Module Description for Undergraduate Courses

Of

Shantou University

汕頭大學

SHANTOU UNIVERSITY

Contents

Note:

Courses marked with an * in the bookmarks indicate courses that have not yet appeared on the current transcript but will be included upon graduation. All other courses are those already listed on the transcript.

Additionally, due to file size limitations, a high-resolution version of this document can be downloaded by clicking *here*.

Below is the semester-by-semester order of all courses I have taken over the past four years.

	Courses	Total workload (Hours)
22 Fall	Classical mechanics	192
	Thermal Physics	144
	Calculus B1	264
23 Spring	Linear algebra	96
	Calculus B2	264
	Electromagnetism	192
	Optics	144
23 Fall	University physics experiments 1	96
	Mathematical methods of Physics	144
	Scientific research A	32
	Advance Calculus	196
24 Spring	Probability and Statistics	146
	Electromagnetic Experiments of General Physics	128
	Theroretical Mechanics	192
	Atomic Physics	144
	Electrodynamics	135
	Scientific research training B	136
24 Fall	Thermodynamics and Statistical Physics	192
	Information optics	144
	Fundamentals of Computational Physics	96
	General Physics Comprehensive Experiment	128
	Quantum Mechanics 1	96
	Modern Physics experiments 1	128
	Comprehensive scientific research training C	40
25 Spring	Structure and Properties	96
	Solidstate Physics	192
	Physics in English	50
	Semiconductor Physics	96
	Advanced Physics Experiments	128
	Comprehensive Scientific Research Training D	100
	Undergraduate Innovation and Entrepreneurship Training Program	100
25 Fall	Optoelectronic Thin Film Technology	96
	Physics of optoelectronic materials	96
	Advanced Quantum Mechanics	64
	Innovative Theoretical Basis of Physics	96
	Functions of Complex Variable	158
26 Spring	Graduation Practice and social practice	240
	Graduation Thesis	240

Shantou University

Module Description for Undergraduate Courses

COURSE TITLE：	University physics experiments 1
COURSE CODE：	PHY1105A
CREDIT VALUE：	2
CONTACT HOURS:	48
PRE-REQUISITE	none
DEPARTMENT/UNIT：	Department of Physics
VERSION:	20240731-PHY1105A
COURSE COORDINATOR:	Chi Lingfei (Signature and Seal)
APPROVER:	Li Pengcheng (Signature and Seal)
APPROVE DATE：	20240731

Shantou University Faculty of Science
July 2024

1. Course Description

(1) Nature of the Course

University physics experiments 1 is one of the most essential foundational courses for science and engineering majors. As the students' first systematic training in experimental methods and laboratory skills, it is a compulsory course for all relevant disciplines.

This module consists of fundamental experiments covering classical topics in mechanics, thermodynamics, electromagnetism, and optics. It aims to develop basic experimental competencies in physics. More importantly, as the first (and for some majors, the only) laboratory-based course, it plays a crucial role in training students in essential experimental skills and in cultivating their abilities in data acquisition and data analysis.

Through the laboratory training provided in this course, students strengthen their hands-on abilities, enhance their capacity to analyze and solve problems, and acquire foundational experimental skills and introductory competence in data collection and interpretation. This creates a solid basis for subsequent specialized laboratory courses and future research training across different science and engineering programs.

(2) Course Content

The course content consists of three experimental modules:

Mechanics and Thermodynamics Module:

- Measurement of Young's modulus
- Simple pendulum experiment
- Determination of viscosity coefficient
- Moment of inertia

Electromagnetism Module:

- Meter modification
- DC bridge
- Oscilloscope
- AC resonance

Optics Module:

- Thin lens experiments
- Newton's rings
- Diffraction grating characteristics
- Michelson interferometer

(3) Course Objectives

1. To cultivate a scientific worldview, a materialist epistemology, and a rigorous methodology of scientific inquiry, while fostering logical and coherent thinking, an exploratory spirit, and a truth-seeking attitude.

2. To enable students to master the fundamental principles of general physics and the measurement principles, instrumentation, and essential testing techniques involved, thereby strengthening their experimental skills.

3. To develop proficiency in data acquisition, processing, and analysis.

This course provides essential practical and research-oriented training supporting the cultivation of academic talents across science and engineering majors. It contributes directly to the fulfillment of graduation requirement indicators for the relevant programs, with strong alignment to the graduation requirement points of the Optoelectronic Information Science and Engineering Program, the Optoelectronic Information Science and Engineering (Microelectronics Track), and the Physics Program:

1. Firm ideals and convictions;

2. Correct values and sense of social responsibility;

3.1 Mastery of fundamental theories and professional knowledge in physics, optoelectronics, and information science;

5.1 Ability to conduct research based on scientific principles and methodologies.

2. Intended Learning Outcomes

The expected learning outcomes of this course are summarized as follows:

Knowledge Unit	Key Knowledge Points	Initial Level	Required Level	Expected Learning Outcomes
1. Measurement of Young's Modulus (Tensile Method)	1.1 Principles and Experimental Concepts	L1	L2	Understand the principles and procedures of the Young's modulus measurement experiment.
	1.2 Instrument Operation	L2	L3	Perform the Young's modulus experiment with proper and standardized instrument operation.
	1.3 Experimental Phenomena and Results	L2	L3	Demonstrate the experimental process and carry out data calculations.
	1.4 Report Writing	L2	L4	Summarize the experimental procedure and complete a structured laboratory report.
	1.5 Result Analysis	L2	L5	Summarize the results and provide personal insights based on data analysis.
	Value-Oriented Insight: Foster an optimistic attitude toward life.			
2. Simple Pendulum Experiment	2.1 Principles and Experimental Concepts	L1	L2	Understand the principles and procedures of the simple pendulum experiment.
	2.2 Instrument Operation	L2	L3	Use instruments properly during the pendulum experiment.
	2.3 Experimental Phenomena and Results	L2	L3	Demonstrate the experiment and perform data calculations.
	2.4 Report Writing	L2	L4	Summarize procedures and complete a laboratory report.
	2.5 Result Analysis	L2	L5	Summarize experimental findings and present personal insights.
	Value-Oriented Insight: Develop a rigorous and truth-seeking scientific attitude.			

3. Falling-Ball Method for Measuring Viscosity	3.1 Principles and Experimental Concepts	L1	L2	Understand the principles and procedures of viscosity measurement.
	3.2 Instrument Operation	L2	L3	Operate instruments properly during the viscosity experiment.
	3.3 Experimental Phenomena and Results	L2	L3	Demonstrate the experiment and perform data calculations.
	3.4 Report Writing	L2	L4	Summarize procedures and complete a laboratory report.
	3.5 Result Analysis	L2	L5	Summarize results and provide personal insights.
	Value-Oriented Insight: Enhance environmental awareness through the discussion of castor-oil recovery and processing.			
4. Torsional Pendulum Method for Measuring Moment of Inertia	4.1 Principles and Experimental Concepts	L1	L2	Understand the principles and procedures of the moment-of-inertia measurement.
	4.2 Instrument Operation	L2	L3	Perform standardized instrument operation during the experiment.
	4.3 Experimental Phenomena and Results	L2	L3	Demonstrate the experiment and perform data calculations.
	4.4 Report Writing	L2	L4	Summarize procedures and complete a laboratory report.
	4.5 Result Analysis	L2	L5	Summarize results and provide personal insights.
	Value-Oriented Insight: When mass is concentrated near the axis, the system responds more quickly—symbolizing the importance of unity.			
5. Modification and Calibration of Electrical Meters	5.1 Principles and Experimental Concepts	L1	L2	Understand principles and procedures of meter modification and calibration.
	5.2 Instrument Operation	L2	L3	Use instruments properly during meter calibration.
	5.3 Experimental Phenomena and Results	L2	L3	Demonstrate the experiment and perform data calculations.
	5.4 Report Writing	L2	L4	Summarize procedures and complete a laboratory report.
	5.5 Result Analysis	L2	L5	Summarize results and provide personal insights.

	Value-Oriented Insight: Careful inspection prevents wiring defects, cultivating patience and attention to detail.			
6. DC Bridge	6.1 Principles and Experimental Concepts	L1	L2	Understand the principles and procedures of the DC bridge experiment.
	6.2 Instrument Operation	L2	L3	Use instruments properly during the experiment.
	6.3 Experimental Phenomena and Results	L2	L3	Demonstrate the experiment and perform data calculations.
	6.4 Report Writing	L2	L4	Summarize procedures and complete a laboratory report.
	6.5 Result Analysis	L2	L5	Summarize results and provide personal insights.
	Value-Oriented Insight: Error analysis reflects rigorous scientific thinking.			
7. Principles and Use of the Oscilloscope	7.1 Principles and Experimental Concepts	L1	L2	Understand oscilloscope principles and procedures.
	7.2 Instrument Operation	L2	L3	Use instruments properly during the experiment.
	7.3 Experimental Phenomena and Results	L2	L3	Demonstrate the experiment and perform data calculations.
	7.4 Report Writing	L2	L4	Summarize procedures and complete a laboratory report.
	7.5 Result Analysis	L2	L5	Summarize results and provide personal insights.
	Value-Oriented Insight: Advancing scientific and technological strength.			
8. Resonance in AC Circuits	8.1 Principles and Experimental Concepts	L1	L2	Understand the principles and procedures of AC resonance.
	8.2 Instrument Operation	L2	L3	Use instruments properly during the experiment.
	8.3 Experimental Phenomena and Results	L2	L3	Demonstrate the experiment and perform data calculations.
	8.4 Report Writing	L2	L4	Summarize procedures and complete a laboratory report.

	8.5 Result Analysis	L2	L5	Summarize results and provide personal insights.
	Value-Oriented Insight: Resonance emerges only when all components work together—reflecting the power of cooperation.			
9. Thin-Lens Focal Length Measurement	9.1 Principles and Experimental Concepts	L1	L2	Understand the principles and procedures of thin-lens experiments.
	9.2 Instrument Operation	L2	L3	Use instruments properly during the experiment.
	9.3 Experimental Phenomena and Results	L2	L3	Demonstrate the experiment and perform data calculations.
	9.4 Report Writing	L2	L4	Summarize procedures and complete a laboratory report.
	9.5 Result Analysis	L2	L5	Summarize results and provide personal insights.
	Value-Oriented Insight: Cooperation and division of labor.			
10. Wavelength Measurement and Diffraction Grating Characteristics	10.1 Principles and Experimental Concepts	L1	L2	Understand the principles and procedures of diffraction-grating experiments.
	10.2 Instrument Operation	L2	L3	Use instruments properly during the experiment.
	10.3 Experimental Phenomena and Results	L2	L3	Demonstrate the experiment and perform data calculations.
	10.4 Report Writing	L2	L4	Summarize procedures and complete a laboratory report.
	10.5 Result Analysis	L2	L5	Summarize results and provide personal insights.
	Value-Oriented Insight: Cultivate rigor, precision, and teamwork.			
11. Newton's Rings and Measurement of Lens Curvature Radius	11.1 Principles and Experimental Concepts	L1	L2	Understand principles and procedures of the Newton's rings experiment.
	11.2 Instrument Operation	L2	L3	Use instruments properly during the experiment.
	11.3 Experimental Phenomena and Results	L2	L3	Demonstrate the experiment and perform data calculations.

	11.4 Report Writing	L2	L4	Summarize procedures and complete a laboratory report.
	11.5 Result Analysis	L2	L5	Summarize results and provide personal insights.
	Value-Oriented Insight: Newton misinterpreted the phenomenon using a corpuscular model—highlighting critical thinking and the importance of questioning authority.			
12. Michelson Interferometer and Measurement of Laser Wavelength	12.1 Principles and Experimental Concepts	L1	L2	Understand the principles and procedures of the Michelson interferometer experiment.
	12.2 Instrument Operation	L2	L3	Use instruments properly during the experiment.
	12.3 Experimental Phenomena and Results	L2	L3	Demonstrate the experiment and perform data calculations.
	12.4 Report Writing	L2	L4	Summarize procedures and complete a laboratory report.
	12.5 Result Analysis	L2	L5	Summarize results and provide personal insights.
	Value-Oriented Insight: Though classical, its principles underpin gravitational-wave detection—illustrating the enduring value of fundamental science and inspiring research enthusiasm.			

3. Pre-requisit

None

4. Textbooks and Other Learning Resources

Required Textbooks

Lecture Notes for Fundamental Physics Experiments, compiled by the Department (internal publication).

Recommended Textbooks

Ma Lijun, *General Physics Experiments*, Tsinghua University Press, June 2015.

Zhang Shumin et al., *Fundamental Physics Experiments*, Science Press, December 2022.

Teaching Platform: 192.168.70.28

5. Teaching and Learning Activities

Teaching Segment	Lectures (Theory)	Experiments	Lab Reports	Seminars	Online Learning	Total
Hours (In-class)	6	36	0	6	0	48
Hours (Out-of-class)	24	0	12	0	12	48

Basis for workload calculation:

Students must complete 12 on-site laboratory experiments. Each experiment requires 3 hours of preparation (including online learning via the teaching platform) and 1 hour for completing the lab report and data analysis.

6. Assessment Scheme

Assessment Component	Description of Assessment Content and Methods	Weight
Experiment Preparation	Before each experiment, students must log into the online laboratory teaching platform and complete the corresponding pre-lab quiz. Questions are randomly drawn from a question bank, and the system automatically grades the results. Each student may attempt the quiz up to three times, and the highest score will be taken as the final pre-lab grade for that experiment.	10%
Experimental Performance	0–59: Shows low engagement throughout the experiment; insufficient understanding of the fundamental principles; weak experimental skills; unable to analyze or reflect on common experimental issues. 60–69: Demonstrates limited engagement; shows an initial understanding of basic principles; average technical skills; inaccurate analysis of common experimental issues. 70–79: Shows good engagement; generally accurate understanding of principles; satisfactory technical skills; reasonably accurate analysis of common issues. 80–89: Actively participates; demonstrates accurate understanding of principles; solid technical skills; able to analyze and reflect on common issues with accuracy. 90–100: Consistently engaged; demonstrates deep understanding of principles; strong experimental skills; proficient operation; provides original and insightful analysis of common experimental problems.	40%
Lab Reports	0–59: Poorly prepared report; missing or incorrect theoretical principles; incorrect procedures; no data analysis or discussion; submitted beyond the required deadline. 60–69: Moderately organized report; demonstrates preliminary understanding of principles and procedures; inaccurate data analysis and discussion. 70–79: Well-organized report; demonstrates good understanding of principles and procedures; generally accurate data analysis and discussion. 80–89: Clear and well-structured report; demonstrates accurate understanding of principles and procedures; correct and reliable data analysis and discussion. 90–100: Highly structured and logically coherent report; demonstrates deep understanding of principles and procedures; accurate data analysis with insightful interpretation.	50%

7. Course Schedule

According to the teaching plan, this course consists of 48 contact hours over 16 weeks.

Week 1 covers error theory, including principles of data processing, methods of data handling, and uncertainty analysis.

Week 2 introduces the course requirements, laboratory regulations, common instruments, and safety instructions, and guides students through course selection on the online platform.

From Week 3 onward, students begin laboratory sessions.

The hands-on component lasts 12 weeks, with the final two weeks reserved for discussion and make-up experiments.

Detailed Weekly Schedule (Example: Group 1)

Week	Hour	Teaching format	Teaching content
1	3	Classroom Teaching	Error theory; organization of laboratory groups.
2	3	Classroom Teaching	Introductory session; laboratory safety instructions; selection of experiment modules on the online platform.
3	3	Laboratory teaching	Measurement of Young's Modulus: explanation of the experimental principle and underlying concepts; demonstration of instrument operation; observation and recording of experimental phenomena and results; presentation of preliminary data analysis.
4	3	Laboratory teaching	Simple Pendulum Experiment: explanation of the experimental principle and underlying concepts; demonstration of instrument operation; observation and recording of experimental phenomena and results; presentation of preliminary data analysis.
5	3	Laboratory teaching	Measurement of Viscosity Coefficient: explanation of the experimental principle and underlying concepts; demonstration of instrument operation; observation and recording of experimental phenomena and results; presentation of preliminary data analysis.
6	3	Laboratory teaching	Measurement of Moment of Inertia: explanation of the experimental principle and underlying concepts; demonstration of instrument operation; observation and recording of experimental phenomena and results; presentation of preliminary data analysis.
7	3	Laboratory teaching	Ammeter Modification and Calibration: explanation of the experimental principle and underlying concepts; demonstration of instrument operation; observation and recording of experimental phenomena and results; presentation of preliminary data analysis.
8	3	Laboratory teaching	DC Bridge Experiment: explanation of the experimental principle and underlying concepts; demonstration of instrument operation; observation and recording of experimental phenomena and results; presentation of preliminary data analysis.
9	3	Laboratory teaching	Oscilloscope Principles and Operation: explanation of the experimental principle and underlying concepts; demonstration of instrument operation; observation and recording of experimental phenomena and results; presentation of preliminary data analysis.
10	3	Laboratory teaching	AC Resonance Experiment: explanation of the experimental principle and underlying concepts; demonstration of instrument operation; observation and recording of experimental phenomena and results; presentation of preliminary data analysis.
11	3	Laboratory teaching	Measurement of Focal Length of a Thin Lens: explanation of the experimental principle and underlying concepts; demonstration of instrument operation; observation and recording of experimental phenomena and results; presentation of preliminary data analysis.
12	3	Laboratory teaching	Diffraction Grating Characteristics: explanation of the experimental principle and underlying concepts; demonstration of instrument operation; observation and recording of experimental phenomena and results; presentation of preliminary data analysis.
13	3	Laboratory teaching	Newton's Rings — Measurement of Lens Radius of Curvature: explanation of the experimental principle and underlying concepts; demonstration of instrument operation; observation and recording of

			experimental phenomena and results; presentation of preliminary data analysis.
14	3	Laboratory teaching	Michelson Interferometer — Measurement of Laser Wavelength: explanation of the experimental principle and underlying concepts; demonstration of instrument operation; observation and recording of experimental phenomena and results; presentation of preliminary data analysis.
15	3	Classroom Discussion	Organization of a discussion session for students to share their learning experiences and reflections on the semester's laboratory work.
16	3	Laboratory Session	Make-up experiments for students who were unable to complete certain experimental projects for various reasons.

汕头大学本科教学

课程教学大纲

课程名（COURSE TITLE）：	大学物理实验（1）
课程代码（COURSE CODE）：	PHY1105A
学分（CREDIT VALUE）：	2
课内课时（CONTACT HOURS）：	48
先修课要求（PRE-REQUISITE）	无
开课单位（DEPARTMENT/UNIT）：	物理学系
版本（VERSION）：	20240731-PHY1105A
课程负责人（COURSE COORDINATOR）：	池凌飞(签章)
审核人（APPROVER）：	李鹏程(签章)
审核日期（APPROVE DATE）：	20240731

汕头大学理学院

2024 年 7 月

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1. 课程简介（Course Description）

（1）课程性质

大学物理实验（1）（The Experiments of College Physics 1）是理工科各专业最重要的基础课程之一，是一门对学生进行系统实验方法和实验技能训练开端的课程，也是各理工专业的必修课。大学物理实验（1）是基础性实验，课程内容覆盖力学、热学、电磁学和光学的若干经典实验，旨在让各理工专业学生具备基本的物理实验技能，更重要的是做为各专业第一门（甚至是唯一的一门）实验课，该课程还承担着训练学生实验基本技能、培养数据获取、分析能力的重要功能。通过本课程的实验训练，提高学生的动手能力和分析问题、解决问题的能力，培养学生实验技能和初步掌握数据获取及分析能力，为今后各个专业后续的专业实验和科研能力培养打下一个良好的基础。

（2）课程内容

本课程主要内容包括：力热模块（杨氏模量测量、单摆实验、粘滞系数、转动惯量），电磁学模块（电表改装、直流电桥、示波器、交流谐振），光学模块（薄透镜、牛顿环、光栅特性、迈克尔孙干涉仪）

（3）课程目标

①培养学生科学的世界观，唯物的认识论和科学的方法论，学习逻辑缜密的思维方式，激发学生勇于探索的精神和实事求是的作风；

②学生熟练掌握普通物理基本原理及其所涉及的测量原理及基本测试技术和方法，从而提高实验动手能力；

③熟练掌握数据的获取、处理和分析方法。

本课程为支持各理工专业学术型人才培养提供专业实践与研究能力培养，支撑上述专业的毕业要求指标；高度支撑光电信息科学与工程专业、光电信息科学与工程专业（微电子方向）、物理学专业毕业要求指标点“1. 坚定的理想信念，2. 正确价值观和社会责任感，3.1 掌握物理学、光电子学和信息学的基础理论和专业知识，5.1 具备基于科学原理和方法进行研究的能力”。

2. 预期学习结果（Intended Learning Outcomes）

本课程的预期学习结果如下表：

知识单元	知识点	初始程度	要求程度	预期学习结果
1.用拉伸法测定杨氏模量	1.1 原理和实验思想	L1	L2	理解杨氏模量测量实验的原理和步骤
	1.2 实验仪器操作使用	L2	L3	杨氏模量测量实验的操作中规范使用仪器
	1.3 实验现象和结果	L2	L3	演示实验过程，对实验数据进行计算
	1.4 报告写作	L2	L4	概述实验过程，撰写实验报告
	1.5 结果分析	L2	L5	总结实验结果并提出自己的见解
	思政思政：乐观向上的生活态度			
2.单摆实验	2.1 原理和实验思想	L1	L2	理解单摆实验的原理和步骤
	2.2 实验仪器操作使用	L2	L3	单摆实验实验操作中规范使用仪器
	2.3 实验现象和结果	L2	L3	演示实验过程，对实验数据进行计算
	2.4 报告写作	L2	L4	概述实验过程，撰写实验报告

	2.5 结果分析	L2	L5	总结实验结果并提出自己的见解
	课程思政：严谨认真，实事求是的科学精神			
3.落球法测量液体粘滞系数	3.1 原理和实验思想	L1	L2	理解粘滞系数测量实验的原理和步骤
	3.2 实验仪器操作使用	L2	L3	粘滞系数测量实验中规范使用仪器
	3.3 实验现象和结果	L2	L3	演示实验过程，对实验数据进行计算
	3.4 报告写作	L2	L4	概述实验过程，撰写实验报告
	3.5 结果分析	L2	L5	总结实验结果并提出自己的见解
	课程思政：从蓖麻油的回收和处理过程，增强环保意识			
4.扭摆法测定物体的转动惯量	4.1 原理和实验思想	L1	L2	理解转动惯量测定实验的原理和步骤
	4.2 实验仪器操作使用	L2	L3	转动惯量测定实验操作中规范使用仪器
	4.3 实验现象和结果	L2	L3	演示实验过程，对实验数据进行计算
	4.4 报告写作	L2	L4	概述实验过程，撰写实验报告
	4.5 结果分析	L2	L5	总结实验结果并提出自己的见解
	课程思政：当质量集中在转轴附近时，对外力矩的的响应更快，说明了团结的重要性			
5.电表的改装和校准	5.1 原理和实验思想	L1	L2	理解电表改装和校准实验的原理和步骤
	5.2 实验仪器操作使用	L2	L3	电表改装和校准实验中规范使用仪器
	5.3 实验现象和结果	L2	L3	演示实验过程，对实验数据进行计算
	5.4 报告写作	L2	L4	概述实验过程，撰写实验报告
	5.5 结果分析	L2	L5	总结实验结果并提出自己的见解
	课程思政：因为接线可能存在虚焊的现象，需要认真排查，培养学生细致耐心的工作态度。			
6.直流电桥	6.1 原理和实验思想	L1	L2	理解直流电桥实验的原理和步骤
	6.2 实验仪器操作使用	L2	L3	直流电桥实验中规范使用仪器
	6.3 实验现象和结果	L2	L3	演示实验过程，对实验数据进行计算
	6.4 报告写作	L2	L4	概述实验过程，撰写实验报告
	6.5 结果分析	L2	L5	总结实验结果并提出自己的见解
	课程思政：误差分析中体现出来的严谨精神。			
7.示波器的原理和使用	7.1 原理和实验思想	L1	L2	理解示波器实验的原理和步骤
	7.2 实验仪器操作使用	L2	L3	示波器实验操作中规范使用仪器
	7.3 实验现象和结果	L2	L3	演示实验过程，对实验数据进行计算
	7.4 报告写作	L2	L4	概述实验过程，撰写实验报告
	7.5 结果分析	L2	L5	总结实验结果并提出自己的见解
	课程思政：科技强国			
8.交流电路的谐振现象	8.1 原理和实验思想	L1	L2	理解交流谐振实验的原理和步骤
	8.2 实验仪器操作使用	L2	L3	交流谐振实验操作中规范使用仪器
	8.3 实验现象和结果	L2	L3	演示实验过程，对实验数据进行计算
	8.4 报告写作	L2	L4	概述实验过程，撰写实验报告
	8.5 结果分析	L2	L5	总结实验结果并提出自己的见解
	课程思政：只有电路中各元件配合得当才能激发出谐振，说明团结的重要性。			
9. 薄透镜焦距测量	9.1 原理和实验思想	L1	L2	理解薄透镜实验的原理和步骤
	9.2 实验仪器操作使用	L2	L3	薄透镜实验操作中规范使用仪器
	9.3 实验现象和结果	L2	L3	演示实验过程，对实验数据进行计算
	9.4 报告写作	L2	L4	概述实验过程，撰写实验报告
	9.5 结果分析	L2	L5	总结实验结果并提出自己的见解
	课程思政：团队协作与分工			
10.光波波长测量及光	10.1 原理和实验思想	L1	L2	理解光栅特性实验的原理和步骤
	10.2 实验仪器操作使	L2	L3	光栅特性实验操作中规范使用仪器

栅特性研究	用			
	10.3 实验现象和结果	L2	L3	演示实验过程，对实验数据进行计算
	10.4 报告写作	L2	L4	概述实验过程，撰写实验报告
	10.5 结果分析	L2	L5	总结实验结果并提出自己的见解
	课程思政：培养严谨细致的科学精神和团队协作精神			
11.用牛顿环测量透镜曲率半径	11.1 原理和实验思想	L1	L2	理解牛顿环实验的原理和步骤
	11.2 实验仪器操作使用	L2	L3	牛顿环实验操作中规范使用仪器
	11.3 实验现象和结果	L2	L3	演示实验过程，对实验数据进行计算
	11.4 报告写作	L2	L4	概述实验过程，撰写实验报告
	11.5 结果分析	L2	L5	总结实验结果并提出自己的见解
	课程思政：牛顿环现象是牛顿发现的，而牛顿错误地用微粒说加以解释，批判性思维，不能迷信权威。			
12.迈克尔孙干涉仪测量激光波长	12.1 原理和实验思想	L1	L2	理解迈克尔孙干涉仪实验的原理和步骤
	12.2 实验仪器操作使用	L2	L3	迈克尔孙干涉仪实验中规范使用仪器
	12.3 实验现象和结果	L2	L3	演示实验过程，对实验数据进行计算
	12.4 报告写作	L2	L4	概述实验过程，撰写实验报告
	12.5 结果分析	L2	L5	总结实验结果并提出自己的见解
	课程思政：虽然是经典实验，其原理可以用于测量引力波，说明了基础科学的重要性，激发学生投身科研的激情。			

3. 先修要求（Pre-requisite）

无

4. 教材及其他教学资源（Textbooks and Other Learning Resources）

指定教材：

《基础物理实验讲义》，自编

推荐参考资料

《普通物理实验》马黎君著清华大学出版社，2015.6
《基础物理实验》张书敏等著，科学出版社，2022.12

教学平台：192.168.70.28

5. 主要教学环节（Teaching and Learning Activities）

教学环节	理论课（小时）	实验（小时）	实验报告（小时）	研讨（小时）	在线学习（小时）	合计
课内	6	36	0	6	0	48
课外	24	0	12	0	12	48

课时计算依据：

学生一共完成12个线下实验，每个线下实验需要预习3个小时（含教学平台学习），1个小时完成实验报告和数据分析。

6. 课程考核（Assessment Scheme）

考核项目	考核内容和考试方法简介	权重
实验预习	每个实验项目开始之前，学生需登录实验教学平台完成对应的实验项目预习考试。考试题目由题库随机抽取，预习成绩由实验平台自动判分。对于每个实验项目，学生有三次预习考试机会，系统取三次考试最高者为该项目预习考试最终成绩。	10%
实验操作	0-59：整个实验参与度低，对实验基本原理理解不准确，实验动手能力差，对实验常见问题没有分析和思考 60-69：整个实验参与度较低，展现对实验基本原理的初步理解，实验动手能力一般，对实验常见问题的分析和思考不准确 70-79：整个实验参与度较高，展现对实验基本原理理解基本准确，实验动手能力较好，对实验常见问题有较准确的分析和思考 80-89：整个实验参与度积极，展现对实验基本原理理解准确，实验动手能力良好，对实验常见问题能进行准确的分析和思考 90-100：整个实验始终积极参与，展现对实验基本原理的深刻理解，实验动手能力强，实验技能熟练，对实验常见问题有独到的分析和思考	40%
实验报告	0-59 实验报告不认真，敷衍了事，实验基本原理缺失、错误，实验流程不正确，没有分析实验数据和进行讨论；在超过规定的时效外提交实验报告 60-69：实验报告条理较清晰，展现对实验基本原理、实验流程的初步理解，实验数据分析和讨论不准确 70-79：实验报告条理清晰，展现对实验基本原理、实验流程的较好理解，实验数据分析和讨论基本准确 80-89：实验报告规范，展现对实验基本原理、实验流程的准确理解，实验数据分析和讨论准确 90-100：实验报告规范，展现对实验基本原理、实验流程的深刻理解，实验数据分析和讨论准确且有独到的见解	50%

7. 学习进度（Course Schedule）

根据教学计划，本课程共 48 学时，共 16 周。第 1 周为误差理论，介绍实验数据处理所遵循的原则、数据处理方法、误差分析等。第 2 周为实验绪论课，介绍课程要求、实验操作规程、常用仪器设备及实验室安全和纪律教育，指导学生在实验平台上选课；第 3 周开始实验课；实践操作共 12 周，最后 2 周安排实验讨论和补做。

以下学习进度以第一组为例。

周次	教学时数	教学形式	教学内容
1	3	课堂教学	误差理论，实验分组
2	3	课堂教学	绪论课，实验室安全教育，实验平台选课
3	3	实验教学	杨氏模量测定实验：讲解实验原理和实验思想、讲解实验仪器操作使用、观察记录实验现象和结果，汇报数据初步分析结果。
4	3	实验教学	单摆实验：讲解实验原理和实验思想、讲解实验仪器操作使用、观察记录实验现象和结果，汇报数据初步分析结果。
5	3	实验教学	粘滞系数测量实验：讲解实验原理和实验思想、讲解实验仪器操作使用、观察记录实验现象和结果，汇报数据初步分析结果。
6	3	实验教学	转动惯量测定实验：讲解实验原理和实验思想、讲解实验仪器操作使用、观察记录实验现象和结果，汇报数据初步分析结果。
7	3	实验教学	电表改装和校准实验：讲解实验原理和实验思想、讲解实验仪器操作使用、观察记录实验现象和结果，汇报数据初步分析结果。
8	3	实验教学	直流电桥实验：讲解实验原理和实验思想、讲解实验仪器操作使用、观察记录实验现象和结果，汇报数据初步分析结果。
9	3	实验教学	示波器原理及使用实验：讲解实验原理和实验思想、讲解实验仪器操作使用、观察记录实验现象和结果，汇报数据初步分析结果。
10	3	实验教学	交流谐振实验：讲解实验原理和实验思想、讲解实验仪器操作使用、观察记录实验现象和结果，汇报数据初步分析结果。
11	3	实验教学	薄透镜焦距测量实验：讲解实验原理和实验思想、讲解实验仪器操作使用、观察记录实验现象和结果，汇报数据初步分析结果。
12	3	实验教学	光栅特性实验：讲解实验原理和实验思想、讲解实验仪器操作使用、观察记录实验现象和结果，汇报数据初步分析结果。
13	3	实验教学	牛顿环测定透镜曲率半径实验：讲解实验原理和实验思想、讲解实验仪器操作使用、观察记录实验现象和结果，汇报数据初步分析结果。
14	3	实验教学	迈克尔孙测量激光波长实验：讲解实验原理和实验思想、讲解实验仪器操作使用、观察记录实验现象和结果，汇报数据初步分析结果。

15	3	课堂讨论	组织学生对本学期实验学习心得进行讨论
16	3	实验教学	因各种原因未完成实验项目的学生补做实验

Shantou University

Module Description for Undergraduate Courses

COURSE TITLE:	Electromagnetic Experiments of General Physics
COURSE CODE:	PHY2006C
CREDIT VALUE:	2
CONTACT HOURS:	64
PRE-REQUISITE	University physics experiments 1
DEPARTMENT/UNIT:	Department of Physics
VERSION:	20240731-PHY2006C
COURSE COORDINATOR:	Fu Shiliu (Signature and Seal)
APPROVER:	Chi Lingfei (Signature and Seal)
APPROVE DATE:	20240731

Shantou University Faculty of Science

July 2024

1. Course Description

(1) Nature of the Course

Electromagnetic Experiments of General Physics *(*In the original document, this course is listed as "The Experiment of College Physics 2", but in the transcript it appears as "Electromagnetic Experiments of General Physics." Therefore, this text consistently follows the title used in the transcript.)* is a compulsory course for students majoring in Physics, Optoelectronic Information Science and Engineering, and Optoelectronic Information Science and Engineering (Microelectronics Track). As a fundamental experimental course for these majors, it aims to train students in the use of basic experimental instruments and equipment in electromagnetism and optics, including equipment connection, debugging, operation, and data reading.

The course cultivates students' ability for observation and hands-on practice, advocates the epistemology of materialism, and promotes the spirit of scientific exploration and dedication. It also aims to inspire students' sense of responsibility to the nation, and help them gradually form good experimental habits. Students will learn to observe and analyze electromagnetic and optical phenomena and their underlying laws through experimental methods, deepening their understanding of key physical principles.

Through systematic experimental training, this course develops students' skills in optoelectronic experimentation and innovation, laying a solid foundation for future scientific research and engineering work in their respective fields.

(2) Course Content

The course includes a total of 16 experiments in electromagnetism and optics. Students are required to complete 14 out of the 16 experiments.

Basic Experiments (8 items, all required):
Each experiment: 4 class hours, total 32 hours

Comprehensive Experiments (4 items):
Experiments 9 and 10 (choose 1), each 8 class hours
Experiments 11 and 12 (both required), each 4 class hours, total 16 hours

Design Experiments (4 items):
Experiments 13 and 14 (choose 1), each 8 class hours
Experiments 15 and 16 (both required), each 4 class hours, total 16 hours

- Basic Experiments (8 items, all required)

Experiment 1: Measuring the Magnetic Field of a Solenoid Using a Ballistic Galvanometer …… (4 hours)
Experiment 2: Measuring Electromotive Force Using a Potentiometer …… (4 hours)
Experiment 3: Using an Oscilloscope to Trace the Magnetization Curve and Hysteresis Loop of Ferromagnetic Materials …… (4 hours)
Experiment 4: Transient Process in an RLC Series Circuit …… (4 hours)
Experiment 5: Biprism Interference Experiment …… (4 hours)
Experiment 6: Single-slit, Double-slit, and Multiple-slit Diffraction …… (4 hours)
Experiment 7: Polarization of Light and Prism Refractive Index Measurement …… (4 hours)
Experiment 8: Measuring the Doublet Separation of Sodium Light Using a Michelson Interferometer …… (4 hours)

- Comprehensive Experiments (4 items; choose 1 from Exp. 9 & 10; Exp. 11 & 12 required)

Experiment 9: Hall Effect, Magnetoresistance Effect, and Magnetoresistive Sensors …… (8 hours)
Experiment 10: Electron and Field Experiment …… (8 hours)
Experiment 11: Speed of Sound Measurement …… (4 hours)
Experiment 12: Comprehensive Polarization Experiment …… (4 hours)

- Design Experiments (4 items; choose 1 from Exp. 13 & 14; Exp. 15 & 16 required)

Experiment 13: Determining Meter Parameters Using a Potentiometer …… (8 hours)
Experiment 14: Measuring Capacitance and Inductance by Multiple Methods …… (8 hours)

Experiment 15: Comprehensive Geometrical Optics Experiment …… (4 hours)
Experiment 16: Recording Diffuse-Reflection Holograms …… (4 hours)

(3) Course Objectives

① Develop students' ability to consciously apply dialectical materialism to observe experimental phenomena and analyze data. Cultivate scientific rigor, pragmatic attitudes, teamwork, and inspire a strong sense of national responsibility, institutional confidence, and cultural confidence.

② Become familiar with commonly used measurement methods for basic physical quantities, laboratory record-keeping, data processing, and interpretation of experimental results.

Electromagnetism: Measuring dry-cell EMF using a potentiometer; magnetic field distribution of a current-carrying solenoid; magnetization curve of ferromagnetic materials; damping in AC series circuits; measuring the electronic charge; Hall effect and magnetoresistance effect.

Optics: Observation and measurement of interference, diffraction, and polarization; geometrical-optics imaging using lenses, such as in microscopes and telescopes.

③ Deepen understanding of theoretical knowledge in electromagnetism and optics, consolidate and expand students' mastery of these subjects.

Electromagnetism: Compensation principle of potentiometers; operating principles of ballistic galvanometers; oscilloscopic display of hysteresis loops; damping behavior of AC series circuits; principles of measuring the electronic charge; principles of Hall effect and magnetoresistance effect.

Optics: Laws of reflection and refraction; conditions for interference and diffraction; principles of polarization interference.

④ Master basic experimental methods in electromagnetism and optics.

Electromagnetism: Measuring EMF and internal resistance of batteries; oscilloscope-based measurement of voltage, current, frequency, and phase difference; measuring magnetic fields using a ballistic galvanometer; measuring the internal resistance of AC sources; observing transient processes in RLC circuits; oscilloscopic display of magnetization and hysteresis curves.

Optics: Adjustment and operation of spectrometers; adjustment of Michelson interferometers; laser collimation techniques; alignment of free-space optical setups.

⑤ Receive systematic and rigorous training in essential experimental skills and cultivate good laboratory practice.

Comprehensive Experiments: Hall effect, magnetoresistance and magnetoresistive sensors, electron and field experiment, speed of sound measurement, comprehensive polarization experiment.

Each experiment integrates two or three theoretical concepts, enhancing systematic and integrative experimental abilities.

⑥ Develop the ability to use equipment, make decisions involving compromise and balance, consult printed and digital references, form hypotheses, test them, and solve problems.

Design Experiments: Determining meter parameters using a potentiometer; measuring capacitance and inductance using multiple methods; comprehensive geometrical optics experiment; diffuse-reflection holography.

Each experiment provides only basic equipment and objectives, requiring students to design experimental procedures independently and improve problem-identification and problem-solving skills.

⑦ Develop the ability to identify and articulate experimental problems, estimate and qualitatively analyze results, organize teams, implement plans, communicate effectively, discuss, summarize, and propose improvements.

This course provides essential practical and research training for the Optoelectronic Information Science and Engineering major, Optoelectronic Information Science and Engineering (Microelectronics Track), and Physics major. It strongly supports the program learning outcomes:

3.1 Mastery of fundamental theories and professional knowledge in physics, optoelectronics, and information science

4.1 Mastery of technologies, resources, information tools, and modern engineering tools in opto-electronics and optical information

5.2 Ability to design experiments, analyze data, and interpret results

2. Intended Learning Outcomes

The expected learning outcomes of this course are summarized as follows:

Knowledge Unit	Key Knowledge Points	Initial Level	Required Level	Expected Learning Outcomes
1. Determination of the Magnetic Field of a Solenoid Using a Ballistic Galvanometer (Compulsory)	1.1 Principles and Experimental Concepts	L1	L2	Principles and experimental concepts
	1.2 Instrument Operation	L2	L3	Use instruments properly during the pendulum experiment.
	1.3 Experimental Phenomena and Results	L2	L3	Demonstrate the experimental process and carry out data calculations.
	1.4 Report Writing	L2	L4	Summarize the experimental procedure and complete a structured laboratory report.
	1.5 Result Analysis	L2	L5	Summarize the results and provide personal insights based on data analysis.
2. Measurement of Electromotive Force Using a Potentiometer (Compulsory)	2.1 Principles and Experimental Concepts	L1	L2	Principles and experimental concepts
	2.2 Instrument Operation	L2	L3	Use instruments properly during the pendulum experiment.
	2.3 Experimental Phenomena and Results	L2	L3	Demonstrate the experiment and perform data calculations.
	2.4 Report Writing	L2	L4	Summarize procedures and complete a laboratory report.
	2.5 Result Analysis	L2	L5	Summarize experimental findings and present personal insights.
3. Oscilloscope Measurement of Magnetization Curves and Hysteresis Loops of Ferromagnetic	3.1 Principles and Experimental Concepts	L1	L2	Principles and experimental concepts
	3.2 Instrument Operation	L2	L3	Operate instruments properly during the viscosity experiment.

Materials (Compulsory)	3.3 Experimental Phenomena and Results	L2	L3	Demonstrate the experiment and perform data calculations.
	3.4 Report Writing	L2	L4	Summarize procedures and complete a laboratory report.
	3.5 Result Analysis	L2	L5	Summarize results and provide personal insights.
4. Transient Processes in Series RLC Circuits (Compulsory)	4.1 Principles and Experimental Concepts	L1	L2	Principles and experimental concepts
	4.2 Instrument Operation	L2	L3	Operate instruments properly during the viscosity experiment.
	4.3 Experimental Phenomena and Results	L2	L3	Demonstrate the experiment and perform data calculations.
	4.4 Report Writing	L2	L4	Summarize procedures and complete a laboratory report.
	4.5 Result Analysis	L2	L5	Summarize results and provide personal insights.
5. Fresnel Biprism Interference Experiment (Compulsory)	5.1 Principles and Experimental Concepts	L1	L2	Principles and experimental concepts
	5.2 Instrument Operation	L2	L3	Use instruments properly during meter calibration.
	5.3 Experimental Phenomena and Results	L2	L3	Demonstrate the experiment and perform data calculations.
	5.4 Report Writing	L2	L4	Summarize procedures and complete a laboratory report.
	5.5 Result Analysis	L2	L5	Summarize results and provide personal insights.
6. Single-Slit, Double-Slit, and Multi-Slit Diffraction (Compulsory)	6.1 Principles and Experimental Concepts	L1	L2	Principles and experimental concepts
	6.2 Instrument Operation	L2	L3	Use instruments properly during the experiment.
	6.3 Experimental Phenomena and Results	L2	L3	Demonstrate the experiment and perform data calculations.
	6.4 Report Writing	L2	L4	Summarize procedures and complete a laboratory report.

