理解物理现象的相对性和物理规律的绝对性。第三部分讲解定量分析所需的数值算法、软件知识基础、以及最新发展趋势(如 AI 计算电磁学)。总之，通过本课程的学习可提高学生运用基本物理规律、数值算法解决应用数学问题的能力，为以后从事专业理论研究和交叉学科研究打下坚实的基础。

预修课程：

课程大纲：

第一部分

第一章 物理量与量纲分析

第二章 量纲分析应用于物理学

第三章 矢量与张量分析

第四章 物理方程的建立

第二部分

第五章 麦氏方程组讨论：初值表述、纳米尺度边界条件、含磁荷的方程

第六章 电磁场波动方程

第七章 电磁场能量、动量和应力张量

第八章 相对论电磁学

第九章 拓扑电磁学

第三部分

第十章 有限元法

第十一章 差分法

第十二章 矩量法

第十三章 MATLAB 与 COMSOL 计算

第十四章 前沿：有限积分技术(FIT)与拟态有限元法(Mimetic FEM)等

第十五章 前沿：神经网络与 PINN(AI 计算电磁学)等

复习与考试

考试形式：数值计算，大作业形式

参考书目：

邵佳佳, 副教授, 数学物理组, BIMSA

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Course Title: Electromagnetic Theory and Computation

Teaching Objectives and Requirements:

This advanced course provides senior undergraduate students in applied mathematics, physics, and related engineering disciplines with a rigorous foundation in electromagnetic theory and computational modeling. The curriculum is structured around three core modules:

Part I: Dimensional Analysis & Mathematical Modeling:

Establishes the principles of scaling, dimensional analysis, and the formal mathematical formulation of physical laws.

Part II: Advanced & Frontier Electromagnetism:

Re-examines Maxwell's equations—incorporating initial value formulations, nanoscale boundary conditions, and magnetic charges—while introducing cutting-edge topics such as relativistic electrodynamics and topological electromagnetism.

Part III: Computational Methods & AI Frontiers:

Covers core numerical algorithms (FEM, FDM, MoM), simulation tools (MATLAB, COMSOL), and modern paradigms including Mimetic FEM, Finite Integration Technique (FIT), and Physics-Informed Neural Networks (PINNs).

Ultimately, students will be equipped to translate fundamental physical laws into rigorous mathematical models, implement state-of-the-art computational algorithms, and address complex interdisciplinary research challenges.

Prerequisites:

Course Syllabus:

Part I:

Chapter 1: Physical Quantities and Dimensional Analysis

Chapter 2: Applications of Dimensional Analysis in Physics

Chapter 3: Vector and Tensor Analysis

Chapter 4: Formulation of Physical Equations

Part II:

Chapter 5: Discussion on Maxwell's Equations: Initial Value Formulations, Nanoscale Boundary Conditions, and Equations with Magnetic Charges

Chapter 6: Wave Equations of Electromagnetic Fields

Chapter 7: Energy, Momentum, and Stress Tensor of Electromagnetic Fields

Chapter 8: Relativistic Electromagnetism

Chapter 9: Topological Electromagnetism

Part III:

Chapter 10: Finite Element Method

Chapter 11: Finite Difference Method

Chapter 12: Method of Moments

Chapter 13: Computation with MATLAB and COMSOL

Chapter 14: Frontiers: Finite Integration Technique (FIT), Mimetic Finite Element Method (Mimetic FEM), etc.

Chapter 15: Frontiers: Neural Networks, Physics-Informed Neural Networks (PINN), etc.

Review and Examination

Please note that:

This course consists of 15 chapters and at least 48 teaching hours.

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