	6.5 Result Analysis	L2	L5	Summarize results and provide personal insights.
7. Polarization of Light and Prism Refractive Index Measurement (Compulsory)	7.1 Principles and Experimental Concepts	L1	L2	Principles and experimental concepts
	7.2 Instrument Operation	L2	L3	Use instruments properly during the experiment.
	7.3 Experimental Phenomena and Results	L2	L3	Demonstrate the experiment and perform data calculations.
	7.4 Report Writing	L2	L4	Summarize procedures and complete a laboratory report.
	7.5 Result Analysis	L2	L5	Summarize results and provide personal insights.
8. Measurement of Sodium Doublet Separation Using a Michelson Interferometer (Compulsory)	8.1 Principles and Experimental Concepts	L1	L2	Principles and experimental concepts
	8.2 Instrument Operation	L2	L3	Use instruments properly during the experiment.
	8.3 Experimental Phenomena and Results	L2	L3	Demonstrate the experiment and perform data calculations.
	8.4 Report Writing	L2	L4	Summarize procedures and complete a laboratory report.
	8.5 Result Analysis	L2	L5	Summarize results and provide personal insights.
9. Hall Effect, Magnetoresistance, and Magnetic Sensor Experiment (Elective)	9.1 Principles and Experimental Concepts	L1	L2	Principles and experimental concepts
	9.2 Instrument Operation	L2	L3	Use instruments properly during the experiment.
	9.3 Experimental Phenomena and Results	L2	L3	Demonstrate the experiment and perform data calculations.
	9.4 Report Writing	L2	L4	Summarize procedures and complete a laboratory report.
	9.5 Result Analysis	L2	L5	Summarize results and provide personal insights.
10. Electron Beam and Field	10.1 Principles and Experimental Concepts	L1	L2	Principles and experimental concepts

Experiment (Elective)	10.2 Instrument Operation	L2	L3	Use instruments properly during the experiment.
	10.3 Experimental Phenomena and Results	L2	L3	Demonstrate the experiment and perform data calculations.
	10.4 Report Writing	L2	L4	Summarize procedures and complete a laboratory report.
	10.5 Result Analysis	L2	L5	Summarize results and provide personal insights.
11. Speed of Sound Measurement (Compulsory)	11.1 Principles and Experimental Concepts	L1	L2	Principles and experimental concepts
	11.2 Instrument Operation	L2	L3	Use instruments properly during the experiment.
	11.3 Experimental Phenomena and Results	L2	L3	Demonstrate the experiment and perform data calculations.
	11.4 Report Writing	L2	L4	Summarize procedures and complete a laboratory report.
	11.5 Result Analysis	L2	L5	Summarize results and provide personal insights.
12. Comprehensive Polarization Experiment (Compulsory)	12.1 Principles and Experimental Concepts	L1	L2	Principles and experimental concepts
	12.2 Instrument Operation	L2	L3	Use instruments properly during the experiment.
	12.3 Experimental Phenomena and Results	L2	L3	Demonstrate the experiment and perform data calculations.
	12.4 Report Writing	L2	L4	Summarize procedures and complete a laboratory report.
	12.5 Result Analysis	L2	L5	Summarize results and provide personal insights.
13. Determination of Meter Parameters Using a Potentiometer (Elective)	13.1 Principles and Experimental Concepts	L1	L2	Principles and experimental concepts
	13.2 Instrument Operation	L2	L3	Use instruments properly during the experiment.
	13.3 Experimental Phenomena and Results	L2	L3	Demonstrate the experiment and perform data calculations.

	13.4 Report Writing	L2	L4	Summarize procedures and complete a laboratory report.
	13.5 Result Analysis	L2	L5	Summarize results and provide personal insights.
14. Measurement of Capacitance and Inductance via Multiple Methods (Elective)	14.1 Principles and Experimental Concepts	L1	L2	Principles and experimental concepts
	14.2 Instrument Operation	L2	L3	Use instruments properly during the experiment.
	14.3 Experimental Phenomena and Results	L2	L3	Demonstrate the experiment and perform data calculations.
	14.4 Report Writing	L2	L4	Summarize procedures and complete a laboratory report.
	14.5 Result Analysis	L2	L5	Summarize results and provide personal insights.
15. Comprehensive Geometrical Optics Experiment (Compulsory)	15.1 Principles and Experimental Concepts	L1	L2	Principles and experimental concepts
	15.2 Instrument Operation	L2	L3	Use instruments properly during the experiment.
	15.3 Experimental Phenomena and Results	L2	L3	Demonstrate the experiment and perform data calculations.
	15.4 Report Writing	L2	L4	Summarize procedures and complete a laboratory report.
	15.5 Result Analysis	L2	L5	Summarize results and provide personal insights.
16. Diffuse Reflection Hologram Recording (Compulsory)	16.1 Principles and Experimental Concepts	L1	L2	Principles and experimental concepts
	16.2 Instrument Operation	L2	L3	Use instruments properly during the experiment.
	16.3 Experimental Phenomena and Results	L2	L3	Demonstrate the experiment and perform data calculations.
	16.4 Report Writing	L2	L4	Summarize procedures and complete a laboratory report.
	16.5 Result Analysis	L2	L5	Summarize results and provide personal insights.

3. Pre-requisit

University physics experiments 1

4. Textbooks and Other Learning Resources

Required Textbooks

University Physics Experiment II – Lecture Notes,, compiled by the Department (internal publication).

Recommended Textbooks

Yang Yanxin et al., *University Physics Experiments (3rd Edition)*, Science Press, January 2021.

Yang Shuwu et al., *General Physics Experiments (2): Electromagnetism Section (5th Edition)*, November 2015.

Yang Shuwu et al., *General Physics Experiments (3): Optics Section (5th Edition)*, November 2015.

Teaching Platform: 192.168.70.28

5. Teaching and Learning Activities

Teaching Segment	Lectures (Theory)	Experiments	Lab Reports	Seminars	Online Learning	Total
Hours (In-class)	0	64	0	0	0	64
Hours (Out-of-class)	28	0	28	0	8	64

Basis for workload calculation:

Students complete 14 experiment projects in total:

- Basic Experiments (8 projects): All compulsory, 4 hours per project.
- Comprehensive Experiments (4 projects):
  Experiments 9 & 10: choose 1 of 2, 8 hours each.
  Experiments 11 & 12: both compulsory, 4 hours each.
- Design Experiments (4 projects):
  Experiments 13 & 14: choose 1 of 2, 8 hours each.
  Experiments 15 & 16: both compulsory, 4 hours each.

Total in-class experiment hours: 64 hours.

Additional workload:

- 2 hours of preparation required per experiment → 28 hours total.
- 2 hours for writing each experiment report → 28 hours total.
- Approx. 8 hours of online literature review.

Total out-of-class hours: 64 hours.

6. Assessment Scheme

Assessment Component	Description of Assessment Content and Methods	Weight
Experiment Preparation	Before each experiment, students must carefully read the experiment manual, consult relevant literature for preparation, and write a preparation report. During class, instructors conduct random questioning based on their preparation.	10%

Experimental Operation	0–59: Low participation; poor understanding of basic principles; weak hands-on ability; unable to analyze common experimental issues. 60–69: Limited participation; basic initial understanding; average operational ability; inaccurate analysis. 70–79: Good participation; mostly accurate understanding; solid hands-on ability; reasonably accurate analysis. 80–89: Active participation; accurate understanding; strong hands-on ability; precise analysis. 90–100: Highly active throughout; deep understanding; excellent skills; insightful analysis of common issues.	40%
Experiment Reports	0–59: Careless or perfunctory; missing or incorrect principles; incorrect procedures; no data analysis or discussion; submitted late beyond allowed period. 60–69: Reasonably structured; demonstrates initial understanding; inaccurate data analysis/discussion. 70–79: Clear structure; good understanding; mostly accurate data analysis/discussion. 80–89: Well-organized; accurate understanding; correct and complete analysis/discussion. 90–100: Fully standardized; deep understanding; accurate and insightful analysis/discussion.	50%

7. Course Schedule

According to the teaching plan, this course consists of 64 contact hours delivered across 16 weeks. Students are divided into groups before the course begins. Each group completes 14 experiment projects in total. The following schedule uses Group 1 as an example.

Week	Hour	Teaching format	Teaching content
1	4	Experimental Teaching	Measurement of the Magnetic Field of a Solenoid Using a Ballistic Galvanometer: Explanation of experimental principles and concepts; instruction on instrument operation; observation and recording of experimental phenomena and results.
2	4	Experimental Teaching	Measurement of Electromotive Force Using a Potentiometer: Explanation of experimental principles and concepts; instruction on instrument operation; observation and recording of experimental phenomena and results.
3	4	Experimental Teaching	Plotting Magnetization Curves and Hysteresis Loops of Ferromagnetic Materials Using an Oscilloscope: Explanation of experimental principles and concepts; instruction on instrument operation; observation and recording of experimental phenomena and results.
4	4	Experimental Teaching	Transient Process in an RLC Series Circuit: Explanation of experimental principles and concepts; instruction on instrument operation; observation and recording of experimental phenomena and results.
5	4	Experimental Teaching	Hall Effect / Magnetoresistance Effect and Magnetoresistive Sensors, or Electron and Electric Field Experiments: Explanation of experimental principles and concepts; instruction on instrument operation; observation and recording of experimental phenomena and results.

6	4	Experimental Teaching	Hall Effect / Magnetoresistance Effect and Magnetoresistive Sensors, or Electron and Electric Field Experiments: Explanation of experimental principles and concepts; instruction on instrument operation; observation and recording of experimental phenomena and results.
7	4	Experimental Teaching	Measurement of Meter Parameters Using a Potentiometer, or Multiple Methods for Measuring Capacitance and Inductance: Explanation of experimental principles and concepts; instruction on instrument operation; observation and recording of experimental phenomena and results.
8	4	Experimental Teaching	Measurement of Meter Parameters Using a Potentiometer, or Multiple Methods for Measuring Capacitance and Inductance: Explanation of experimental principles and concepts; instruction on instrument operation; observation and recording of experimental phenomena and results.
9	4	Experimental Teaching	Biprism Interference Experiment: Explanation of experimental principles and concepts; instruction on instrument operation; observation and recording of experimental phenomena and results.
10	4	Experimental Teaching	Single-slit, Double-slit, and Multiple-slit Diffraction Experiments: Explanation of experimental principles and concepts; instruction on instrument operation; observation and recording of experimental phenomena and results.
11	4	Experimental Teaching	Polarization of Light and Prism Refractive Index Measurement: Explanation of experimental principles and concepts; instruction on instrument operation; observation and recording of experimental phenomena and results.
12	4	Experimental Teaching	Measurement of Sodium Doublet Separation Using a Michelson Interferometer: Explanation of experimental principles and concepts; instruction on instrument operation; observation and recording of experimental phenomena and results.
13	4	Experimental Teaching	Speed of Sound Measurement: Explanation of experimental principles and concepts; instruction on instrument operation; observation and recording of experimental phenomena and results.
14	4	Experimental Teaching	Comprehensive Polarization Experiment: Explanation of experimental principles and concepts; instruction on instrument operation; observation and recording of experimental phenomena and results.
15	4	Experimental Teaching	Comprehensive Geometrical Optics Experiment: Explanation of experimental principles and concepts; instruction on instrument operation; observation and recording of experimental phenomena and results.
16	4	Experimental Teaching	Fabrication of Diffuse Reflection Holograms: Explanation of experimental principles and concepts; instruction on instrument operation; observation and recording of experimental phenomena and results.

汕头大学本科教学

课程教学大纲

课程名（COURSE TITLE）：	大学物理实验(2)
课程代码（COURSE CODE）：	PHY2006C
学分（CREDIT VALUE）：	2
课内课时（CONTACT HOURS）：	64
先修课要求（PRE-REQUISITE）	大学物理实验(1)
开课单位（DEPARTMENT/UNIT）：	物理系
版本（VERSION）：	20240731-PHY2006C
课程负责人（COURSE COORDINATOR）：	符史流(签章)
审核人（APPROVER）：	池凌飞(签章)
审核日期（APPROVE DATE）：	20240731

汕头大学理学院

2024 年 7 月

1. 课程简介（Course Description）

（1）课程性质

大学物理实验(2)（The Experiment of College Physics 2）是物理学专业、光电信息科学与工程专业、光电信息科学与工程专业（微电子方向）的必修课。本课程是上述专业的专业基础实验，旨在训练学生使用基本的电磁学和光学实验仪器和设备，包括连接、调试、操作和读数，培养学生的观察和动手能力，主张唯物主义认识论，以及探索与奉献的科学精神，激发学生的家国情怀，逐步养成好的实验习惯；学习用实验方法观察和分析电磁学与光学现象和规律，通过实验加深对一些重要的物理规律的认识与理解。通过实验训练，培养学生光电实验技能和创新能力，为今后从事本专业的科学研究和工程技术工作打下坚实的基础。

（2）课程内容

本课程开出电磁学实验和光学实验共 16 项，学生需要修满其中 14 项实验。

基础性实验 8 个项目：必做，每个实验 4 学时，合计 32 学时；

综合性实验 4 个项目：其中实验九、十 2 选 1，每个实验 8 学时；实验十一、十二必做，每个实验 4 学时，合计 16 学时；

设计性实验 4 个项目：其中实验十三、十四 2 选 1，每个实验 8 学时；实验十五、十六必做，每个实验 4 学时，合计 16 学时；

- 基础性实验（8 个项目，必做）

实验一　用冲击电流计测定螺线管磁场……………………………………（4 学时）
实验二　用电位差计测量电动势……………………………………………（4 学时）
实验三　示波器测绘铁磁材料的磁化曲线和磁滞回线……………………（4 学时）
实验四　RLC 串联电路的暂态过程…………………………………………（4 学时）
实验五　双棱镜干涉实验……………………………………………………（4 学时）
实验六　单缝、双缝、多缝衍射实验；……………………………………（4 学时）
实验七　光的偏振及棱镜折射率实验；……………………………………（4 学时）
实验八　用迈克尔逊干涉仪测钠光灯双线差………………………………（4 学时）

- 综合性实验（4 个项目，实验九、十 2 选 1，实验十一、十二必做）

实验九　霍尔效应　磁阻效应及磁阻传感器………………………………（8 学时）
实验十　电子和场实验………………………………………………………（8 学时）
实验十一　声速测量实验……………………………………………………（4 学时）
实验十二　偏振综合实验……………………………………………………（4 学时）

- 设计性实验（4 个项目，实验十三、十四 2 选 1，实验十五、十六必做）

实验十三　用电位差计测定表头参数………………………………………（8 学时）
实验十四　多种方法测量电容与电感量……………………………………（8 学时）
实验十五　几何光学综合实验………………………………………………（4 学时）
实验十六　漫反射全息图摄制………………………………………………（4 学时）

（3）课程目标

① 培养学生自觉地运用辩证唯物主义认识论，对实验现象进行观测和数据分析的能力，培养学生严谨和实事求是的科学态度，以及团队合作精神，激发学生的家国情怀、制度自信和文化自信；

② 熟悉基本物理量常用的测量方法、做实验记录、处理数据、分析实验结果。电磁学方面：电位差计测量干电池电动势；通电螺线管的磁场

分布；铁磁材料的磁化曲线；串联交流电路阻尼运动规律；测定基本电荷电量、霍尔效应和磁阻效应。光学方面：光的干涉、衍射、偏振现象的观察与测量分析，及几何光学透镜成像运用，如显微镜和望远镜；

③ 加深对电磁学及光学理论知识的理解，巩固并应用和扩大学生的电磁学及光学知识。电磁学方面：电位差计的补偿原理；冲击电流计工作原理；示波器显示磁滞回线原理；串联交流电路阻尼运动规律；测量基本电荷电量原理；霍尔效应原理和磁阻效应原理。光学方面：光的反射和折射定律；光的干涉和衍射条件；光的偏振干涉原理；

④ 掌握电磁学及光学实验的基本方法。电磁学方面：测量电池电电动势、内阻方法；示波器测量电压、电流、频率以及相位差；冲击电流计测量磁场方法；测量交流电源内阻方法，观测 RLC 电路瞬态过程；示波器显示磁化曲线和磁滞回线方法。光学方面：掌握分光计调节和使用方法；掌握迈克尔逊干涉仪调节方法；掌握激光器准直调节；掌握空间光路的调节方法；

⑤ 实验的基本技能方面得到系统和严格训练，培养学生良好的实验素养和技能。综合性实验：霍尔效应、磁阻效应及磁阻传感器、电子和场实验、声速测量实验、偏振综合实验；其中的任一实验都是两个或三个知识点，提高系统、综合的实验应用能力；

⑥ 利用设备解决和建议，解决问题时的妥协、判断与平衡，查询印刷资料和电子文献，建立假设，检验与解决。设计性实验：用电位差计测定表头参数、各种方法测量电容与电感量、几何光学综合实验、漫反射全息图摄制；其中的任一实验都仅提供基本器材和目标，中间实验过程需要学生自行设计，提升学生发现问题、解决问题的能力；

⑦ 发现实验问题和表述问题，估计与定性分析，组织团队，实施计划和有效交流，讨论、小结，给出讨论结果和改善方法。

本课程为支持光电信息科学与工程专业、光电信息科学与工程专业（微电子方向）、物理学专业学术型人才培养提供专业实践与研究能力培养，高度支撑上述专业毕业要求指标点“1. 坚定的理想信念，2. 正确价值观和社会责任感，3.1 掌握物理学、光电子学和信息学的基础理论和专业知识，4.1 掌握光电子、光信息等领域的技术、资源、信息技术工具和现代工程工具，5.2 具备设计实验、分析与解释数据的能力”。

2. 预期学习结果（Intended Learning Outcomes）

本课程的预期学习结果如下表：

知识单元	知识点	初始程度	要求程度	预期学习结果
1.用冲击电流计测定螺线管磁场（必做）	1.1 原理和实验思想	L1	L2	理解用冲击电流计测定螺线管磁场实验的原理和步骤
	1.2 实验仪器操作使用	L1	L3	实施用冲击电流计测定螺线管磁场实验的操作，规范使用仪器
	1.3 实验现象和结果	L1	L3	演示实验过程，对实验数据进行计算
	1.4 报告写作	L2	L4	概述实验过程，撰写实验报告
	1.5 结果分析	L1	L5	总结实验结果并提出自己的见解

2. 用电位差计测量电动势（必做）	2.1 原理和实验思想	L1	L2	理解用电位差计测量电动势实验的原理和步骤
	2.2 实验仪器操作使用	L1	L3	实施用电位差计测量电动势实验的操作，规范使用仪器
	2.3 实验现象和结果	L1	L3	演示实验过程，对实验数据进行计算
	2.4 报告写作	L2	L4	概述实验过程，撰写实验报告
	2.5 结果分析	L1	L5	总结实验结果并提出自己的见解
3.示波器测绘铁磁材料的磁化曲线和磁滞回线（必做）	3.1 原理和实验思想	L1	L2	理解示波器测绘铁磁材料的磁化曲线和磁滞回线实验的原理和步骤
	3.2 实验仪器操作使用	L1	L3	实施示波器测绘铁磁材料的磁化曲线和磁滞回线实验的操作，规范使用仪器
	3.3 实验现象和结果	L1	L3	演示实验过程，对实验数据进行计算
	3.4 报告写作	L2	L4	概述实验过程，撰写实验报告
	3.5 结果分析	L1	L5	总结实验结果并提出自己的见解
4.RLC 串联电路的暂态过程（必做）	4.1 原理和实验思想	L1	L2	理解 RLC 串联电路的暂态过程实验的原理和步骤
	4.2 实验仪器操作使用	L1	L3	实施 RLC 串联电路的暂态过程实验操作，规范使用仪器
	4.3 实验现象和结果	L1	L3	演示实验过程，对实验数据进行计算
	4.4 报告写作	L2	L4	概述实验过程，撰写实验报告
	4.5 结果分析	L1	L5	总结实验结果并提出自己的见解
5.双棱镜干涉实验（必做）	5.1 原理和实验思想	L1	L2	理解双棱镜干涉实验的原理和步骤
	5.2 实验仪器操作使用	L1	L3	实施双棱镜干涉实验的操作，规范使用仪器
	5.3 实验现象和结果	L1	L3	演示实验过程，对实验数据进行计算
	5.4 报告写作	L2	L4	概述实验过程，撰写实验报告
	5.5 结果分析	L1	L5	总结实验结果并提出自己的见解
6.单缝、双缝、多缝衍射实验（必做）	6.1 原理和实验思想	L1	L2	理解单缝、双缝、多缝衍射实验的原理和步骤
	6.2 实验仪器操作使用	L1	L3	实施单缝、双缝、多缝衍射实验操作，规范使用仪器
	6.3 实验现象和结果	L1	L3	演示实验过程，对实验数据进行计算
	6.4 报告写作	L2	L4	概述实验过程，撰写实验报告
	6.5 结果分析	L1	L5	总结实验结果并提出自己的见解
7.光的偏振及棱镜折射率实验（必做）	7.1 原理和实验思想	L1	L2	理解光的偏振及棱镜折射率实验的原理和步骤
	7.2 实验仪器操作使用	L1	L3	实施光的偏振及棱镜折射率实验操作，规范使用仪器
	7.3 实验现象和结果	L1	L3	演示实验过程，对实验数据进行计算
	7.4 报告写作	L2	L4	概述实验过程，撰写实验报告
	7.5 结果分析	L1	L5	总结实验结果并提出自己的见解
8.用迈克尔逊干涉仪测钠光灯双线差（必做）	8.1 原理和实验思想	L1	L2	理解用迈克尔逊干涉仪测钠光灯双线差实验的原理和步骤
	8.2 实验仪器操作使用	L1	L3	实施用迈克尔逊干涉仪测钠光灯双线差实验操作，规范使用仪器
	8.3 实验现象和结果	L1	L3	演示实验过程，对实验数据进行计算
	8.4 报告写作	L2	L4	概述实验过程，撰写实验报告
	8.5 结果分析	L1	L5	总结实验结果并提出自己的见解
9. 霍尔效应　磁阻效	9.1 原理和实验思想	L1	L2	理解霍尔效应/磁阻效应及磁阻传感器综合实验的原理和步骤

应及磁阻传感器（选做）	9.2 实验仪器操作使用	L1	L3	实施霍尔效应/磁阻效应及磁阻传感器综合实验操作，规范使用仪器
	9.3 实验现象和结果	L1	L3	演示实验过程，对实验数据进行计算
	9.4 报告写作	L2	L4	概述实验过程，撰写实验报告
	9.5 结果分析	L1	L5	总结实验结果并提出自己的见解
10.电子和场实验（选做）	10.1 原理和实验思想	L1	L2	理解电子和场实验的原理和步骤
	10.2 实验仪器操作使用	L1	L3	实施电子和场实验的操作，规范使用仪器
	10.3 实验现象和结果	L1	L3	演示实验过程，对实验数据进行计算
	10.4 报告写作	L2	L4	概述实验过程，撰写实验报告
	10.5 结果分析	L1	L5	总结实验结果并提出自己的见解
11.声速测量实验（必做）	11.1 原理和实验思想	L1	L2	理解声速测量实验的原理和步骤
	11.2 实验仪器操作使用	L1	L3	实施声速测量实验的操作，规范使用仪器
	11.3 实验现象和结果	L1	L3	演示实验过程，对实验数据进行计算
	11.4 报告写作	L2	L4	概述实验过程，撰写实验报告
	11.5 结果分析	L1	L5	总结实验结果并提出自己的见解
12.偏振综合实验（必做）	12.1 原理和实验思想	L1	L2	理解偏振综合实验的原理和步骤
	12.2 实验仪器操作使用	L1	L3	实施偏振综合实验的操作，规范使用仪器
	12.3 实验现象和结果	L1	L3	演示实验过程，对实验数据进行计算
	12.4 报告写作	L2	L4	概述实验过程，撰写实验报告
	12.5 结果分析	L1	L5	总结实验结果并提出自己的见解
13.用电位差计测定表头参数（选做）	13.1 原理和实验思想	L1	L2	理解用电位差计测定表头参数实验的原理和步骤
	13.2 实验仪器操作使用	L1	L3	实施用电位差计测定表头参数实验操作，规范使用仪器
	13.3 实验现象和结果	L1	L3	演示实验过程，对实验数据进行计算
	13.4 报告写作	L2	L4	概述实验过程，撰写实验报告
	13.5 结果分析	L1	L5	总结实验结果并提出自己的见解
14.多种方法测量电容与电感量（选做）	14.1 原理和实验思想	L1	L2	理解多种方法测量电容与电感量实验的原理和步骤
	14.2 实验仪器操作使用	L1	L3	实施多种方法测量电容与电感量实验操作，规范使用仪器
	14.3 实验现象和结果	L1	L3	演示实验过程，对实验数据进行计算
	14.4 报告写作	L2	L4	概述实验过程，撰写实验报告
	14.5 结果分析	L1	L5	总结实验结果并提出自己的见解
15.几何光学综合实验（必做）	15.1 原理和实验思想	L1	L2	理解几何光学综合实验实验的原理和步骤
	15.2 实验仪器操作使用	L1	L3	实施几何光学综合实验实验操作，规范使用仪器
	15.3 实验现象和结果	L1	L3	演示实验过程，对实验数据进行计算
	15.4 报告写作	L2	L4	概述实验过程，撰写实验报告
	15.5 结果分析	L1	L5	总结实验结果并提出自己的见解
16.漫反射全息图摄制（必做）	16.1 原理和实验思想	L1	L2	理解漫反射全息图摄制实验的原理和步骤
	16.2 实验仪器操作使用	L1	L3	实施漫反射全息图摄制实验的操作，规范使用仪器
	16.3 实验现象和结果	L1	L3	演示实验过程，对实验数据进行计算
	16.4 报告写作	L2	L4	概述实验过程，撰写实验报告

	16.5 结果分析	L1	L5	总结实验结果并提出自己的见解

3. 先修要求（Pre-requisite）

大学物理实验(1)

4. 教材及其他教学资源（Textbooks and Other Learning Resources）

指定教材：

《大学物理实验 2 讲义》，自编

推荐参考资料

《大学物理实验（第三版）》，杨延欣等 编，科学出版社，2021.1
《普通物理实验（2）电磁学部分（第五版）》，杨述武等编，2015.11
《普通物理实验（3）光学部分（第五版）》，杨述武等编，2015.11

教学平台：192.168.70.28

5. 主要教学环节（Teaching and Learning Activities）

教学环节	理论课（小时）	实验（小时）	实验报告（小时）	研讨（小时）	在线学习（小时）	合计
课内	0	64	0	0	0	64
课外	28	0	28	0	8	64

课时计算依据：

学生一共完成 14 个实验项目，其中基础性实验 8 个项目：必做，每个实验 4 学时；综合性实验 4 个项目：其中实验九、十 2 选 1，每个实验 8 学时；实验十一、十二必做，每个实验 4 学时；设计性实验 4 个项目：其中实验十三、十四 2 选 1，每个实验 8 学时；实验十五、十六必做，每个实验 4 学时。综上合计课内实验 64 小时；

每个实验需要预习2个小时，合计课外理论课28小时；每个实验需要2个小时完成实验报告，合计课外实验报告28小时；此外，学生需要约8小时网上查阅相关资料（在线学习）。综上合计课外学时64小时；

6. 课程考核（Assessment Scheme）

考核项目	考核内容和考试方法简介	权重
实验预习	每个实验项目开始之前，学生需仔细阅读实验讲义、查找相关资料进行预习，写预习报告，上课讲解过程中任课教师随机提问，据此给出预习成绩。	10%

实验操作	0-59：整个实验参与度低，对实验基本原理理解不准确，实验动手能力差，对实验常见问题没有分析和思考 60-69：整个实验参与度较低，展现对实验基本原理的初步理解，实验动手能力一般，对实验常见问题的分析和思考不准确 70-79：整个实验参与度较高，展现对实验基本原理理解基本准确，实验动手能力较好，对实验常见问题有较准确的分析和思考 80-89：整个实验参与度积极，展现对实验基本原理理解准确，实验动手能力良好，对实验常见问题能进行准确的分析和思考 90-100：整个实验始终积极参与，展现对实验基本原理的深刻理解，实验动手能力强，实验技能熟练，对实验常见问题有独到的分析和思考	40%
实验报告	0-59 实验报告不认真，敷衍了事，实验基本原理缺失、错误，实验流程不正确，没有分析实验数据和进行讨论；在超过规定的时效外提交实验报告 60-69：实验报告条理较清晰，展现对实验基本原理、实验流程的初步理解，实验数据分析和讨论不准确 70-79：实验报告条理清晰，展现对实验基本原理、实验流程的较好理解，实验数据分析和讨论基本准确 80-89：实验报告规范，展现对实验基本原理、实验流程的准确理解，实验数据分析和讨论准确 90-100：实验报告规范，展现对实验基本原理、实验流程的深刻理解，实验数据分析和讨论准确且有独到的见解	50%

7. 学习进度（Course Schedule）

根据教学计划，本课程共 64 学时，共 16 周。开课前对学生进行分组，学生工完成 14 个实验项目，以下学习进度以第一组为例。

周次	教学时数	教学形式	教学内容
1	4	实验教学	用冲击电流计测定螺线管磁场实验：讲解实验原理和实验思想、讲解实验仪器操作使用、观察记录实验现象和结果。
2	4	实验教学	用电位差计测量电动势实验：讲解实验原理和实验思想、讲解实验仪器操作使用、观察记录实验现象和结果。
3	4	实验教学	示波器测绘铁磁材料的磁化曲线和磁滞回线实验：讲解实验原理和实验思想、讲解实验仪器操作使用、观察记录实验现象和结果。
4	4	实验教学	RLC 串联电路的暂态过程实验：讲解实验原理和实验思想、讲解实验仪器操作使用、观察记录实验现象和结果。
5	4	实验教学	霍尔效应/磁阻效应及磁阻传感器或电子和场实验：讲解实验原理和实验思想、讲解实验仪器操作使用、观察记录实验现象和结果。

6	4	实验教学	霍尔效应/磁阻效应及磁阻传感器或电子和场实验：讲解实验原理和实验思想、讲解实验仪器操作使用、观察记录实验现象和结果。
7	4	实验教学	用电位差计测定表头参数实验或多种方法测量电容与电感量：讲解实验原理和实验思想、讲解实验仪器操作使用、观察记录实验现象和结果。
8	4	实验教学	用电位差计测定表头参数实验或多种方法测量电容与电感量：讲解实验原理和实验思想、讲解实验仪器操作使用、观察记录实验现象和结果。
9	4	实验教学	双棱镜干涉实验：讲解实验原理和实验思想、讲解实验仪器操作使用、观察记录实验现象和结果。
10	4	实验教学	单缝、双缝、多缝衍射实验：讲解实验原理和实验思想、讲解实验仪器操作使用、观察记录实验现象和结果。
11	4	实验教学	光的偏振及棱镜折射率实验：讲解实验原理和实验思想、讲解实验仪器操作使用、观察记录实验现象和结果。
12	4	实验教学	用迈克尔逊干涉仪测钠光灯双线差：讲解实验原理和实验思想、讲解实验仪器操作使用、观察记录实验现象和结果。
13	4	实验教学	声速测量实验：讲解实验原理和实验思想、讲解实验仪器操作使用、观察记录实验现象和结果。
14	4	实验教学	偏振综合实验：讲解实验原理和实验思想、讲解实验仪器操作使用、观察记录实验现象和结果。
15	4	实验教学	几何光学综合实验：讲解实验原理和实验思想、讲解实验仪器操作使用、观察记录实验现象和结果。
16	4	课堂讨论	漫反射全息图摄制：讲解实验原理和实验思想、讲解实验仪器操作使用、观察记录实验现象和结果。

Shantou University
Module Description for Undergraduate Courses

COURSE TITLE:	General Physics Comprehensive Experiment
COURSE CODE:	PHY3027A
CREDIT VALUE:	2
CONTACT HOURS:	64
PRE-REQUISITE	University physics experiments (1), Electromagnetic Experiments of General Physics
DEPARTMENT/UNIT:	Department of Physics
VERSION:	20240731-PHY3027A
COURSE COORDINATOR:	李明根 (Signature and Seal)
APPROVER:	Chi Lingfei (Signature and Seal)
APPROVE DATE:	20240731

Shantou University Faculty of Science
July 2024

1. Course Description

(1) Nature of the Course

General Physics Comprehensive Experiment is designed primarily for physics majors. Building upon traditional general physics experiments and integrating modern detection techniques and digital tools, it serves as a bridging module between foundational laboratory work and advanced experimental courses. As an essential practical component of the physics curriculum, it provides the groundwork for cultivating academically oriented undergraduate talents in physics.

(2) Course Content

According to the teaching plan, the course consists of 64 contact hours over 16 weeks.

- Week 1 is dedicated to preparation and an introductory session covering course requirements, experimental procedures, commonly used instruments, laboratory safety, and regulations.
- Weeks 2–16 involve 15 weeks of practical laboratory work, including virtual simulation experiments.

Through these experimental projects, students gain insight into the role of modern detection technologies in shaping experimental methodology, deepen their understanding and application of theoretical physics, and develop essential experimental skills—including apparatus setup and debugging, observation and analysis of experimental phenomena and data, and proper presentation of experimental results.

(3) Course Objectives

This course aims to cultivate students' ability to apply theoretical physics knowledge effectively in experimental practice and to foster a spirit of innovation and scientific exploration. Emphasizing the integration of theory and practice, the course focuses on strengthening experimental literacy and scientific professionalism, laying a solid foundation for further academic study and research.

Students are encouraged to uphold scientific integrity, develop strong ideals and convictions, and demonstrate a sense of social responsibility. Through teamwork, rigorous data processing, and standardized report writing, the course helps students develop precision, critical thinking, and a realistic scientific attitude.

2. Intended Learning Outcomes

Knowledge Unit	Key Knowledge Points	Initial Level	Target Level	Expected Learning Outcomes
1. Standing Waves on a String Using a Sonometer	Principles and Experimental Concepts	Identify	Explain	Students will be able to explain the operating principles of the experiment and the underlying experimental concepts, and understand their scientific significance.
	Instrument Operation	Apply	Operate	Students will be able to proficiently operate the experimental apparatus and apply relevant knowledge under various experimental conditions.
	Experimental Phenomena and Results	Correct	Evaluate	Students will be able to analyze observed phenomena, correctly evaluate experimental results, and identify

				potential sources of error.
	Report Writing	Standardize	Assess	Students will be able to produce properly structured laboratory reports and perform self-evaluation of their work.
	Result Analysis	Accurate and Reasonable	Innovate	Students will be able to correctly interpret experimental results and propose improved or innovative experimental designs.
	Scientific and Practical Competence	Appreciate	Implement	Students will be able to integrate scientific reasoning and practical skills, implementing creative approaches in experimental practice.
2. Study of Motion Using High-Speed Imaging	Principles and Experimental Concepts	Identify	Explain	Students will be able to explain the operating principles of the experiment and the underlying experimental concepts, and understand their scientific significance.
	Instrument Operation	Apply	Operate	Students will be able to proficiently operate the experimental apparatus and apply relevant knowledge under various experimental conditions.
	Experimental Phenomena and Results	Correct	Evaluate	Students will be able to analyze observed phenomena, correctly evaluate experimental results, and identify potential sources of error.
	Report Writing	Standardize	Assess	Students will be able to produce properly structured laboratory reports and perform self-evaluation of their work.
	Result Analysis	Accurate and Reasonable	Innovate	Students will be able to correctly interpret experimental results and propose improved or innovative experimental designs.
	Scientific and Practical Competence	Appreciate	Implement	Students will be able to integrate scientific reasoning and practical skills, implementing

				creative approaches in experimental practice.
3. Forced Vibration Experiment	Principles and Experimental Concepts	Identify	Explain	Students will be able to explain the operating principles of the experiment and the underlying experimental concepts, and understand their scientific significance.
	Instrument Operation	Apply	Operate	Students will be able to proficiently operate the experimental apparatus and apply relevant knowledge under various experimental conditions.
	Experimental Phenomena and Results	Correct	Evaluate	Students will be able to analyze observed phenomena, correctly evaluate experimental results, and identify potential sources of error.
	Report Writing	Standardize	Assess	Students will be able to produce properly structured laboratory reports and perform self-evaluation of their work.
	Result Analysis	Accurate and Reasonable	Innovate	Students will be able to correctly interpret experimental results and propose improved or innovative experimental designs.
	Scientific and Practical Competence	Appreciate	Implement	Students will be able to integrate scientific reasoning and practical skills, implementing creative approaches in experimental practice.
4. Quasi-Steady-State Method for Measuring Thermal Conductivity and Specific Heat	Principles and Experimental Concepts	Identify	Explain	Students will be able to explain the operating principles of the experiment and the underlying experimental concepts, and understand their scientific significance.
	Instrument Operation	Apply	Operate	Students will be able to proficiently operate the experimental apparatus and apply relevant knowledge under various experimental conditions.

	Experimental Phenomena and Results	Correct	Evaluate	Students will be able to analyze observed phenomena, correctly evaluate experimental results, and identify potential sources of error.
	Report Writing	Standardize	Assess	Students will be able to produce properly structured laboratory reports and perform self-evaluation of their work.
	Result Analysis	Accurate and Reasonable	Innovate	Students will be able to correctly interpret experimental results and propose improved or innovative experimental designs.
	Scientific and Practical Competence	Appreciate	Implement	Students will be able to integrate scientific reasoning and practical skills, implementing creative approaches in experimental practice.
5. Air Heat Engine Experiment Study	Principles and Experimental Concepts	Identify	Explain	Students will be able to explain the operating principles of the experiment and the underlying experimental concepts, and understand their scientific significance.
	Instrument Operation	Apply	Operate	Students will be able to proficiently operate the experimental apparatus and apply relevant knowledge under various experimental conditions.
	Experimental Phenomena and Results	Correct	Evaluate	Students will be able to analyze observed phenomena, correctly evaluate experimental results, and identify potential sources of error.
	Report Writing	Standardize	Assess	Students will be able to produce properly structured laboratory reports and perform self-evaluation of their work.
	Result Analysis	Accurate and Reasonable	Innovate	Students will be able to correctly interpret experimental results and propose improved or innovative experimental designs.

	Scientific and Practical Competence	Appreciate	Implement	Students will be able to integrate scientific reasoning and practical skills, implementing creative approaches in experimental practice.
6. Measurement of Sound Velocity in Different Media	Principles and Experimental Concepts	Identify	Explain	Students will be able to explain the operating principles of the experiment and the underlying experimental concepts, and understand their scientific significance.
	Instrument Operation	Apply	Operate	Students will be able to proficiently operate the experimental apparatus and apply relevant knowledge under various experimental conditions.
	Experimental Phenomena and Results	Correct	Evaluate	Students will be able to analyze observed phenomena, correctly evaluate experimental results, and identify potential sources of error.
	Report Writing	Standardize	Assess	Students will be able to produce properly structured laboratory reports and perform self-evaluation of their work.
	Result Analysis	Accurate and Reasonable	Innovate	Students will be able to correctly interpret experimental results and propose improved or innovative experimental designs.
	Scientific and Practical Competence	Appreciate	Implement	Students will be able to integrate scientific reasoning and practical skills, implementing creative approaches in experimental practice.
7. Comprehensive Doppler Effect Experiment	Principles and Experimental Concepts	Identify	Explain	Students will be able to explain the operating principles of the experiment and the underlying experimental concepts, and understand their scientific significance.
	Instrument Operation	Apply	Operate	Students will be able to proficiently operate the experimental apparatus and apply relevant knowledge under

				various experimental conditions.
	Experimental Phenomena and Results	Correct	Evaluate	Students will be able to analyze observed phenomena, correctly evaluate experimental results, and identify potential sources of error.
	Report Writing	Standardize	Assess	Students will be able to produce properly structured laboratory reports and perform self-evaluation of their work.
	Result Analysis	Accurate and Reasonable	Innovate	Students will be able to correctly interpret experimental results and propose improved or innovative experimental designs.
	Scientific and Practical Competence	Appreciate	Implement	Students will be able to integrate scientific reasoning and practical skills, implementing creative approaches in experimental practice.
8. Computer-Assisted Physics Experimentation	Principles and Experimental Concepts	Identify	Explain	Students will be able to explain the operating principles of the experiment and the underlying experimental concepts, and understand their scientific significance.
	Instrument Operation	Apply	Operate	Students will be able to proficiently operate the experimental apparatus and apply relevant knowledge under various experimental conditions.
	Experimental Phenomena and Results	Correct	Evaluate	Students will be able to analyze observed phenomena, correctly evaluate experimental results, and identify potential sources of error.
	Report Writing	Standardize	Assess	Students will be able to produce properly structured laboratory reports and perform self-evaluation of their work.
	Result Analysis	Accurate and Reasonable	Innovate	Students will be able to correctly interpret experimental results and propose improved or

				innovative experimental designs.
	Scientific and Practical Competence	Appreciate	Implement	Students will be able to integrate scientific reasoning and practical skills, implementing creative approaches in experimental practice.
9. Electro-Optic Modulation Experiment	Principles and Experimental Concepts	Identify	Explain	Students will be able to explain the operating principles of the experiment and the underlying experimental concepts, and understand their scientific significance.
	Instrument Operation	Apply	Operate	Students will be able to proficiently operate the experimental apparatus and apply relevant knowledge under various experimental conditions.
	Experimental Phenomena and Results	Correct	Evaluate	Students will be able to analyze observed phenomena, correctly evaluate experimental results, and identify potential sources of error.
	Report Writing	Standardize	Assess	Students will be able to produce properly structured laboratory reports and perform self-evaluation of their work.
	Result Analysis	Accurate and Reasonable	Innovate	Students will be able to correctly interpret experimental results and propose improved or innovative experimental designs.
	Scientific and Practical Competence	Appreciate	Implement	Students will be able to integrate scientific reasoning and practical skills, implementing creative approaches in experimental practice.
10. Acousto-Optic Modulation Experiment	Principles and Experimental Concepts	Identify	Explain	Students will be able to explain the operating principles of the experiment and the underlying experimental concepts, and understand their scientific significance.
	Instrument Operation	Apply	Operate	Students will be able to proficiently operate the experimental apparatus

				and apply relevant knowledge under various experimental conditions.
	Experimental Phenomena and Results	Correct	Evaluate	Students will be able to analyze observed phenomena, correctly evaluate experimental results, and identify potential sources of error.
	Report Writing	Standardize	Assess	Students will be able to produce properly structured laboratory reports and perform self-evaluation of their work.
	Result Analysis	Accurate and Reasonable	Innovate	Students will be able to correctly interpret experimental results and propose improved or innovative experimental designs.
	Scientific and Practical Competence	Appreciate	Implement	Students will be able to integrate scientific reasoning and practical skills, implementing creative approaches in experimental practice.
11. Photovoltaic Characterization of Solar Cells	Principles and Experimental Concepts	Identify	Explain	Students will be able to explain the operating principles of the experiment and the underlying experimental concepts, and understand their scientific significance.
	Instrument Operation	Apply	Operate	Students will be able to proficiently operate the experimental apparatus and apply relevant knowledge under various experimental conditions.
	Experimental Phenomena and Results	Correct	Evaluate	Students will be able to analyze observed phenomena, correctly evaluate experimental results, and identify potential sources of error.
	Report Writing	Standardize	Assess	Students will be able to produce properly structured laboratory reports and perform self-evaluation of their work.

	Result Analysis	Accurate and Reasonable	Innovate	Students will be able to correctly interpret experimental results and propose improved or innovative experimental designs.
	Scientific and Practical Competence	Appreciate	Implement	Students will be able to integrate scientific reasoning and practical skills, implementing creative approaches in experimental practice.
12. Virtual Simulation Experiment on Liquid-Crystal Device Fabrication and Testing	Principles and Experimental Concepts	Identify	Explain	The student has a basic grasp of the experimental principles and can operate the virtual instrument equipment. They are able to analyze experimental phenomena, correctly evaluate the results, and write a well-structured lab report, including self-evaluation. They can also interpret the results accurately and propose new experimental designs or improvement plans.
	Virtual Instrument Operation and Application	Basic Mastery	Mastery	
	Experimental Phenomena and Results	Basically Correct	Correct	
	Report Writing	Standardized	Standardized	
	Results Analysis	Correct and Reasonable	Correct and Reasonable	
	Scientific Rigor and Practicality	Comprehend	Comprehend	
13. Virtual Simulation Experiment on Thermal-Evaporation Nanomaterial Fabrication	Principles and Experimental Concepts	Identify	Explain	The student has a basic grasp of the experimental principles and can operate the virtual instrument equipment. They are able to analyze experimental phenomena, correctly evaluate the results, and write a well-structured lab report, including self-evaluation. They can also interpret the results accurately and propose new experimental designs or improvement plans.
	Virtual Instrument Operation and Application	Basic Mastery	Mastery	
	Experimental Phenomena and Results	Basically Correct	Correct	
	Report Writing	Standardized	Standardized	
	Results Analysis	Correct and Reasonable	Correct and Reasonable	
	Scientific Rigor and Practicality	Comprehend	Comprehend	

3. Pre-requisit

University physics experiments (1), Electromagnetic Experiments of General Physics

4. Textbooks and Other Learning Resources

Required Textbooks

General Physics Comprehensive Experiment Lecture Notes, July 2024 Edition, Compiled by the General Physics and Thermodynamics Laboratory.

Recommended References

1. *University Physics Experiments*, 1st Edition, Shen Han, Zhao Fuli, et al., Science Press, 2024.

2. *University Physics Experiments*, 2nd Edition, Lin Weihua, Zhang Wenbing, Zou Yong, Jiang Xianyang, Higher Education Press, 2023.

Course websites

my.stu.edu.cn

University Physics Experiment Portal: http//lab.stu.edu.cn

5. Teaching and Learning Activities

Teaching Segment	Lectures (Theory)	Tutorial Session	Experi-ment	Seminar	Social Pratice	Project	Online Learning	Total
Hours (In-class)			64					64
Hours (Out-of-class)			64					64

In this course, the in-class component consists primarily of experimental operations. In addition to the scheduled laboratory sessions, students are required to engage in self-directed study. The ratio of classroom hours to self-study hours is 1:1, resulting in a total of 64 hours of self-study. The self-study tasks mainly include preparing for experiments, processing and analyzing experimental data, and writing laboratory reports. All self-study activities are carried out under the students' own supervision.

6. Assessment Scheme

Assessment Component	Description	Weight
Experimental Operation	Complete experimental operations according to the requirements	60%
Laboratory Report & Presentation	Completion of written reports and oral presentations as required	30%
Preparation	Completion and accuracy of pre-lab preparation	10%

The assessment consists of three parts: pre-lab preparation, experimental operation, and laboratory reports & presentations, weighted as shown in the table above.

- Pre-lab preparation is assessed based on the completeness and accuracy of the preparation report.

- Experimental operation is evaluated through class attendance, hands-on skills, problem-solving ability, completion and quality of experimental tasks, and the ability to raise meaningful questions.
- Laboratory reports and presentations are assessed based on the quality of the written report and performance in the course presentation.

7. Course Schedule

Note: Due to limited availability of experimental instruments, the laboratory sessions are organized in four-week teaching units. The following schedule uses Group 1 as an example; detailed rotation arrangements are provided in the attached rotation table.

Week	Contact Hours	Teaching Format	Laboratory Content
1	4	Lecture	Introduction to course requirements, course arrangement, laboratory safety, and regulations.
2	4	Laboratory Session	Standing Waves on a String Using a String Vibrator: explanation of experimental principles and concepts, demonstration of instrument operation, observation and recording of experimental phenomena and results.
3	4	Laboratory Session	Motion Analysis with High-Speed Imaging: explanation of experimental principles and concepts, demonstration of instrument operation, observation and recording of experimental phenomena and results.
4	4	Laboratory Session	Forced Vibration Experiment: explanation of experimental principles and concepts, demonstration of instrument operation, observation and recording of experimental phenomena and results.
5	4	Laboratory Session	Quasi-Steady-State Method for Measuring Thermal Conductivity and Specific Heat: explanation of experimental principles and concepts, demonstration of instrument operation, observation and recording of experimental phenomena and results.
6	4	Classroom Summary	Reflection, summary, and reporting on the experimental results and issues encountered during Weeks 1–4; instructor feedback.
7	4	Laboratory Session	Air Heat Engine Experiment: explanation of experimental principles and concepts, demonstration of instrument operation, observation and recording of experimental phenomena and results.
8	4	Laboratory Session	Measurement of the Speed of Sound in Different Media: explanation of experimental principles and concepts, demonstration of instrument operation, observation and recording of experimental phenomena and results.
9	4	Laboratory Session	Comprehensive Doppler Effect Experiment: explanation of experimental principles and concepts, demonstration of instrument operation, observation and recording of experimental phenomena and results.
10	4	Laboratory Session	Computer-Based Comprehensive Physics Experiment: explanation of experimental principles and concepts, demonstration of instrument operation, observation and recording of experimental phenomena and results.
11	4	Lecture	Explanation of requirements for the third round of experiments; training on the virtual simulation experiment platform.
12	4	Laboratory Session	Electro-Optic Modulation Experiment: explanation of experimental principles and concepts, demonstration of instrument operation, observation and recording of experimental phenomena and results.

13	4	Laboratory Session	Acousto-Optic Modulation Experiment: explanation of experimental principles and concepts, demonstration of instrument operation, observation and recording of experimental phenomena and results.
14	4	Laboratory Session	Measurement of Photovoltaic Characteristics of Solar Cells: explanation of experimental principles and concepts, demonstration of instrument operation, observation and recording of experimental phenomena and results.
15	4	Laboratory Session	Virtual Simulation Experiment on Fabrication and Testing of Liquid Crystal Devices: explanation of experimental principles and concepts, demonstration of instrument operation, observation and recording of experimental phenomena and results.
16	4	Presentation Session	Virtual Simulation Experiment on Thermal Evaporation Fabrication of Nanomaterials: explanation of experimental principles and concepts, demonstration of instrument operation, observation and recording of experimental phenomena and results.

汕头大学本科教学

课程教学大纲

课程名（COURSE TITLE）： 普通物理综合实验

课程代码（COURSE CODE）： PHY3027A

学分（CREDIT VALUE）： 2

课内课时（CONTACT HOURS）： 64

先修课要求（PRE-REQUISITE） 大学物理实验（1）、大学物理实验（2）

开课单位（DEPARTMENT/UNIT）： 物理学系

版本（VERSION）： 20240731-PHY3027A

课程负责人（COURSE COORDINATOR）： 李明根 (签章)

审核人（APPROVER）： 池凌飞(签章)

审核日期（APPROVE DATE）： 20240731

汕头大学理学院

2024 年 7 月

1、课程简介（Course Description）

（1） 课程性质：普通物理综合实验（General Physics Comprehensive Experiment）课程主要针对物理学专业学生开设，实验项目在由传统的普通物理实验项目基础上，与现代探测手段、信息化紧密结合，是基础实验与专业实验之间的衔接课程，是物理学专业的重要实践环节，为培养物理学专业学术型本科人才奠定基础。

（2） 课程内容：根据教学计划，本课程共 64 学时，共 16 周。第 1 周为实验准备、绪论课，讲解课程要求、实验操作规程、常用仪器设备及实验室安全和纪律教育；实践操作共 15 周（含虚拟仿真实验）。通过实验项目的学习，使学生体会到现代探测技术对实验方法的作用，加深对物理理论知识的理解与应用，使学生掌握调试、搭建实验系统的能力；观察、分析实验现象（数据）的能力；正确表述实验结果的能力。

（3） 课程目标：本课程旨在培养学生综合运用物理理论知识指导实践的能力，培养学生勇于探索的创新精神。本课程注重理论与实践相结合，强调学生的实验素养和科学精神的培养，为学生后续的专业学习和科学研究打下坚实基础。通过本课程的学习，学生应该坚定中国特色社会主义道路，树立坚定的理想信念，遵守科学道德；培养和树立正确的价值观和社会责任感；通过实验过程中团队合作、实验数据的严谨处理、实验报告的规范撰写等环节，培养严谨求实的科学态度。弘扬爱国主义精神，增强服务国家和社会发展的使命感。

2、预期学习结果（Intended Learning Outcomes）

本课程的预期学习结果如下表：

知识单元	知识点	初始程度	要求程度	预期学习结果
1. 用弦音计研究弦线上驻波	1.1 原理和实验思想	识别	解释	学生能够解释弦音计原理和实验思想，理解其科学意义。
	1.2 实验仪器操作使用	应用	操作	学生能够熟练操作实验仪器，并在不同环境下应用所学知识进行实验。
	1.3 实验现象和结果	正确	评估	学生能够分析实验现象，正确评估实验结果，识别可能的误差来源。
	1.4 报告写作	规范	评价	学生能够撰写规范的实验报告，并对报告内容进行自我评价。
	1.5 结果分析	正确合理	创新	学生能够正确分析实验结果，提出新的实验设计或改进方案。
	1.6 科学性和实践性	体会	实现	学生能够在实验中实现科学性和实践性的结合，提出创新的实验方法。
2. 高速摄像下物体的运动研	2.1 原理和实验思想	识别	解释	学生能够解释高速摄像研究物体各种运动学和动力学过程的原理和实验思想，理解

究				其科学意义。
	2.2 实验仪器操作使用	应用	操作	学生能够熟练操作实验仪器，并在不同环境下应用所学知识进行实验。
	2.3 实验现象和结果	正确	评估	学生能够分析实验现象，正确评估实验结果，识别可能的误差来源。
	2.4 报告写作	规范	评价	学生能够撰写规范的实验报告，并对报告内容进行自我评价。
	2.5 结果分析	正确合理	创新	学生能够正确分析实验结果，提出新的实验设计或改进方案。
	2.6 科学性和实践性	体会	实现	学生能够在实验中实现科学性和实践性的结合，提出创新的实验方法。
3. 受迫振动实验	3.1 原理和实验思想	识别	解释	学生能够解释物体受迫振动状态下的特性和实验思想，理解其科学意义。
	3.2 实验仪器操作使用	应用	操作	学生能够熟练操作实验仪器，并在不同环境下应用所学知识进行实验。
	3.3 实验现象和结果	正确	评估	学生能够分析实验现象，正确评估实验结果，识别可能的误差来源。
	3.4 报告写作	规范	评价	学生能够撰写规范的实验报告，并对报告内容进行自我评价。
	3.5 结果分析	正确合理	创新	学生能够正确分析实验结果，提出新的实验设计或改进方案。
	3.6 科学性和实践性	体会	实现	学生能够在实验中实现科学性和实践性的结合，提出创新的实验方法。
4. 准稳态法测导热系数和比热	4.1 原理和实验思想	识别	解释	学生能够解释准稳态法测量导热系数和比热的原理和实验思想，理解其科学意义。
	4.2 实验仪器操作使用	应用	操作	学生能够熟练操作实验仪器，并在不同环境下应用所学知识进行实验。
	4.3 实验现象和结果	正确	评估	学生能够分析实验现象，正确评估实验结果，识别可能的误差来源。
	4.4 报告写作	规范	评价	学生能够撰写规范的实验报告，并对报告内容进行自我评价。
	4.5 结果分析	正确合理	创新	学生能够正确分析实验结果，提出新的实验设计或改进方案。
	4.6 科学性和实践性	体会	实现	学生能够在实验中实现科学

				性和实践性的结合，提出创新的实验方法。
5. 空气热机实验研究	5.1 原理和实验思想	识别	解释	学生能够解释用空气热机研究卡诺定理的工作原理和实验思想，理解其科学意义。
	5.2 实验仪器操作使用	应用	操作	学生能够熟练操作实验仪器，并在不同环境下应用所学知识进行实验。
	5.3 实验现象和结果	正确	评估	学生能够分析实验现象，正确评估实验结果，识别可能的误差来源。
	5.4 报告写作	规范	评价	学生能够撰写规范的实验报告，并对报告内容进行自我评价。
	5.5 结果分析	正确合理	创新	学生能够正确分析实验结果，提出新的实验设计或改进方案。
	5.6 科学性和实践性	体会	实现	学生能够在实验中实现科学性和实践性的结合，提出创新的实验方法。
6.测量声波在不同介质中的传播速度	6.1 原理和实验思想	识别	解释	学生能够解释声速测量的原理和实验思想，理解其科学意义。
	6.2 实验仪器操作使用	应用	操作	学生能够熟练操作实验仪器，并在不同环境下应用所学知识进行实验。
	6.3 实验现象和结果	正确	评估	学生能够分析实验现象，正确评估实验结果，识别可能的误差来源。
	6.4 报告写作	规范	评价	学生能够撰写规范的实验报告，并对报告内容进行自我评价。
	6.5 结果分析	正确合理	创新	学生能够正确分析实验结果，提出新的实验设计或改进方案。
	6.6 科学性和实践性	体会	实现	学生能够在实验中实现科学性和实践性的结合，提出创新的实验方法。
7.多普勒效应综合实验	7.1 原理和实验思想	识别	解释	学生能够解释多普勒效应的原理和利用该效应研究物体运动的实验思想，理解其科学意义。
	7.2 实验仪器操作使用	应用	操作	学生能够熟练操作实验仪器，并在不同环境下应用所学知识进行实验。
	7.3 实验现象和结果	正确	评估	学生能够分析实验现象，正确评估实验结果，识别可能的误差来源。
	7.4 报告写作	规范	评价	学生能够撰写规范的实验报告，并对报告内容进行自我

				评价。
	7.5 结果分析	正确合理	创新	学生能够正确分析实验结果，提出新的实验设计或改进方案。
	7.6 科学性和实践性	体会	实现	学生能够在实验中实现科学性和实践性的结合，提出创新的实验方法。
8.计算机实测物理实验	8.1 原理和实验思想	识别	解释	学生能够解释计算机实时测量的原理和利用该方法研究物体碰撞、摩擦、摆动过程状态的实验思想，理解其科学意义。
	8.2 实验仪器操作使用	应用	操作	学生能够熟练操作实验仪器，并在不同环境下应用所学知识进行实验。
	8.3 实验现象和结果	正确	评估	学生能够分析实验现象，正确评估实验结果，识别可能的误差来源。
	8.4 报告写作	规范	评价	学生能够撰写规范的实验报告，并对报告内容进行自我评价。
	8.5 结果分析	正确合理	创新	学生能够正确分析实验结果，提出新的实验设计或改进方案。
	8.6 科学性和实践性	体会	实现	学生能够在实验中实现科学性和实践性的结合，提出创新的实验方法。
9.电光调制实验	9.1 原理和实验思想	识别	解释	学生能够解释电光调制的原理和实验思想，理解其科学意义。
	9.2 实验仪器操作使用	应用	操作	学生能够熟练操作实验仪器，并在不同环境下应用所学知识进行实验。
	9.3 实验现象和结果	正确	评估	学生能够分析实验现象，正确评估实验结果，识别可能的误差来源。
	9.4 报告写作	规范	评价	学生能够撰写规范的实验报告，并对报告内容进行自我评价。
	9.5 结果分析	正确合理	创新	学生能够正确分析实验结果，提出新的实验设计或改进方案。
	9.6 科学性和实践性	体会	实现	学生能够在实验中实现科学性和实践性的结合，提出创新的实验方法。
10. 声光调制实验	10.1 原理和实验思想	识别	解释	学生能够解释声光调制原理和实验思想，理解其科学意义。
	10.2 实验仪器操作使用	应用	操作	学生能够熟练操作实验仪器，并在不同环境下应用所

				学知识进行实验。
	10.3 实验现象和结果	正确	评估	学生能够分析实验现象，正确评估实验结果，识别可能的误差来源。
	10.4 报告写作	规范	评价	学生能够撰写规范的实验报告，并对报告内容进行自我评价。
	10.5 结果分析	正确合理	创新	学生能够正确分析实验结果，提出新的实验设计或改进方案。
	10.6 科学性和实践性	体会	实现	学生能够在实验中实现科学性和实践性的结合，提出创新的实验方法。
11. 太阳能电池光伏特性测量实验	11.1 原理和实验思想	识别	解释	学生能够解释太阳能电池光伏特性原理和实验思想，理解其科学意义。
	11.2 实验仪器操作使用	应用	操作	学生能够熟练操作实验仪器，并在不同环境下应用所学知识进行实验。
	11.3 实验现象和结果	正确	评估	学生能够分析实验现象，正确评估实验结果，识别可能的误差来源。
	11.4 报告写作	规范	评价	学生能够撰写规范的实验报告，并对报告内容进行自我评价。
	11.5 结果分析	正确合理	创新	学生能够正确分析实验结果，提出新的实验设计或改进方案。
	11.6 科学性和实践性	体会	实现	学生能够在实验中实现科学性和实践性的结合，提出创新的实验方法。
12. 液晶器件制备与测试虚拟仿真实验	12.1 原理和实验思想	识别	解释	学生基本掌握实验的原理,掌握虚拟仪器设备的操作。能够分析实验现象，正确评估实验结果，能够撰写规范的实验报告，并对报告内容进行自我评价。能够正确分析实验结果，提出新的实验设计或改进方案。
	12.2 虚拟仪器操作使用	基本掌握	掌握	
	12.3 实验现象和结果	基本正确	正确	
	12.4 报告写作	规范	规范	
	12.5 结果分析	正确合理	正确合理	
	12.6 科学性和实践性	体会	体会	
13. 热蒸发制备纳米材料虚拟仿真实验	13.1 原理和实验思想	识别	解释	学生基本掌握实验的原理,掌握虚拟仪器设备的操作。能够分析实验现象，正确评估实验结果，能够撰写规范的实验报告，并对报告内容进行自我评价。能够正确分析实验结果，提出新的实验设计或改进方案。
	13.2 虚拟仪器操作使用	基本掌握	掌握	
	13.3 实验现象和结果	基本正确	正确	
	13.4 报告写作	规范	规范	
	13.5 结果分析	正确合理	正确合理	
	13.6 科学性和实践性	体会	体会	

3、先修要求（Pre-requisite）

大学物理实验（1）、大学物理实验（2）

4、教材及其他教学资源（Textbooks and Other Learning Resources）

指定教材：《普物物理综合实验讲义》2024.7 版　普物力、热学实验室编

推荐教材：《大学物理实验》**第一版，**沈韩，赵福利等，科学出版社，2024 年《大学物理实验》第二版，林伟华，　张文炳 邹勇 江先阳，高等教育出版社 2023 年

课程网站：

(1) my.stu.edu.cn

(2)大学物理实验门户网站，网址：http：//lab.stu.edu.cn

5、主要教学环节（Teaching and Learning Activities）

教学环节	理论课（小时）	习题课（小时）	实验（小时）	研讨（小时）	社会实践（小时）	项目（小时）	在线学习（小时）	期中测试（小时）	合计
课内			64						64
课外			64						64

本课程课内为实验操作环节，在课内实验教学环节之外还需要学生自学。自学环节课时与课堂教学课时比例为 1：1，即自学环节为 64 学时，主要进行实验预习、处理分析实验数据和撰写实验报告。自学环节由学生自我监督完成。

6、课程考核（Assessment Scheme）

考核项目	考核内容和考试方法简介	权重
实验操作	按要求完成实验操作	30%
实验报告及汇报	按要求完成实验报告及课程汇报	60%
预习准备	按要求完成实验预习	10%

本课程考核由实验预习、实验操作、实验报告及汇报三部分组成。占比分别如上表。实验预习以撰写预习报告的完成度和准确度为标准；实验操作以学生课堂上出勤情况、实验中动手能力及解决问题能力、实验内容完成度及质量、提出有意义的问题为考量标准；实验报告及汇报以实验报告撰写要求及汇报表现为评分标准。

7、学习进度（Course Schedule）

周次	教学时数	教学形式	教学内容
1	4	课堂教学	讲解课程要求、课程安排、实验室安全和纪律。
2	4	实验课堂	用弦音计研究弦线上驻波实验：讲解实验原理和实验思想、讲解实验仪器操作使用、观察记录实验现象和结果。

3	4	实验课堂	高速摄像下物体的运动研究：讲解实验原理和实验思想、讲解实验仪器操作使用、观察记录实验现象和结果。
4	4	实验课堂	受迫振动实验：讲解实验原理和实验思想、讲解实验仪器操作使用、观察记录实验现象和结果。
5	4	实验课堂	准稳态法测导热系数和比热：讲解实验原理和实验思想、讲解实验仪器操作使用、观察记录实验现象和结果。
6	4	课堂总结	组织学生对 1-4 周实验结果、实验过程出现的问题进行思考、总结、汇报，教师点评
7	4	实验课堂	空气热机实验研究：讲解实验原理和实验思想、讲解实验仪器操作使用、观察记录实验现象和结果。
8	4	实验课堂	测量声波在不同介质中的传播速度：讲解实验原理和实验思想、讲解实验仪器操作使用、观察记录实验现象和结果。
9	4	实验课堂	多普勒效应综合实验：讲解实验原理和实验思想、讲解实验仪器操作使用、观察记录实验现象和结果。
10	4	实验课堂	计算机实测物理综合实验：讲解实验原理和实验思想、讲解实验仪器操作使用、观察记录实验现象和结果。
11	4	课堂教学	讲解第三轮实验项目要求、虚拟仿真实验平台使用培训
12	4	实验课堂	电光调制实验：讲解实验原理和实验思想、讲解实验仪器操作使用、观察记录实验现象和结果。
13	4	实验课堂	声光调制实验：讲解实验原理和实验思想、讲解实验仪器操作使用、观察记录实验现象和结果。
14	4	实验课堂	太阳能电池光伏特性测量实验：讲解实验原理和实验思想、讲解实验仪器操作使用、观察记录实验现象和结果。
15	4	实验课堂	液晶器件制备与测试虚拟仿真实验：讲解实验原理和实验思想、讲解实验仪器操作使用、观察记录实验现象和结果。

16	4	实验课堂	热蒸发制备纳米材料虚拟仿真实验：讲解实验原理和实验思想、讲解实验仪器操作使用、观察记录实验现象和结果。

Shantou University
Module Description for Undergraduate Courses

COURSE TITLE:	Modern physics experiments 1
COURSE CODE:	PHY3015 A
CREDIT VALUE:	2
CONTACT HOURS:	64
PRE-REQUISITE	Atomic Physics, Electromagnetic Expernments of General Physics
DEPARTMENT/UNIT:	Department of Physics
VERSION:	20240731-PHY3070A
COURSE COORDINATOR:	(Signature and Seal)
APPROVER:	(Signature and Seal)
APPROVE DATE:	20240731

Shantou University　　Faculty of Science
July 2024

1. Course Description

Modern Physics Experiment 1 (The original document lists the course as "Advanced Physics Experiment 1," while the transcript shows it as "Modern Physics Experiments 1." This document will adopt the transcript title for consistency.) is a compulsory course for physics majors. As the first module in the Modern Physics Experiment series, it integrates experimental techniques with methodological training. After students have acquired fundamental classical physics theories and basic experimental skills, this course introduces advanced and comprehensive experimental methods that emerged from the development of modern physics. It aims to further strengthen students' overall experimental competence and deepen their understanding of relevant physical concepts, theories, and phenomena.

The experimental modules include vacuum generation and measurement, thermal evaporation coating, nuclear magnetic resonance, single-photon technologies, nuclear and particle physics experiments, the Ramsauer–Townsend effect, the Franck–Hertz experiment, sodium atomic spectroscopy, the Zeeman effect, microwave and waveguide characteristics, and weak-signal detection techniques. Several of these experiments originate from landmark research that has been recognized by the Nobel Prize and have played crucial roles in shaping the development of modern physics; their methods remain representative and influential in contemporary experimental practice.

Through this course, students enhance their comprehension of core theoretical physics content while cultivating a more vivid and flexible scientific mindset. The experiments further train students' abilities in observation, analysis, and problem-solving, while introducing a range of commonly used techniques, methodologies, and instruments in modern physics. By engaging in rigorous scientific inquiry, students develop foundational research skills, scientific curiosity, and a sense of commitment to contributing to scientific and technological progress.

This course corresponds to the following graduation requirement indicators of the physics major training framework:

3.2 Mastery of professional theoretical knowledge and the ability to learn complex theories;
4.2 Proficiency in professional tools and experimental techniques;
5.2 Capacity for innovation and research;
6.1 Research and engineering capabilities for problem-solving.

2. Intended Learning Outcomes

Knowledge Unit	Key Knowledge Points	Initial Level	Target Level	Expected Learning Outcomes
1. Vacuum Generation and Measurement and Thermal Evaporation Coating Technology	Experimental principle and philosophy	L1	L3	1. Master the experimental principle. 2. Operate the equipment proficiently. 3. Develop professional knowledge application and ability to learn complex theories. 4. Uphold responsibility, and academic ideals. 5. Complete group tasks and evaluate other members' contributions.
	Instrument operation	L1	L3	
	Experimental phenomena and results	L1	L3	
	Report writing and result analysis	L1	L4	
	Scientific rigor and practical skills	L1	L4	
	Teamwork and communication	L1	L5	
2. Nuclear Magnetic Resonance (NMR)	Experimental principle and philosophy	L1	L3	1. Master the principle. 2. Operate the equipment proficiently.
	Instrument operation	L1	L3	

	Experimental phenomena and results	L1	L3	3. Develop experimental skills and cultivate research innovation in problem-solving. 4. Deepen understanding and application of professional knowledge. 5. Uphold, responsibility, and academic ideals.
	Report writing and result analysis	L1	L4	
	Scientific rigor and practical skills	L1	L4	
	Teamwork and communication	L1	L5	
3. Single-Photon Techniques	Experimental principle and philosophy	L1	L3	1. Master the principle. 2. Operate the equipment proficiently. 3. Develop experimental skills and cultivate research innovation in problem-solving. 4. Deepen understanding and application of professional knowledge. 5. Uphold, responsibility, and academic ideals.
	Instrument operation	L1	L3	
	Experimental phenomena and results	L1	L3	
	Report writing and result analysis	L1	L4	
	Scientific rigor and practical skills	L1	L4	
	Teamwork and communication	L1	L5	
4. Nuclear and Particle Physics Experiments	Experimental principle and philosophy	L1	L3	1. Master the principle. 2. Operate the equipment proficiently. 3. Develop experimental skills and cultivate research innovation in problem-solving. 4. Deepen understanding and application of professional knowledge. 5. Uphold, responsibility, and academic ideals.
	Instrument operation	L1	L3	
	Experimental phenomena and results	L1	L3	
	Report writing and result analysis	L1	L4	
	Scientific rigor and practical skills	L1	L4	
	Teamwork and communication	L1	L5	
5. Ramsauer–Townsend Effect	Experimental principle and philosophy	L1	L3	1. Master the principle. 2. Operate the equipment proficiently. 3. Develop experimental skills and cultivate research innovation in problem-solving. 4. Deepen understanding and application of professional knowledge.
	Instrument operation	L1	L3	
	Experimental phenomena and results	L1	L3	
	Report writing and result analysis	L1	L4	
	Scientific rigor and practical skills	L1	L4	

	Teamwork and communication	L1	L5	5. Uphold, responsibility, and academic ideals.
6. Franck–Hertz Experiment	Experimental principle and philosophy	L1	L3	1. Master the principle. 2. Operate the equipment proficiently. 3. Develop experimental skills and cultivate research innovation in problem-solving. 4. Deepen understanding and application of professional knowledge. 5. Uphold, responsibility, and academic ideals.
	Instrument operation	L1	L3	
	Experimental phenomena and results	L1	L3	
	Report writing and result analysis	L1	L4	
	Scientific rigor and practical skills	L1	L4	
	Teamwork and communication	L1	L5	
7. Sodium Atomic Spectroscopy	Experimental principle and philosophy	L1	L3	1. Master the principle. 2. Operate the equipment proficiently. 3. Develop experimental skills and cultivate research innovation in problem-solving. 4. Deepen understanding and application of professional knowledge. 5. Uphold, responsibility, and academic ideals.
	Instrument operation	L1	L3	
	Experimental phenomena and results	L1	L3	
	Report writing and result analysis	L1	L4	
	Scientific rigor and practical skills	L1	L4	
	Teamwork and communication	L1	L5	
8. Zeeman Effect	Experimental principle and philosophy	L1	L3	1. Master the principle. 2. Operate the equipment proficiently. 3. Develop experimental skills and cultivate research innovation in problem-solving. 4. Deepen understanding and application of professional knowledge. 5. Uphold, responsibility, and academic ideals.
	Instrument operation	L1	L3	
	Experimental phenomena and results	L1	L3	
	Report writing and result analysis	L1	L4	
	Scientific rigor and practical skills	L1	L4	
	Teamwork and communication	L1	L5	
9. Microwave and Waveguide Characteristics	Experimental principle and philosophy	L1	L3	1. Master the principle. 2. Operate the equipment proficiently.
	Instrument operation	L1	L3	

	Experimental phenomena and results	L1	L3	3. Develop experimental skills and cultivate research innovation in problem-solving. 4. Deepen understanding and application of professional knowledge. 5. Uphold, responsibility, and academic ideals.
	Report writing and result analysis	L1	L4	
	Scientific rigor and practical skills	L1	L4	
	Teamwork and communication	L1	L5	
10. Weak-Signal Detection Techniques	Experimental principle and philosophy	L1	L3	1. Master the principle. 2. Operate the equipment proficiently. 3. Develop experimental skills and cultivate research innovation in problem-solving. 4. Deepen understanding and application of professional knowledge. 5. Uphold, responsibility, and academic ideals.
	Instrument operation	L1	L3	
	Experimental phenomena and results	L1	L3	
	Report writing and result analysis	L1	L4	
	Scientific rigor and practical skills	L1	L4	
	Teamwork and communication	L1	L5	

3. Pre-requisit

Atomic Physics, Electromagnetic Expernments of General Physics

4. Textbooks and Other Learning Resources

Required Textbooks

Self-prepared Laboratory Manual for the Course

Recommended References

1. *Modern Physics Experiments* (4th Edition), Wu Sicheng & Xun Kun, Higher Education Press, 2015

2. *Modern Physics Experiment Tutorial* (3rd Edition), Wu Xianqiu, Science Press, 2023

Course websites

MYSTU Learning Platform: my.stu.edu.cn

Rain Classroom: https://stu.yuketang.cn

5. Teaching and Learning Activities*

Teaching Segment	Lectures (Theory)	Tutorial Session	Experiment	Semi-nar	Social Pratice	Project	Online Learning	Midterm test	Total
Hours (In-class)	4	0	48	0	0	12	0	0	64
Hours (Out-of-class)	4	0	12	24	0	24	0	0	64

6. Assessment Scheme

Assessment Component	Description	Weight
Laboratory Performance and Discipline	Complete experimental operations according to the requirements	40%
Reports and Communication	Submit experimental reports or deliver PPT presentations as required	50%
Pre-lab Preparation	Complete pre-lab preparation as required	10%

7. Course Schedule

Note: Due to limited availability of experimental instruments, the laboratory sessions are organized in four-week teaching units. The following schedule uses Group 1 as an example; detailed rotation arrangements are provided in the attached rotation table.

Week	Contact Hours	Teaching Format	Laboratory Content
1	4	Lecture	Safety training; laboratory regulations; course overview; grouping of students.
2	4	Laboratory Session	*Vacuum Generation and Measurement* and *Thermal Evaporation Coating*: introduction to experimental principles and methodology; instruction on instrument operation; observation and recording of experimental phenomena and results.
3	4	Laboratory Session	*Nuclear Magnetic Resonance (NMR)* experiment: explanation of principles and methodology; instruction on instrument operation; observation and documentation of results.
4	4	Laboratory Session	*Single-Photon Techniques* experiment: explanation of principles and methodology; instruction on instrument operation; observation and documentation of results.
5	4	Laboratory Session	*Ramsauer–Townsend Effect* experiment: explanation of principles and methodology; instruction on instrument operation; observation and documentation of results.
6	4	Presentation Session	Student presentations summarizing results and experimental experience from Weeks 2–5; instructor feedback and commentary.

*This section has been updated. For details, please refer to “Update Notes on the Teaching and Learning Activities of Advanced Physics Experiments” in the table of contents.

7	4	Laboratory Session	*Nuclear and Particle Physics* experiment: explanation of principles and methodology; instruction on instrument operation; observation and documentation of results.
8	4	Laboratory Session	*Franck–Hertz Experiment*: explanation of principles and methodology; instrument operation; observation and documentation of results.
9	4	Laboratory Session	*Zeeman Effect* experiment: explanation of principles and methodology; instruction on instrument operation; observation and documentation of results.
10	4	Laboratory Session	*Sodium Atomic Spectroscopy* experiment: explanation of principles and methodology; instruction on instrument operation; observation and documentation of results.
11	4	Presentation Session	Student presentations summarizing results and experimental experience from Weeks 7–10; instructor feedback and commentary.
12	4	Laboratory Session	*Weak-Signal Detection Techniques I*: explanation of principles and methodology; instruction on instrument operation.
13	4	Laboratory Session	*Weak-Signal Detection Techniques II*: continued instruction on instrument operation; observation and documentation of results.
14	4	Laboratory Session	*Microwave and Waveguide Characteristics I*: explanation of principles and methodology; instruction on instrument operation.
15	4	Laboratory Session	*Microwave and Waveguide Characteristics II*: continued instrument operation; observation and documentation of results.
16	4	Presentation Session	Student presentations summarizing results and experimental experience from Weeks 11–15; instructor feedback and commentary.

编号	实验名称	台套数	学生/周次	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	真空获得与测量，热蒸发镀膜技术	1	1		实验1-1	实验2-1	实验3-1	实验4-1		实验9-1	实验9-1	实验10-1	实验10-1		实验5-1	实验6-1	实验7-1	实验8-1	
			2		实验1-1	实验2-2	实验3-2	实验4-2		实验9-1	实验9-1	实验10-1	实验10-1		实验5-1	实验6-2	实验7-2	实验8-2	
2	核磁共振	2	3		实验2-1	实验3-1	实验4-1	实验1-1		实验9-1	实验9-1	实验10-2	实验10-2		实验6-1	实验7-1	实验8-1	实验5-1	
3	单光子计数	2	4		实验2-2	实验3-2	实验4-2	实验1-1		实验9-2	实验9-2	实验10-2	实验10-2		实验6-2	实验7-2	实验8-2	实验5-1	
4	冉绍尔汤普森效应	2	5		实验3-1	实验2-1	实验1-1	实验4-1	汇报	实验9-2	实验9-2	实验10-2	实验10-2	汇报	实验7-1	实验6-1	实验5-1	实验8-1	汇报
5	核与粒子物理实验	1	6		实验3-1	实验4-1	实验1-1	实验2-1		实验10-1	实验10-1	实验9-1	实验9-1		实验7-1	实验8-1	实验5-1	实验6-1	
6	钠原子光谱分析	2	7		实验3-2	实验4-2	实验1-1	实验2-2		实验10-1	实验10-1	实验9-1	实验9-1		实验7-2	实验8-2	实验5-1	实验6-2	
7	塞曼效应	2	8		实验3-2	实验1-1	实验4-2	实验2-2		实验10-2	实验10-2	实验9-1	实验9-1		实验7-2	实验5-1	实验8-2	实验6-2	
8	弗兰克赫兹实验	2	9		实验4-1	实验1-1	实验2-1	实验3-1		实验10-2	实验10-2	实验9-2	实验9-2		实验8-1	实验5-1	实验6-1	实验7-1	
9	微弱信号检测技术	2	10		实验4-2	实验1-1	实验2-2	实验3-2		实验10-2	实验10-2	实验9-2	实验9-2		实验8-2	实验5-1	实验6-2	实验7-2	
10	微波及波导特性	2	11		实验5-1	实验6-1	实验7-1	实验8-1		实验1-1	实验2-1	实验3-1	实验4-1		实验9-1	实验9-1	实验10-1	实验10-1	
			12		实验5-1	实验6-2	实验7-2	实验8-2		实验1-1	实验2-2	实验3-2	实验4-2		实验9-1	实验9-1	实验10-1	实验10-1	
			13		实验6-1	实验7-1	实验8-1	实验5-1		实验2-1	实验3-1	实验4-1	实验1-1		实验9-1	实验9-1	实验10-2	实验10-2	
			14		实验6-2	实验7-2	实验8-2	实验5-1		实验2-2	实验3-2	实验4-2	实验1-1		实验9-2	实验9-2	实验10-2	实验10-2	
			15	安全教育、绪论	实验7-1	实验6-1	实验5-1	实验8-1	汇报	实验3-1	实验2-1	实验1-1	实验4-1	汇报	实验9-2	实验9-2	实验10-2	实验10-2	汇报
			16		实验7-1	实验8-1	实验5-1	实验6-1		实验3-1	实验4-1	实验1-1	实验2-1		实验10-1	实验10-1	实验9-1	实验9-1	
			17		实验7-2	实验8-2	实验5-1	实验6-2		实验3-2	实验4-2	实验1-1	实验2-2		实验10-1	实验10-1	实验9-1	实验9-1	
			18		实验7-2	实验5-1	实验8-2	实验6-2		实验3-2	实验1-1	实验4-2	实验2-2		实验10-2	实验10-2	实验9-1	实验9-1	
			19		实验8-1	实验5-1	实验6-1	实验7-1		实验4-1	实验1-1	实验2-1	实验3-1		实验10-2	实验10-2	实验9-2	实验9-2	
			20		实验8-2	实验5-1	实验6-2	实验7-2		实验4-2	实验1-1	实验2-2	实验3-2		实验10-2	实验10-2	实验9-2	实验9-2	
			21		实验9-1	实验9-1	实验10-1	实验10-1		实验5-1	实验6-1	实验7-1	实验8-1		实验1-1	实验2-1	实验3-1	实验4-1	
			22		实验9-1	实验9-1	实验10-1	实验10-1		实验5-1	实验6-2	实验7-2	实验8-2		实验1-1	实验2-2	实验3-2	实验4-2	
			23		实验9-1	实验9-1	实验10-2	实验10-2		实验6-1	实验7-1	实验8-1	实验5-1		实验2-1	实验3-1	实验4-1	实验1-1	
			24		实验9-2	实验9-2	实验10-2	实验10-2		实验6-2	实验7-2	实验8-2	实验5-1		实验2-2	实验3-2	实验4-2	实验1-1	
			25		实验9-2	实验9-2	实验10-2	实验10-2	汇报	实验7-1	实验6-1	实验5-1	实验8-1	汇报	实验3-1	实验2-1	实验1-1	实验4-1	汇报
			26		实验10-1	实验10-1	实验9-1	实验9-1		实验7-1	实验8-1	实验5-1	实验6-1		实验3-1	实验4-1	实验1-1	实验2-1	
			27		实验10-1	实验10-1	实验9-1	实验9-1		实验7-2	实验8-2	实验5-1	实验6-2		实验3-2	实验4-2	实验1-1	实验2-2	
			28		实验10-2	实验10-2	实验9-1	实验9-1		实验7-2	实验5-1	实验8-2	实验6-2		实验3-2	实验1-1	实验4-2	实验2-2	
			29		实验10-2	实验10-2	实验9-2	实验9-2		实验8-1	实验5-1	实验6-1	实验7-1		实验4-1	实验1-1	实验2-1	实验3-1	
			30		实验10-2	实验10-2	实验9-2	实验9-2		实验8-2	实验5-1	实验6-2	实验7-2		实验4-2	实验1-1	实验2-2	实验3-2	

汕头大学本科教学

课程教学大纲

课程名（COURSE TITLE）：	近代物理实验 1
课程代码（COURSE CODE）：	PHY3070A
学分（CREDIT VALUE）：	2
课内课时（CONTACT HOURS）：	64
先修课要求（PRE-REQUISITE）	原子物理学、大学物理实验(2)
开课单位（DEPARTMENT/UNIT）：	物理学系
版本（VERSION）：	20240731-PHY3070A
课程负责人（COURSE COORDINATOR）：	(签章)
审核人（APPROVER）：	(签章)
审核日期（APPROVE DATE）：	2024/7/31

汕头大学理学院

2024 年 7 月

1、课程简介（Course Description）

近代物理实验 1（Advanced Physics Experiment 1）是物理学专业学生的专业必修课，是一门综合性的实验技术和实验方法课程。此门课为近代物理实验系列课程的第一部分，学生在掌握了经典物理理论和普通物理实验技术方法之后，学习近代物理学发展中的一些较先进和较综合的实验方法和技能，进一步提升物理实验的整体素养，加深对相关物理概念、理论和现象的理解。

本课程实验项目包括真空的获得与测量，热蒸发镀膜技术、核磁共振、单光子技术、核与粒子物理实验、冉绍尔汤普森效应、弗兰克赫兹实验、钠原子光谱分析、塞曼效应、微波及波导特性、微弱信号检测技术，部分是获得诺奖的工作，在物理学发展中有里程碑作用，其实验方法和技术有代表性。

通过本课程的学习，有助于学生加深对核心理论课程内容的理解，丰富和活跃学生的物理思想；在实验中锻炼他们的观察、分析和解决问题的能力，学习近代物理中的一些常用技术、方法和仪器，具备进行严谨科学实验探究的基本能力。在实验中培养学生的科学兴趣、科学精神，和为国家科技事业做奉献的追求。

本课程目标对应物理学专业人才培养方案毕业要求指标点：1.坚定的理想信念；2.正确价值观和社会责任感；3.2 掌握专业理论知识及复杂理论的学习能力；4.2 掌握专业工具和实验技巧；5.2 具备创新思维和研究能力；6.1 解决问题的研究和工程能力。

2、预期学习结果（Intended Learning Outcomes）

<table>
<tr><th>知识单元</th><th>知识点</th><th>初始程度</th><th>要求程度</th><th>预期学习结果</th></tr>
<tr><td rowspan="6">1. 真空的获得与测量，热蒸发镀膜技术</td><td>实验原理和实验思想</td><td>L1</td><td>L3</td><td rowspan="6">1.掌握实验的原理。
2.掌握设备的操作。
3.深化对专业知识的理解、应用和对复杂理论的学习能力。
4.在实验过程中主张正确价值观、责任感和理想信念。
5.完成分组任务，并对其他成员的贡献做出评价。</td></tr>
<tr><td>实验仪器操作使用</td><td>L1</td><td>L3</td></tr>
<tr><td>实验现象和结果</td><td>L1</td><td>L3</td></tr>
<tr><td>报告写作、结果分析</td><td>L1</td><td>L4</td></tr>
<tr><td>科学性和实践性</td><td>L1</td><td>L4</td></tr>
<tr><td>团队合作交流能力</td><td>L1</td><td>L5</td></tr>
<tr><td rowspan="6">2. 核磁共振</td><td>实验原理和实验思想</td><td>L1</td><td>L3</td><td rowspan="6">1.掌握实验的原理。
2.掌握设备的操作。
3.培养实验技巧，在解决问题中锻炼研究创新能力。
4.深化对专业知识的理解、应用和对复杂理论的学习能力。
5.在实验过程中主张正确价值观、责任感和理想信念。</td></tr>
<tr><td>实验仪器操作使用</td><td>L1</td><td>L3</td></tr>
<tr><td>实验现象和结果</td><td>L1</td><td>L3</td></tr>
<tr><td>报告写作、结果分析</td><td>L1</td><td>L4</td></tr>
<tr><td>科学性和实践性</td><td>L1</td><td>L4</td></tr>
<tr><td>团队合作交流能力</td><td>L1</td><td>L5</td></tr>
<tr><td rowspan="6">3.单光子技术</td><td>实验原理和实验思想</td><td>L1</td><td>L3</td><td rowspan="6">1.掌握实验的原理。
2.掌握设备的操作。
3.培养实验技巧，在解决问题中锻炼研究创新能力。
4.深化对专业知识的理解、应用和对复杂理论的学习能力。
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<tr><td>团队合作交流能力</td><td>L1</td><td>L5</td></tr>
<tr><td>4.核与粒子物</td><td>实验原理和实验思想</td><td>L1</td><td>L3</td><td>1.掌握实验的原理。</td></tr>
</table>

理实验	实验仪器操作使用	L1	L3	2.掌握设备的操作。 3.培养实验技巧，在解决问题中锻炼研究创新能力。 4.深化对专业知识的理解、应用和对复杂理论的学习能力。 5.在实验过程中主张正确价值观、责任感和理想信念。
	实验现象和结果	L1	L3	
	报告写作、结果分析	L1	L4	
	科学性和实践性	L1	L4	
	团队合作交流能力	L1	L5	
5.冉绍尔汤普森效应	实验原理和实验思想	L1	L3	1.掌握实验的原理。 2.掌握设备的操作。 3.培养实验技巧，在解决问题中锻炼研究创新能力。 4.深化对专业知识的理解、应用和对复杂理论的学习能力。 5.在实验过程中主张正确价值观、责任感和理想信念。
	实验仪器操作使用	L1	L3	
	实验现象和结果	L1	L3	
	报告写作、结果分析	L1	L4	
	科学性和实践性	L1	L4	
	团队合作交流能力	L1	L5	
6.弗兰克赫兹实验	实验原理和实验思想	L1	L3	1.掌握实验的原理。 2.掌握设备的操作。 3.培养实验技巧，在解决问题中锻炼研究创新能力。 4.深化对专业知识的理解、应用和对复杂理论的学习能力。 5.在实验过程中主张正确价值观、责任感和理想信念。
	实验仪器操作使用	L1	L3	
	实验现象和结果	L1	L3	
	报告写作、结果分析	L1	L4	
	科学性和实践性	L1	L4	
	团队合作交流能力	L1	L5	
7.钠原子光谱分析	实验原理和实验思想	L1	L3	1.掌握实验的原理。 2.掌握设备的操作。 3.培养实验技巧，在解决问题中锻炼研究创新能力。 4.深化对专业知识的理解、应用和对复杂理论的学习能力。 5.在实验过程中主张正确价值观、责任感和理想信念。
	实验仪器操作使用	L1	L3	
	实验现象和结果	L1	L3	
	报告写作、结果分析	L1	L4	
	科学性和实践性	L1	L4	
	团队合作交流能力	L1	L5	
8.塞曼效应	实验原理和实验思想	L1	L3	1.掌握实验的原理。 2.掌握设备的操作。 3.培养实验技巧，在解决问题中锻炼研究创新能力。 4.深化对专业知识的理解、应用和对复杂理论的学习能力。 5.在实验过程中主张正确价值观、责任感和理想信念。
	实验仪器操作使用	L1	L3	
	实验现象和结果	L1	L3	
	报告写作、结果分析	L1	L4	
	科学性和实践性	L1	L4	
	团队合作交流能力	L1	L5	
9. 微波及波导特性	实验原理和实验思想	L1	L3	1.掌握实验的原理。 2.掌握设备的操作。 3.培养实验技巧，在解决问题中锻炼研究创新能力。 4.深化对专业知识的理解、应用和对复杂理论的学习能力。 5.在实验过程中主张正确价值观、责任感和理想信念。
	实验仪器操作使用	L1	L3	
	实验现象和结果	L1	L3	
	报告写作、结果分析	L1	L4	
	科学性和实践性	L1	L4	
	团队合作交流能力	L1	L5	
10.微弱信号检测技术	实验原理和实验思想	L1	L3	1.掌握实验的原理。 2.掌握设备的操作。
	实验仪器操作使用	L1	L3	

	实验现象和结果	L1	L3	3.培养实验技巧，在解决问题中锻炼研究创新能力。 4.深化对专业知识的理解、应用和对复杂理论的学习能力。 5.在实验过程中主张正确价值观、责任感和理想信念。
	报告写作、结果分析	L1	L4	
	科学性和实践性	L1	L4	
	团队合作交流能力	L1	L5	

3、先修要求（Pre-requisite）

原子物理学、大学物理实验(2)

4、教材及其他教学资源（Textbooks and Other Learning Resources）

课程教材：

课程自编实验讲义

推荐参考资料：

《近代物理实验》（第四版） 吴思诚 荀坤 主编 高等教育出版社
《近代物理实验教程》（第三版） 吴先球 主编 科学出版社

课程网站与网络资源：

MYSTU 学习平台 https://my.stu.edu.cn
雨课堂 https://stu.yuketang.cn

5、主要教学环节（Teaching and Learning Activities）

教学环节	理论课(小时)	习题课(小时)	实验(小时)	研讨(小时)	社会实践(小时)	项目(小时)	在线学习(小时)	期中测试(小时)	合计
课内	0	0	52	0	0	12	0	0	64
课外	0	0	0	0	0	0	0	0	0

6、课程考核（Assessment Scheme）

考核项目	考核内容和考试方法简介	权重
实验操作和纪律	按要求完成实验操作	40%
报告及交流	按要求完成实验 ppt 汇报或实验报告	50%
预习准备	按要求完成实验预习	10%

7、学习进度（Course Schedule）

注：由于实验仪器台套数限制，除第一周绪论外，每五周为一教学单元，进行轮换教学，以下学习进度以第一组为例，具体轮换安排见后附轮换表

周次	教学时数	教学形式	教学内容
1	4	课堂教学	安全教育，实验室注意事项讲解，课程安排讲解，实验分组
2	4	实验课堂	真空的获得与测量，热蒸发镀膜技术实验：讲解实验原理和实验思想、讲解实验仪器操作使用、观察记录实验现象和结果。
3	4	实验课堂	核磁共振实验：讲解实验原理和实验思想、讲解实验仪器操作使用、观察记录实验现象和结果。
4	4	实验课堂	单光子技术实验：讲解实验原理和实验思想、讲解实验仪器操作使用、观察记录实验现象和结果。

5	4	实验课堂	冉绍尔汤普森效应实验：讲解实验原理和实验思想、讲解实验仪器操作使用、观察记录实验现象和结果。
6	4	课堂汇报	组织学生对 2-5 周实验的结果和实验过程的经验总结进行汇报，教师点评
7	4	实验课堂	核与粒子物理实验：讲解实验原理和实验思想、讲解实验仪器操作使用、观察记录实验现象和结果。
8	4	实验课堂	弗兰克赫兹实验：讲解实验原理和实验思想、讲解实验仪器操作使用、观察记录实验现象和结果。
9	4	实验课堂	塞曼效应实验：讲解实验原理和实验思想、讲解实验仪器操作使用、观察记录实验现象和结果。
10	4	实验课堂	钠原子光谱分析实验：讲解实验原理和实验思想、讲解实验仪器操作使用、观察记录实验现象和结果。
11	4	课堂汇报	组织学生对 7-10 周实验的结果和实验过程的经验总结进行汇报，教师点评
12	4	实验课堂	微弱信号检测技术实验-1：讲解实验原理和实验思想、讲解实验仪器操作使用。
13	4	实验课堂	微弱信号检测技术实验-2：讲解实验仪器操作使用（续）、观察记录实验现象和结果。
14	4	实验课堂	微波及波导特性-1：讲解实验原理和实验思想、讲解实验仪器操作使用。
15	4	实验课堂	微波及波导特性-2：讲解实验仪器操作使用（续）、观察记录实验现象和结果。
16	4	课堂汇报	组织学生对 11-15 周实验的结果和实验过程的经验总结进行汇报，教师点评

编号	实验名称	台套数	学生/周次	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	真空获得与测量，热蒸发镀膜技术	1	1	安全教育、绪论	实验1-1	实验2-1	实验3-1	实验4-1	汇报	实验9-1	实验9-1	实验10-1	实验10-1	汇报	实验5-1	实验6-1	实验7-1	实验8-1	汇报
			2		实验1-1	实验2-2	实验3-2	实验4-2		实验9-1	实验9-1	实验10-1	实验10-1		实验5-1	实验6-2	实验7-2	实验8-2	
2	核磁共振	2	3		实验2-1	实验3-1	实验4-1	实验1-1		实验9-1	实验9-1	实验10-2	实验10-2		实验6-1	实验7-1	实验8-1	实验5-1	
3	单光子计数	2	4		实验2-2	实验3-2	实验4-2	实验1-1		实验9-2	实验9-2	实验10-2	实验10-2		实验6-2	实验7-2	实验8-2	实验5-1	
4	冉绍尔汤普森效应	2	5		实验3-1	实验2-1	实验1-1	实验4-1		实验9-2	实验9-2	实验10-2	实验10-2		实验7-1	实验6-1	实验5-1	实验8-1	
5	核与粒子物理实验	1	6		实验3-1	实验4-1	实验1-1	实验2-1		实验10-1	实验10-1	实验9-1	实验9-1		实验7-1	实验8-1	实验5-1	实验6-1	
6	钠原子光谱分析	2	7		实验3-2	实验4-2	实验1-1	实验2-2		实验10-1	实验10-1	实验9-1	实验9-1		实验7-2	实验8-2	实验5-1	实验6-2	
7	塞曼效应	2	8		实验3-2	实验1-1	实验4-2	实验2-2		实验10-2	实验10-2	实验9-1	实验9-1		实验7-2	实验5-1	实验8-2	实验6-2	
8	弗兰克赫兹实验	2	9		实验4-1	实验1-1	实验2-1	实验3-1		实验10-2	实验10-2	实验9-2	实验9-2		实验8-1	实验5-1	实验6-1	实验7-1	
9	微弱信号检测技术	2	10		实验4-2	实验1-1	实验2-2	实验3-2		实验10-2	实验10-2	实验9-2	实验9-2		实验8-2	实验5-1	实验6-2	实验7-2	
10	微波及波导特性	2	11		实验5-1	实验6-1	实验7-1	实验8-1	汇报	实验1-1	实验2-1	实验3-1	实验4-1	汇报	实验9-1	实验9-1	实验10-1	实验10-1	汇报
			12		实验5-1	实验6-2	实验7-2	实验8-2		实验1-1	实验2-2	实验3-2	实验4-2		实验9-1	实验9-1	实验10-1	实验10-1	
			13		实验6-1	实验7-1	实验8-1	实验5-1		实验2-1	实验3-1	实验4-1	实验1-1		实验9-1	实验9-1	实验10-2	实验10-2	
			14		实验6-2	实验7-2	实验8-2	实验5-1		实验2-2	实验3-2	实验4-2	实验1-1		实验9-2	实验9-2	实验10-2	实验10-2	
			15		实验7-1	实验6-1	实验5-1	实验8-1		实验3-1	实验2-1	实验1-1	实验4-1		实验9-2	实验9-2	实验10-2	实验10-2	
			16		实验7-1	实验8-1	实验5-1	实验6-1		实验3-1	实验4-1	实验1-1	实验2-1		实验10-1	实验10-1	实验9-1	实验9-1	
			17		实验7-2	实验8-2	实验5-1	实验6-2		实验3-2	实验4-2	实验1-1	实验2-2		实验10-1	实验10-1	实验9-1	实验9-1	
			18		实验7-2	实验5-1	实验8-2	实验6-2		实验3-2	实验1-1	实验4-2	实验2-2		实验10-2	实验10-2	实验9-1	实验9-1	
			19		实验8-1	实验5-1	实验6-1	实验7-1		实验4-1	实验1-1	实验2-1	实验3-1		实验10-2	实验10-2	实验9-2	实验9-2	
			20		实验8-2	实验5-1	实验6-2	实验7-2		实验4-2	实验1-1	实验2-2	实验3-2		实验10-2	实验10-2	实验9-2	实验9-2	
			21		实验9-1	实验9-1	实验10-1	实验10-1	汇报	实验5-1	实验6-1	实验7-1	实验8-1	汇报	实验1-1	实验2-1	实验3-1	实验4-1	汇报
			22		实验9-1	实验9-1	实验10-1	实验10-1		实验5-1	实验6-2	实验7-2	实验8-2		实验1-1	实验2-2	实验3-2	实验4-2	
			23		实验9-1	实验9-1	实验10-2	实验10-2		实验6-1	实验7-1	实验8-1	实验5-1		实验2-1	实验3-1	实验4-1	实验1-1	
			24		实验9-2	实验9-2	实验10-2	实验10-2		实验6-2	实验7-2	实验8-2	实验5-1		实验2-2	实验3-2	实验4-2	实验1-1	
			25		实验9-2	实验9-2	实验10-2	实验10-2		实验7-1	实验6-1	实验5-1	实验8-1		实验3-1	实验2-1	实验1-1	实验4-1	
			26		实验10-1	实验10-1	实验9-1	实验9-1		实验7-1	实验8-1	实验5-1	实验6-1		实验3-1	实验4-1	实验1-1	实验2-1	
			27		实验10-1	实验10-1	实验9-1	实验9-1		实验7-2	实验8-2	实验5-1	实验6-2		实验3-2	实验4-2	实验1-1	实验2-2	
			28		实验10-2	实验10-2	实验9-1	实验9-1		实验7-2	实验5-1	实验8-2	实验6-2		实验3-2	实验1-1	实验4-2	实验2-2	
			29		实验10-2	实验10-2	实验9-2	实验9-2		实验8-1	实验5-1	实验6-1	实验7-1		实验4-1	实验1-1	实验2-1	实验3-1	
			30		实验10-2	实验10-2	实验9-2	实验9-2		实验8-2	实验5-1	实验6-2	实验7-2		实验4-2	实验1-1	实验2-2	实验3-2	

Shantou University

Module Description for Undergraduate Courses

COURSE TITLE:	Advanced Physics Experiment
COURSE CODE:	PHY3080A
CREDIT VALUE:	2
CONTACT HOURS:	64
PRE-REQUISITE	Modern physics experiments 1, Quantum Mechanics 1
DEPARTMENT/UNIT:	Department of Physics
VERSION:	20240731-PHY3080A
COURSE COORDINATOR:	(Signature and Seal)
APPROVER:	(Signature and Seal)
APPROVE DATE:	20240731

Shantou University Faculty of Science

July 2024

1. Course Description

Advanced Physics Experiment (The original document lists the course as “Advanced Physics Experiments 2,” while the transcript shows it as “Advanced Physics Experiments.” Therefore, this document will uniformly use “Advanced Physics Experiments.”) is a compulsory course for undergraduate students majoring in Physics. It is a comprehensive course on experimental techniques and methods. As the second part of the Modern Physics Experiment series, this course builds on students’ mastery of classical physics theories and basic experimental techniques, introducing more advanced and integrated experimental methods developed in modern physics. The course aims to further enhance students’ overall experimental literacy and deepen their understanding of relevant physical concepts, theories, and phenomena.

The experimental projects include optically pumped magnetic resonance, surface plasmon resonance-based liquid refractive index measurement, ellipsometry, crystal electro-optic modulation, electron diffraction, electron spin resonance, tunnel magnetoresistance effect, C-V measurement of semiconductor junctions, temperature-dependent Hall measurement, molecular and crystal Raman spectroscopy, optical spin Hall effect and quantum weak measurement. Many of these experiments are based on Nobel Prize-winning work and have played milestone roles in the development of physics. They represent key experimental methods and techniques.

Through this course, students are expected to enhance their understanding of core theoretical courses, enrich and stimulate their physical intuition, and develop observation, analysis, and problem-solving skills. They will learn common experimental techniques, methods, and instruments in modern physics, and acquire the fundamental ability to conduct rigorous scientific investigations. The course also aims to cultivate students’ scientific interest and spirit, as well as a dedication to contributing to national scientific and technological development.

This course aligns with the graduation requirements for Physics undergraduates, including:

3.2 Mastery of professional theoretical knowledge and the ability to learn complex theories;
4.2 Mastery of professional tools and experimental skills;
5.2 Development of innovative thinking and research abilities;
6.1 Research and engineering problem-solving capabilities.

2. Intended Learning Outcomes

Knowledge Unit	Key Knowledge Points	Initial Level	Target Level	Expected Learning Outcomes
1. Optically Pumped Magnetic Resonance	Experimental principle and philosophy	L1	L3	1. Master the experimental principle. 2. Operate the equipment proficiently. 3. Develop professional knowledge application and ability to learn complex theories. 4. Uphold responsibility, and academic ideals. 5. Complete group tasks and evaluate other members' contributions.
	Instrument operation	L1	L3	
	Experimental phenomena and results	L1	L3	
	Report writing and result analysis	L1	L4	
	Scientific rigor and practical skills	L1	L4	
	Teamwork and communication	L1	L5	
2. Surface Plasmon Resonance for Liquid Refractive Index Measurement	Experimental principle and philosophy	L1	L3	1. Master the principle. 2. Operate the equipment proficiently. 3. Develop experimental skills and cultivate research
	Instrument operation	L1	L3	
	Experimental phenomena and results	L1	L3	

	Report writing and result analysis	L1	L4	innovation in problem-solving. 4. Deepen understanding and application of professional knowledge. 5. Uphold, responsibility, and academic ideals.
	Scientific rigor and practical skills	L1	L4	
	Teamwork and communication	L1	L5	
3. Ellipsometry	Experimental principle and philosophy	L1	L3	1. Master the principle. 2. Operate the equipment proficiently. 3. Develop experimental skills and cultivate research innovation in problem-solving. 4. Deepen understanding and application of professional knowledge. 5. Uphold, responsibility, and academic ideals.
	Instrument operation	L1	L3	
	Experimental phenomena and results	L1	L3	
	Report writing and result analysis	L1	L4	
	Scientific rigor and practical skills	L1	L4	
	Teamwork and communication	L1	L5	
4. Crystal Electro-optic Modulation	Experimental principle and philosophy	L1	L3	1. Master the principle. 2. Operate the equipment proficiently. 3. Develop experimental skills and cultivate research innovation in problem-solving. 4. Deepen understanding and application of professional knowledge. 5. Uphold, responsibility, and academic ideals.
	Instrument operation	L1	L3	
	Experimental phenomena and results	L1	L3	
	Report writing and result analysis	L1	L4	
	Scientific rigor and practical skills	L1	L4	
	Teamwork and communication	L1	L5	
5. Electron Diffraction	Experimental principle and philosophy	L1	L3	1. Master the principle. 2. Operate the equipment proficiently. 3. Develop experimental skills and cultivate research innovation in problem-solving. 4. Deepen understanding and application of professional knowledge. 5. Uphold, responsibility, and academic ideals.
	Instrument operation	L1	L3	
	Experimental phenomena and results	L1	L3	
	Report writing and result analysis	L1	L4	
	Scientific rigor and practical skills	L1	L4	
	Teamwork and communication	L1	L5	

6. Electron Paramagnetic Resonance	Experimental principle and philosophy	L1	L3	1. Master the principle. 2. Operate the equipment proficiently. 3. Develop experimental skills and cultivate research innovation in problem-solving. 4. Deepen understanding and application of professional knowledge. 5. Uphold, responsibility, and academic ideals.
	Instrument operation	L1	L3	
	Experimental phenomena and results	L1	L3	
	Report writing and result analysis	L1	L4	
	Scientific rigor and practical skills	L1	L4	
	Teamwork and communication	L1	L5	
7. Tunnel Magnetoresistance Effect	Experimental principle and philosophy	L1	L3	1. Master the principle. 2. Operate the equipment proficiently. 3. Develop experimental skills and cultivate research innovation in problem-solving. 4. Deepen understanding and application of professional knowledge. 5. Uphold, responsibility, and academic ideals.
	Instrument operation	L1	L3	
	Experimental phenomena and results	L1	L3	
	Report writing and result analysis	L1	L4	
	Scientific rigor and practical skills	L1	L4	
	Teamwork and communication	L1	L5	
8. Semiconductor Junction C-V Measurement	Experimental principle and philosophy	L1	L3	1. Master the principle. 2. Operate the equipment proficiently. 3. Develop experimental skills and cultivate research innovation in problem-solving. 4. Deepen understanding and application of professional knowledge. 5. Uphold, responsibility, and academic ideals.
	Instrument operation	L1	L3	
	Experimental phenomena and results	L1	L3	
	Report writing and result analysis	L1	L4	
	Scientific rigor and practical skills	L1	L4	
	Teamwork and communication	L1	L5	
9. Variable Temperature Hall Measurement	Experimental principle and philosophy	L1	L3	1. Master the principle. 2. Operate the equipment proficiently. 3. Develop experimental skills and cultivate research
	Instrument operation	L1	L3	
	Experimental phenomena and results	L1	L3	

	Report writing and result analysis	L1	L4	innovation in problem-solving. 4. Deepen understanding and application of professional knowledge. 5. Uphold, responsibility, and academic ideals.
	Scientific rigor and practical skills	L1	L4	
	Teamwork and communication	L1	L5	
10. Molecular and Crystal Raman Spectroscopy	Experimental principle and philosophy	L1	L3	1. Master the principle. 2. Operate the equipment proficiently. 3. Develop experimental skills and cultivate research innovation in problem-solving. 4. Deepen understanding and application of professional knowledge. 5. Uphold, responsibility, and academic ideals.
	Instrument operation	L1	L3	
	Experimental phenomena and results	L1	L3	
	Report writing and result analysis	L1	L4	
	Scientific rigor and practical skills	L1	L4	
	Teamwork and communication	L1	L5	
11. Optical Spin Hall Effect & Quantum Weak Measurement	Experimental principle and philosophy	L1	L3	1. Master the principle. 2. Operate the equipment proficiently. 3. Develop experimental skills and cultivate research innovation in problem-solving. 4. Deepen understanding and application of professional knowledge. 5. Uphold, responsibility, and academic ideals.
	Instrument operation	L1	L3	
	Experimental phenomena and results	L1	L3	
	Report writing and result analysis	L1	L4	
	Scientific rigor and practical skills	L1	L4	
	Teamwork and communication	L1	L5	

3. Pre-requisit

Modern physics experiments 1、Quantum Mechanics 1

4. Textbooks and Other Learning Resources

Textbook:

Self-prepared Laboratory Manual for the Course

Recommended References

1. *Modern Physics Experiments* (4th Edition), Wu Sicheng & Xun Kun, Higher Education Press, 2015

2. *Modern Physics Experiment Tutorial* (3rd Edition), Wu Xianqiu, Science Press, 2023

Course website

MYSTU Learning Platform: my.stu.edu.cn

Rain Classroom: https://stu.yuketang.cn

5. Teaching and Learning Activities*

Teaching Segment	Lectures (Theory)	Tutorial Session	Experi-ment	Seminar	Social Pratice	Project	Online Learning	Other	Total
Hours (In-class)	0	0	52	0	0	12	0	0	64
Hours (Out-of-class)	0	0	0	0	0	0	0	0	0

6. Assessment Scheme

Assessment Component	Description	Weight
Laboratory Performance and Discipline	Complete experimental operations according to the require-ments	40%
Reports and Communi-cation	Submit experimental reports or deliver PPT presentations as required	50%
Pre-lab Preparation	Complete pre-lab preparation as required	10%

7. Course Schedule

Note: Due to limited availability of experimental instruments, the laboratory sessions are organized in four-week teaching units. The following schedule uses Group 1 as an example; detailed rotation arrangements are provided in the attached rotation table.

Week	Contact Hours	Teaching Format	Laboratory Content
1	4	Laboratory Session	**Optical Pumping Magnetic Resonance (OPMR)**: Introduction to experimental principles and concepts, equipment operation, observation and recording of experimental phenomena and results.
2	4	Laboratory Session	**Surface Plasmon Resonance (SPR) for Liquid Refractive Index Measurement**: Introduction to experimental principles and concepts, equipment operation, observation and recording of experimental phenomena and results.
3	4	Laboratory Session	**Ellipsometry Measurement Technique**: Introduction to experimental principles and concepts, equipment operation, observation and recording of experimental phenomena and results.

*This section has been updated. For details, please refer to “Update Notes on the Teaching and Learning Activities of Advanced Physics Experiments” in the table of contents.

4	4	Class Presentation	Students present and summarize results and experiences from Weeks 1–3 experiments; instructor provides feedback.
5	4	Laboratory Session	**Crystal Electro-optic Modulation**: Introduction to experimental principles and concepts, equipment operation, observation and recording of experimental phenomena and results.
6	4	Laboratory Session	**Electron Diffraction**: Introduction to experimental principles and concepts, equipment operation, observation and recording of experimental phenomena and results.
7	4	Laboratory Session	**Electron Spin Resonance (ESR)**: Introduction to experimental principles and concepts, equipment operation, observation and recording of experimental phenomena and results.
8	4	Class Presentation	Students present and summarize results and experiences from Weeks 5–7 experiments; instructor provides feedback.
9	4	Laboratory Session	**Tunneling Magnetoresistance (TMR) Effect**: Introduction to experimental principles and concepts, equipment operation, observation and recording of experimental phenomena and results.
10	4	Laboratory Session	**C-V Measurement of Semiconductor Junctions**: Introduction to experimental principles and concepts, equipment operation, observation and recording of experimental phenomena and results.
11	4	Laboratory Session	**Variable-Temperature Hall Measurement**: Introduction to experimental principles and concepts, equipment operation, observation and recording of experimental phenomena and results.
12	4	Class Presentation	Students present and summarize results and experiences from Weeks 9–11 experiments; instructor provides feedback.
13	4	Laboratory Session	**Molecular and Crystal Raman Spectroscopy – Part 1**: Introduction to experimental principles and concepts, equipment operation.
14	4	Laboratory Session	**Molecular and Crystal Raman Spectroscopy – Part 2**: Continuation of equipment operation, observation and recording of experimental phenomena and results.
15	4	Laboratory Session	**Optical Spin Hall Effect & Quantum Weak Measurement – Part 1**: Introduction to experimental principles and concepts, equipment operation.
16	4	Laboratory Session	**Optical Spin Hall Effect & Quantum Weak Measurement – Part 2**: Continuation of equipment operation, observation and recording of experimental phenomena and results.

编号	实验名称	台套数	学生/周次	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	表面等离激元共振	2	万昀晶	实验1-1	实验2-1	实验3-1	实验4-1	汇报	实验9-1	实验10-1	实验11-1	实验12-1	五一放假	汇报	实验5-1	实验6-1	实验7-1	实验8-1	汇报
2	电子自旋共振	2	苏美婷	实验1-2	实验2-2	实验3-2	实验4-2		实验9-1	实验10-1	实验11-1	实验12-2			实验5-2	实验6-2	实验7-2	实验8-2	
3	光泵磁共振	2	陈彦东	实验2-1	实验3-1	实验4-1	实验1-1		实验9-1	实验10-2	实验11-1	实验12-2			实验6-1	实验7-1	实验8-1	实验5-1	
4	光速测量	2	古豫	实验2-2	实验3-2	实验4-2	实验1-1		实验11-1	实验12-1	实验9-1	实验10-1			实验6-2	实验7-2	实验8-2	实验5-1	
5	隧道磁阻	2	钟元	实验3-1	实验2-1	实验1-1	实验4-1		实验11-1	实验12-1	实验9-1	实验10-1			实验7-1	实验6-1	实验5-1	实验8-1	
6	激光模式	2	蔡雨馨	实验3-1	实验4-1	实验1-1	实验2-1		实验11-1	实验12-2	实验9-1	实验10-2			实验7-1	实验8-1	实验5-1	实验6-1	
7	黑体辐射	2	魏志翔	实验3-2	实验4-2	实验1-1	实验2-2		实验10-1	实验11-1	实验12-1	实验9-1			实验7-2	实验8-2	实验5-1	实验6-2	
8	电子衍射	2	张文轩	实验3-2	实验1-1	实验4-2	实验2-2		实验10-2	实验11-1	实验12-2	实验9-1			实验7-2	实验5-1	实验8-2	实验6-2	
9	拉曼光谱	1	黄力文	实验4-1	实验1-1	实验2-1	实验3-1		实验12-1	实验9-1	实验10-1	实验11-1			实验8-1	实验5-2	实验6-1	实验7-1	
10	椭偏光谱	2	丘兰坤	实验4-2	实验1-2	实验2-2	实验3-2		实验12-2	实验9-1	实验10-2	实验11-1			实验8-2	实验5-2	实验6-2	实验7-2	
11	高温超导	1	刘恭文	实验5-1	实验6-1	实验7-1	实验8-1	汇报	实验1-1	实验2-1	实验3-1	实验4-1		汇报	实验9-1	实验10-1	实验11-1	实验12-1	汇报
12	变温霍尔	2	梁竞宇	实验5-2	实验6-2	实验7-2	实验8-2		实验1-2	实验2-2	实验3-2	实验4-2			实验9-1	实验10-1	实验11-1	实验12-2	
			潘明辉	实验6-1	实验7-1	实验8-1	实验5-1		实验2-1	实验3-1	实验4-1	实验1-1			实验9-1	实验10-2	实验11-1	实验12-2	
			孙静雪	实验6-2	实验7-2	实验8-2	实验5-1		实验2-2	实验3-2	实验4-2	实验1-1			实验11-1	实验12-1	实验9-1	实验10-1	
			谢延祖	实验7-1	实验6-1	实验5-1	实验8-1		实验3-1	实验2-1	实验1-1	实验4-1			实验11-1	实验12-1	实验9-1	实验10-1	
			王昭霖	实验7-1	实验8-1	实验5-1	实验6-1		实验3-1	实验4-1	实验1-1	实验2-1			实验11-1	实验12-2	实验9-1	实验10-2	
			陈宝仪	实验7-2	实验8-2	实验5-1	实验6-2		实验3-2	实验4-2	实验1-1	实验2-2			实验10-1	实验11-1	实验12-1	实验9-1	
			苏志斌	实验7-2	实验5-1	实验8-2	实验6-2		实验3-2	实验1-1	实验4-2	实验2-2			实验10-2	实验11-1	实验12-2	实验9-1	
			张智铸	实验8-1	实验5-2	实验6-1	实验7-1		实验4-1	实验1-1	实验2-1	实验3-1			实验12-1	实验9-1	实验10-1	实验11-1	
			韦荣良	实验8-2	实验5-2	实验6-2	实验7-2		实验4-2	实验1-2	实验2-2	实验3-2			实验12-2	实验9-1	实验10-2	实验11-1	
			毛锦驹	实验9-1	实验10-1	实验11-1	实验12-1	汇报	实验5-1	实验6-1	实验7-1	实验8-1		汇报	实验1-1	实验2-1	实验3-1	实验4-1	汇报
			陈殷	实验9-1	实验10-1	实验11-1	实验12-2		实验5-2	实验6-2	实验7-2	实验8-2			实验1-2	实验2-2	实验3-2	实验4-2	
			梁浩均	实验9-1	实验10-2	实验11-1	实验12-2		实验6-1	实验7-1	实验8-1	实验5-1			实验2-1	实验3-1	实验4-1	实验1-1	
			曹瀚文	实验11-1	实验12-1	实验9-1	实验10-1		实验6-2	实验7-2	实验8-2	实验5-1			实验2-2	实验3-2	实验4-2	实验1-1	
			洪灿纯	实验11-1	实验12-1	实验9-1	实验10-1		实验7-1	实验6-1	实验5-1	实验8-1			实验3-1	实验2-1	实验1-1	实验4-1	
			曾令豪	实验11-1	实验12-2	实验9-1	实验10-2		实验7-1	实验8-1	实验5-1	实验6-1			实验3-1	实验4-1	实验1-1	实验2-1	
			蔡铭灿	实验10-1	实验11-1	实验12-1	实验9-1		实验7-2	实验8-2	实验5-1	实验6-2			实验3-2	实验4-2	实验1-1	实验2-2	
			窦俊宇	实验10-2	实验11-1	实验12-2	实验9-1		实验7-2	实验5-1	实验8-2	实验6-2			实验3-2	实验1-1	实验4-2	实验2-2	
			李路田	实验12-1	实验9-1	实验10-1	实验11-1		实验8-1	实验5-2	实验6-1	实验7-1			实验4-1	实验1-1	实验2-1	实验3-1	
			潘恬恬	实验12-2	实验9-1	实验10-2	实验11-1		实验8-2	实验5-2	实验6-2	实验7-2			实验4-2	实验1-2	实验2-2	实验3-2	

汕头大学本科教学

课程教学大纲

课程名（COURSE TITLE）： 近代物理实验 2

课程代码（COURSE CODE）： PHY3080A

学分（CREDIT VALUE）： 2

课内课时（CONTACT HOURS）： 64

先修课要求（PRE-REQUISITE） 近代物理实验 1、量子力学 1

开课单位（DEPARTMENT/UNIT）： 物理学系

版本（VERSION）： 20240731-PHY3080A

课程负责人（COURSE COORDINATOR）： (签章)

审核人（APPROVER）： (签章)

审核日期（APPROVE DATE）： 20240731

汕头大学理学院

2024 年 7 月

1、课程简介（Course Description）

近代物理实验 2（Advanced Physics Experiment 2）是物理学专业学生的专业必修课，是一门综合性的实验技术和实验方法课程。此门课为近代物理实验系列课程的第二部分，学生在掌握了经典物理理论和普通物理实验技术方法之后，学习近代物理学发展中的一些较先进和较综合的实验方法和技能，进一步提升物理实验的整体素养，加深对相关物理概念、理论和现象的理解。

本课程实验项目包括光泵磁共振、表面等离激元共振法测液体折射率、椭偏光谱测量技术、晶体电光调制技术、电子衍射、电子自旋共振、隧道磁电阻效应、半导体结 C-V 测量技术、变温霍尔测量技术、分子与晶体拉曼光谱、光自旋霍尔效应与量子弱测量，大部分是获得诺奖的工作，在物理学发展中有里程碑作用，其实验方法和技术有代表性。

通过本课程的学习，有助于学生加深对核心理论课程内容的理解，丰富和活跃学生的物理思想；在实验中锻炼他们的观察、分析和解决问题的能力，学习近代物理中的一些常用技术、方法和仪器，具备进行严谨科学实验探究的基本能力。在实验中培养学生的科学兴趣、科学精神，和为国家科技事业做奉献的追求。

本课程目标对应物理学专业人才培养方案毕业要求指标点：1.坚定的理想信念；2.正确价值观和社会责任感；3.2 掌握专业理论知识及复杂理论的学习能力；4.2 掌握专业工具和实验技巧；5.2 具备创新思维和研究能力；6.1 解决问题的研究和工程能力。

2、预期学习结果（Intended Learning Outcomes）

<table>
<tr><th>知识单元</th><th>知识点</th><th>初始程度</th><th>要求程度</th><th>预期学习结果</th></tr>
<tr><td rowspan="6">1. 光泵磁共振</td><td>实验原理和实验思想</td><td>L1</td><td>L3</td><td rowspan="6">1.掌握实验的原理。
2.掌握设备的操作。
3.深化对专业知识的理解、应用和对复杂理论的学习能力。
4.在实验过程中主张正确价值观、责任感和理想信念。
5.完成分组任务，并对其他成员的贡献做出评价。</td></tr>
<tr><td>实验仪器操作使用</td><td>L1</td><td>L3</td></tr>
<tr><td>实验现象和结果</td><td>L1</td><td>L3</td></tr>
<tr><td>报告写作、结果分析</td><td>L1</td><td>L4</td></tr>
<tr><td>科学性和实践性</td><td>L1</td><td>L4</td></tr>
<tr><td>团队合作交流能力</td><td>L1</td><td>L5</td></tr>
<tr><td rowspan="6">2. 表面等离激元共振法测液体折射率</td><td>实验原理和实验思想</td><td>L1</td><td>L3</td><td rowspan="6">1.掌握实验的原理。
2.掌握设备的操作。
3.培养实验技巧，在解决问题中锻炼研究创新能力。
4.深化对专业知识的理解、应用和对复杂理论的学习能力。
5.在实验过程中主张正确价值观、责任感和理想信念。</td></tr>
<tr><td>实验仪器操作使用</td><td>L1</td><td>L3</td></tr>
<tr><td>实验现象和结果</td><td>L1</td><td>L3</td></tr>
<tr><td>报告写作、结果分析</td><td>L1</td><td>L4</td></tr>
<tr><td>科学性和实践性</td><td>L1</td><td>L4</td></tr>
<tr><td>团队合作交流能力</td><td>L1</td><td>L5</td></tr>
<tr><td rowspan="6">3. 椭偏光谱测量技术</td><td>实验原理和实验思想</td><td>L1</td><td>L3</td><td rowspan="6">1.掌握实验的原理。
2.掌握设备的操作。
3.培养实验技巧，在解决问题中锻炼研究创新能力。
4.深化对专业知识的理解、应用和对复杂理论的学习能力。
5.在实验过程中主张正确价值观、责任感和理想信念。</td></tr>
<tr><td>实验仪器操作使用</td><td>L1</td><td>L3</td></tr>
<tr><td>实验现象和结果</td><td>L1</td><td>L3</td></tr>
<tr><td>报告写作、结果分析</td><td>L1</td><td>L4</td></tr>
<tr><td>科学性和实践性</td><td>L1</td><td>L4</td></tr>
<tr><td>团队合作交流能力</td><td>L1</td><td>L5</td></tr>
</table>

4. 晶体电光调制技术	实验原理和实验思想	L1	L3	1.掌握实验的原理。 2.掌握设备的操作。 3.培养实验技巧，在解决问题中锻炼研究创新能力。 4.深化对专业知识的理解、应用和对复杂理论的学习能力。 5.在实验过程中主张正确价值观、责任感和理想信念。
	实验仪器操作使用	L1	L3	
	实验现象和结果	L1	L3	
	报告写作、结果分析	L1	L4	
	科学性和实践性	L1	L4	
	团队合作交流能力	L1	L5	
5. 电子衍射	实验原理和实验思想	L1	L3	1.掌握实验的原理。 2.掌握设备的操作。 3.培养实验技巧，在解决问题中锻炼研究创新能力。 4.深化对专业知识的理解、应用和对复杂理论的学习能力。 5.在实验过程中主张正确价值观、责任感和理想信念。
	实验仪器操作使用	L1	L3	
	实验现象和结果	L1	L3	
	报告写作、结果分析	L1	L4	
	科学性和实践性	L1	L4	
	团队合作交流能力	L1	L5	
6. 电子自旋共振	实验原理和实验思想	L1	L3	1.掌握实验的原理。 2.掌握设备的操作。 3.培养实验技巧，在解决问题中锻炼研究创新能力。 4.深化对专业知识的理解、应用和对复杂理论的学习能力。 5.在实验过程中主张正确价值观、责任感和理想信念。
	实验仪器操作使用	L1	L3	
	实验现象和结果	L1	L3	
	报告写作、结果分析	L1	L4	
	科学性和实践性	L1	L4	
	团队合作交流能力	L1	L5	
7. 隧道磁电阻效应	实验原理和实验思想	L1	L3	1.掌握实验的原理。 2.掌握设备的操作。 3.培养实验技巧，在解决问题中锻炼研究创新能力。 4.深化对专业知识的理解、应用和对复杂理论的学习能力。 5.在实验过程中主张正确价值观、责任感和理想信念。
	实验仪器操作使用	L1	L3	
	实验现象和结果	L1	L3	
	报告写作、结果分析	L1	L4	
	科学性和实践性	L1	L4	
	团队合作交流能力	L1	L5	
8. 半导体结 C-V 测量技术	实验原理和实验思想	L1	L3	1.掌握实验的原理。 2.掌握设备的操作。 3.培养实验技巧，在解决问题中锻炼研究创新能力。 4.深化对专业知识的理解、应用和对复杂理论的学习能力。 5.在实验过程中主张正确价值观、责任感和理想信念。
	实验仪器操作使用	L1	L3	
	实验现象和结果	L1	L3	
	报告写作、结果分析	L1	L4	
	科学性和实践性	L1	L4	
	团队合作交流能力	L1	L5	
9. 变温霍尔测量技术	实验原理和实验思想	L1	L3	1.掌握实验的原理。 2.掌握设备的操作。 3.培养实验技巧，在解决问题中锻炼研究创新能力。 4.深化对专业知识的理解、应用和对复杂理论的学习能力。 5.在实验过程中主张正确价值观、责任感和理想信念。
	实验仪器操作使用	L1	L3	
	实验现象和结果	L1	L3	
	报告写作、结果分析	L1	L4	
	科学性和实践性	L1	L4	
	团队合作交流能力	L1	L5	
10. 分子与晶体拉曼光谱	实验原理和实验思想	L1	L3	1.掌握实验的原理。 2.掌握设备的操作。
	实验仪器操作使用	L1	L3	

	实验现象和结果	L1	L3	3.培养实验技巧，在解决问题中锻炼研究创新能力。 4.深化对专业知识的理解、应用和对复杂理论的学习能力。 5.在实验过程中主张正确价值观、责任感和理想信念。
	报告写作、结果分析	L1	L4	
	科学性和实践性	L1	L4	
	团队合作交流能力	L1	L5	
11. 光自旋霍尔效应与量子弱测量	实验原理和实验思想	L1	L3	1.掌握实验的原理。 2.掌握设备的操作。 3.培养实验技巧，在解决问题中锻炼研究创新能力。 4.深化对专业知识的理解、应用和对复杂理论的学习能力。 5.在实验过程中主张正确价值观、责任感和理想信念。
	实验仪器操作使用	L1	L3	
	实验现象和结果	L1	L3	
	报告写作、结果分析	L1	L4	
	科学性和实践性	L1	L4	
	团队合作交流能力	L1	L5	

3、先修要求（Pre-requisite）

量子力学 1、近代物理实验 1

4、教材及其他教学资源（Textbooks and Other Learning Resources）

课程教材：

课程自编实验讲义

推荐参考资料：

《近代物理实验》（第四版） 吴思诚 荀坤 主编 高等教育出版社 2015 年
《近代物理实验教程》（第三版） 吴先球 主编 科学出版社 2023 年

课程网站与网络资源：

MYSTU 学习平台 https://my.stu.edu.cn
雨课堂 https://stu.yuketang.cn

5、主要教学环节（Teaching and Learning Activities）

教学环节	理论课(小时)	习题课(小时)	实验(小时)	研讨(小时)	社会实践(小时)	项目(小时)	在线学习(小时)	期中测试(小时)	合计
课内	0	0	52	0	0	12	0	0	64
课外	0	0	0	0	0	0	0	0	0

6、课程考核（Assessment Scheme）

考核项目	考核内容和考试方法简介	权重
实验操作和纪律	按要求完成实验操作	40%
报告及交流	按要求完成实验 ppt 汇报或实验报告	50%
预习准备	按要求完成实验预习	10%

7、学习进度（Course Schedule）

注：由于实验仪器台套数限制，以每四周为一教学单元，进行轮换教学，以下学习进度以第一组为例，具体轮换安排见后附轮换表

周次	教学时数	教学形式	教学内容
1	4	实验课堂	光泵磁共振实验：讲解实验原理和实验思想、讲解实验仪器操作使用、观察记录实验现象和结果。
2	4	实验课堂	表面等离激元共振法测液体折射率实验：讲解实验原理和实验思想、讲解实验仪器操作使用、观察记录实验现象和结果。
3	4	实验课堂	椭偏测量技术实验：讲解实验原理和实验思想、讲解实验仪器操作使用、观察记录实验现象和结果。
4	4	课堂汇报	组织学生对 1-3 周实验的结果和实验过程的经验总结进行汇报，教师点评
5	4	实验课堂	晶体电光调制技术：讲解实验原理和实验思想、讲解实验仪器操作使用、观察记录实验现象和结果。
6	4	实验课堂	电子衍射实验：讲解实验原理和实验思想、讲解实验仪器操作使用、观察记录实验现象和结果。
7	4	实验课堂	电子自旋共振：讲解实验原理和实验思想、讲解实验仪器操作使用、观察记录实验现象和结果。
8	4	课堂汇报	组织学生对 5-7 周实验的结果和实验过程的经验总结进行汇报，教师点评
9	4	实验课堂	隧道磁电阻效应实验：讲解实验原理和实验思想、讲解实验仪器操作使用、观察记录实验现象和结果。
10	4	实验课堂	半导体结 C-V 测量技术实验：讲解实验原理和实验思想、讲解实验仪器操作使用、观察记录实验现象和结果。
11	4	实验课堂	变温霍尔测量技术实验：讲解实验原理和实验思想、讲解实验仪器操作使用、观察记录实验现象和结果。
12	4	课堂汇报	组织学生对 9-11 周实验的结果和实验过程的经验总结进行汇报，教师点评
13	4	实验课堂	分子与晶体拉曼光谱实验-1：讲解实验原理和实验思想、讲解实验仪器操作使用。
14	4	实验课堂	分子与晶体拉曼光谱实验-2：讲解实验仪器操作使用（续）、观察记录实验现象和结果。
15	4	实验课堂	光自旋霍尔效应与量子弱测量-1：讲解实验原理和实验思想、讲解实验仪器操作使用。
16	4	实验课堂	光自旋霍尔效应与量子弱测量-2：讲解实验仪器操作使用（续）、观察记录实验现象和结果。

编号	实验名称	台套数
1	光泵磁共振	2
2	表面等离激元共振法测液体折射率	1
3	椭偏光谱测量技术	2
4	晶体电光调制技术	1
5	电子衍射	2
6	电子自旋共振	2
7	隧道磁电阻效应	2
8	半导体结C-V测量技术	2
9	变温霍尔测量技术	2
10	分子与晶体拉曼光谱	2
11	光自旋霍尔效应与量子弱测量	2

学生/周次	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	实验1-1	实验2-1	实验3-1	汇报	实验6-1	实验4-1	实验5-1	汇报	实验7-1	实验9-1	实验8-1	汇报	实验10-1	实验10-1	实验11-1	实验11-1
2	实验1-2	实验2-1	实验3-2		实验6-1	实验4-1	实验5-1		实验7-2	实验9-2	实验8-2		实验10-1	实验10-1	实验11-1	实验11-1
3	实验2-1	实验3-1	实验1-1		实验6-2	实验4-1	实验5-2		实验8-1	实验7-1	实验9-1		实验10-2	实验10-2	实验11-2	实验11-2
4	实验2-1	实验3-1	实验1-2		实验6-2	实验4-1	实验5-2		实验8-1	实验7-1	实验9-1		实验10-2	实验10-2	实验11-2	实验11-2
5	实验3-1	实验1-1	实验2-1		实验4-1	实验5-1	实验6-1		实验8-2	实验7-2	实验9-2		实验11-1	实验11-1	实验10-1	实验10-1
6	实验3-1	实验1-1	实验2-1		实验4-1	实验5-2	实验6-2		实验8-2	实验7-2	实验9-2		实验11-1	实验11-1	实验10-1	实验10-1
7	实验3-2	实验1-2	实验2-1		实验5-1	实验6-1	实验4-1		实验9-1	实验8-1	实验7-1		实验11-2	实验11-2	实验10-2	实验10-2
8	实验3-2	实验1-2	实验2-1		实验5-2	实验6-2	实验4-1		实验9-2	实验8-2	实验7-2		实验11-2	实验11-2	实验10-2	实验10-2
9	实验10-1	实验10-1	实验11-1	实验11-1	实验1-1	实验2-1	实验3-1	汇报	实验6-1	实验4-1	实验5-1	汇报	实验7-1	实验9-1	实验8-1	汇报
10	实验10-1	实验10-1	实验11-1	实验11-1	实验1-2	实验2-1	实验3-2		实验6-1	实验4-1	实验5-1		实验7-2	实验9-2	实验8-2	
11	实验10-2	实验10-2	实验11-2	实验11-2	实验2-1	实验3-1	实验1-1		实验6-2	实验4-1	实验5-2		实验8-1	实验7-1	实验9-1	
12	实验10-2	实验10-2	实验11-2	实验11-2	实验2-1	实验3-1	实验1-2		实验6-2	实验4-1	实验5-2		实验8-1	实验7-1	实验9-1	
13	实验11-1	实验11-1	实验10-1	实验10-1	实验3-1	实验1-1	实验2-1		实验4-1	实验5-1	实验6-1		实验8-2	实验7-2	实验9-2	
14	实验11-1	实验11-1	实验10-1	实验10-1	实验3-1	实验1-1	实验2-1		实验4-1	实验5-2	实验6-2		实验8-2	实验7-2	实验9-2	
15	实验11-2	实验11-2	实验10-2	实验10-2	实验3-2	实验1-2	实验2-1		实验5-1	实验6-1	实验4-1		实验9-1	实验8-1	实验7-1	
16	实验11-2	实验11-2	实验10-2	实验10-2	实验3-2	实验1-2	实验2-1		实验5-2	实验6-2	实验4-1		实验9-2	实验8-2	实验7-2	
17	实验7-1	实验9-1	实验8-1	汇报	实验10-1	实验10-1	实验11-1	实验11-1	实验1-1	实验2-1	实验3-1	汇报	实验6-1	实验4-1	实验5-1	汇报
18	实验7-2	实验9-2	实验8-2		实验10-1	实验10-1	实验11-1	实验11-1	实验1-2	实验2-1	实验3-2		实验6-1	实验4-1	实验5-1	
19	实验8-1	实验7-1	实验9-1		实验10-2	实验10-2	实验11-2	实验11-2	实验2-1	实验3-1	实验1-1		实验6-2	实验4-1	实验5-2	
20	实验8-1	实验7-1	实验9-1		实验10-2	实验10-2	实验11-2	实验11-2	实验2-1	实验3-1	实验1-2		实验6-2	实验4-1	实验5-2	
21	实验8-2	实验7-2	实验9-2		实验11-1	实验11-1	实验10-1	实验10-1	实验3-1	实验1-1	实验2-1		实验4-1	实验5-1	实验6-1	
22	实验8-2	实验7-2	实验9-2		实验11-1	实验11-1	实验10-1	实验10-1	实验3-1	实验1-1	实验2-1		实验4-1	实验5-2	实验6-2	
23	实验9-1	实验8-1	实验7-1		实验11-2	实验11-2	实验10-2	实验10-2	实验3-2	实验1-2	实验2-1		实验5-1	实验6-1	实验4-1	
24	实验9-2	实验8-2	实验7-2		实验11-2	实验11-2	实验10-2	实验10-2	实验3-2	实验1-2	实验2-1		实验5-2	实验6-2	实验4-1	
25	实验6-1	实验4-1	实验5-1	汇报	实验7-1	实验9-1	实验8-1	汇报	实验10-1	实验10-1	实验11-1	实验11-1	实验1-1	实验2-1	实验3-1	汇报
26	实验6-2	实验4-1	实验5-2		实验7-2	实验9-2	实验8-2		实验10-1	实验10-1	实验11-1	实验11-1	实验1-2	实验2-1	实验3-2	
27	实验4-1	实验5-1	实验6-1		实验8-1	实验7-1	实验9-1		实验10-2	实验10-2	实验11-2	实验11-2	实验2-1	实验3-1	实验1-1	
28	实验4-1	实验5-2	实验6-2		实验8-2	实验7-2	实验9-2		实验10-2	实验10-2	实验11-2	实验11-2	实验2-1	实验3-2	实验1-2	
29	实验5-1	实验6-1	实验4-1		实验9-1	实验8-1	实验7-1		实验11-1	实验11-1	实验10-1	实验10-1	实验3-1	实验1-1	实验2-1	
30	实验5-2	实验6-2	实验4-1		实验9-2	实验8-2	实验7-2		实验11-2	实验11-2	实验10-2	实验10-2	实验3-2	实验1-2	实验2-1	

Update Notes on the Teaching and Learning Activities of Advanced Physics Experiments

*Note:

Our university previously miscalculated the contact hours for the Advanced Physics Experiments courses. The syllabus has been corrected by the course supervisor, and the updated content is shown below. (Items in red indicate changes from the original version.)

Revised Version:

Teaching Segment	Lectures (Theory)	Tutorial Session	Experiment	Seminar	Social Pratice	Project	Online Learning	Midterm test	Total
Hours (In-class)	4	0	48	0	0	12	0	0	64
Hours (Out-of-class)	4	0	12	24	0	24	0	0	64

5、主要教学环节（Teaching and Learning Activities）

教学环节	理论课(小时)	习题课(小时)	实验(小时)	研讨(小时)	社会实践(小时)	项目(小时)	在线学习(小时)	期中测试(小时)	合计
课内	4	0	48	0	0	12	0	0	64
课外	4	0	12	24	0	24	0	0	64

Original (Uncorrected) Version:

Teaching Segment	Lectures (Theory)	Tutorial Session	Experiment	Seminar	Social Pratice	Project	Online Learning	Midterm test	Total
Hours	0	0	52	0	0	12	0	0	64

(In-class)									
Hours (Out-of-class)	0	0	0	0	0	0	0	0	0

The calculation of contact hours has now been corrected, and **all Teaching and Learning Activities** related to Advanced Physics Experiments should follow the revised version.
Because updating the official syllabus requires processing time and cannot be completed before the application deadline, the Course Syllabus – Original Version still uses the uncorrected contact hours. This note is provided for clarification. If required, the updated version can be submitted later by email once officially issued.

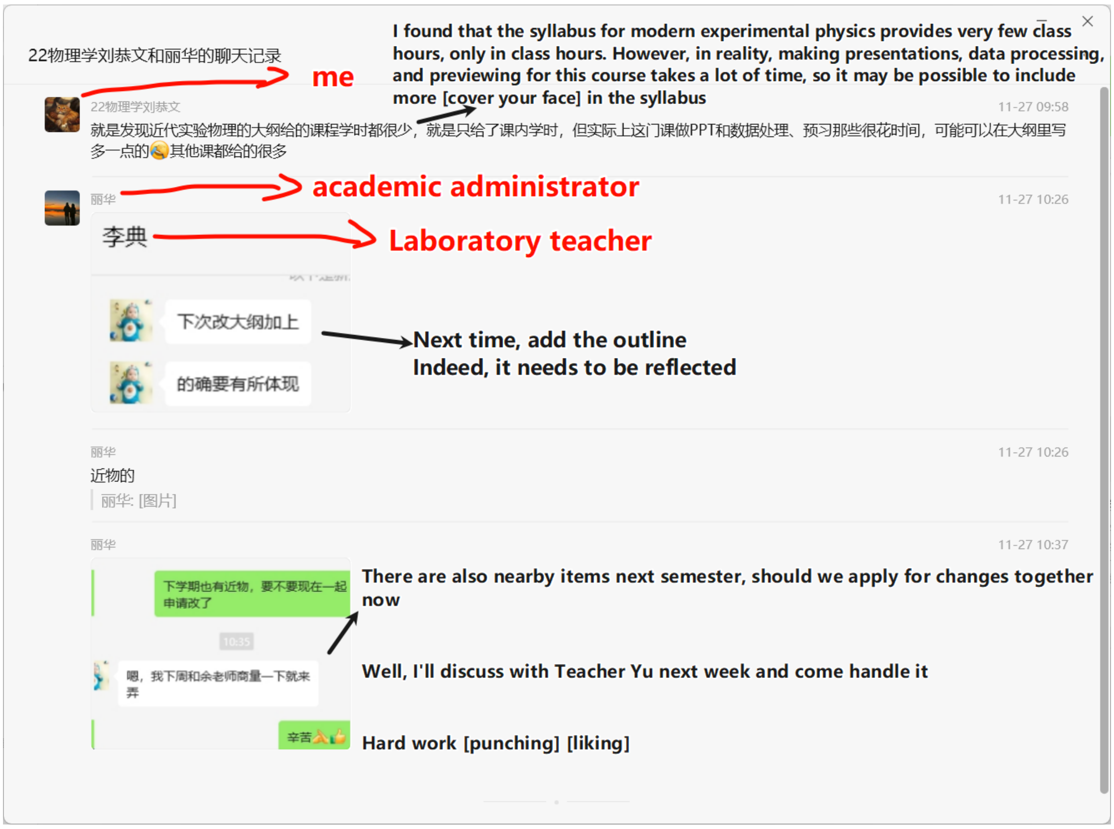
Additional Explanation

In practice, the actual workload of this course far exceeds the hours indicated in the original official table. The experimental principles involved are substantially more advanced, requiring considerably more theoretical preparation than regular laboratory courses. The instruments used are more sophisticated, with more intricate operating procedures, leading to significantly longer preparation and experimental durations. Some experiments even require up to two lessons to complete.

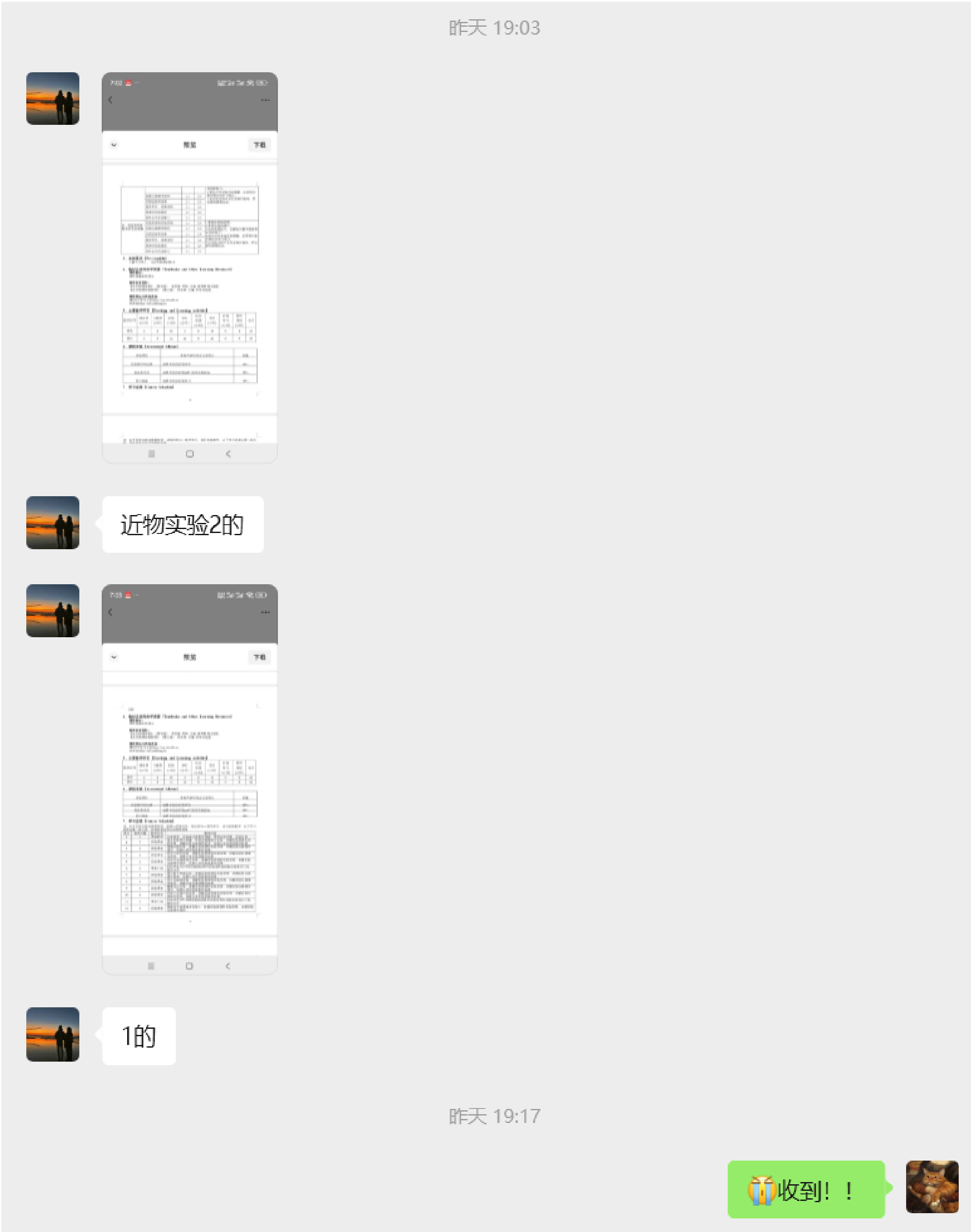
Furthermore, the amount of data processing required is much greater—certain experiments require more than six hours of data analysis alone. As this course is an advanced frontier-physics laboratory offered exclusively to students of this major, each experiment must be presented to the supervisor in the form of a slide report, covering experimental principles, procedures, data, proposed improvements, and reflection questions. This dramatically increases the time commitment for each experiment.

As a result, **the actual total workload easily exceeds 128 hours**. (In comparison, ordinary experimental courses typically total around 128 hours; this course requires much more time than standard laboratory courses.)

I have already identified the unreasonable time allocation in the original table and have communicated this issue to the instructor. The syllabus is currently being revised, but the updated version cannot be submitted at present due to time constraints. Your understanding is greatly appreciated. Detailed descriptions of several experiments can be found in the Document on Experimental Lab Courses (*) that has been uploaded.



The corrected version of the syllabus was issued at 19:03 China Standard Time on 9 December 2025, after being reviewed and approved by the course supervisor and forwarded to the teaching administration officer.



Only the Teaching and Learning Activities (i.e., the calculation and distribution of contact hours) were modified. The original text is provided below.

				究创新能力。 4.深化对专业知识的理解、应用和对复杂理论的学习能力。 5.在实验过程中主张正确价值观、责任感和理想信念。
	实验仪器操作使用	L1	L3	
	实验现象和结果	L1	L3	
	报告写作、结果分析	L1	L4	
	科学性和实践性	L1	L4	
	团队合作交流能力	L1	L5	
12. 高温超导体基本特性的测量	实验原理和实验思想	L1	L3	1.掌握实验的原理。 2.掌握设备的操作。 3.培养实验技巧，在解决问题中锻炼研究创新能力。 4.深化对专业知识的理解、应用和对复杂理论的学习能力。 5.在实验过程中主张正确价值观、责任感和理想信念。
	实验仪器操作使用	L1	L3	
	实验现象和结果	L1	L3	
	报告写作、结果分析	L1	L4	
	科学性和实践性	L1	L4	
	团队合作交流能力	L1	L5	

3、先修要求（Pre-requisite）

《量子力学》、《近代物理实验1》

4、教材及其他教学资源（Textbooks and Other Learning Resources）

课程教材：
课程自编实验讲义

推荐参考资料：
《近代物理实验》（第四版） 吴思诚 荀坤 主编 高等教育出版社
《近代物理实验教程》（第三版） 吴先球 主编 科学出版社

课程网站与网络资源：
MYSTU学习平台https://my.stu.edu.cn
雨课堂https://stu.yuketang.cn

5、主要教学环节（Teaching and Learning Activities）

教学环节	理论课（小时）	习题课（小时）	实验（小时）	研讨（小时）	社会实践（小时）	项目（小时）	在线学习（小时）	期中测试（小时）	合计
课内	4	0	48	0	0	12	0	0	64
课外	4	0	12	24	0	24	0	0	64

6、课程考核（Assessment Scheme）

考核项目	考核内容和考试方法简介	权重
实验操作和纪律	按要求完成实验操作	40%
报告及交流	按要求完成实验ppt汇报或实验报告	50%
预习准备	按要求完成实验预习	10%

7、学习进度（Course Schedule）

4

注：由于实验仪器台套数限制，以每四周为一教学单元，进行轮换教学，以下学习进度以第一组为例，具体轮换安排见后附轮换表

(2)》

4、教材及其他教学资源（Textbooks and Other Learning Resources）

课程教材：
课程自编实验讲义

推荐参考资料：
《近代物理实验》（第四版） 吴思诚 荀坤 主编 高等教育出版社
《近代物理实验教程》（第三版） 吴先球 主编 科学出版社

课程网站与网络资源：
MYSTU学习平台https://my.stu.edu.cn
雨课堂https://stu.yuketang.cn

5、主要教学环节（Teaching and Learning Activities）

教学环节	理论课（小时）	习题课（小时）	实验（小时）	研讨（小时）	社会实践（小时）	项目（小时）	在线学习（小时）	期中测试（小时）	合计
课内	4	0	48	0	0	12	0	0	64
课外	4	0	12	24	0	24	0	0	64

6、课程考核（Assessment Scheme）

考核项目	考核内容和考试方法简介	权重
实验操作和纪律	按要求完成实验操作	40%
报告及交流	按要求完成实验ppt汇报或实验报告	50%
预习准备	按要求完成实验预习	10%

7、学习进度（Course Schedule）

注：由于实验仪器台套数限制，除第一周绪论外，每五周为一教学单元，进行轮换教学，以下学习进度以第一组为例，具体轮换安排见后附轮换表

周次	教学时数	教学形式	教学内容
1	4	课堂教学	安全教育，实验室注意事项讲解，课程安排讲解，实验分组
2	4	实验课堂	真空的获得与测量，热蒸发镀膜技术实验：讲解实验原理和实验思想、讲解实验仪器操作使用、观察记录实验现象和结果。
3	4	实验课堂	核磁共振实验：讲解实验原理和实验思想、讲解实验仪器操作使用、观察记录实验现象和结果。
4	4	实验课堂	单光子技术实验：讲解实验原理和实验思想、讲解实验仪器操作使用、观察记录实验现象和结果。
5	4	实验课堂	冉绍尔汤普森效应实验：讲解实验原理和实验思想、讲解实验仪器操作使用、观察记录实验现象和结果。
6	4	课堂汇报	组织学生对2-5周实验的结果和实验过程的经验总结进行汇报，教师点评
7	4	实验课堂	核与粒子物理实验：讲解实验原理和实验思想、讲解实验仪器操作使用、观察记录实验现象和结果。
8	4	实验课堂	弗兰克赫兹实验：讲解实验原理和实验思想、讲解实验仪器操作使用、观察记录实验现象和结果。
9	4	实验课堂	塞曼效应实验：讲解实验原理和实验思想、讲解实验仪器操作使用、观察记录实验现象和结果。
10	4	实验课堂	钠原子光谱分析实验：讲解实验原理和实验思想、讲解实验仪器操作使用、观察记录实验现象和结果。
11	4	课堂汇报	组织学生对7-10周实验的结果和实验过程的经验总结进行汇报，教师点评
12	4	实验课堂	微弱信号检测技术实验-1：讲解实验原理和实验思想、讲解实验仪器操作使用。

4

Shantou University
Module Description for Undergraduate Courses

COURSE TITLE:	Quantum Mechanics 1
COURSE CODE:	PHY3040A
CREDIT VALUE:	3
CONTACT HOURS:	48
PRE-REQUISITE	Calculus B-I, Calculus B-II, Advance Calculus, Linear algebra, Probability and Statistics, Mathematical methods of physics, Atomic Physics
DEPARTMENT/UNIT:	Department of Physics
VERSION:	20240731-PHY3040A
COURSE COORDINATOR:	李飞 (Signature and Seal)
APPROVER:	池凌 (Signature and Seal)
APPROVE DATE:	20240731

Shantou University Faculty of Science
July 2024

1. Course Description

Quantum Mechanics 1 is one of the core courses in the physics major. It examines the fundamental properties and dynamical behavior of particles in the microscopic world, forming—together with relativity—one of the two foundational pillars of modern physics. The establishment of quantum mechanics resolved major difficulties that classical physics could not overcome, such as blackbody radiation, the photoelectric effect, and Compton scattering. It also reshaped our understanding of particle motion and microscopic physical laws, and has driven a wide range of technological innovations, including lasers, semiconductors, computers, fiber-optic communication, electron microscopy, nuclear magnetic resonance, and nuclear energy. Consequently, this course provides essential theoretical grounding for undergraduate students pursuing academic training in physics.

Within the physics curriculum at Shantou University, Quantum Mechanics 1 is designated as a core module. The major topics include wave–particle duality, the wavefunction and the Schrödinger equation, operators of physical observables, representations of dynamical variables, perturbation theory, scattering theory, spin, and identical particles. Upon completing the course, students are expected to:

1. Understand the limitations of classical physics and gain familiarity with the experimental foundations, historical development, and applications of quantum mechanics.
2. Master the fundamental concepts, principles, and essential analytical techniques of quantum mechanics.
3. Acquire methodological tools for studying microscopic systems and develop coherent scientific thinking.

This course corresponds to the following graduation requirement indicators of the physics major training scheme: 3.2 Mastery of fundamental theories and professional knowledge in physics; 5.1 Ability to conduct research based on scientific principles and methods; 6.1 Research and engineering capabilities for problem-solving.

2. Intended Learning Outcomes

Knowledge Unit	Knowledge Point	Initial Level	Required Level	Expected Learning Outcomes
1: Introduction	1.1 Difficulties of Classical Physics	L1	L2	Understand the fundamental limitations of classical physics; cultivate scientific creativity.
	1.2 Wave–Particle Duality of Light	L1	L4 L3	Master the concept of wave–particle duality; explain blackbody radiation, the photoelectric effect, and Compton scattering; understand scientific contributions in the historical context.
	1.3 Bohr's Model of the Atom	L1	L3	Explain Bohr's model of atomic structure; appreciate the cultural and scientific significance of early quantum theory.
	1.4 Wave–Particle Duality of Microscopic Particles	L1	L4	Master the wave–particle duality of microscopic particles; connect physical principles with dialectical thinking in scientific methodology.
2: Wavefunction and the Schrödinger Equation	2.1 Statistical Interpretation of the Wavefunction	L1	L5	Evaluate the statistical interpretation of the wavefunction.

	2.2 Principle of Superposition	L1	L5	Evaluate the principle of quantum superposition.
	2.3 The Schrödinger Equation	L1	L4	Master the Schrödinger equation; understand contributions to early quantum discoveries within the broader development of modern physics.
	2.4 Probability Current Density and Conservation Laws	L1	L3	Apply particle-number and charge conservation laws.
	2.5 Time-Independent Schrödinger Equation	L1	L4	Master the time-independent Schrödinger equation.
	2.6 One-Dimensional Infinite Square Well	L1	L3	Compute the energy levels and wavefunctions in a 1D infinite square well.
	2.7 Harmonic Oscillator	L1	L3	Compute the energy spectrum and wavefunctions of the harmonic oscillator.
	2.8 Potential Barrier Penetration	L1	L3	Explain quantum tunnelling through a 1D potential barrier; recognize its relevance to scanning tunnelling microscopy and scientific innovation.
3: Physical Quantities in Quantum Mechanics	3.1 Operators Representing Physical Observables	L1	L4	Summarize the fundamental properties of operators.
	3.2 Momentum and Angular Momentum Operators	L1	L3	Apply momentum and angular momentum operators.
	3.3 Hydrogen Atom	L1	L4	Deconstruct the solution of the time-independent Schrödinger equation for the hydrogen atom.
	3.4 Orthogonality of Eigenfunctions of Hermitian Operators	L1	L3	Analyze the orthogonality of eigenfunctions of Hermitian operators.
	3.5 Relationship Between Operators and Physical Observables	L1	L4	Summarize the connection between operators and measured quantities.
	3.6 Commutation Relations and Conditions for Simultaneous Measurability	L1	L4 / L3	Summarize commutation relations; explain conditions under which two observables can have definite values simultaneously.

	3.7 Uncertainty Relations	L1	L4	Analyze the uncertainty principle.
	3.8 Time Evolution of Expectation Values and Conservation Laws	L1	L4 / L4	Analyze the time evolution of expectation values; summarize conservation laws.
4: Representations of States and Operators	4.1 Representations of Quantum States	L1	L3	Explain representations of quantum states.
	4.2 Matrix Representation of Operators	L1	L4	Master matrix representations of operators.
	4.3 Matrix Formulation of Quantum Mechanical Relations	L1	L4	Master the matrix formulation of quantum mechanics.
	4.4 Unitary Transformations	L1	L4	Analyze unitary transformations; develop the ability to connect physical phenomena with underlying principles.
	4.5 Dirac Notation	L1	L3	Apply Dirac bra–ket notation.
	4.6 Harmonic Oscillator and Number Representation	L1	L3	Explain the number-state representation of the harmonic oscillator.
5: Perturbation Theory	5.1 Non-Degenerate Time-Independent Perturbation Theory	L1	L3	Explain non-degenerate time-independent perturbation theory; develop systematic problem-solving skills.
	5.2 Degenerate Perturbation Theory	L1	L3	Explain degenerate perturbation theory.
	5.3 First-Order Stark Effect of Hydrogen	L1	L4	Deconstruct the first-order Stark effect in hydrogen.
	5.4 Variational Method	L1	L3	Apply the variational method.
	5.5 Ground State of Helium (Variational Method)	L1	L3	Explain the variational calculation of helium's ground-state energy and wavefunction.
	5.6 Time-Dependent Perturbation Theory	L1	L3	Explain time-dependent perturbation theory.
	5.7 Transition Probabilities	L1	L3	Compute transition probabilities.

	5.8 Emission and Absorption of Radiation	L1	L4	Summarize radiation emission and absorption processes.
	5.9 Selection Rules	L1	L4	Deconstruct selection rules.
6: Scattering	6.1 Scattering Cross Section in Collision Processes	L1	L3	Explain scattering cross sections in collision processes.
	6.2 Elastic Scattering in Central Potentials (Partial-Wave Method)	L1	L3	Explain the partial-wave method in elastic scattering under a central potential.
	6.3 Scattering from Square Wells and Barriers	L1	L3	Explain scattering arising from square wells and barriers.
	6.4 Born Approximation	L1	L4	Analyze the Born approximation.
	6.5 Center-of-Mass and Laboratory Reference Frames	L1	L4	Compare the centre-of-mass frame and laboratory frame.
7: Spin	7.1 Electron Spin	L1	L2	Interpret the physical nature of electron spin.
	7.2 Spin Operators and Spin Wavefunctions	L1	L3	Apply spin operators and spin wavefunctions.
	7.3 Zeeman Effect	L1	L4	Deconstruct the Zeeman effect.
	7.4 Coupling of Two Angular Momenta	L1	L3	Compute the coupling of two angular momenta.
	7.5 Fine Structure of Spectra	L1	L3	Explain the origin of fine-structure splitting.
8: Identical Particles	8.1 Properties of Identical Particles	L1	L2	Interpret the physical characteristics of identical particles.
	8.2 Wavefunctions of Identical Particles and the Pauli Exclusion Principle	L1	L3	Explain many-particle wavefunctions; explain the Pauli exclusion principle.
	8.3 Spin Wavefunctions of Two Electrons	L1	L4	Deconstruct the spin wavefunctions of two-electron systems.

	8.4 Helium Atom (Perturbation Method)	L1	L3	Explain the perturbation treatment of the helium atom.
	8.5 Hydrogen Molecule (Heitler–London Method) and Chemical Bonding	L1	L2	Understand the Heitler–London theory of H_2 and the quantum origin of chemical bonding.

3. Pre-requisit

Calculus B-I, Calculus B-II, Advance Calculus, Linear algebra, Probability and Statistics, Mathematical methods of physics, Atomic Physics

4. Textbooks and Other Learning Resources

Required Textbooks

Quantum Mechanics: A Tutorial (3rd Edition), by Zhou Shixun & Chen Hao, Higher Education Press, 2022.

Recommended References

Quantum Mechanics (1st Edition), by Qian Bochu, Higher Education Press, 2006.

Modern Quantum Mechanics: A Contemporary Tutorial (1st Edition), by Sun Changpu, Peking University Press, 2024.

Advanced Quantum Mechanics (2nd Edition), by Ke Xinglin, Higher Education Press, 2001.

Course websites

MYSTU Learning Platform: my.stu.edu.cn

Rain Classroom: https://stu.yuketang.cn

5. Teaching and Learning Activities

Teaching Segment	Lectures (Theory)	Exercise Classes	Experiment	Seminar	Social Pratice	Project	Online Learning	Other	Total
Hours (In-class)	48	0	0	0	0	0	0	0	48
Hours (Out-of-class)	0	36	0	12	0	0	0	0	48

Given the breadth of this course, in-class instruction alone is not sufficient for students to fully grasp all of the material. Accordingly, independent study is required in addition to the lectures. The ratio of independent study hours to lecture hours is 1:1, corresponding to 48 hours of self-directed learning. These include: 24 hours devoted to reviewing theoretical content, 18 hours to solving assigned problems, and 6 hours to participation in discussion-based study.

The independent study component is carried out under students' own self-management.

7. Assessment Scheme

Assessment Component	Description of Content and Methods	Weight
Reports and Communication	After-class exercises and in-class engagement. Evaluation criteria: For homework: Whether the fundamental concepts and physical intuition are clearly demonstrated in the problem-solving process. Whether formulas are applied correctly. Whether the reasoning is coherent and complete. For class participation: attentiveness during lectures; willingness to engage in discussion or raise questions; initiative in consulting additional sources to resolve uncertainties.	40%
Final Examination	Assessment of fundamental concepts, core principles, and basic analytical methods. Closed-book examination.	60%

Assessment Structure

The assessment of this course consists of two components: continuous assessment and the final examination. Continuous assessment accounts for 40%, and the final examination accounts for 60% of the total grade.

Continuous Assessment: Attendance, in-class participation, and questions (20%): evaluated by the instructor. Assignments (20%): evaluated jointly by the instructor and the teaching assistant.

Final Examination: The final examination assesses the student's mastery of fundamental concepts, core principles, basic procedures, and standard analytical methods in quantum mechanics. The exam is closed-book.

7. Course Schedule

Note: Due to limited availability of experimental instruments, the laboratory sessions are organized in four-week teaching units. The following schedule uses Group 1 as an example; detailed rotation arrangements are provided in the attached rotation table.

Week	Contact Hours	Teaching Format	Teaching Content
1	3	Lecture	Difficulties in classical physics; wave–particle duality of light; blackbody radiation; photoelectric effect; Compton scattering; Bohr model of atomic structure; wave–particle duality of microscopic particles.
2	3	Lecture	Statistical interpretation of the wave function; principle of superposition; Schrödinger equation; probability current density and conservation of particle number; time-independent Schrödinger equation.
3	3	Lecture	One-dimensional infinite potential well; harmonic oscillator; quantum tunneling.
4	3	Lecture	Representation of operators corresponding to mechanical quantities; momentum and angular-momentum operators; the hydrogen atom.
5	3	Lecture	Orthogonality of eigenfunctions of Hermitian operators; relation between operators and observables; commutation relations; conditions for simultaneous observability; uncertainty relations.
6	3	Lecture	Time evolution of expectation values; conservation laws; representations of quantum states; matrix representation of operators; matrix formulation of quantum theory.
7	3	Lecture	Unitary transformations; Dirac notation; harmonic oscillator and the occupation-number representation.

8	3	Lecture	Non-degenerate and degenerate time-independent perturbation theory; first-order Stark effect of the hydrogen atom.
9	3	Lecture	Variational method; ground state of the helium atom; time-dependent perturbation theory.
10	3	Lecture	Transition probability; emission and absorption of light; selection rules.
11	3	Lecture	Collision processes; scattering cross sections; elastic scattering in central potentials.
12	3	Lecture	Scattering from square wells and barriers; Born approximation; center-of-mass coordinates vs. laboratory frame.
13	3	Lecture	Electron spin; spin operator and spin wave functions; Zeeman effect.
14	3	Lecture	Coupling of angular momenta; fine structure of spectra; identical particles.
15	3	Lecture	Wave functions of identical-particle systems; Pauli exclusion principle; two-electron spin wave functions.
16	3	Lecture	Helium atom; hydrogen molecule; chemical bonding.

汕头大学本科教学

课程教学大纲

课程名（COURSE TITLE）：	量子力学 1
课程代码（COURSE CODE）：	PHY3040A
学分（CREDIT VALUE）：	3
课内课时（CONTACT HOURS）：	48
先修课要求（PRE-REQUISITE）	微积分 B-I、微积分 B-II、高等微积分、线性代数、概率论与数理统计、数学物理方法、原子物理学
开课单位（DEPARTMENT/UNIT）：	物理学系
版本（VERSION）：	20240731- PHY3040A
课程负责人（COURSE COORDINATOR）：	李飞 (签章)
审核人（APPROVER）：	池凌飞(签章)
审核日期（APPROVE DATE）：	20240731

汕头大学理学院

2024 年 7 月

1、课程简介（Course Description）

量子力学 1（Quantum Mechanics 1）课程是物理学专业的核心课程之一，其研究对象是微观世界粒子的基本性质和运动规律的物理学科，它与相对论一起构成了现代物理学的两个基本支柱。量子力学的建立，不仅解决了经典物理学难以克服的诸如黑体辐射、光电效应和康普顿散射等问题，厘清了人们对微观世界粒子的运动形式和规律的认识，而且导致了诸多技术创新，例如激光器、半导体、计算机、光纤电子通讯、电子显微镜、核磁共振和核能等。因此，量子力学课程为物理学专业学术型本科人才的培养奠定了良好的基础。量子力学课程属于汕头大学物理学专业人才培养方案的专业核心模块课程，其主要内容是微观粒子的波粒二象性、波函数和薛定谔方程、力学量算符，力学量表象、微扰理论、散射、自旋、全同粒子。学完本课程后学生应该能够：

1.坚定中国特色社会主义道路，树立坚定的理想信念、正确的价值观和社会责任感；

2.培养学生的家国情怀，勇于探索、乐于奉献的精神，树立文化自信；

3.理解经典物理的困难，了解量子力学的实验基础、发展史和应用；

4.掌握量子力学的基本概念、基本原理和处理量子系统问题的基本方法;

5.掌握微观体系的研究方法，建立一定的科学思维能力。

本课程目标对应物理学专业人才培养方案毕业要求指标点：1.坚定的理想信念；2.正确价值观和社会责任感；3.2 掌握物理学的基础理论和专业知识；5.1 具备基于科学原理和方法进行研究的能力；6.1 解决问题的研究和工程能力。

2、预期学习结果（Intended Learning Outcomes）

本课程的预期学习结果如下表：

知识单元	知识点	初始程度	要求程度	预期学习结果
1.绪论	1.1 经典物理的困难	L1	L2	理解经典物理学面临的困难 思政：培养学生的创新精神
	1.2 光的波粒二象性	L1	L4 L3	掌握光的波粒二象性 说明黑体辐射、光电效应和康普顿散射 思政：介绍吴有训的故事，弘扬爱国精神
	1.3 原子结构的玻尔理论	L1	L3	说明原子结构的玻尔理论 思政：介绍玻尔访华的事迹，培养家

				国情怀
	1.4 微粒的波粒二象性	L1	L4	掌握微观粒子的波粒二象性 思政：马克思主义哲学中的对立统一规律
2.波函数和薛定谔方程	2.1 波函数的统计解释	L1	L5	评论波函数的统计解释
	2.2 态叠加原理	L1	L5	评论态叠加原理
	2.3 薛定谔方程	L1	L4	掌握薛定谔方程 思政：介绍赵忠尧发现正电子的故事，培养爱国精神
	2.4 粒子流密度和粒子数守恒定律	L1	L3	应用粒子数守恒定律和电荷守恒定律
	2.5 定态薛定谔方程	L1	L4	掌握定态薛定谔方程
	2.6 一维无限深方势阱	L1	L3	计算一维无限深方势阱中粒子的能量和波函数
	2.7 线性谐振子	L1	L3	计算线性谐振子的能量和波函数
	2.8 势垒穿透	L1	L3	说明粒子穿透一维方势垒 思政：介绍扫描隧道显微镜，培养创新精神
3.量子力学中的力学量	3.1 表示力学量的算符	L1	L4	总结算符的基本性质
	3.2 动量算符和角动量算符	L1	L3	使用动量算符和角动量算符
	3.3 氢原子	L1	L4	解构氢原子定态薛定谔方程的求解
	3.4 厄米算符本征函数的正交性	L1	L3	分析厄米算符本征函数的正交性
	3.5 算符与力学量的关系	L1	L4	总结算符与力学量的关系
	3.6 算符的对易关系　两力学量同时具有确定值的条件	L1	L4 L3	总结算符的对易关系 说明两力学量同时具有确定值的条件
	3.7 不确定关系	L1	L4	分析不确定关系
	3.8 力学量期望值随时间的变化　守恒定律	L1	L4 L4	分析力学量期望值随时间的变化 总结守恒定律
4.态和力学量的表象	4.1 态的表象	L1	L3	说明态的表象
	4.2 算符的矩阵表示	L1	L4	掌握算符的矩阵表示
	4.3 量子力学公式的矩阵表述	L1	L4	掌握量子力学公式的矩阵表述
	4.4 幺正变换	L1	L4	分析幺正变换 思政：透过现象看本质，现象与本质的对立统一。
	4.5 狄拉克符号	L1	L3	应用狄拉克符号
	4.6 线性谐振子与占有数表象	L1	L3	说明线性谐振子的占有数表象
5.微扰理论	5.1 非简并定态微扰理论	L1	L3	说明非简并定态微扰理论 思政：抓住主要矛盾，解决问题
	5.2 简并情况下的微扰理论	L1	L3	说明简并情况下的微扰理论
	5.3 氢原子的一级斯达克效应	L1	L4	解构氢原子的一级斯达克效应
	5.4 变分法	L1	L3	应用变分法
	5.5 氦原子基态（变分法）	L1	L3	说明变分法求解氦原子基态能量和波

				函数
	5.6 与时间有关的微扰理论	L1	L3	说明与时间有关的微扰理论
	5.7 跃迁概率	L1	L3	计算跃迁概率
	5.8 光的发射和吸收	L1	L4	总结光的发射和吸收
	5.9 选择定则	L1	L4	解构选择定则
6.散射	6.1 碰撞过程　散射截面	L1	L3	说明粒子碰撞过程中的散射截面
	6.2 中心力场中的弹性散射（分波法）	L1	L3	说明分波法求解中心力场中的弹性散射
	6.3 方形势阱与势垒所产生的散射	L1	L3	说明方形势阱与势垒所产生的散射
	6.4 玻恩近似	L1	L4	分析玻恩近似
	6.5 质心系与实验室坐标系	L1	L4	比较质心系与实验室坐标系
7.自旋	7.1 电子自旋	L1	L2	阐释电子自旋
	7.2 电子的自旋算符和自旋波函数	L1	L3	应用电子的自旋算符和自旋波函数
	7.3 塞曼效应	L1	L4	解构塞曼效应
	7.4 两个角动量的耦合	L1	L3	计算两个角动量的耦合
	7.5 光谱的精细结构	L1	L3	说明光谱的精细结构
8.全同粒子	8.1 全同粒子的特性	L1	L2	阐释全同粒子的特性
	8.2 全同粒子体系的波函数　泡利不相容原理	L1	L3 L3	说明全同粒子体系的波函数 说明泡利不相容原理
	8.3 两个电子的自旋波函数	L1	L4	解构两个电子的自旋波函数
	8.4 氦原子（微扰法）	L1	L3	说明微扰法求解氦原子的本征方程
	8.5 氢分子（海特勒-伦敦法）　化学键	L1	L2	理解海特勒-伦敦法讨论氢分子的结合能及化学键

3、先修要求（Pre-requisite）

微积分 B-I、微积分 B-II、高等微积分、线性代数、概率论与数理统计、数学物理方法、原子物理学

4、教材及其他教学资源（Textbooks and Other Learning Resources）

指定教材：

《量子力学教程》，周世勋，陈灏，第 3 版，高等教育出版社出版，2022 年

推荐教材：

《量子力学》，钱伯初，第 1 版，　高等教育出版社出版，2006 年

《量子力学现代教程》，孙昌璞，第 1 版，　北京大学出版社，2024 年

《高等量子力学》，喀兴林，第 2 版，高等教育出版社出版，2001 年

课程网站与网络资源

（1）https://my.stu.edu.cn

（2）雨课堂

5、主要教学环节（Teaching and Learning Activities）

教学环节	理论课（小时）	习题课（小时）	实验（小时）	研讨（小时）	社会实践（小时）	项目（小时）	在线学习（小时）	期中测试（小时）	合计
课内	48	0	0	0	0	0	0	0	48
课外	0	36	0	12	0	0	0	0	48

本课程内容较多，只进行课堂教学，学生无法全部理解课程内容，因此需要在课堂教学环节之外进行自学。自学环节课时与课堂教学课时比例为1:1，即自学环节为48学时，其中理论内容学习24学时，完成习题18学时，研讨6学时。

自学环节由学生自我监督完成。

6、课程考核（Assessment Scheme）

考核项目	考核内容和考试方法简介	权重
作业、提问、讨论	课后习题和课堂参与度 评判标准： 课后作业：解题过程中基本概念和图像是否清晰？公式使用是否正确？逻辑方面是否完整？ 课堂参与度：是否认真听课？是否积极参与讨论或提出问题？是否会积极查询资料解决自己的疑问？	40%
期末考试	基本概念、基本原理、基本方法　闭卷考试	60%

本课程考核由课程平时学习表现和期末考试两部分组成，其中平时学习表现评分占比为40%，期末考试评分占比60%。

平时学习表现：出勤、课堂参与程度、提问等占比20%，由教师评定；课程作业占比20%，由教师和助教共同评定。

期末考试：主要考察学生对量子力学的基本概念、基本原理、基本过程和基本方法的掌握情况。

7、学习进度（Course Schedule）

周次	教学时数	教学形式	教学内容
1	3	课堂教学	经典物理的困难、光的波粒二象性、黑体辐射、光电效应和康普顿散射、原子结构的玻尔理论、微观粒子的波粒二象性
2	3	课堂教学	波函数的统计解释、态叠加原理、薛定谔方程、粒子流密度和粒子数守恒定律、定态薛定谔方程
3	3	课堂教学	一维无限深方势阱、线性谐振子、势垒穿透
4	3	课堂教学	力学量的算符的表示、动量算符和角动量算符、氢原子
5	3	课堂教学	厄米算符本征函数的正交性、算符与力学量的关系、算符的对易关系、两力学量同时具有确定值的条件、不确定关系
6	3	课堂教学	力学量期望值随时间的变化、守恒定律、态的表象、算符的矩阵表示、量子力学公式的矩阵表述
7	3	课堂教学	幺正变换、狄拉克符号、线性谐振子与占有数表象
8	3	课堂教学	非简并定态微扰理论、简并情况下的微扰理论、氢原子的一级斯达克效应
9	3	课堂教学	变分法、氦原子基态与时间有关的微扰理论、
10	3	课堂教学	跃迁概率、光的发射和吸收、选择定则
11	3	课堂教学	碰撞过程、散射截面、中心力场中的弹性散射
12	3	课堂教学	方形势阱与势垒所产生的散射、玻恩近似、质心系与实验室坐标系
13	3	课堂教学	电子自旋、电子的自旋算符和自旋波函数、塞曼效应
14	3	课堂教学	两个角动量的耦合、光谱的精细结构、全同粒子的特性
15	3	课堂教学	全同粒子体系的波函数、泡利不相容原理、两个电子的自旋波函数
16	3	课堂教学	氦原子、氢分子、化学键

Shantou University

Module Description for Undergraduate Courses

COURSE TITLE:	Advanced Quantum Mechanics
COURSE CODE:	PHY5100A
CREDIT VALUE:	2
CONTACT HOURS:	32
PRE-REQUISITE	Quantum Mechanics I, Linear Algebra, and Mathematical methods of physics
DEPARTMENT/UNIT:	Department of Physics
VERSION:	
COURSE COORDINATOR:	李明根 (Signature and Seal)
APPROVER:	Chi Lingfei (Signature and Seal)
APPROVE DATE:	2025.4.28

Shantou University Faculty of Science

April 2025

1. Course Description

Advanced Quantum Mechanics is a higher-level course in quantum theory and one of the core subjects within theoretical physics. Building upon Elementary Quantum Mechanics, the course systematically develops the mathematical structure, formalism, and advanced applications of quantum mechanics. It provides an essential theoretical foundation for understanding modern physics, including quantum field theory, condensed matter physics, and quantum information science. With an emphasis on both theoretical rigor and physical intuition, the course integrates macroscopic and microscopic perspectives to illuminate the fundamental principles underlying quantum phenomena.

Upon completing this course, students are expected to:

1. **Master the formal theory of quantum mechanics:**
   Gain a deep understanding of Hilbert spaces, operator algebra, symmetries, and conservation laws, and apply the Dirac notation and matrix-mechanics formulation with confidence.
2. **Understand approximation methods and scattering theory:**
   Including time-independent and time-dependent perturbation theory, the variational method, the WKB approximation, the Born approximation, and partial-wave analysis.
3. **Become familiar with many-body physics and second quantization:**
   Understand the quantum statistical properties of identical particles and acquire an introductory familiarity with mathematical tools relevant to quantum field theory.
4. **Cultivate scientific thinking and innovation:**
   Engage with open problems—such as quantum measurement and entanglement—to develop critical thinking skills and gain insights into frontier developments in quantum theory, including quantum information and topological quantum states.
5. **Develop a modern scientific worldview:**
   Understand the conceptual transition from determinism to probabilistic interpretations and recognize the profound impact of quantum mechanics on contemporary scientific thought.

This course serves not only as a cornerstone of theoretical physics research but also as an essential gateway to understanding the microscopic world. Through this learning process, students will obtain the theoretical foundation necessary for research in condensed matter physics, quantum optics, particle physics, and quantum computing, while fostering a spirit of critical inquiry and scientific exploration.

2. Intended Learning Outcomes

Knowledge Unit	Key Knowledge Points	Initial Level	Target Level	Expected Learning Outcomes
1. Hilbert Space	1.1 Vector Spaces and Linear Operators	L1	L4	Master the definition and properties of Hilbert spaces; competently employ Dirac notation and operator algebra.
	1.2 Eigenvectors and Eigenvalues	L1	L4	Understand the physical meaning of eigenvalue problems; solve typical operators (position, momentum, Hamiltonian); grasp the identification of degenerate states.
	1.3 Representation Theory	L1	L4	Perform representation transformations proficiently; understand distinctions between continuous and discrete spectra.

	1.4 Angular Momentum Theory	L1	L4	Master commutation relations of angular-momentum operators; compute level splitting of spin–orbit coupled systems; understand Clebsch–Gordan coefficients and their applications in atomic physics.
2. Fundamentals of Quantum Mechanics	2.1 Position and Momentum Representations	L1	L4	Derive the transformation relations between position- and momentum-space wavefunctions; understand the mathematical origin of the uncertainty principle; encourage multi-perspective thinking and cultivate innovation.
	2.2 Angular-Momentum Operators and Representations	L1	L3	Master the expression of angular-momentum operators in spherical coordinates; solve radial and angular equations in central-force problems; guide students toward precision and methodological rigor in research.
	2.3 Time-Independent Schrödinger Equation	L1	L3	Proficiently solve selected simple eigenvalue problems.
	2.4 Equations of Motion	L1	L4	Master the equivalence of Heisenberg and Schrödinger pictures; derive the time-evolution operator; analyze time evolution of quantum states.
	2.6 Coherent States of the Harmonic Oscillator	L1	L3	Master the definition and key properties of coherent states and understand their applications in quantum optics, such as their role in describing the classical limit of a light field.
3. Symmetry Theory	3.1 Spatial Symmetry and Conservation Laws	L1	L3	Master the relations between translational/rotational symmetry and momentum/angular-momentum conservation; understand spatial inversion and parity; recognize the connection between symmetry and energy-level degeneracy; appreciate the unity of natural laws.
	3.2 Time Translation and Time Reversal	L1	L3	Understand constraints of time-reversal symmetry on quantum states (e.g., Kramers degeneracy); determine whether a Hamiltonian is invariant under time reversal.
4. Second Quantization	4.1 Hilbert Space of Identical Particles	L1	L3	Master the symmetrization postulate for identical particles; construct many-body wavefunctions with correct bosonic/fermionic symmetry.
	4.2 Creation and Annihilation Operators	L1	L4	Competently apply algebraic properties of creation and annihilation operators.
	4.3 Occupation-Number Representation	L1	L3	Master the construction of Fock space; master second quantization for bosonic and fermionic systems.
	4.4 Quantization of the Free Electromagnetic Field	L1	L3	Understand the quantization of the electromagnetic field; master the physical meaning of photon creation and annihilation operators.

3. Pre-requisit

Quantum Mechanics I, *Linear Algebra*, and *Mathematical methods of physics*

4. Textbooks and Other Learning Resources

Required Textbooks

Self-compiled lecture notes.

Recommended Textbooks

Tian Shi (Ed.), *Physical Properties of Materials*, Beihang University Press.

Course website`

https://www.icourse163.org/

5. Teaching and Learning Activities

Teaching Segment	Lectures (Theory)	Exercise Classes	Laboratory Work	Seminars	Social Practice	Project Work	Mid-Term Test	Total
Hours (In-class)	30	2	0	0	0	0	0	32
Hours (Out-of-class)	0	0	0	32	0	0	0	32

6. Assessment Scheme

Assessment item	Description / Assessment criteria	Weight
Exercises, Discussion, and Questions	Homework and reflective tasks; in-class quizzes; class participation, responses, and questions. Evaluation criteria: **Homework:** clarity of basic concepts and reasoning; correctness of formula usage; completeness of logical steps. **Quizzes**: ability to complete required content within the allotted time. **Participation**: attentiveness, active engagement in discussion, ability to ask meaningful questions, and initiative in consulting relevant materials.	40%
Final Presentation	Students must complete an assigned project and deliver a presentation on a topic related to quantum mechanics (quantum mechanics).	60%

7. Course Schedule

Week	Hour	Teaching format	Teaching content
1–2	4	Lecture	Course introduction and review of mathematical foundations; overview of the quantum-mechanical framework (Hilbert space, superposition principle); advanced Dirac notation (bras/kets, completeness); Hermitian operators, eigenvalue problems, completeness relations.
3–5	6	Lecture	Formal structure of quantum mechanics; precise definitions of state space and operators (closure, unbounded operators); spatial translation and momentum operators; complete sets of observables, measurement, and uncertainty relations; coordinate and momentum representations; matrix representation theory; direct product and direct sum of linear spaces.
6–8	6	Lecture	Spatial rotations and angular-momentum operators; algebraic properties and eigenvalue problems; algebraic derivation of spherical harmonics; angular-momentum coupling and spin–orbit interaction; spherically symmetric problems and stationary

			solutions; numerical practice: computing Clebsch–Gordan coefficients using Mathematica.
9–11	6	Lecture	Quantum dynamics; time translation and the Hamiltonian; Heisenberg and Schrödinger pictures; Heisenberg equation of motion; harmonic oscillator (algebraic and wave-function solutions); time evolution; coherent states; exact solution of the driven two-level system; Bell inequalities; density matrices and mixed states.
11–12	4	Lecture	Many-particle systems; indistinguishability and many-body wavefunctions; introduction to multi-electron atoms and molecules; second quantization for bosons and fermions; field operators and their correspondence with many-body wavefunctions; advanced extension: BEC superfluidity and the BCS framework.
13	2	Lecture	Introduction to scattering theory, perturbation theory, and variational methods.
14–15	4	Lecture	Symmetry, conservation, and degeneracy; necessary and sufficient conditions for conservation laws; continuous symmetries and Noether's theorem; discrete symmetries (P, T, C and their physical implications); symmetry and energy-level degeneracy.
16	2	Lecture	Final review and examination: synthesis of key concepts and analysis of representative problems.

汕头大学本科教学

课程教学大纲

课程名（COURSE TITLE）：	高等量子力学
课程代码（COURSE CODE）：	PHY5100A
学分（CREDIT VALUE）：	2
课内课时（CONTACT HOURS）：	32
先修课要求（PRE-REQUISITE）	量子力学 1、线性代数、数学物理方法
开课单位（DEPARTMENT/UNIT）：	物理系
版本（VERSION）：	
课程负责人（COURSE COORDINATOR）：	李明根(签章)
审核人（APPROVER）：	池凌飞(签章)
审核日期（APPROVE DATE）：	2025.4.28

汕头大学理学院

2025 年 04 月

1、课程简介（Course Description）

《高等量子力学》是量子力学理论的高级进阶课程，属于理论物理学的核心学科之一。本课程在初等量子力学的基础上，系统阐述量子力学的数学结构、形式理论及其前沿应用，是理解现代物理（如量子场论、凝聚态物理、量子信息等）的重要理论基础。课程内容兼顾理论严谨性与物理直观性，通过宏观与微观方法的结合，揭示量子现象的深层规律。通过本课程的学习，学生应能够：

1.掌握量子力学的形式理论：深入理解希尔伯特空间、算符代数、对称性与守恒律，熟练运用狄拉克符号与矩阵力学表述。

2.理解近似方法与散射理论：包括微扰论（定态与含时）、变分法、WKB 近似，Born近似和分波法等。

3.熟悉多体问题与二次量子化：掌握全同粒子系统的量子统计性质，初步了解量子场论的数学工具。

4.培养科学思维与创新能力：通过量子测量、纠缠等开放问题的探讨，激发批判性思维，理解量子理论的前沿进展（如量子信息、拓扑量子态）。

5.建立辩证唯物主义方法论：从确定论到概率论的哲学转变，认识量子力学对现代科学观的深远影响。

本课程不仅是理论物理研究的基石，更是探索微观世界本质的钥匙。通过学习，学生将具备在凝聚态物理、量子光学、粒子物理、量子计算等领域开展研究的理论储备，同时培养批判性思维与科学探索精神。

2、预期学习结果（Intended Learning Outcomes）

本课程的预期学习结果如下表：

知识单元	知识点	初始程度	要求程度	预期学习结果
1.希尔伯特空间	1.1 矢量空间与线性算符	L1	L4	掌握希尔伯特空间的定义与性质，熟练运用狄拉克符号与算符代数。
	1.2 本征矢量和本征值	L1	L4	理解本征值问题的物理意义，能求解典型算符（如位置、动量、哈密顿量）的本征值和本征态，掌握简并态的判别方法。
	1.3 表象理论	L1	L4	熟练进行表象变换，理解连续谱与离散谱的表象差异。
	1.4 角动量理论	L1	L4	掌握角动量算符的对易关系，能计算自旋-轨道耦合系统的能级分裂，理解角动量耦合的 CG 系数及其在原子物理中的应用。

2. 量子力学基础	2.1 位置表象和动量表象	L1	L4	熟练推导位置与动量表象的波函数转换关系，理解不确定性原理的数学根源。启发学生多角度看待问题，培养创新思维
	2.2 角动量算符和角动量表象	L1	L3	掌握角动量算符在球坐标系中的表示，能求解中心力场问题的径向方程与角向方程。引导学生在科研中追求精准、注重方法
	2.3 定态薛定谔方程	L1	L3	熟练求解 一些简单的本征值问题。
	2.4 运动方程	L1	L4	掌握海森堡绘景与薛定谔绘景的等价性，能推导含时演化算符的表达式，分析量子态的时间演化。
	2.6 谐振子的相干态	L1	L3	掌握相干态的定义与性质，理解其在量子光学中的应用（如光场的经典极限）。
3.对称性理论	3.1 空间对称性与守恒律	L1	L3	掌握平移、旋转对称性与动量、角动量守恒的关系。了解空间反演及宇称。了解对称与能级简并的关系等。 体会自然规律的和谐统一，增强对科学的敬畏
	3.2 时间平移和时间反演	L1	L3	理解时间反演对称性对量子态的限制（如 Kramers 简并），能判断哈密顿量的时间反演不变性。
4.二次量子化	4.1 全同粒子系统的希尔伯特空间	L1	L3	掌握全同粒子系统的对称化假设，能构造多体波函数的对称性（玻色子/费米子）。
	4.2 产生算符和消灭算符	L1	L4	熟练运用产生-湮灭算符的代数性质。
	4.3 占有数表象	L1	L3	掌握 Fock 空间的构建方法，掌握波色系和费米系的二次量子化。
	4.4 自由电磁场的量子化	L1	L3	理解电磁场的量子化方法，掌握光子产生-湮灭算符的物理意义。

3、先修要求（Pre-requisite）

量子力学 1、线性代数、数学物理方法

4、教材及其他教学资源（Textbooks and Other Learning Resources）

指定教材：

自编讲义。

推荐教材：

1.《高等量子力学》（喀兴林，高等教育出版社）
2.《现代量子力学》（樱井纯，拿波里塔塔 著， 丁亦兵等译，世界图书出版公司）

课程网站：中国大学 MOOC_优质在线课程学习平台

5、主要教学环节（Teaching and Learning Activities）

教学环节	理论课（小时）	习题课（小时）	实验（小时）	研讨（小时）	社会实践（小时）	项目（小时）	在线学习（小时）	期中测试（小时）	合计
课内	30	2	无	无	无	无	无	无	32
课外	无	无	无	32	无	无	无	无	32

6、课程考核（Assessment Scheme）

考核项目	考核内容和考试方法简介	权重
练习、讨论、提问	课后作业及思考；课堂测验；课堂参与、发言、提问（评判标准： **课后作业：**解题过程中基本概念和思路是否清晰？公式使用是否正确？逻辑方面是否完整？ **课堂测沿：**能否在规定时间完成测验内容？ **课堂参与、发言、提问：**是否认真听课？是否积极参与讨论或提出问题？是否会积极查询准备资料？）	40%
期末汇报	完成一个命题大作业，做一个量子力学相关的课题汇报	60%

7、学习进度（Course Schedule）

周次	教学时数	教学形式	教学内容
1-2	4	课堂教学	**课程导论与数学基础复习** 量子力学理论框架回顾（Hilbert 空间、态叠加原理） Dirac 符号系统的深化（左矢/右矢、完备性关系）

			厄米算符，本征值问题，完备性关系
3-5	6	课堂教学	**量子力学形式理论** 态空间与算符的严格定义（封闭性、无界算符处理） 空间平移与动量算符的引入 力学量完全集，测量和不确定关系 坐标表象和动量表象 矩阵表示理论 线性空间的直积和直和
6-8	6	课堂教学	**空间旋转与角动量算符的引入** 角动量算符的代数性质及角动量的本征值问题代数求解 球谐函数的代数推导 角动量耦合及自旋轨道相互作用 球对称问题及其定态解 **数值实践：**Mathematica 计算 CG 系数
9-11	6	课堂教学	**量子动力学** 时间平移和哈密顿算符的引入 海森堡绘景与薛定谔绘景，海森堡运动方程 简谐振子的代数解和波函数，时间演化 相干态介绍 二能级含时问题的精确解及其应用 Bell 不等式 密度矩阵与混合态的物理意义
11-12	4	课堂教学	**多粒子问题** 量子全同性和多体波函数 多电子原子和分子简介 波色系统的二次量子化 费米系统的二次量子化 场算符与多体波函数的对应关系 **前沿扩展：**BEC 超流性与BCS 理论框架

13	2	课堂教学	散射，微扰论，变分法简介
14-15	4	课堂教学	**对称性，守恒和简并** 力学量守恒的充要条件 连续对称性与Noether 定理 离散对称性（P、T、C 算符的物理效应） 对称与能级简并
16	2	课堂教学	**总复习与考试** 知识框架串讲与典型习题解析

Shantou University

Module Description for Undergraduate Courses

COURSE TITLE: Thermodynamics and Statistical Physics

COURSE CODE: PHY2011B

CREDIT VALUE: 3

CONTACT HOURS: 48

PRE-REQUISITE Thermal Physics, Theroretical Mechanics, Advance Calculus, Mathematical methods of Physics

DEPARTMENT/UNIT: Department of Physics

VERSION: 20240731-PHY2011B

COURSE COORDINATOR: 李明根 (Signature and Seal)

APPROVER: Chi Lingfei (Signature and Seal)

APPROVE DATE: 20240731

Shantou University Faculty of Science

July 2024

1. Course Description

(1) Nature of the Course

Thermodynamics and Statistical Physics is a compulsory core course for Physics majors. It is a theoretical physics module concerned with the laws governing thermal phenomena and thermal motion. As one of the foundational disciplines of theoretical physics, thermodynamics develops a macroscopic theoretical framework for thermal motion, whereas statistical physics constructs a microscopic theoretical description based on the statistical behavior of microscopic particles. The two approaches complement and reinforce each other, forming an integrated theoretical system.

This course examines the laws of thermal motion and their influence on macroscopic properties in solids, liquids, gases, and plasmas. Starting from several fundamental laws derived from empirical observations, it employs rigorous mathematical reasoning to study relations between physical properties. From the microscopic perspective, it derives macroscopic system properties and their evolution using probabilistic and statistical methods grounded in microscopic mechanics. By unifying the three fundamental laws of thermodynamics under a single statistical principle, this course establishes a solid foundation for the academic training of physics undergraduates.

(2) Course Content

As a core module within Shantou University's Physics undergraduate training program, this course covers:

- Fundamental laws of thermodynamics
- Thermodynamic properties of homogeneous matter
- Phase equilibrium and phase transitions
- Statistical thermodynamics
- Boltzmann statistics
- Ensemble theory
- Quantum statistics

(3) Course Objectives

1. Deepen understanding of thermal phenomena

   Through studying the laws of thermal motion, students enhance their understanding of the thermal properties of matter and further develop a rigorous scientific worldview.

2. Apply thermodynamics and statistical physics to real problems

   Students should be able to apply acquired knowledge to practical problems, understand recent developments in the field, and appreciate the exploratory spirit and scientific dedication of leading scholars, thereby strengthening their curiosity and motivation for inquiry.

3. Master core concepts and methods

   Students will understand the laws governing thermal phenomena and how thermal motion shapes macroscopic properties of matter. They will master the methodological framework of thermodynamics and statistical physics, strengthening their ability to analyze and solve problems and laying groundwork for addressing real-world physics challenges.

4. Develop statistical physics competence

   Students will learn to derive properties of physical systems using statistical physics, understand underlying microscopic mechanisms, and master statistical techniques such as the probability method, ensemble method, and statistical distributions. They will recognize the central role of statistical physics in modern physics.

5. Engage with frontier developments

   Students will become familiar with major conceptual, methodological, and practical advances in thermodynamics and statistical physics, gain exposure to cutting-edge scientific developments, broaden their academic horizons, and cultivate autonomous, research-oriented, and innovative learning abilities. Their physical intuition and problem-solving competence will be strengthened, with encouragement toward creative thinking.

6. Develop scientific worldview and research spirit
   Students will transition from deterministic to probabilistic thinking, cultivate scientific integrity, and build a sense of responsibility for innovation and exploration at the frontiers and interdisciplinary intersections of physics.

This course supports the following Graduation Requirement Indicators of the Physics major:

3.1 Mastery of core theoretical knowledge and ability to learn complex theories

5.1 Innovative thinking and research competence

6.1 Research and engineering problem-solving ability

2. Intended Learning Outcomes

The intended learning outcomes of this course are summarized in the table below.

Knowledge Unit	Key Knowledge Points	Initial Level	Required Level	Expected Learning Outcomes
1. Basic Laws of Thermodynamics	1.1 Equations of state and state variables	L1	L4	Identify different equations of state;
			L4	Distinguish among the three state variables.
	1.2 First law of thermodynamics and thermometers	L1	L4	Apply the first law of thermodynamics to analyze common thermal phenomena;
			L4	Outline the design principles of thermometers and the concept of temperature.
	1.3 First law of thermodynamics	L1	L3	Use the first law to explain common thermodynamic phenomena;
			L3	Calculate internal energy in common thermodynamic processes.
	1.4 Second law of thermodynamics	L1	L3	Use the second law to explain practical problems;
			L2	Comprehend the concept of equilibrium states.
	1.5 Entropy calculation and the third law of thermodynamics	L1	L3	Calculate the total entropy change of four kinds of system–environment combinations;
			L3	Comprehend the physical implications of the third law;
2. Thermodynamic Properties of Homogeneous Substances	2.1 Enthalpy, free energy, and Gibbs function	L1	L4	Outline the motivation for introducing internal energy and entropy;
			L3	Calculate enthalpy, free energy, and Gibbs function for relevant systems.
	2.2 Characteristic functions and Maxwell relations	L1	L5	Identify four characteristic functions;
			L4	Derive characteristic functions and the four Maxwell relations;
				Solve specific problems using Maxwell relations.

			L3	
	2.3 Thermodynamics of homogeneous substances	L1	L4 L4	Illustrate the correspondence between thermodynamic quantities of surface systems or magnetoelectric media and those of gases; Analyze methods for achieving low temperatures.
	2.4 Summary and selected exercises	L1	L5	Skillfully apply Maxwell relations to prove certain thermodynamic identities.
3. Phase Equilibrium and Phase Transitions	3.1 Open systems and phase rule	L1	L3 L4	Explain the concepts of phase and phase transition; Illustrate Gibbs' phase rule.
	3.2 Clapeyron equation	L1	L4	Derive the Clapeyron equation.
	3.3 Gas–liquid coexistence and transition	L1	L4	Analyze behaviors associated with gas–liquid coexistence and transitions.
	3.4 Classification of phase transitions	L1	L5	Distinguish among types of phase transitions.
4. Statistical Thermodynamics	4.1 Thermodynamic probability	L1	L3	Calculate phase volume and density of states.
	4.2 Phase volume and density of states	L1	L3	Explain the meaning of thermodynamic probability.
	4.3 Quantum description of microstates	L1	L2	Summarize the relationship between quantum states and energy levels.
	4.4 Thermodynamic fluctuations	L1	L2	Comprehend the quasi-thermodynamic fluctuation theory.
5. Boltzmann Statistics	5.1 Boltzmann statistics	L1	L4 L5	Outline how Lagrange multipliers determine the most probable Boltzmann distribution; Relate thermodynamic functions to particle partition functions; Learn about Boltzmann's life and develop critical thinking.
	5.2 Partition-function techniques	L1	L3	Compute the partition function of a single particle (especially for separable cases).
	5.3 Equipartition theorem	L1	L5	Prove the equipartition theorem.
	5.4 Applications of Boltzmann statistics	L1	L3	Calculate the quantum heat capacity of an ideal gas composed of diatomic molecules.
6. Ensemble Theory	6.1 Γ-space and statistical ensembles	L1	L4	Derive the canonical distribution.

	6.2 Microcanonical ensemble	L1	L3	Calculate the grand partition function.
	6.3 Canonical ensemble	L1	L4	Compare similarities and differences among the three ensembles.
	6.4 Grand canonical ensemble	L1	L2	Explain the content of Gibbs' paradox.
7. Quantum Statistics	7.1 Bosons and fermions	L1	L4	Derive the Fermi–Dirac and Bose–Einstein distributions.
	7.2 Quantum distribution laws	L1	L4 L4	Compare quantum and classical distributions; Outline the conditions under which quantum distributions reduce to classical ones.
	7.3 Ideal Fermi gas	L1	L2 L2	Explain the behavior of an ideal Fermi gas; Describe the free-electron model of metals.
	7.4 Ideal Bose gas	L1	L4 L4	Illustrate ideal Bose gases and BEC; Illustrate photon gases and phonon gases.
9. Computational Statistical Physics	9.1 Molecular dynamics	L1	L2	Explain the concept of molecular dynamics.
	9.2 Monte Carlo simulation	L1	L2	Comprehend the computational ideas of Monte Carlo simulation.
Scientific Literacy	Understand the impact of the natural world and human activities; use scientific knowledge to identify problems and draw evidence-based conclusions.	L1	L2	Intended learning outcomes include understanding the historical development of thermodynamics and its influence on human progress; recognizing the role of thermodynamics and statistical physics in understanding and shaping the world; and cultivating scientific spirit, dedication, and curiosity.
Critical Thinking	Analyze problems, identify contradictions and logical fallacies, select arguments and solutions, deduce theories, and test hypotheses with evidence.	L1	L4	Intended learning outcomes include understanding the development history of thermodynamics and statistical physics, recognizing past theoretical errors and resolutions.
Problem Identification and Formulation; Model Building	Analyze and synthesize meaningful questions, and articulate them in a scientifically accurate manner.	L1	L4	Identify a thermodynamics-related phenomenon in your surroundings and provide an accurate description of the problem.
Building models	Determine the key issues that need to be validated, and establish appropriate assumptions; apply these assumptions to simplify complex systems and environments, and develop	L1	L2	Comprehend the thermodynamic laws covered in the course and summarize the models used to solve the problem.

	both qualitative and quantitative models.			
Communication skills	Engage in communication, group discussion, and task completion.	L1	L2	Summarize the challenges encountered during the historical development of thermodynamics and the corresponding solutions.
Information Retrieval	Use library resources and tools (online search systems, databases, search engines, etc.) to search for and obtain relevant information.	L2	L3	For problems encountered in thermodynamics and statistical physics, use library resources and related tools to locate the relevant information.

3. Pre-requisit

Thermal Physics, Theroretical Mechanics, Advance Calculus, Mathematical methods of Physics.

4. Textbooks and Other Learning Resources

Required Textbooks

Bao Jingdong, *Concise Course of Thermodynamics and Statistical Physics*, 2nd Edition, Higher Education Press, 2021.

Recommended Textbooks

(1) Wang Zhicheng, *Thermodynamics and Statistical Physics*, 6th Edition, Higher Education Press, 2023.

(2) Su Rukeng, *Statistical Physics*, 2nd Edition, Higher Education Press, 2004.

(3) W. Greiner, L. Neise, H. Stocker, *Thermodynamics and Statistical Mechanics* (Springer-Verlag, New York, 1995).

(4) R.K. Pathria, *Statistical Mechanics*, 2nd Edition (Elsevier (Singapore) Pte Ltd., 2001), Chinese translation by Zhong Yunxiao, edited by Zhang Qiren, Peking University Press, 2001.

5. Teaching and Learning Activities

Teaching Segment	Lectures (Theory)	Exercise Classes	Laboratory Work	Seminars	Social Practice	Project Work	Online Learning	Mid-Term Test	Total
Hours (In-class)	60	0	0	4	0	0	0	0	64
Hours (Out-of-class)	80	44	0	4	0	0	0	0	128

Given the extensive content of this course, classroom instruction alone is insufficient for students to fully grasp all materials. Therefore, substantial self-study is required outside of class. The ratio of self-study hours to classroom instruction is 2:1. The self-study component totals 128 hours, including 80 hours of theoretical study, 44 hours of problem-solving, and 4 hours of literature review and discussion.

The self-study component is to be completed under students' self-supervision.

6. Assessment Scheme

Assessment item	Description	Weight
Exercises, Discussions, and Questions	Homework and reflections; classroom participation, contributions, and questions. Evaluation criteria:	40%

	• **Homework:** clarity of fundamental concepts and reasoning; correctness in the use of formulas; logical completeness. • **Classroom participation, contributions, and questions:** whether the student listened attentively in class; whether they actively participated in discussions or raised questions; and whether they proactively searched for and prepared relevant materials.	
Final Examination	Closed-book final exam	60%

The final grade consists of two components: continuous assessment and the final exam. Continuous assessment accounts for 40%, and the final exam accounts for 60%. Continuous assessment includes attendance, classroom participation, contributions, and questions (20%, evaluated by the instructor), and course assignments (20%, evaluated jointly by the instructor and the teaching assistant).

Final Exam (Weight: 60%):

The final exam primarily evaluates students' ability to correctly construct physical models, apply scientific thinking methods such as analysis, synthesis, inference, and analogy, and use mathematical techniques such as differentiation and integration to analyze and solve physical problems.

7. Course Schedule

Week	Hour	Teaching format	Teaching content
3	3	Lecture	Introduction; Fundamental Laws of Thermodynamics; 1.1 Equations of State and State Variables
4	3	Lecture	Fundamental Laws of Thermodynamics; 1.2 First Law of Thermodynamics and Thermometers; 1.3 First Law of Thermodynamics
5	3	Lecture	National Day Holiday
6	3	Lecture	Thermodynamic Properties of Homogeneous Substances; 2.1 Enthalpy, Free Energy, and Gibbs Function; 2.2 Characteristic Functions and Maxwell Relations
7	3	Lecture	Thermodynamic Properties of Homogeneous Substances; 2.2 Characteristic Functions and Maxwell Relations; 2.3 Thermal Properties of Homogeneous Substances; 2.4 Summary and Selected Exercises; Assignment of homework
8	3	Lecture	Phase Equilibrium and Phase Transitions; 3.1 Open Systems and Phase Rule; 3.2 Clausius–Clapeyron Equation
9	3	Lecture	Phase Equilibrium and Phase Transitions; 3.3 Gas–Liquid Equilibrium and Transformations; 3.4 Classification of Phase Transitions; Assignment of homework

10	3	Lecture	Statistical Thermodynamics; 4.1 Thermodynamic Probability; 4.2 Phase Volume and Density of States; 4.3 Quantum Description of Microstates; 4.4 Thermodynamic Fluctuations; Assignment of homework
11	3	Lecture	Boltzmann Statistics; 5.1 Boltzmann Statistics; 5.2 Partition Function Techniques
12	3	Lecture	Boltzmann Statistics; 5.3 Equipartition Theorem; 5.4 Applications of Boltzmann Statistics
13	3	Lecture	Ensemble Theory; 6.1 Γ-Space and Statistical Ensembles; 6.2 Microcanonical Ensemble
14	3	Lecture	Ensemble Theory; 6.3 Canonical Ensemble
15	3	Lecture	Ensemble Theory; 6.4 Grand Canonical Ensemble; Assignment of homework
16	3	Lecture	Quantum Statistics; 7.1 Bosons and Fermions; 7.2 Quantum Distribution Laws; Assignment of homework
17	3	Lecture	Quantum Statistics; 7.3 Ideal Fermi Gas; 7.4 Ideal Bose Gas; Assignment of homework
18	3	Lecture	Computational Statistical Physics; 9.1 Molecular Dynamics; 9.2 Monte Carlo Simulation Methods

Note: The final grade consists of 40% continuous assessment and 60% final written exam.

The class scheduled for October 2 is cancelled due to the National Day holiday.

汕头大学本科教学

课程教学大纲

课程名（COURSE TITLE）： 热力学与统计物理

课程代码（COURSE CODE）： PHY2011B

学分（CREDIT VALUE）： 3

课内课时（CONTACT HOURS）： 48

先修课要求（PRE-REQUISITE） 热学、理论力学、高等微积分、数学物理方法

开课单位（DEPARTMENT/UNIT）： 物理学系

版本（VERSION）： 20240731-PHY2011B

课程负责人（COURSE COORDINATOR）： 李明根 (签章)

审核人（APPROVER）： 池凌飞(签章)

审核日期（APPROVE DATE）： 20240731

汕头大学理学院

2024 年 7 月

1. 课程简介（Course Description）

（1）课程性质

热力学与统计物理（Thermodynamics and Statistical Physics）属于物理学专业的专业必修课，是研究物质的热现象和热运动规律的理论物理课程， 它是理论物理学基础学科之一。热力学研究热运动的宏观理论，主要采用宏观的研究方法，统计物理是热运动的微观理论，主要采用微观的研究方法，两种方法相辅相成，相互融会贯通， 取长补短。热力学与统计物理学研究物质热运动的规律以及热运动对宏观性质的影响，是固体、液体、气体、等离子体理论之一。该课程以由观察和实验总结出的几个基本定律为基础，经过严密的数学推理，来研究物性之间的关系；从物质的微观结构出发，依据微观粒子所遵循的力学规律，再用概率统计的方法求出系统的宏观性质及其变化规律；将热力学三个基本定律统一于一个基本的统计原理，为培养物理学专业学术型本科人才奠定基础。

（2）课程内容

本课程属于汕头大学物理学专业人才培养方案的专业基础模块课程，主要内容包含热力学的基本定律，均匀物质的热力学性质，相平衡与相变，统计热力学，玻尔兹曼统计，系综理论和量子统计。

（3）课程目标

① 通过对热运动规律的学习，加深对物质热性质的理解，进一步培养辩证唯物主义世界观。

② 能够运用所学的热力学和统计物理的知识解决一些实际问题，理解本学科最新发展动态，知道一些学者、科学家勇于探索，无私奉献的爱国主义精神，激发求知欲。

③ 掌握热现象与热运动的规律及其对物质宏观性质的影响；掌握热力学与统计物理学处理问题的方法，提高分析问题与解决问题的能力，为解决实际问题打下基础。

④ 应用统计物理学理论得出具体物质的特性，理解其微观机理，掌握概率法、系综法等统计方法，以及统计分布律的意义及应用，充分认识到统计物理在现代物理中的重要地位。

⑤ 了解热力学与统计物理在概念、理论方法和实际应用上的重要进展，了解与本课程相关的最新科学前沿发展，拓宽学生视野，培养学生自主性、研究性、创新性学习的能力。提高学生物理直觉和解决实际问题的能力，鼓励创新性思维。

⑥ 建立辩证唯物主义世界观和由确定论的方法改变为概率论的方法论；培养学生的科学精神，勇于在物理学前沿及交叉领域探索、创新与攀登的责任感和使命感。

本课程目标对应物理学专业人才培养方案毕业要求指标点：1.2 坚定的理想信念；2.2 确价值观和社会责任感；3.1 掌握专业理论知识及复杂理论的学习能力；5.1 具备创新思维和研究能力；6.1 解决问题的研究和工程能力。

2. 预期学习结果（Intended Learning Outcomes）

本课程的预期学习结果如下表：

知识单元	知识点	初始程度	要求程度	预期学习结果
1.热力学的基本定律	1.1 物态方程和状态参量	L1	L4 L4	鉴别不同气体的物态方程； 区分三个物态参数。
	1.2 热力学第一定律和温度计	L1	L4 L4	应用热力学第一定律分析常见的热现象； 概述温度计的设计原理和温度的概念。
	1.3 热力学第一定律	L1	L3 L3	应用热力学第一定律的内容说明常见的热力学现象； 计算常见的热力学过程的内能；
	1.4 热力学第二定律	L1	L3 L2	使用热力学第二定律说明实际问题； 领悟平衡态的概念；
	1.5 熵的计算和热力学第三定律	L1	L3 L2	计算四种系统加环境的总熵变； 领悟热力学第三定律的物理内涵； 了解建立热力学三大定律的科学家，培养学生崇高的道德情操和科学素养，主张唯物主义认识论，主张奉献精神。
2.均匀物质的热力学性质	2.1 焓、自由能和吉布斯函数	L1	L4 L3	概述引入内能和熵的动机； 计算相关系统中的焓、自由能和吉布斯函数。
	2.2 特性函数与麦克斯韦关系	L1	L5 L4 L3	辨认四个特性函数； 推理出特性函数和四个麦克斯韦关系； 使用麦克斯韦关系计算具体问题。
	2.3 热均匀物质热力学	L1	L4 L4	举例说明表面系统、磁电介质的热力学量与气体的对应; 分析低温的获得方式。 了解我国目前的能源应用现状，主张爱国奉献，投身祖国卡脖子的方向中去。
	2.4 小结和习题选讲	L1	L5	熟练运用麦克斯韦关系证明一些热力学等式。
3.相平衡与相变	3.1 开放系统与相律	L1	L3 L4	说明相，相变等物理概念； 图解吉布斯相律。 开放视野，学会利用互联网+扩充知识面，主张自由探索。
	3.2 克拉珀龙方程	L1	L4	推理克拉珀龙方程。
	3.3 气液两相的平衡与转变	L1	L4	分析气液两项共存与转变的行为。
	3.4 相变的分类	L1	L5	区分相变的类型。
4.统计热力学	4.1 热力学概率	L1	L3	计算相体积和态密度。
	4.2 相体积、态密度	L1	L3	说明热力学概率的意义。
	4.3 微观态的量子描写	L1	L2	总结量子态与能级的关系。
	4.4 热力学涨落	L1	L2	领悟准热力学涨落理论。 了解我国科学家在分子马达方面做出的

				杰出贡献，主张爱国奉献的精神。
5.玻尔兹曼统计	5.1 玻耳兹曼统计	L1	L4 L5	概述由朗格朗日乘子确定玻耳兹曼最概然统计； 联系热力学函数与粒子配分函数的关系。 了解玻尔兹曼的生平，主张批判性思维。
	5.2 配分函数技术	L1	L3	计算单个粒子的配函数(特别是分离情况)；
	5.3 能量均分定理	L1	L5	证明能量均分定理。
	5.4 玻耳兹曼统计的应用	L1	L3	计算双原子分子组成的理想气体的量子热容量。
6.系综理论	6.1 Γ空间与统计系综	L1	L4	会推理正则分布。
	6.2 微正则系综	L1	L3	会计算巨配分函数。
	6.3 正则系综	L1	L4	比较三种系综的异同点。
	6.4 巨正则系综	L1	L2	可以说明吉布斯佯谬的内容。
7.量子统计	7.1 玻色子和费米子	L1	L4	推理 F-D 和 B-E 分布。
	7.2 量子分布律	L1	L4 L4	比较量子和经典分布的不同点； 概述量子分布向经典分布过渡的条件；
	7.3 理想费米气体	L1	L2 L2	解释理想费米气体的行为； 说明金属的自由电子气模型。
	7.4 理想玻色气体	L1	L4 L4	举例说明理想玻色气体和 BEC; 举例说明光子气体和声子气体。
9. 计算统计物理	9.1 分子动力学	L1	L2	说明分子动力学的概念。
	9.2 蒙特卡罗模拟方法	L1	L2	领悟蒙特卡罗模拟的计算方法。
科学素养	理解自然世界和人类活动对自然世界的影响；运用科学知识，明确问题并做出具有证据的结论。	L1	L2	领悟热力学的发展过程及对人类进步带来的巨大影响、热力学与统计物理是如何来认识世界和改造世界。 **主张唯物主义认识论，主张奉献精神，主张勇于探索精神。**
批判性思维	分析问题，识别有矛盾的观点和逻辑谬误，选择逻辑论点和解决方法；归纳理论和事实验证假设与结论	L1	L4 L2	概述对热力学统计物理发展史的了解。 说明热力学与统计物理体系建立和发展过程中某些理论和逻辑的谬误和解决方法。 **主张唯物主义认识论。**

发现问题和表述问题	分析并归纳有价值的问题，科学准确地表述问题；	L1	L4	选择身边热力学现象相关的问题，准确地概述问题。 **主张批判性思维。**
建立模型	选择需要验证的关键问题，制定假设；应用假设简化复杂的系统和环境，制定定性和定量模型	L1	L2	领悟课程中热力学定律和总结解决问题所用到的相关模型。 **个人追求如何与国家需求结合起来，才能达到最佳接收效果。**
交流能力	分组讨论及完成任务	L1	L2	总结热力学发展过程遇到的困难和解决方法。
查询资料	应用图书馆工具（在线检索、数据库、搜索引擎等）检索并获取信息	L2	L3	针对遇到的热力学和统计物理中的问题，使用图书馆等场所和工具找到相关信息。

3. 先修要求（Pre-requisite）

热学、理论力学、高等微积分、数学物理方法。

4. 教材及其他教学资源（Textbooks and Other Learning Resources）

指定教材：

《热力学与统计物理简明教程》，第二版，包景东，高等教育出版社 2021 年

推荐教材：

（1）《热力学 • 统计物理》，第六版，汪志诚，高等教育出版社，2023 年

（2）《统计物理学》，第二版，苏汝铿，高等教育出版社，2004 年

（3）W. Greiner, L. Neise, H. Stocker Thermodynamics and Statistical Mechanics (Springer-Verlag, New York, 1995)

（4）钟云霄 译、张启仁 校，北京大学出版社，2001 年 R.K. Pathria Statistical Mechanics (Second Edition) (Elsevier (Singapore) Pte Ltd., 2001)

课程网站：

5. 主要教学环节（Teaching and Learning Activities）

教学环节	理论课（小时）	习题课（小时）	实验（小时）	研讨（小时）	社会实践（小时）	项目（小时）	在线学习（小时）	期中测试（小时）	合计

课内	60	0	0	4	0	0	0	0	64
课外	80	44	0	4	0	0	0	0	128

本课程内容较多，只进行课堂教学，学生无法全部理解课程内容，因此需要在课堂教学环节之外进行自学。自学环节课时与课堂教学课时比例为 2：1，即自学环节为 128 学时，其中理论内容学习 80 学时，完成习题 44 学时，查阅资料、讨论等 4 学时。

自学环节由学生自我监督完成。

6. 课程考核（Assessment Scheme）

考核项目	考核内容和考试方法简介	权重
练习、讨论、提问	课后作业及思考；课堂参与、发言、提问 （评判标准： **课后作业：**解题过程中基本概念和思路是否清晰？公式使用是否正确？逻辑方面是否完整？ **课堂参与、发言、提问：**是否认真听课？是否积极参与讨论或提出问题？是否会积极查询准备资料？）	40%
期末考试	期末闭卷考试	60%

本课程考核由课程平时学习表现和期末考试两部分组成，其中平时学习表现评分占比为40%，期末考试评分占比60%。平时学习表现：出勤、课堂参与程度、发言、提问等占比20%，由教师评定；课程习题占比20%，由教师和助教共同评定。

期末考试：主要考察学生是否能够正确构建物理模型，掌握分析、综合、推理类比等科学思维方法，运用求导、积分等数学方法分析和解决物理问题。

7. 学习进度（Course Schedule）

周次	教学时数	教学形式	教学内容
3	3	课堂教学	绪论 热力学的基本定律 1.1 物态方程和状态参量
4	3	课堂教学	热力学的基本定律 1.2 热力学第一定律和温度计 1.3 热力学第一定律

5	3	课堂教学	国庆节放假
6	3	课堂教学	均匀物质的热力学性质 2.1 焓、自由能和吉布斯函数 2.2 特性函数与麦克斯韦关系
7	3	课堂教学	均匀物质的热力学性质 2.2 特性函数与麦克斯韦关系 2.3 热均匀物质热力学 2.4 小结和习题选讲 布置课后练习
8	3	课堂教学	相平衡与相变 3.1 开放系统与相律 3.2 克拉珀龙方程
9	3	课堂教学	相平衡与相变 3.3 气液两相的平衡与转变 3.4 相变的分类 布置课后练习
10	3	课堂教学	统计热力学 4.1 热力学概率 4.2 相体积、态密度 4.3 微观态的量子描写 4.4 热力学涨落 布置课后练习
11	3	课堂教学	玻尔兹曼统计 5.1 玻耳兹曼统计 5.2 配分函数技术
12	3	课堂教学	玻尔兹曼统计 5.3 能量均分定理 5.4 玻耳兹曼统计的应用
13	3	课堂教学	系综理论 6.1 Γ空间与统计系综 6.2 微正则系综
14	3	课堂教学	系综理论 6.3 正则系综
15	3	课堂教学	系综理论 6.4 巨正则系综 布置课后练习
16	3	课堂教学	量子统计 7.1 玻色子和费米子 7.2 量子分布律 布置课后练习
17	3	课堂教学	量子统计 7.3 理想费米气体 7.4 理想玻色气体 布置课后练习

18	3	课堂教学	计算统计物理 9.1 分子动力学 9.2 蒙特卡罗模拟方法

说明：期末总分：平时成绩占 40%，期末卷面 60%。10 月 2 日的课因国庆假期留空。

Shantou University

Module Description for Undergraduate Courses

COURSE TITLE: Theoretical Mechanics

COURSE CODE: PHY2017A

CREDIT VALUE: 3

CONTACT HOURS: 48

PRE-REQUISITE Advance Calculus, Classical mechanics

DEPARTMENT/UNIT: Department of Physics

VERSION: 20240731-PHY2017A

COURSE COORDINATOR: 李明根 (Signature and Seal)

APPROVER: Chi Lingfei (Signature and Seal)

APPROVE DATE: 20240731

Shantou University Faculty of Science

July 2024

1. Course Description

Theoretical Mechanics is a core course in the physics curriculum. It examines the fundamental laws that universally govern the mechanical motion of physical bodies. Mechanical motion refers to the change of an object's position in space over time, representing the simplest and most essential form of material motion. All complex and advanced forms of motion addressed in other scientific disciplines ultimately contain this basic form. Therefore, Theoretical Mechanics serves both as an entry point to subsequent theoretical physics courses and as a theoretical foundation for modern engineering and technology.

The primary aim of this course is to distill the basic laws governing mechanical motion and apply them to determine the motion of physical bodies or the nature of the forces acting upon them. The course establishes a foundational basis for cultivating academically oriented undergraduate students in physics.

This course is part of the "Fundamental Module for Physics Majors" in the Physics Programme of Shantou University. The main topics include:

- Description of particles and systems of particles, and the formulation and solution of equations of motion;
- Newton's laws of motion, the principle of relativity, and inertial forces;
- Work and energy, the momentum theorem and momentum conservation, the angular momentum theorem and angular momentum conservation, the kinetic energy theorem and conservation of mechanical energy;
- Universal gravitation and planetary motion;
- Analysis of rigid-body motion, including equations of motion, equilibrium equations, moments of inertia, and rigid-body dynamics;
- Analytical mechanics.

After completing this course, students are expected to:

(1) Approach scientific questions from a materialist and dialectical perspective;

(2) Develop a sense of national responsibility and foster curiosity, exploration, and dedication, strengthening confidence in the prevailing societal framework, theory, system, and culture;

(3) Establish a sound worldview, system of values, and philosophy of life;

(4) Use mathematical tools to solve simple physical problems and gain a deeper understanding of mechanics;

(5) Attain a comprehensive and systematic understanding of the laws governing macroscopic mechanical motion, master general methods for solving mechanical problems, build a solid foundation for further theoretical physics courses, and develop abstract thinking and rigorous logical reasoning;

(6) Apply mathematical tools within mechanics, recognise the close connection between mathematics and physics, and strengthen the ability to use mathematical methods to solve physical problems.

This course corresponds to the following programme learning outcomes:

3.1 Mastery of theoretical knowledge and the ability to learn complex theories

5.1 Innovative thinking and research capability

6.1 Research and engineering problem-solving ability

2. Intended Learning Outcomes

The intended learning outcomes of this course are summarized in the table below.

Knowledge Unit	Key Knowledge Points / Competency Standards	Initial Level	Required Level	Expected Learning Outcomes
Mechanics of a Single Particle	Description of motion; laws of particle motion; dynamics in non-inertial reference frames; work and energy; fundamental conservation laws in	L1	L4 L3	1. Compare the motion of a particle described in different reference frames. 2. Apply calculus to solve kinematics problems involving a single particle.

	particle dynamics; central-force motion.		L3	3. Use the three major conservation laws in particle dynamics to solve related problems.
Mechanics of Systems of Particles	Systems of particles; momentum theorem and momentum conservation; angular momentum theorem and conserved quantities; work–energy relations and mechanical energy conservation; two-body problems; centre-of-mass reference frame.	L1	L5 L3	1. Compare the momentum theorem and mechanical energy conservation for a single particle versus a system of particles. 2. Use the centre-of-mass reference frame to analyse problems involving systems of particles.
Rigid-Body Mechanics	Analysis of rigid-body motion; angular velocity vectors; equations of motion and equilibrium for rigid bodies; moments of inertia; planar motion and rotation about a fixed axis.	L1	L2 L3 L3	1. Demonstrate a correct understanding of the concept of a rigid body. 2. Use systems thinking to analyse problems in rigid-body mechanics. 3. Apply calculus to determine moments of inertia and analyse planar motion of rigid bodies.
Rotating Reference Frames	Planar and spatial rotating reference frames; dynamics in non-inertial frames.	L1	L4 L3 L4	1. Demonstrate correct understanding of torque, angular momentum, and the angular momentum theorem. 2. Apply calculus to solve dynamics problems involving systems of particles or special systems such as rigid bodies. 3. Analyse everyday physical phenomena, such as the eastward deviation of falling objects.
Analytical Mechanics	Constraints and generalized coordinates; principle of virtual work; Lagrange's equations.	L1	L4 L3 L3	1. Demonstrate correct understanding of generalized coordinates. 2. Use the principle of virtual work to solve problems involving systems of particles. 3. Derive the equations of motion of particle systems using Lagrange's equations.
Scientific Literacy	Understanding the natural world and human impact on it; using scientific knowledge to identify problems and draw evidence-based conclusions.	L1	L2	Understand the development of mechanics and its profound impact on human progress; recognise how mechanics is used to understand and transform the world.
Critical Thinking	Analysing problems, identifying contradictions and logical fallacies, choosing logical arguments and solutions; synthesising theories and using facts to test hypotheses.	L1	L1 L2	1. Demonstrate understanding of the history of mechanics. 2. Explain certain logical challenges and erroneous theories that arose during the development of mechanics, along with their resolutions.

Problem Discovery and Formulation	Identifying valuable problems; accurately articulating scientific questions.	L1	L2	Select physics-related problems from everyday life and formulate them clearly.
Model Building	Formulating hypotheses, simplifying complex systems, constructing qualitative and quantitative models.	L1	L2	Explain the mechanical laws and modelling methods used to solve problems in this course.
Communication Skills	Group discussion; completion of assigned tasks; summarising viewpoints.	L1	L2	Summarise personal viewpoints clearly during discussions.
Information Retrieval	Use library resources and tools (online search systems, databases, search engines, etc.) to search for and obtain relevant information.	L2	L2	For problems encountered in Theoretical Mechanics, locate relevant information using library facilities and digital research tools, and provide proper source documentation.

3. Pre-requisit

Calculus B1, Classical mechanics

4. Textbooks and Other Learning Resources

Required Textbooks

Zhou Yanbai, *Tutorial of Theoretical Mechanics*, 5th Edition, Higher Education Press, 2023.

Recommended Textbooks

(1) Chen Jianping & Fan Qinshan, *Theoretical Mechanics*, Higher Education Press, 3rd Edition, 2018;

(2) Hong Jiazhen, Liu Zhuyong & Yang Changjun, *Theoretical Mechanics*, Higher Education Press, 4th Edition, 2015;

(3) Xie Chuanfeng, Wang Qi & Cheng Yao, *Theoretical Mechanics*, Higher Education Press, 2nd Edition, 2015.

Course Websites

(1) my.stu.edu.cn

(2) Rain Classroom

5. Teaching and Learning Activities

Teaching Segment	Lectures (Theory)	Exercise Classes	Laboratory Work	Seminars	Social Practice	Project Work	Online Learning Others	Mid-Term Test	Total
Hours (In-class)	60	0	0	4	0	0	0	0	64
Hours (Out-of-class)	80	44	0	4	0	0	0	0	128

Because the course content is extensive, classroom teaching alone is not sufficient for students to fully grasp the material. Therefore, students are required to engage in self-directed study outside the regular class hours. The ratio of self-study hours to classroom hours is 2:1, amounting to 128 hours of self-study, including 80 hours of theoretical study, 44 hours of problem-solving, and 4 hours of literature review and discussion.

All self-study activities are to be completed under the students' self-supervision.

6. Assessment Scheme

Assessment item	Description	Weight
Exercises, Discussions, and Questions	Homework and reflections; classroom participation, contributions, and questions. Evaluation criteria: • **Homework:** clarity of fundamental concepts and reasoning; correctness in the use of formulas; logical completeness. • **Classroom participation, contributions, and questions:** attentiveness, active engagement in discussion or inquiry, willingness to search and prepare materials.	40%
Final Examination	Closed-book final exam	60%

The overall assessment consists of two components: continuous assessment during the semester and the final examination. Continuous assessment accounts for 40%, and the final examination accounts for 60%.

Continuous assessment includes attendance, classroom participation, contributions, and questions (20%), evaluated by the instructor, and homework assignments (20%), evaluated jointly by the instructor and the teaching assistant.

The final examination mainly evaluates whether students can correctly construct physical models, master analytical, synthetic, and logical reasoning methods, and apply mathematical tools such as differentiation and integration to analyze and solve physical problems.

7. Course Schedule

Week	Hour	Teaching format	Teaching content
1	3	Lecture	Mathematical preliminaries: solution of ordinary differential equations and calculus.
2	3	Lecture	Particle Mechanics: (1) Descriptions of motion; (2) Component expressions of velocity and acceleration; (3) Translational reference frames. Homework assigned.
3	3	Lecture	Particle Mechanics: (1) Laws of motion for a particle; (2) Differential equations of particle motion; (3) Dynamics in non-inertial reference frames. Homework assigned.
4	3	Lecture	Particle Mechanics: (1) Work and energy; (2) Fundamental theorems and conservation laws of particle dynamics; (3) Central forces. Homework assigned.
5	3	Lecture	System of Particles: (1) System of particles; (2) Momentum theorem and momentum conservation; (3) Angular momentum theorem and conservation. Homework assigned.
6	3	Lecture	System of Particles: (1) Work–energy theorem and mechanical energy conservation; (2) Two-body problem; (3) Center-of-mass reference frame. Homework assigned.

7	3	Lecture	System of Particles: (1) Center-of-mass reference frame; (2) Laboratory reference frame. Homework assigned.
8	3	Lecture	Rigid Body Mechanics: (1) Analysis of rigid body motion; (2) Angular velocity vector; (3) Equations of motion and equilibrium equations of a rigid body. Homework assigned.
9	3	Lecture	Rigid Body Mechanics: (1) Moment of inertia; (2) Planar parallel motion of a rigid body and rotation about a fixed axis. Homework assigned.
10	3	Lecture	Rigid Body Mechanics: (1) Planar parallel motion of a rigid body; (2) Rotation of a rigid body about a fixed point. Homework assigned.
11	3	Lecture	Rotating Reference Frames: (1) Planar rotating reference frame; (2) Spatial rotating reference frame. Homework assigned.
12	3	Lecture	Rotating Reference Frames: (1) Dynamics in non-inertial frames (Part II); (2) Effects of Earth's rotation. Homework assigned.
13	3	Lecture	Analytical Mechanics: (1) Constraints and generalized coordinates; (2) Principle of virtual work. Homework assigned.
14	3	Lecture	Analytical Mechanics: (1) Lagrange's equations; (2) Hamilton's canonical equations. Homework assigned.
15	3	Lecture	Analytical Mechanics: (1) Poisson brackets and Poisson theorem; (2) Hamilton's principle. Homework assigned.
16	3	Lecture	Analytical Mechanics: (1) Canonical transformations. Homework assigned.

汕头大学本科教学

课程教学大纲

课程名（COURSE TITLE）： 理论力学

课程代码（COURSE CODE）： PHY2017A

学分（CREDIT VALUE）： 3

课内课时（CONTACT HOURS）： 48

先修课要求（PRE-REQUISITE） 高等微积分；力学

开课单位（DEPARTMENT/UNIT）： 物理学系

版本（VERSION）： 20240731-PHY2017A

课程负责人（COURSE COORDINATOR）： 李明根 (签章)

审核人（APPROVER）： 池凌飞(签章)

审核日期（APPROVE DATE）： 20240731

汕头大学理学院

2024 年 7 月

1. 课程简介（Course Description）

理论力学（Theoretical mechanics）属于物理学专业的核心课程。它是研究物体机械运动普遍遵循的基本规律的一门学科。所谓机械运动，就是物体在空间的相对位置随时间而改变的现象，它是物质运动最简单、最基本的运动形态。将来其它学科所涉及有关物质的各种复杂、高级的运动形态，都包括有这种最简单的运动形态。因此，理论力学是今后学习其它理论物理学科的入门向导，也是近代工程技术的理论基础。理论力学的主要任务，就是归纳机械运动所遵循的基本规律，用以确定物体的运动情况或者作用在它上面的某些力的性质，为培养物理学专业学术型本科人才奠定基础。。

本课程属于汕头大学物理学专业人才培养方案的专业基础模块课程，主要内容有：质点和质点组的描述以及运动方程的建立与求解；牛顿运动定律，相对性原理与惯性力；功与能，动量定理与动量守恒，角动量定理与角动量守恒，动能定理与机械能守恒；万有引力和行星运动；刚体运动分析，运动方程与平衡方程，转动惯量，刚体动力学；分析力学。学完本课程后学生应能够：

（1）能从唯物的、辩证的角度去看待科学问题；

（2）培养学生的家国情怀，树立勇于探索、乐于奉献的精神，坚定中国特色社会主义道路自信、理论自信、制度自信和文化自信。

（3）培养和树立正确的世界观、价值观和人生观。

（4）用数学知识求解物理学中的一些简单问题，对力学有一个更高层次上的认识；

（5）使学生对宏观机械运动的规律有较全面较系统的认识，能掌握处理力学问题的一般方法，为后继理论物理课程的学习打下坚实基础，并培养一定的抽象思维与严密的逻辑推理能力，为今后独立钻研创造条件。

（6）在力学理论的学习中结合运用数学工具处理问题，使学生认识数学与物理的密切关系，培养学生运用数学工具解决物理问题的能力。

本课程目标对应物理学专业人才培养方案毕业要求指标点：1.2 坚定的理想信念； 2.2 正确价值观和社会责任感；3.1 掌握专业理论知识及复杂理论的学习能力 5.1 具备创新思维和研究能力 6.1 解决问题的研究和工程能力。

2. 预期学习结果（Intended Learning Outcomes）

本课程的预期学习结果如下表：

培养目标 知识单元/能力标准		知识点/能力标准	初始程度	要求程度	预期学习结果
	质点力学	运动的描述方式；质点的运动规律；非惯性系动力学；功与能；质点动力学的基本守恒定律；有心力。	L1	L4 L3 L3	1.比较不同参考系下质点的运动。 2. 应用微积分知识解决质点的运动学问题。 3、应用质点动力学三大守恒定律去求解相关问题。 **4、思政：通过中国发射火箭卫星等实际情景培养学生的社会主义制度自信。**

知识能力	质点组动力学	质点组；动量定理与动量守恒定律；动量矩定理与守恒量；动量定理与机械能守恒定律；两体问题；质心参考系。	L1	L5 L3	1. 对比质点和质点组的动量定理以及机械能守恒定律。 2. 应用质心参考系解决质点组运动学的相关问题。 **3. 思政：通过视频观看我国拥有粒子加速器等装置，培养学生求实创新的科学精神。**
	刚体力学	刚体运动的分析；角速度矢量；刚体运动方程与平衡方程；转动惯量；刚体的平面平行运动和绕固定轴的转动。	L1	L2 L3 L3	1. 展现对刚体概念的正确解释。 2. 应用系统的思想处理刚体力学问题。 3. 应用微积分解决刚体的转动惯量与平面平行运动等力学问题。 **4. 思政：通过刚体力学在实际生产和工程中的应用，培养学生的家国情怀。**
	转动参考系	平面转动参考系；空间转动参考系；非惯性系动力学。	L1	L4 L3 L4	1. 展现对力矩，角动量，角动量定理的正确理解。 2. 应用微积分解决质点组或特殊质点组（例如刚体）的动力学问题。 3. 分析生活中的一些物理现象，如落体偏东等。
	分析力学	约束与广义坐标；虚功原理；拉格朗日方程。	L1	L4 L3 L3	1. 展现对广义坐标的正确理解。 2. 应用虚功原理解决质点系运动问题。 3. 应用拉格朗日方程推导质点系满足的运动学方程。
	科学素养	理解自然世界和人类活动对自然世界的影响；运用科学知识，明确问题并做出具有证据的结论。	L1	L2	理解力学的发展过程及对人类进步带来的巨大影响、力学是如何来认识世界和改造世界。 **思政：支持我国的社会制度，主张唯物主义认识论，主张奉献精神，主张勇于探索精神。**
	批判性思维	分析问题，识别有矛盾的观点和逻辑谬误，选择逻辑论点和解决方法；归纳理论和事实验证假设与结论	L1	L1 L2	1.展示对力学史的了解。 2.说明力学体系建立和发展过程中某些理论和逻辑的谬误和解决方法。 **3.思政：主张唯物主义认识论。**
	发现问题和	分析并归纳有价值的问	L1	L2	1.选择身边力学现象相关的问题，

	表述问题	题，科学准确地表述问题；			准确地表达问题。 **2.思政：中外教育费用对比——制度自信和家国情怀**
	建立模型	选择需要验证的关键问题，制定假设；应用假设简化复杂的系统和环境，制定定性和定量模型	L1	L2	1.解释课程中力学定律和解决问题所用到的相关模型。 **2.思政：个人追求如何与国家需求结合起来，才能达到最佳接收效果。**
	交流能力	分组讨论及完成任务	L1	L2	1．总结自己的观点。
	查询资料	应用图书馆工具（在线检索、数据库、搜索引擎等）检索并获取信息	L2	L2	1. 针对遇到的理论力学问题，应用图书馆等场所和工具找到相关信息。报告信息出处。

3. 先修要求（Pre-requisite）

高等微积分；力学

4. 教材及其他教学资源（Textbooks and Other Learning Resources）

指定教材：

《理论力学教程》，第五版，周衍柏，高等教育出版社，2023。

推荐教材：

（1）理论力学，陈建平，范钦珊著，高等教育出版社，第 3 版，2018；

（2）理论力学，洪嘉振，刘铸勇，杨长俊著，高等教育出版社，第四版，2015；

（3）理论力学，谢传锋，王琪，程耀等编，高等教育出版社，第 2 版，2015.

课程网站：

（1）my.stu.edu.cn；

（2）雨课堂。

5. 主要教学环节（Teaching and Learning Activities）

教学环节	理论课（小时）	习题课（小时）	实验（小时）	研讨（小时）	社会实践（小时）	项目（小时）	在线学习（小时）	期中测试（小时）	合计
课内	60	无	无	4	无	无	0	无	64
课外	80	44	无	4	无	无	0	无	128

本课程内容较多，只进行课堂教学，学生无法全部理解课程内容，因此需要在课堂教学环节之外进行自学。自学环节课时与课堂教学课时比例为 2：1，即自学环节为 128 学时，其中理论内容学习 80 学时，完成习题 44 学时，查阅资料、讨论等 4 学时。

自学环节由学生自我监督完成。

6. 课程考核（Assessment Scheme）

考核项目	考核内容和考试方法简介	权重
练习、讨论、提问	课后作业及思考；课堂参与、发言、提问 （评判标准： **课后作业：**解题过程中基本概念和思路是否清晰？公式使用是否正确？逻辑方面是否完整？ **课堂参与、发言、提问：**是否认真听课？是否积极参与讨论或提出问题？是否会积极查询准备资料？）	40%
期末考试	期末闭卷考试	60%

本课程考核由课程平时学习表现和期末考试两部分组成，其中平时学习表现评分占比为40%，期末考试评分占比60%。

平时学习表现：出勤、课堂参与程度、发言、提问等占比20%，由教师评定；课程习题占比20%，由教师和助教共同评定。

期末考试：主要考察学生是否能够正确构建物理模型，掌握分析、综合、推理类比等科学思维方法，运用求导、积分等数学方法分析和解决物理问题。

7. 学习进度（Course Schedule）

周次	教学时数	教学形式	教学内容
1	3	课堂教学	数学预备知识；内容：常微分方程求解和微积分。
2	3	课堂教学	质点力学 内容：1.运动的描述方式 2.速度加速度的分量表达式 3.平动参考系 布置课后练习
3	3	课堂教学	质点力学 内容：1.质点的运动定律 2.质点运动微分方程 3.非惯性系动力学 布置课后练习
4	3	课堂教学	质点力学 内容：1.功与能 2.质点动力学的基本定理和基本守恒律 3.有心力 布置课后练习
5	3	课堂教学	质点组动力学 内容：1、质点组 2、动量定理与动量守恒定律 3、动量矩定理与守恒定律 布置课后练习

6	3	课堂教学	质点组动力学 内容：1、动能定理与机械能守恒定律 2、两体问题 3、质心参考系 布置课后练习
7	3	课堂教学	质点组动力学 内容：1.质心参考系 2.实验参考系 布置课后练习
8	3	课堂教学	刚体力学 内容：1. 刚体运动的分析 2. 角速度矢量 3.刚体运动方程与平衡方程 布置课后练习
9	3	课堂教学	刚体力学 内容：1.转动惯量 2.刚体的平面平行运动和绕固定轴的转动 布置课后练习
10	3	课堂教学	刚体力学 内容：1.刚体的平面平行运动 2.刚体绕固定点的转动 布置课后练习
11	3	课堂教学	转动参考系 内容：1.平面转动参考系 2.空间转动参考系布置课后作业
12	3	课堂教学	转动参考系 内容：1.非惯性系动力学(二) 2.地球自转产生的影响 布置课后练习
13	3	课堂教学	分析力学 内容：1.约束与广义坐标 2.虚功原理 布置课后练习
14	3	课堂教学	分析力学 1.拉格朗日方程 2.哈密顿正则方程 布置课后作业
15	3	课堂教学	分析力学 1.泊松括号和泊松原理 2.哈密顿原理 布置课后作业
16	3	课堂教学	分析力学 1.正则变换 布置课后作业

Shantou University

Module Description for Undergraduate Courses

COURSE TITLE: Mechanics

COURSE CODE: PHY2010B

CREDIT VALUE: 4

CONTACT HOURS: 64

PRE-REQUISITE none

DEPARTMENT/UNIT: Department of Physics

VERSION: 20240731-PHY2010B

COURSE COORDINATOR:  (Signature and Seal)

APPROVER: Chi Lingfei (Signature and Seal)

APPROVE DATE: 20240731

Shantou University Faculty of Science

July 2024

1. Course Description

(1) Course Nature

The course Mechanics is the first fundamental professional course for students majoring in Physics and is a compulsory module in the Physics curriculum. Through this course, students are introduced to new ideas, concepts, and methods. Building on their knowledge of high school physics, students will learn to approach problems from a higher-level perspective and begin to apply the principles and methods of physics in their reasoning. This course lays a solid foundation for subsequent courses such as Optics, Electromagnetism, and Theoretical Mechanics. It aims to cultivate students' spirit of inquiry, scientific literacy, and critical thinking, enabling them to connect theory with practice and to apply scientific theories and methods to solve practical problems. Moreover, students will be encouraged, to some extent, to propose their own interpretations of new physical phenomena and to construct simple physical models, thereby preparing them for an academic-oriented undergraduate education in Physics.

(2) Course Contant

This course is part of the core module curriculum for Physics undergraduates at Shantou University. The main topics include particle kinematics, momentum, Newton's laws of motion, conservation of momentum, kinetic and potential energy, angular momentum and symmetry, the law of universal gravitation, rigid body mechanics, stress and strain of elastic bodies, vibrations, waves and sound, fluid mechanics, and an introduction to special relativity.

(3) Course Objectives

Upon completion of this course, students are expected to:

1. Strengthen their commitment to the path of socialism with Chinese characteristics and establish firm ideals and convictions.

2. Cultivate and uphold correct values and a sense of social responsibility.

3. Systematically master the fundamental knowledge and research methods of Mechanics, including the ability to select simplified models, perform dimensional analysis, estimate orders of magnitude, and carry out quantitative calculations.

4. Identify and articulate problems in real-world processes, construct theoretical models, apply appropriate theoretical methods to describe these processes, and perform both qualitative and quantitative analyses. Students are expected to develop independent thinking and innovative problem-solving skills.

These course objectives correspond to the graduation requirement indicators ofthe Physics undergraduate program:

1: Correct values and social responsibility

2: Mastery of fundamental physics theories and specialized knowledge

3: Ability to conduct research based on scientific principles and methods

2. Intended Learning Outcomes

Training Objectives		Knowledge Units / Competencies Standards	Initial Level	Target Level	Expected Learning Outcomes
Knowledge	Particle Kinematics	Kinematic equations of a particle	L1	L2	Correct understanding of: particle, position vector, displacement, and path length
		Instantaneous velocity vector and instantaneous acceleration vector	L1	L2	Ability to understand and explain: average vs. instantaneous velocity, and average vs. instantaneous acceleration

		One-Dimensional Motion of a Particle — From Position to Velocity and Acceleration	L1	L3	Compute velocity and acceleration from the position vector.Understand the relationship between coordinate functions and kinematic quantities.
		One-Dimensional Motion — From Acceleration to Velocity and Position	L1	L3	Determine velocity and position from a given acceleration and initial conditions.
		Cartesian Coordinates and Projectile Motion	L1	L3	Apply coordinate systems, acceleration, and velocity to solve basic kinematics problems.
		Natural Coordinates; Tangential and Normal Accelerations	L1	L3	Compute speed, normal acceleration, tangential acceleration, and angular velocity.
		Polar Coordinates; Radial and Transverse Velocities	L1	L2	Understand radial and transverse components of velocity.
		Galilean Transformation	L1	L3	1. Calculate absolute velocity using Galilean transformations. 2. Explain the invariance of acceleration under Galilean transformation.
	Newton's Laws of Motion	Newton's First Law and Inertial Reference Frames	L1	L2	Correctly understand Newton's First Law and the definition of an inertial reference frame.
		Inertial Mass and Momentum	L1	L3	Explain inertial mass, momentum, Newton's Second Law, and Newton's Third Law.
		Active and Passive Forces	L1	L2	Identify whether a given force acting on an object is an active force or a passive force.
		Applications of Newton's Laws	L1	L3	Apply Newton's laws of motion to solve basic dynamical problems.
		Dynamics in Non-inertial Frames	L1	L4	Distinguish between inertial and non- inertial reference frames.
		Momentum Theorem for a System of Particles and the Motion of the Center of Mass	L1	L3	Perform calculations involving systems of particles and center-of-mass dynamics..
		Impulse Form of the Momentum Theorem	L1	L3	Use the impulse–momentum theorem to solve physical problems.

		Conservation of Momentum	L1	L4	Illustrate the conservation of momentum with examples and apply the conservation law in problem-solving.
		Discussion of the Applicability of Different Reference Frames			
	Kinetic Energy and Potential Energy	Energy — Another Conserved Quantity	L1	L2	Understand the concept of energy.
		Infinitesimal Work and Line-Integral Representation of Work	L1	L2	Understand work, infinitesimal work, and power.
		Work–Energy Theorem for a Particle and a System of Particles	L1	L3	Apply the work–energy theorem for a particle and for a system of particles to solve practical problems.
		Conservative and Non-conservative Forces; Potential Energy	L1	L4	Outline the concepts of field and potential energy; distinguish between conservative and non-conservative forces.
		Principle of Virtual Work and Conservation of Mechanical Energy	L1	L3	Apply the conservation of mechanical energy to compute physical processes.
		Central (Head-on) Collisions	L1	L3	Calculate conserved quantities in central collisions.
		Non-central Collisions	L1	L2	Understand the physical process of non-central collisions.
		Use of the Center-of-Mass Frame; Particle Collisions	L1	L2	Understand the center-of-mass reference frame.
	Angular Momentum and Symmetry	Angular Momentum of a Particle	L1	L3	Apply the angular momentum theorem and conservation law of a particle about a reference point (or axis).
		Angular Momentum Theorem and Conservation for a System of Particles	L1	L4	Analyze whether the angular momentum of a system of particles is conserved about a reference point (or axis).
		Angular Momentum Theorem and Conservation for a System about Its Center of Mass	L1	L2	Understand angular momentum of a system about its center of mass and the associated conservation law.
		Understand angular momentum of a system about its center of mass and the associated conservation law.	L1	L2	Understand the relationship between symmetries and conserved quantities.
		Range of Validity of Classical Dynamics	L1	L2	Understand the limitations of classical dynamics.

	Law of Universal Gravitation	Kepler's Laws	L1	L2	Understand Kepler's laws.
		Law of Universal Gravitation; Gravitational Mass and Inertial Mass	L1	L2	Understand gravitational mass and inertial mass, and the range of applicability of Newton's law of universal gravitation.
		Gravitational Potential Energy	L1	L2	Understand the gravitational field.
		Introduce ancient Chinese observations of gravitational phenomena.			
	Rigid Body Mechanics	Description of Rigid Body Motion	L1	L3	Understand rigid body rotation and the angular velocity vector.
		Momentum of a Rigid Body and the Center-of-Mass Theorem	L1	L2	Understand the momentum of a rigid body and the theorem of center-of-mass motion.
		Angular Momentum and Moment of Inertia for Fixed-Axis Rotation	L1	L3	Calculate angular momentum and moment of inertia for fixed-axis rotation; apply the angular momentum theorem and torque theorem for fixed-axis rigid body motion.
		Work–Energy Theorem for Fixed-Axis Rotation of a Rigid Body	L1	L3	Calculate the kinetic energy of a rigid body; apply the work–energy theorem for rigid body rotation.
		Dynamics of Planar Motion of a Rigid Body	L1	L2	Understand the kinetic energy and dynamical equations of planar rigid body motion.
		Equilibrium of a Rigid Body	L1	L2	Understand the equilibrium equations of rigid bodies.
		Spin and Precession	L1	L2	Understand the precession of a rotating body.
	Stress and Strain in Elastic Bodies	Tension and Compression in Elastic Materials	L1	L2	Understand stress, strain, and Young's modulus.
		Shear Deformation of Elastic Bodies	L1	L2	Understand shear deformation and the shear modulus.
		Bending and Torsion	L1	L2	Describe tensile/compressive deformation and shear deformation occurring in bending and torsion.
	Oscillations	Dynamical Characteristics of Simple Harmonic Motion(SHM)	L1	L4	Analyze the dynamics of simple harmonic motion.

		Kinematics of SHM	L1	L3	Apply the kinematic equations of SHM, including the $x-t$ relation and vector (phasor) representation.
		Energy Transformation in SHM	L1	L2	Understand the kinetic and potential energies in simple harmonic motion.
		Superposition of Simple Harmonic Motions	L1	L3	Apply the principles of superposition to combine two simple harmonic motions.
		Damped Oscillations	L1	L2	Understand underdamped, overdamped, and critically damped states in damped oscillatory motion.
		Forced Oscillations	L1	L2	Understand the characteristics of forced oscillations and the phenomenon of resonance.
	Waves and Sound	Basic Concepts of Waves	L1	L2	Understand the generation of waves and different types of waves.
		Plane Harmonic Wave Equation	L1	L3	Explain the various forms of the plane harmonic wave equation.
		Wave Equation and Wave Speed	L1	L3	Relate the wave equation to the propagation speed of waves.
		Average Energy Flux, Sound Intensity, and Sound Pressure	L1	L3	Calculate average energy flux density and half-wave loss.
		Superposition, Interference, and Standing Waves	L1	L3	Relate interference phenomena to the formation of standing waves.
		Doppler Effect	L1	L2	Provide examples illustrating the Doppler effect.
	Fluid Mechanics	Ideal Fluids	L1	L2	Understand the concepts of fluids and ideal fluids.
		Pressure in Static Fluids	L1	L2	Understand pressure in a static fluid and its spatial distribution.
		Basic Concepts of Fluid Kinematics	L1	L2	Understand steady flow and the continuity equation for incompressible fluids.
		Bernoulli's Equation	L1	L3	Apply Bernoulli's equation to solve basic fluid-flow problems.
	Introduction to Relativity	Historical Background of Special Relativity		L2	Summarize the development of special relativity and the significance of the Michelson–Morley experiment.

		Lorentz Transformation		L2	Describe the relativistic concepts of space and time, including length contraction and time dilation.
		Relativistic Velocity Transformation		L2	Understand how velocities transform between different inertial frames in special relativity.
		Relativistic Momentum and Energy		L2	Understand the mass–energy relation and the relativistic formulas for kinetic energy and total energy.
a b il it y	Scientific Literacy	Understand the natural world and the impact of human activities on it; use scientific knowledge to identify problems and draw evidence-based conclusions.	L1	L2	Understand the historical development of mechanics and its major contributions to human progress, and recognize how mechanics provides tools for describing, interpreting, and transforming the physical world.。
	Critical Thinking	Analyze problems, identify conflicting viewpoints and logical fallacies, and select logically coherent arguments and methods of solution.	L1	L2	Summarize a preliminary understanding of the history of mechanics; identify logical gaps or erroneous assumptions in the development of mechanical theories and the ways these issues were resolved.
	Problem Identification and Formulation	Analyze and distill meaningful scientific questions, and express them clearly and accurately.	L1	L2	Reformulate everyday phenomena related to mechanics into well-defined physical questions.
	Model Building	Identify key questions requiring verification, formulate assumptions, and use them to simplify complex systems and environments.	L1	L4	Construct qualitative and quantitative models and apply appropriate theoretical tools to analyze real physical processes.
	Communication Skills	Group Discussion and Task Completion	L1	L2	Summarize and articulate one's own viewpoints clearly in group discussions and collaborative tasks.
	Information Retrieval	Use library tools (online catalogues, databases, search engines, etc.) to search for and obtain relevant information.	L2	L3	Locate appropriate information related to mechanics problems using library resources and other information platforms, and provide proper citation of information sources.

3. Pre-requisit

None

4. Textbooks and Other Learning Resources

Recommended Textbook

General Physics Course – Mechanics, 4th Edition, Qi Anshen & Du Chanying, Higher Education Press, 2021

Recommended References

(1) *Mechanics*, 4th Edition, Zhang Hanzhuang, Higher Education Press, 2019.

(2) *New Concept Physics Course – Mechanics*, 3rd Edition, Zhao Kaihua & Luo Weiyin, Higher Education Press, 2023.

Online Resources
my.stu.edu.cn；Rain Classroom

5. Teaching and Learning Activities

Teaching Segment	Lectures (Theory)	Exercise Classes	Laboratory Work	Seminars	Social Practice	Project Work	Online Learning Others	Others	Total
Hours (In-class)	64	0	0	0	0	0	0	0	64
Hours (Out-of-class)	96	28	0	0	0	0	0	4	128

Due to the extensive scope of the course content, classroom instruction alone is not sufficient for students to fully master all material. Therefore, a substantial self-study component is required in addition to in-class teaching. The ratio of self-study hours to classroom teaching hours is 2:1. A total of **128 self-study hours** are designated, including **96 hours for theoretical study**, **28 hours for problem-solving**, and **4 hours for literature review, information searching, and discussion**.

The self-study component is completed under students' self-management and responsibility

7. Assessment Scheme

Assessment item	Description / Assessment criteria	Weight
Exercises, Discussions, and In-Class Participation	After-class assignments and reflections; in-class participation, presentations and questions. Assessment criteria: • **After-class assignments:** clarity of basic concepts and solution approach; correct use of formulas; logical completeness; ability to solve problems by different methods. • **In-class participation / presentations / questions:** attentiveness, active participation in discussions or question-asking; initiative in preparing and consulting background materials.	40%
Final Examination	A closed-book final exam	60%

The final course grade comprises continuous assessment (40%) and the final examination (60%).

Continuous assessment (40%): attendance and in-class engagement (20%, assessed by the instructor); course exercises/homework (20%, jointly assessed by instructor and teaching assistants).

Final examination (60%): assesses students' ability to construct appropriate physical models, apply scientific reasoning (analysis, synthesis, inference, analogy), and use mathematical tools (differentiation, integration, etc.) to analyse and solve physics problems.

7. Course Schedule

Week	Hour	Teaching format	Teaching content
1	4	Lecture	Physics and Mechanics; Mathematical foundations of physics.
2	4	Lecture	Kinematic equations of a particle; instantaneous velocity and instantaneous acceleration vectors; velocity and acceleration in particle motion; one-dimensional particle motion; Cartesian coordinates; projectile motion; natural coordinates; tangential and normal acceleration; worked examples.
3	4	Lecture	Polar coordinates; radial and transverse velocities; Galilean transformation. Newton's First Law; inertial reference frames; inertial mass and momentum; active (applied) and passive forces; applications of Newton's laws. Suggested reading: uniformly accelerated linear motion. Assign homework.
4	4	Lecture	Dynamics in non-inertial frames; impulse form of the momentum theorem; momentum theorem for a system of particles; centre-of-mass motion theorem; conservation of momentum; worked examples. Suggested reading: rocket motion. Assign homework.
5	4	Lecture	Energy: elemental work of a force; expression of work as a line integral; work–energy theorem for a particle and for a system of particles; conservative vs non-conservative forces; potential energy; work principle and conservation of mechanical energy; worked examples.
6	4	Lecture	Head-on (central) and off-centre collisions; use of centre-of-mass frame; particle collisions. Angular momentum of a particle; angular momentum theorem for a system of particles; conservation of angular momentum; worked examples. Suggested reading: stability of particle equilibrium. Assign homework.
7	4	Lecture	Angular momentum theorem about the centre of mass for a system of particles and its conservation; symmetry and conservation laws; applicability limits of classical mechanics. Kepler's laws; Newton's law of universal gravitation; gravitational mass vs inertial mass; gravitational potential energy. Suggested reading: applications of angular momentum conservation in biomechanics; tides. Assign homework.

8	4	Lecture	Description of rigid body motion; linear momentum and centre-of-mass theorem for a rigid body; angular momentum for fixed-axis rotation; moment of inertia; representative examples and worked problems.
9	4	Lecture	Kinetic energy of fixed-axis rotation; dynamics of plane motion of a rigid body; equilibrium of rigid bodies; spin and precession; worked examples. Suggested reading: composition of angular velocities follows the parallelogram rule. Assign homework.
10	4	Lecture	Tension and compression in elastic bodies; shear deformation; bending and torsion. Dynamics and kinematics of simple harmonic motion (SHM); energy transformations in SHM; suggested reading on deformation of springs. Assign homework.
11	4	Lecture	Superposition and decomposition of SHM; damped oscillations; forced oscillations. Application example of SHM — simple pendulum method for measuring. Suggested reading: parametric excitation, self-oscillation, lattice vibrations in crystals. Assign homework.
12	4	Lecture	Basic concepts of waves; plane harmonic wave equation; wave equation and wave speed; average energy flux density, sound intensity and sound pressure; worked examples.
13	4	Lecture	Superposition and interference of waves; standing waves; Doppler effect; representative problems and worked examples. Suggested reading: solitons, reflection/transmission coefficients, half-wave loss. Assign homework.
14	4	Lecture	Ideal fluids; pressure in static fluids and its spatial distribution; basic concepts of fluid kinematics; Bernoulli’s equation.
15	4	Lecture	Momentum and angular momentum in fluids; viscous flow; drag on bodies in a fluid. Historical background of special relativity; Lorentz transformation. Suggested reading: lift on an airfoil. Assign homework.

16	4	Lecture	Special relativity: historical background; Lorentz transformations; relativistic velocity addition; relativistic momentum and energy. Course summary and review. Suggested reading: general theory of relativity, gravitational fields and curved spacetime.

汕头大学本科教学

课程教学大纲

课　程　名（COURSE TITLE）： 力学

课程代码（COURSE CODE）： PHY2010B

学　　　　分（CREDIT VALUE）： 4

课内课时（CONTACT OURS）： 64

先修课要求（PRE-REQUISIT） 无

开课单位（DEPARTMENT/UNIT）： 物理学系

版　　　　本 （VERSION） ： 20240731-PHY2010B

课程负责人（COURSE COORDINATOR）： 王志诚 (签章)

审　核　人（APPROVER）： 池凌飞(签章)

审核日期（APPROVE DATE）： 20240731

汕头大学　理学院

2024 年　7 月

1. 课程简介 （Course Description）

（1）课程性质

力学（Mechanics）课程是物理学专业学生入学之后的第一门专业基础课程，属于物理学专业的专业必修课。通过本课程的学习，学生要接受一些新思想、新概念和新方法。学生将在中学物理的基础上站在一个更高的角度、初步学会用物理学的思想、方法考虑问题。为后续课程（例如光学、电磁学、理论力学等）的学习打下坚实基础。本课程将培养学生具备一定的探索精神、科学素养和批判性思维，能够理论联系实际，运用科学的理论和方法解决实际问题，对于新的物理现象，能够在一定程度上提出自己的看法并建立简单的物理模型，为培养物理学专业学术型本科人才奠定基础。

（2）课程内容

本课程属于汕头大学物理学专业人才培养方案的专业基础模块课程，主要内容包含质点运动学、动量、牛顿运动定律、动量守恒定律、动能和势能、角动量和对称性、万有引力定律、刚体力学、弹性体的应力和应变、振动、波动和声、流体力学、狭义相对论简介。

（3）课程目标

通过本课程的学习，学生应能够：

①坚定中国特色社会主义道路，树立坚定的理想信念；

②培养和树立正确的价值观和社会责任感；

③系统掌握力学的基础知识和研究方法，具备简化模型的选取、量纲分析、数量级估计与定量计算的能力；

④对于实际过程，能够发现问题和表述问题，建立理论模型，运用相应的理论方法描述该过程并进行定性乃至定量计算。具备一定的独立思考问题的能力和创新能力。

本课程目标对应物理学专业人才培养方案毕业要求指标点：1.坚定的理想信念；2.正确价值观和社会责任感；3.1 掌握物理学的基础理论和专业知识；5.1 具备基于科学原理和方法进行研究的能力。

2. 预期学习结果 （Intended Learning Outcomes）

培养目标 知识单元/能力标准		知识点/能力标准	初始程度	要求程度	预期学习结果
知识	质点运动学	质点的运动学方程	L1	L2	正确理解质点、位置矢量、位移、路程
		瞬时速度矢量与瞬时加速度矢量	L1	L2	理解和解释平均速度和瞬时速度、平均加速度和瞬时加

					速度
		质点直线运动——从坐标到速度和加速度	L1	L3	利用位置矢量计算速度和加速度
		质点直线运动——从加速度到速度和坐标	L1	L3	使用加速度及已知条件计算速度和位置矢量
		平面直角坐标系、抛体运动	L1	L3	应用坐标系、加速度、速度等解决简单问题
		自然坐标、切向和法向加速度	L1	L3	计算速度、法向加速度、切向加速度、角速度
		极坐标系、径向速度与横向速度	L1	L2	理解径向速度和横向速度
		伽利略变换	L1	L3	计算绝对速度；说明加速度对伽利略变换的不变性
	牛顿运动定律	牛顿第一定律和惯性参考系	L1	L2	正确理解牛顿第一定律、惯性参考系
		惯性质量和动量	L1	L3	说明惯性质量、动量、牛顿第二定律、牛顿第三定律
		主动力和被动力	L1	L2	辨别物体受到的力是主动力或被动力
		牛顿运动定律的应用	L1	L3	应用牛顿运动定律解决简单的运动学问题
		非惯性系中的动力学	L1	L4	区分惯性系和非惯性系
		用冲量表述的动量定理	L1	L3	应用动量定理解决物理问题
		质点系动量定理和质心运动定理	L1	L3	计算质点系动力学问题
		动量守恒定律	L1	L4	举例说明动量守恒、应用动量守恒定律
		思政：讨论各种参考系的适用场合，主张我国社会主义制度			
	动能和势能	能量——另一个守恒量	L1	L2	理解能量的概念
		力的元功、用线积分表示功	L1	L2	理解功、元功、功率
		质点和质点系动能定理	L1	L3	应用质点的动能定理和质点系的动能定理解决实际问题
		保守力与非保守力、势能	L1	L4	概述场和势能的概念；划分

					保守力与非保守力
		功能原理和机械能守恒定律	L1	L3	应用机械能守恒定律计算物理过程
		对心碰撞	L1	L3	计算物体对心碰撞过程中的守恒量
		非对心碰撞	L1	L2	理解非对心碰撞的物理过程
		质心参考系的运用、粒子的对撞	L1	L2	理解质心参考系
	角动量、关于对称性	质点的角动量	L1	L3	应用质点对参考点（轴）的角动量定理和守恒定律
		质点系的角动量定理及角动量守恒定律	L1	L4	分析质点系对参考点（轴）的角动量是否守恒
		质点系对质心的角动量定理和守恒定律	L1	L2	理解质点系对质心的角动量和角动量守恒
		对称性、对称性与守恒律	L1	L2	理解对称性与守恒量的关系
		经典动力学的适用范围	L1	L2	理解经典动力学的局限性
		思政：通过“天宫课堂”实验中关于角动量的实验，向学生介绍我国在高科技领域的成就和影响。 强调创新意识，勉励学生勇于创新，不断提高自己的能力和水平，奉献社会。			
	万有引力定律	开普勒定律	L1	L2	理解开普勒定律
		万有引力定律、引力质量与惯性质量	L1	L2	理解引力质量和惯性质量、牛顿万有引力定律的适用范围
		引力势能	L1	L2	理解万有引力场
		思政：介绍我国古代对引力现象的观测，强调文化自信			
	刚体力学	刚体运动的描述	L1	L3	理解刚体的转动、角速度矢量
		刚体的动量和质心运动定理	L1	L2	理解刚体的动量、质心运动定理
		刚体定轴转动的角动量、转动惯量	L1	L3	计算刚体定轴转动的角动量和转动惯量；应用刚体定轴转动的角动量定理和转动定理

		刚体定轴转动的动能定理	L1	L3	计算刚体的动能；应用刚体的动能定理
		刚体平面运动的动力学	L1	L2	理解刚体平面运动的动能与动力学方程
		刚体的平衡	L1	L2	理解刚体的平衡方程
		自转与进动	L1	L2	理解物体的进动
		思政：支持我国的社会制度，主张奉献精神。			
	弹性体的应力和应变	弹性体的拉伸和压缩	L1	L2	理解应力、应变、杨氏模量
		弹性体的剪切形变	L1	L2	理解剪切形变和切变模量
		弯曲和扭转	L1	L2	概述弯曲和扭转现象中的拉伸压缩形变和剪切形变
	振动	简谐振动的动力学特征	L1	L4	分析物体振动的动力学
		简谐振动的运动学	L1	L3	应用简谐振动的运动学方程、x-t 曲线、矢量表示法
		简谐振动的能量转化	L1	L2	理解简谐振动的动能、势能
		简谐振动的合成	L1	L3	应用两个简谐振动的合成
		阻尼振动	L1	L2	理解物体受迫振动的欠阻尼状态、过阻尼状态、临界阻尼状态
		受迫振动	L1	L2	理解受迫振动的运动特征、共振
		思政：从机械振动转移到思想共鸣，让学生意识到抽象事物也能够共振。从全国众志成城抗击疫情，宣扬我国社会主义制度的优越性,是快速有效控制疫情的根本所在。			
	波动和声	波的基本概念	L1	L2	理解波的形成、波的种类
		平面简谐波方程	L1	L3	说明平面简谐波方程的不同形式
		波动方程与波速	L1	L3	关联波动方程、波速
		平均能流密度、声强与声压	L1	L3	计算平均能流密度、半波损失
		波的叠加和干涉、驻波	L1	L3	关联干涉现象和驻波形成
		多普勒效应	L1	L2	举例多普勒效应
		思政：对比不同波相关的物理现象，主张社会主义制度的优越性。			

	流体力学	理想流体	L1	L2	理解流体、理想流体
		静止流体内的压强	L1	L2	理解静止流体内的压强、不同空间点的压强分布
		流体运动学的基本概念	L1	L2	理解定常流动、不可压缩流体的连续性方程
		伯努利方程	L1	L3	应用伯努利方程
	相对论简介	狭义相对论的历史背景		L2	概括狭义相对论的发展背景和迈克尔逊-莫雷实验
		洛伦兹变换		L2	概述相对论的时空观、相对论的尺缩钟慢效应
		相对论的速度变换		L2	理解相对论下不同参考系中的速度变换
		相对论的动量和能量		L2	理解相对论的质能公式、动能-能量公式
		思政：支持我国的社会制度，主张唯物主义认识论，主张奉献精神，主张勇于探索精神。			
能力	科学素养	理解自然世界和人类活动对自然世界的影响；运用科学知识，明确问题并做出具有证据的结论。	L1	L2	理解力学的发展过程及对人类进步带来的巨大影响、力学是如何来认识世界和改造世界。 思政：介绍力学发展历史和我国在相关领域取得的一系列成就，激发学生的探索精神和科学素养。
	批判性思维	分析问题，识别有矛盾的观点和逻辑谬误，选择逻辑论点和解决方法；归纳理论和事实验证假设与结论	L1	L2	概述对力学史的粗浅了解；总结力学体系建立和发展过程中某些理论和逻辑的谬误和解决方法。 思政：主张唯物主义认识论
	发现问题和表述问题	分析并归纳有价值的问题，科学准确地表述问题	L1	L2	改述身边力学现象相关的问题，准确地表达问题。
	建立模型	选择需要验证的关键问题，制定假设；应用假设简化复杂的系统和环境，制定定性和定量模型	L1	L4	分析实际现象，选择合适的理论解决相应的物理问题。 思政：个人追求如何与国家需求结合起来，才能达到最

					佳接收效果
	交流能力	分组讨论及完成任务	L1	L2	概括说明自己的观点
	查询资料	应用图书馆工具（在线检索、数据库、搜索引擎等）检索并获取信息	L2	L3	针对遇到的力学问题，应用图书馆等场所和工具找到相关信息。报告信息出处。 思政：中外教育医疗费用对比——制度自信和家国情怀

3. 先修要求 （Pre-requisit）

无

4. 教材及其他教学资源 （Textbooks and Other Learning Resources）

推荐教材

《普通物理学教程-力学》，第四版，漆安慎、杜婵英，高等教育出版社，2021 年

推荐参考资料

（1）《力学》，第四版，张汉壮，高教出版社出版，2019 年

（2）《新概念物理教程-力学》，第三版，赵凯华、罗蔚茵编，高教出版社出版，2023 年

网络资源

my.stu.edu.cn；雨课堂

5. 主要教学环节 （Teaching and Learning Activities）

教学环节	理论课（小时）	习题课（小时）	实验（小时）	研讨（小时）	社会实践（小时）	项目（小时）	在线学习（小时）	其他（小时）	合计
课内	64	0	0	0	0	0	0	0	64
课外	96	28	0	0	0	0	0	4	128

本课程内容较多，只进行课堂教学，学生无法全部理解课程内容，因此需要在课堂教学环节之外进行自学。自学环节课时与课堂教学课时比例为 2:1，即自学环节为 128 学时，其中理论内容学习 96 课时，完成习题 28 学时，查阅资料、讨论等 4 学时。

自学环节由学生自我监督完成。

7. 课程考核 （Assessment Scheme）

考核项目	考核内容和考试方法简介	权重
练习、讨论、提问	课后作业及思考；课堂参与、发言、提问 评判标准： **课后作业：**解题过程中基本概念和思路是否清晰？公式使用是否正确？逻辑方面是否完整？是否能够运用不同方法解决问题？ **课堂参与、发言、提问：**是否认真听课？是否积极参与讨论或提出问题？是否会积极查询准备资料？	40%
期末考试	期末闭卷考试	60%

本课程考核由课程平时学习表现和期末考试两部分组成，其中平时学习表现评分占比为40%，期末考试评分占比60%。

平时学习表现：出勤、课堂参与程度、发言、提问等占比20%，由教师评定；课程习题占比20%，由教师和助教共同评定。

期末考试：主要考察学生是否能够正确构建物理模型，掌握分析、综合、推理类比等科学思维方法，运用求导、积分等数学方法分析和解决物理问题。

7. 学习进度 （Course Schedule）

周次	教学时数	教学形式	教　学　内　容
1	4	课堂教学	物理学和力学 物理学的数学基础
2	4	课堂教学	质点的运动学方程、瞬时速度矢量与瞬时加速度矢量、速度和加速度、质点直线运动、平面直角坐标系、抛体运动、自然坐标、切向加速度、法向加速度、例题讲解
3	4	课堂教学	极坐标、径向速度、横向速度、伽利略变换 牛顿第一定律、惯性参考系、惯性质量和动量、主动力和被动力、牛顿运动定律的应用 建议课后阅读内容：匀变速直线运动 布置课后练习
4	4	课堂教学	非惯性系中的动力学、冲量表示的动量定理、质点系动量定理、质心运动定理、动量守恒定律、例题讲解 建议课后阅读内容：火箭运动 布置课后练习
5	4	课堂教学	能量、力的元功、线积分表示功、质点和质点系动能定理、保守力与非保守力、势能、功能原理和机械能守恒定律、例题讲解
6	4	课堂教学	对心碰撞、非对心碰撞、质心参考系的运用、粒子对撞 质点的角动量、质点系角动量定理、角动量守恒定律、例题讲解 建议课后阅读内容：质点平衡的稳定性 布置课后练习

7	4	课堂教学	质点系对质心的角动量定理和守恒律、对称性、对称性与守恒律、经典力学的适用范围 开普勒定律、万有引力定律、引力质量与惯性质量、引力势能 建议阅读内容：角动量守恒定律在运动生物力学中的应用、潮汐 布置课后练习
8	4	课堂教学	刚体运动的描述、刚体的动量和质心运动定理、刚体定轴转动的角动量、转动惯量、典型例子、例题讲解
9	4	课堂教学	刚体定轴转动的动能定理、刚体平面运动的动力学、刚体的平衡、自转与进动、例题讲解 建议阅读内容：角速度合成符合平行四边形法则 布置课后练习
10	4	课堂教学	弹性体的拉伸和压缩、弹性体的剪切形变、弯曲和扭曲 简谐振动的动力学特征、简谐振动的运动、简谐振动的能量转化 建议阅读内容：弹簧的形变 布置课后练习
11	4	课堂教学	简谐振动的合成、振动的分解、阻尼振动、受迫振动 简谐振动的应用举例——单摆法测重力加速度 建议课后阅读内容：参数振动、自激振动、晶体中原子的振动 布置课后练习
12	4	课堂教学	波的基本概念、平面简谐波方程、波动方程与波速、平均能流密度、声强与声压、例题讲解
13	4	课堂教学	波的叠加和干涉、驻波、多普勒效应、典型例题讲解 建议阅读内容：孤子、发射系数、透射系数和半波损失 布置课后练习
14	4	课堂教学	理想流体、静止流体内的压强、流体运动学的基本概念、伯努利方程
15	4	课堂教学	流体的动量和角动量、黏性流体的运动、固体在流体中受到的阻力 狭义相对论的历史背景、洛伦兹变换 建议阅读内容：机翼的升力 布置课后练习
16	4	课堂教学	狭义相对论的历史背景、洛伦兹变换、相对论的速度变换、相对论的动量和能量 本课程的总结与复习 建议阅读内容：广义相对原理、引力场与弯曲时空

Shantou University

Module Description for Undergraduate Courses

COURSE TITLE: Electrodynamics

COURSE CODE: PHY3030

CREDIT VALUE: 3

CONTACT HOURS: 48

PRE-REQUISITE

DEPARTMENT/UNIT: Department of Physics

VERSION: 20240731-PHY3030

COURSE COORDINATOR: (Signature and Seal)

APPROVER: Chi Lingfei (Signature and Seal)

APPROVE DATE: 20240731

Shantou University Faculty of Science

July 2024

1. Course Description

Electrodynamics is one of the fundamental courses for students majoring in Physics and Optoelectronic Information Science and Engineering. The course primarily covers the study of electrostatic fields, magnetostatic fields, electromagnetic-wave propagation and radiation, as well as the basic principles of special relativity. It aims to develop students' ability to apply mathematical tools to solve concrete physical problems, and to strengthen analytical and logical reasoning skills. This course also lays an essential foundation for subsequent modules such as Laser Principles. Moreover, the scientific ways of thinking, epistemological perspectives, and methodological approaches embedded in this course help foster a correct worldview, value system, and philosophy of life, and contribute significantly to cultural literacy, personal qualities, and overall intellectual development.

Through this course, students are expected to:

1. Examine scientific questions from a materialist and dialectical perspective.
2. Master the fundamental laws governing electromagnetic fields.
3. Master the basic methods for solving problems related to electrostatic fields.
4. Master the basic methods for solving problems related to magnetostatic fields.
5. Understand the basic laws of electromagnetic-wave propagation.
6. Master the fundamental mechanisms that generate electromagnetic-wave radiation and the corresponding computational methods.
7. Acquire an introductory understanding of the basic principles of special relativity.

This course corresponds to the following graduation requirement indicators outlined in the Physics major training program:

3.1 Mastery of fundamental theories and core knowledge of physics;
5.1 Ability to conduct research based on scientific principles and methodologies;
6.1 Research and engineering ability to solve scientific problems.

2. Intended Learning Outcomes

Training Objectives		**Knowledge Units / Competencies Standards**	**Initial Level**	**Target Level**	**Expected Learning Outcomes**
Knowledge	Electrostatic and Magnetostatic Fields	Fundamental laws of electrostatics Basic properties of the electrostatic field Solution methods for electrostatic fields and boundary-value problems Basic properties of the magnetostatic field Solution methods for magnetostatic fields and boundary-value problems Conductors and dielectrics in electric and magnetic fields	L2	L4	1. Demonstrate a correct understanding of electric charge, electric fields, magnetic fields, Maxwell's equations, and the polarization and magnetization of media. 2. Understand how Maxwell's equations lead to boundary conditions of electromagnetic fields. 3. Understand different formulations of electromagnetic energy and energy flow. 4. Understand the physical meaning of the Uniqueness Theorem and apply it to solving electrostatic-field problems. 5. Demonstrate correct understanding of electric potential, magnetic scalar

					potential, and magnetic vector potential. 6. Apply various methods to solve electrostatic-field and magnetostatic-field problems.
	Electromagnetic Waves	Mathematical formulation of classical fields Electromagnetic induction Fundamental properties of the electromagnetic field Propagation of electromagnetic waves Radiation of electromagnetic fields	L1	L4	1. Understand how the electromagnetic wave equation arises and the characteristics of plane electromagnetic waves. 2. Apply electromagnetic boundary conditions to obtain reflection and refraction properties of electromagnetic waves. 3. Understand conductors as special media, the transmission characteristics of electromagnetic waves inside conductors, and the reflection characteristics on conductor surfaces. 4. Understand the field distribution in resonant cavities and the transmission characteristics of electromagnetic waves in waveguides. 5. Demonstrate understanding of electromagnetic vector and scalar potentials. 6. Demonstrate understanding of retarded potentials and use them to compute electric-dipole radiation and other types of radiation.
	Special Relativity	Basic principles of relativity Lorentz transformation Relativity of simultaneity	L0	L2	1. Understand the principle of relativity and the invariance of the speed of light. 2. Understand invariant spacetime intervals and Lorentz transformations. 3. Demonstrate understanding of relativity of simultaneity, time dilation, and length contraction.
a b il it y	Scientific Literacy	Understanding the natural world and the impact of human activities on it; applying scientific knowledge to define problems and draw evidence-based conclusions.	L1	L2	Understand the development of science, its enormous impact on human progress, and how electrodynamics helps reveal and transform natural laws.
	Critical Thinking	Analyzing problems, identifying conflicting viewpoints and logical fallacies, selecting logical arguments and solutions; synthesizing theories and	L1	L2	1. Demonstrate some understanding of the historical development of electrodynamics.

		factual evidence to verify hypotheses and conclusions.			2. Understand how theoretical logic continuously corrects errors during the formation and development of electrodynamics.
	Systems Thinking	Examining system concepts, properties, relationships, and structures; exploring system functions and behaviors; identifying connections among internal elements and between the system and its external environment; applying holistic, structural, hierarchical, multidimensional, and dynamic modes of thinking.	L1	L2	1. Gain a systematic understanding of Maxwell's equations through the study of electrostatic, magnetostatic, and time-varying electromagnetic fields. 2. Demonstrate mastery of electrodynamic systems through understanding electromagnetic-wave emission and propagation. 3. Demonstrate comprehensive and systematic analytical ability when addressing scientific questions.
	Innovative Thinking	Approaching and addressing problems from multiple perspectives and dimensions, employing divergent thinking, lateral thinking, reverse thinking, associative thinking, and visual thinking.	L1	L2	Exhibit the ability to analyze and solve physical problems from multiple angles, demonstrating flexible reasoning and analogy-based problem solving.
	Model Building	Identifying key issues requiring verification and formulating hypotheses; using hypotheses to simplify complex systems and environments, and constructing qualitative and quantitative models.	L1	L2	Demonstrate understanding of applying physical models—such as image-charge methods and dipole-radiation models—to solve electrodynamics problems, and apply these modeling ideas to other physical contexts.
	Information Retrieval	Using library tools (online search platforms, databases, search engines, etc.) to retrieve and obtain information.	L2	L2	Retrieve information using library tools (online databases, search engines, etc.) to resolve physics-related questions, and appropriately cite sources.

3. Pre-requisit

None

4. Textbooks and Other Learning Resources

Required Textbooks

Guo Shuohong, *Electrodynamics*, Higher Education Press, 4th Edition, March 2024.

Recommended Textbooks

[1] Chen Shimin, *Concise Course in Electrodynamics*, Higher Education Press, January 2004.

[2] Yu Fuchun and Zheng Chunkai, *Electrodynamics*, Peking University Press, September 2003.

Online Resources

my.stu.edu.cn

Rain Classroom

5. Teaching and Learning Activities

Teaching Segment	Lectures (Theory)	Exercise Classes	Laboratory Work	Seminars	Social Practice	Project Work	Online Learning	Total
Hours (In-class)	48	0	0	0	0	0	0	48
Hours (Out-of-class)	40	15	0	16	0	0	16	87

Basis for calculating out-of-class hours:

This course covers a substantial amount of foundational knowledge and requires considerable independent reading. Each week includes 3 in-class hours, with an estimated 1 hour of pre-class preparation and 1.5 hours of post-class review. In addition, there is 1 hour of online learning and 1 hour of online seminar each week. Completing each assignment requires approximately 3 hours, with about five assignments in total.

6. Assessment Scheme

Assessment item	Description	Weight
Attendance	Attendance is recorded; 1% is deducted for each unexcused absence until the score is reduced to zero.	5%
Continuous Assessment	**In-class quizzes:** Short tests based on lecture content.	10%
	Homework: Timely submission; clarity of key concepts and problem-solving approaches; correctness of formulas; logical completeness. (4% deducted for each missing assignment; further deductions applied as appropriate, until the score reaches zero.)	20%
	Class participation: Attentiveness during class; active participation in discussions or question-raising; preparation of materials when required.	15%
Final Examination	Closed-book final exam	50%

7. Course Schedule

Week	Hour	Teaching format	Teaching content
1	3	Lecture	Electric charge and electric field
2	3	Lecture	Electric current and magnetic field
3	3	Lecture	Maxwell’s equations; electromagnetic properties of materials
4	3	Lecture	Boundary conditions of electromagnetic fields; electromagnetic energy and energy flow

5	3	Lecture	Differential equation of the electrostatic scalar potential
6	3	Lecture	Uniqueness theorem; separation-of-variables solutions of scalar potential equations
7	3	Lecture	Method of images
8	3	Lecture	Electric multipole moments; differential equation of the magnetostatic vector potential
9	3	Lecture	Scalar potential method for magnetostatic fields
10	3	Lecture	Electromagnetic wave equation; plane electromagnetic waves
11	3	Lecture	Reflection and refraction of electromagnetic waves at material interfaces
12	3	Lecture	Electromagnetic waves on conducting surfaces
13	3	Lecture	Resonant cavities and waveguides
14	3	Lecture	Vector and scalar potentials of electromagnetic fields; gauge invariance of field equations
15	3	Lecture	Electric dipole radiation; basic principles of relativity
16	3	Lecture	Lorentz transformation; relativity of simultaneity

汕头大学本科教学

课程教学大纲

课　程　名（COURSE TITLE）：	电动力学
课程代码（COURSE CODE）：	PHY3030
学　　　分（CREDIT VALUE）：	3
课内课时（CONTACT OURS）：	48
先修课要求（PRE-REQUISIT）	
开课单位（DEPARTMENT/UNIT）：	物理学系
版　　　本（VERSION）：	20240731-PHY3030
课程负责人（COURSE COORDINATOR）：	李邵辉(签章)
审　核　人（APPROVER）：	池凌飞(签章)
审核日期（APPROVE DATE）：	20240731

汕头大学　理学院

2024 年 7 月

1.课程简介 （Course Description）

电动力学（Electrodynamics）是物理学专业和光电信息科学与工程专业的基础课程之一，主要讲授静电场和静磁场、电磁波的传播和辐射、狭义相对论基本原理等知识内容，培养学生应用数学知识解决具体物理问题的能力，以及分析、推理等思维能力，为激光原理等后续课程打好基础。课程中所体现的科学的思维方式以及认识论和方法论有助于树立正确的世界观、价值观和人生观，对文化修养、素质和能力的培养以及知识构成也有着重要的意义。

学完本课程后学生应能够：

1.能从唯物的、辩证的角度去看待科学问题；
2.培养学生的家国情怀，培养和树立正确的价值观和社会责任感，以及勇于探索、乐于奉献的精神；
3.掌握电磁场基本规律
4.掌握解决静电场问题的基本方法。
5.掌握解决静磁场问题的基本方法。
6.掌握电磁波的基本传播规律。
7.掌握产生电磁波辐射的基本方法和相应的计算方法。
8.初步了解狭义相对论的基本原理。

本课程目标对应物理学专业人才培养方案毕业要求指标点：1.坚定的理想信念；2.正确价值观和社会责任感；3.1 掌握物理学的基础理论和专业知识；5.1 具备基于科学原理和方法进行研究的能力；6.1 解决问题的研究和工程能力。

2. 预期学习结果 （Intended Learning Outcomes）

培养目标 知识单元/能力标准		知识点/能力标准	初始程度	要求程度	预期学习结果
知识	静电场和静磁场	静电基本规律，静电场的基本性质，静电场的求解和边值问题，静磁场的基本性质，静磁场的求解和边值问题，电、磁场中的导体和介质	L2	L4	1.展现对电荷、电场、磁场、麦克斯韦方程、介质的极化和磁化的正确理解； 2．理解如何利用麦克斯韦方程获得电磁场的边值关系； 3.理解电场和磁场的能量和能流及其不同表述； 4.理解唯一性定理的物理含义及其在求解静电场中的应用； 5 展现对电势、磁标势和磁矢势的正确理解； 6．应用不同方法求解静电场和静磁场。 7. 强调唯物主义认识论
	电磁波	经典场的数学描述，电磁感应，电磁场的基本性质，电磁波的	L1	L4	1.理解电磁场波动方程的产生过程，理解平面电磁波的特性； 2.应用电磁场的边值关系得到电磁波

		传播，电磁场的辐射			的反射和折射特性； 3.理解导体作为一种特殊介质，电磁波在其中的传输特征和在导体表面上的反射特征； 4.理解电磁波在谐振腔中的分布特征及在波导中的传输特性； 5.展现对电磁场矢势和标势的理解； 6.展现对推迟势的理解及应用推迟势求解电偶极辐射和其它不同辐射； 7. 建立正确的世界观，树立勇于探索精神。
	狭义相对论	相对论基本原理，洛伦兹变换，同时相对性	L0	L2	1.理解相对性原理和光速不变原理； 2.理解间隔不变性和洛伦兹变换； 3.展现对同时相对性、时钟变缓和长度变短的理解。 4.建立正确的世界观，树立勇于探索精神。
能力	思政目标	1.政治认同 2.家国情怀 3.公民品格 4.法治意识 5.全球视野	L2	L5	1.拥护中国共产党的领导和我国社会主义制度 2.主张爱国主义，主张中华传统文化 3.敬业、诚信、友善，遵守行业规则 4.主张公民的权利和义务、爱岗敬业 5.主张人类共同体的大局观
	科学素养	理解自然世界和人类活动对自然世界的影响；运用科学知识，明确问题并做出具有证据的结论。	L1	L2	1.理解科学的发展过程及对人类进步带来的巨大影响、电动力学是如何来认识自然规律并利用它改造世界。 2.建立唯物主义人生观和世界观。
	批判性思维	分析问题，识别有矛盾的观点和逻辑谬误，选择逻辑论点和解决方法；归纳理论和事实验证假设与结论	L1	L2	1.展示对电动力学发展历史一定程度的了解； 2.了解电动力学体系建立和发展过程中，理论和逻辑是如何不断修正谬误向前发展的；介绍我国社会主义事业是如何不断自我革命向前发展的
	系统性思维	分析系统概念、性质、关系和结构，探究系统的功能和行为，识别系统内部各要素之间以及系统与外部环境间的联系；应用整体性、结构性、主次性、立体性、动态性等思维方式进行思	L1	L2	1.通过对静电场、静磁场、时变电磁场互生共存特性的了解，系统展示对麦克斯韦方程的理解； 2.通过对电磁场的发射、传播的了解，展示对电动力学系统的掌握； 3.展示对某科学问题系统全面的分析能力。

		维；			
	创新性思维	选择多角度、多侧面看待和处理问题，实施发散思维、侧向思维、逆向思维、联想思维和形象思维。	L1	L2	在解决物理问题时，展现多角度分析问题和举一反三的能力。
	建立模型	选择需要验证的关键问题，制定假设；应用假设简化复杂的系统和环境，制定定性和定量模型	L1	L2	1.通过镜像电荷求解电场方法、偶极辐射等内容的学习，展现对应用模型解决课程中物理学问题的了解，并应用到其它物理问题的处理中。 2. 建立国情意识，树立制度自信和文化自信。
	查询资料	应用图书馆工具（在线检索、数据库、搜索引擎等）检索并获取信息	L2	L2	针对遇到的物理问题，应用图书馆等场所和工具找到相关信息。 报告信息出处。

3. 先修要求 （Pre-requisit）

无

4. 教材及其他教学资源 （Textbooks and Other Learning Resources）

课程教材

《电动力学》，郭硕鸿著，高等教育出版社，第 4 版， 2024.3

推荐参考资料

(1)《电动力学简明教程》，陈世民编，高等教育出版社，2004 年 1 月
(2)《电动力学》，虞福春，郑春开编著，北京大学出版社，2003 年 9 月

网络资源

my.stu.edu.cn
雨课堂

5. 主要教学环节 （Teaching and Learning Activities）

理论学习（学时）		作业（学时）		实验（学时）		研讨（学时）		项目（学时）		在线学习（学时）		合计（学时）	
课内	课外	课内	课外	课内	课外	课内	课外	课内	课外	课内	课外	课内	课外
48	40	无	15	无	无	无	16	无	无	0	16	48	87

课外课时计算依据：

本课程涉及较多的基础知识，内容较多且需要一定的课外阅读量，预计每周课内学时3学时，需要学生课外预习1小时，课外复习1.5小时；另外，每周在线学习和线上研讨各1学时，课外完成每次作业需3小时（约5次作业）。

12. 课程考核 （Assessment Scheme）

考核项目	考核内容和方法	权重
上课出勤	考核上课出勤情况 （无故缺勤一次扣 1%，扣完为止）	5%
平时表现	**课内小测试：**课内就课堂相关内容进行的测试	10%
	课后作业：是否及时提交作业？解题过程中基本概念和思路是否清晰？公式使用是否正确？逻辑方面是否完整？ （缺一次作业扣 4%，其余根据情况适当扣分，扣完为止）	20%
	课堂参与：是否认真听课？是否积极参与讨论或提出问题？是否会根据要求查询准备资料？	15%
期末考试	期末闭卷考试	50%

7. 学习进度 （Course Schedule）

周次	教学时数	教学形式	教　学　内　容
1	3	课堂教学	电荷和电场
2	3	课堂教学	电流和磁场
3	3	课堂教学	麦克斯韦方程组，介质的电磁性质
4	3	课堂教学	电磁场边值条件，电磁场能量和能流
5	3	课堂教学	静电场标势的微分方程
6	3	课堂教学	唯一性定理，标势方程的分离变量求法
7	3	课堂教学	镜象法
8	3	课堂教学	电多极矩,静磁场矢势的微分方程
9	3	课堂教学	静磁场标势方法
10	3	课堂教学	电磁场波动方程，平面电磁波
11	3	课堂教学	电磁波在介质界面的反射和折射

12	3	课堂教学	导体表面的电磁波
13	3	课堂教学	谐振腔和波导管
14	3	课堂教学	电磁场的矢势和标势,电磁场方程的规范不变性，
15	3	课堂教学	电偶极辐射,相对论基本原理，
16	3	课堂教学	洛伦兹变换，同时相对性

Shantou University
Module Description for Undergraduate Courses

COURSE TITLE:	Electromagnetism
COURSE CODE:	PHY1002A
CREDIT VALUE:	4
CONTACT HOURS:	64
PRE-REQUISITE	Calculus B-I
DEPARTMENT/UNIT:	Department of Physics
VERSION:	20240731-PHY1002A
COURSE COORDINATOR:	Fu Shiliu (Signature and Seal)
APPROVER:	Li Pengcheng (Signature and Seal)
APPROVE DATE:	20240731

Shantou University Faculty of Science
July 2024

1. Course Description

(1) Nature of the Course

Electromagnetics is a compulsory course for Physics majors. As a central component of classical physics, it examines the laws governing how electric charges and electric currents generate electric fields and magnetic fields, the intrinsic connection between these two fields, the interactions of electromagnetic fields with charges and currents, and various material responses to electromagnetic fields.

The course introduces major historical discoveries and inventions in electromagnetics through a methodological scientific perspective, helping students understand the underlying physical phenomena and experimental approaches. It aims to provide a systematic grasp of the fundamental phenomena, concepts, and laws related to electromagnetic processes, while developing students' ability to analyze and solve problems in electromagnetics (Electromagnetics). It also lays a foundation for subsequent courses and for cultivating academic-track undergraduate students in physics.

(2) Course Content

The course mainly covers electrostatic fields, steady-current fields, magnetostatic fields, electromagnetic induction, electromagnetic media, electric circuits, and an introduction to Maxwell's electromagnetic theory.

(3) Course Objectives

1. Develop students' understanding of the basic concepts and laws of electrostatics and magnetostatics, the interactions between electromagnetic fields and charges/currents, and the fundamental concepts and principles of electromagnetic induction.
2. Train students to apply Coulomb's law, the Biot–Savart law, the laws of electromagnetic induction, and related theorems to solve electromagnetic field problems.
3. Help students understand the principles of direct-current circuits, transient circuits, and alternating-current circuits, and apply fundamental circuit laws and analytical methods to compute and analyze circuit-related problems.

This course provides essential theoretical and research training for academic-oriented physics students and strongly supports the program's graduation requirements, including: 3.1 mastery of fundamental theories and professional knowledge in physics; and 5.1 the ability to conduct research based on scientific principles and methodologies.

2. Intended Learning Outcomes

The expected learning outcomes of this course are summarized as follows:

Training Objectives		Knowledge Units / Competencies Standards	Initial Level	Target Level	Expected Learning Outcomes
Knowledge	Electrostatic Field and Steady Current Field	Basic phenomena and laws of electrostatics	L1	L2	Understand electric charge, its properties, the structure of matter, and Coulomb's law
		Electric field and electric field intensity	L1	L3	Compute electric field intensity
		Gauss's theorem	L1	L3	Apply Gauss's theorem to compute electric field intensity
		Electric potential and its gradient	L1	L3	Compute electric potential

		Conductors in electrostatic fields	L1	L3	Apply electrostatic equilibrium conditions to solve problems involving electric fields and potentials
		Capacitors and capacitance	L1	L3	Compute capacitance
		Steady-current field	L1	L3	Understand the relation between current fields and electromotive force, compute current, and apply Ohm's law
	Steady Magnetic Field	Basic magnetic phenomena and laws	L1	L2	Explain basic magnetic phenomena and laws; understand Ampère's law and the Biot–Savart law
		Magnetic field of a current loop	L1	L3	Compute magnetic induction
		" Gauss's theorem" for magnetic fields and Ampère's circuital law	L1	L3	Understand these laws and apply Ampère's law to compute magnetic induction
		Force on a current-carrying conductor	L1	L3	Compute the force exerted by a magnetic field
		Action of a Magnetic Field on Charged Particles	L1	L3	Understand the Lorentz force and its applications; compute the Lorentz force
	Electromagnetic Induction	Faraday's law of induction	L1	L3	Describe electromagnetic induction phenomena and compute induced electromotive force
		Motional emf and induced emf	L1	L3	Compute motional and induced electromotive force
		Mutual inductance and self-inductance	L1	L3	Describe mutual and self-induction phenomena and compute related quantities
	Electromagnetic Media	Dielectrics	L1	L3	Understand polarization, its characterization, polarization laws; apply Gauss's theorem with dielectrics
		Magnetic media	L1	L3	Understand magnetization, its characterization, magnetization laws; apply Ampère's law to compute magnetic fields
		Energy of electromagnetic fields	L1	L3	Compute electromagnetic field energy
	Electric Circuits	DC circuits	L1	L3	Compute simple and complex DC circuits

		Transient circuits	L1	L3	Understand transient processes and compute transient circuits
		AC circuits	L1	L3	Use phasor diagrams and complex methods to compute AC circuits
	Maxwell's Electromagnetic Theory and Electromagnetic Waves	Maxwell's theory	L1	L2	Describe the experimental foundations, basic assumptions, Maxwell's equations
		Electromagnetic waves	L1	L2	Understanding electromagnetic waves

3. Pre-requisit

Calculus B-I

4. Textbooks and Other Learning Resources

Required Textbooks

David Halliday & Robert Resnick. *Fundamentals of Physics* (Volume Two). Higher Education Press, 3rd Edition, 1988.

Zhang Sanhui. *Electromagnetics*. Tsinghua University Press, 2nd Edition, December 1999.

Chen Bingqian, Shu Yousheng & Hu Wangyu. *Studies in Electromagnetics. Higher Education Press,* 1st Edition, December 2001.

Course Website:

Shantou University E-Learning Platform:

https://my.stu.edu.cn/v2/course/index.html

5. Teaching and Learning Activities

Teaching Segment	Lectures (Theory)	Exercise Classes	Lab Reports	Seminars	Others	Total
Hours (In-class)	64					64
Hours (Out-of-class)	96	28			4	128

Given the extensive content covered in this course, classroom teaching alone is insufficient for students to fully master all topics. Therefore, students are expected to complete additional self-study outside of class hours. The ratio of self-study hours to in-class hours is 2:1, corresponding to 128 hours of self-study, including 96 hours of theoretical study, 28 hours of problem-solving, and 4 hours dedicated to literature review and discussion.

The self-study component is completed under students' own supervision.

6. Assessment Scheme

Assessment Component	Description of Assessment Content and Methods	Weight
Exercises	All knowledge units; evaluation based on homework completion	20%

Quizzes	Basic laws of electrostatics, fundamental properties of electrostatic and magnetostatic fields; mid-term test	10%
Final Examination	All knowledge units; closed-book final exam	70%

7. Course Schedule

Week	Hour	Teaching format	Teaching content
1	4	Classroom Teaching	Ch. 1 Electrostatic Fields and Steady Current Fields § 1 Basic phenomena and laws of electrostatics § 2 Electric field and electric field intensity
2	4	Classroom Teaching	§ 3 Gauss's theorem § 4 Electric potential and its gradient
3	4	Classroom Teaching	§ 5 Conductors in electrostatic fields § 6 Capacitance and capacitors
4	4	Classroom Teaching	§ 7 Steady current fields Discussion of selected problems from Ch. 1
5	4	Classroom Teaching	Ch. 2 Magnetostatics § 1 Basic magnetic phenomena and fundamental laws § 2 Magnetic induction and the Biot–Savart law
6	4	Classroom Teaching	§ 3 "Gauss's theorem" for magnetic fields and Ampère's circuital law § 4 Force on a current-carrying conductor
7	4	Classroom Teaching	§ 5 Motion of charged particles in a magnetic field Discussion of selected problems from Ch. 2
8	4	Classroom Teaching	Ch. 3 Electromagnetic Induction § 1 Faraday's law of electromagnetic induction § 2 Motional emf and induced emf
9	4	Classroom Teaching	§ 3 Mutual inductance and self-inductance Discussion of selected problems from Ch. 3 Mid-term Examination
10	4	Classroom Teaching	Ch. 4 Electromagnetic Media § 1 Dielectrics
11	4	Classroom Teaching	§ 2 Magnetic media — molecular-current viewpoint § 3 Magnetization laws of magnetic media
12	4	Classroom Teaching	§ 4 Boundary conditions and magnetic-circuit theorem § 5 Energy of electromagnetic fields Discussion of selected problems from Ch. 4

13	4	Classroom Teaching	Ch. 5 Electric Circuits § 1 Sources in direct-current circuits § 2 Conduction mechanisms in various conductors § 3 Calculation of steady-state circuits
14	4	Classroom Teaching	§ 4 Transient processes § 5 Overview of alternating current § 6 Circuit elements in AC circuits § 7 Phasor diagram method
15	4	Classroom Teaching	§ 8 Complex-number method § 9 AC power § 10 Resonant circuits § 11 AC bridges § 12 Principle of transformers § 13 Three-phase alternating current
16	4	Classroom Teaching	Ch. 6 Introduction to Maxwell's Electromagnetic Theory Discussion of selected problems from Ch. 5 Final review

汕头大学本科教学
课程教学大纲

课　程　名（COURSE TITLE）：	电磁学
课程代码（COURSE CODE）：	PHY1002A
学　　　分（CREDIT VALUE）：	4
课内课时（CONTACT OURS）：	64
先修课要求（PRE-REQUISIT）	微积分 B-I
开课单位（DEPARTMENT/UNIT）：	物理学系
版　　　本（VERSION）：	20240731-PHY1002A
课程负责人（COURSE COORDINATOR）：	符史流(签章)
审　核　人（APPROVER）：	池凌飞(签章)
审核日期（APPROVE DATE）：	20240731

汕头大学理学院
2024 年 7 月

1. 课程简介 （Course Description）

（1）课程性质

电磁学（Electromagnetics）是物理学专业的必修课程。电磁学是经典物理学的一个重要组成部分，它主要研究电荷、电流产生电场、磁场的规律，电场与磁场的相互联系，电磁场对电荷、电流的作用，以及电磁场对物质的各种效应等。本课程以科学的方法论了解电磁学发展史上的某些重大发现和发明过程中的物理现象和实验方法，系统地掌握电磁学运动的基本现象、基本概念和基本规律，培养学生分析和解决电磁学问题的能力，以及唯物与辩证地看待科学问题，为学习后续有关专业课程和培养物理学专业学术型本科人才奠定基础。

（2）课程内容

本课程主要内容包含静电场、恒定电流场、稳恒磁场、电磁感应、电磁介质、电路和麦克斯韦电磁理论简介。

（3）课程目标

① 坚定中国特色社会主义道路，使学生树立坚定的理想信念；培养和树立正确的价值观和社会责任感；

② 理解静电场和静磁场的基本概念和基本规律、电磁场对电荷和电流的作用以及电磁感应基本概念和基本规律；

③ 应用库仑定律、毕奥-萨伐尔定律、电磁感应定律及其本质定理解决电磁场问题；

④ 理解直流电路、暂态电路和交流电路基本原理，应用电路基本定律和解法分析和计算电路问题。

本课程为物理学专业学术型人才培养提供专业理论与研究能力培养，高度支撑该专业毕业要求指标点“1.坚定的理想信念；2.正确价值观和社会责任感；3.1 掌握物理学的基础理论和专业知识；5.1 具备基于科学原理和方法进行研究的能力”。

2. 预期学习结果 （Intended Learning Outcomes）

本课程的预期学习结果为

<table>
<tr><th colspan="2">知识单元</th><th>知识点</th><th>初始程度</th><th>要求程度</th><th>预期学习结果</th></tr>
<tr><td rowspan="3">知识</td><td rowspan="3">静电场和恒定电流场</td><td>静电的基本现象和基本规律</td><td>L1</td><td>L2</td><td>理解电荷及其性质、物质电结构和库仑定律</td></tr>
<tr><td>电场和电场强度</td><td>L1</td><td>L3</td><td>计算电场强度</td></tr>
<tr><td>高斯定理</td><td>L1</td><td>L3</td><td>应用高斯定理计算电场强度</td></tr>
</table>

		电位及其梯度	L1	L3	计算电位
		静电场中的导体	L1	L3	应用静电平衡条件解决电场和电位问题
		电容器及其电容	L1	L3	计算电容
		恒定电流场	L1	L3	理解电流场与电动势、计算电流强度、应用欧姆定律
		思政：了解电磁学发展史上相关的重大发现和发明对自然世界和人类活动的影响，唯物与辩证地理解科学问题。主张唯物主义认识论和探索与奉献的科学精神，介绍中国先进技术中的相关电磁学问题，树立家国情怀、制度自信和文化自信，培养正确的世界观、价值观和人生观。			
	稳恒磁场	磁的基本现象和基本规律	L1	L2	说明磁的基本现象和基本规律、理解安培定律和毕奥-萨伐尔定律
		载流回路的磁场	L1	L3	计算磁感应强度
		磁场的“高斯定理”与安培环路定理	L1	L3	理解高斯定理与安培环路定理、应用安培环路定理计算磁感应强度
		磁场对载流导线的作用	L1	L3	计算磁场对载流导线的作用力
		带电粒子在磁场中的作用	L1	L3	理解洛仑兹力及其应用、计算洛仑兹力
		思政：通过对电磁炮的应用举例，强化学生的文化自信和制度自信，培养学生对国家科技进步的自信和对国家制度的认同。			
	电磁感应	电磁感应定律	L1	L3	说明电磁感应现象、应用法拉第定律计算感应电动势
		动生电动势和感生电动势	L1	L3	计算动生电动势和感生电动势
		互感和自感	L1	L3	说明互感和自感现象、计算互感和自感
		思政：展现法拉第电磁感应定律的发现过程，培养学生唯物主义观点和科学方法论。探讨科技发展对社会的影响，认识科技创新对社会进步的推动作用。			
	电磁介质	电介质	L1	L3	理解电介质的极化及其表征、电介质的极化规律；应

					用有电介质时的高斯定理计算电场强度
		磁介质	L1	L3	理解磁介质的磁化及其表征、磁介质的磁化规律、应用安培环路定理 计算磁场
		电磁场能	L1	L3	计算电磁场能量
	电路	恒定电路	L1	L3	计算直流简单电路和复杂电路
		暂态过程	L1	L3	理解暂态过程、计算暂态电路
		交流电路	L1	L3	应用矢量图解法和复数解法计算交流电路
	麦克斯韦电磁理论和电磁波	麦克斯韦电磁理论	L1	L2	说明电磁理论的实验基础、基本假设、麦克斯韦方程组
		电磁波	L1	L2	理解电磁波

3. 先修要求 （Pre-requisit）

微积分B-I

4. 教材及其他教学资源 （Textbooks and Other Learning Resources）

课程教材

赵凯华、陈熙谋 主编 《电磁学》，高等教育出版社，2023.12 第3版

推荐参考资料

（1） David Halliday,Robert Resnick，Fundamentals of Physics(Volume Two), 高等教育出版社,1988,第 3 版

（2） 张三慧,《电磁学》,清华大学出版社,1999.12,第 2 版

（3） 陈秉乾，舒幼生，胡望雨,《电磁学专题研究》,高等教育出版社,2001.12, 第 1 版

课程网站

汕头大学电化教学网站 https://my.stu.edu.cn/v2/course/index.html

5. 主要教学环节 （Teaching and Learning Activities）

教学环节	理论课(小时)	习题课(小时)	实验(小时)	研讨（小时）	社会实践（小时）	项目（小时）	在线学习（小时）	其他（小时）	合计
课内	64	0	0	0	0	0	0	0	64
课外	96	28	0	0	0	0	0	4	128

本课程内容较多，只进行课堂教学，学生无法全部理解课程内容，因此需要在课堂教学环节之外进行自学。自学环节课时与课堂教学课时比例为 2:1，即自学环节为 128 学时，其中理论内容学习 96 学时，完成习题 28 学时，查阅资料和讨论等 4 学时。自学环节由学生自我监督完成。

6. 课程考核 （Assessment Scheme）

考核项目	考核内容和考试方法简介	权重
练习	所有知识单元；作业完成情况	20%
测验	静电基本规律，静电场的基本性质，静磁场的基本性质；期中考试	10%
考试	所有知识单元；期末闭卷考试	70%

7. 学习进度 （Course Schedule）

周次	教学时数	教学形式	教 学 内 容
1	4	课堂教学	Ch1 静电场和恒定电流场 §1 静电的基本象和基本规律 §2 电场和电场强度
2	4	课堂教学	§3 高斯定理 §4 电位及其梯度
3	4	课堂教学	§5 静电场中的导体 §6 电容和电容器
4	4	课堂教学	§7 恒定电流场 Ch1 习题中的问题讲解
5	4	课堂教学	Ch2 稳恒磁场 §1 磁的基本现象和基本规律 §2 磁感应强度和毕奥－萨伐尔定律

6	4	课堂教学	§3 磁场的"高斯定理"与安培环路定理 §4 磁场对载流导线的作用
7	4	课堂教学	§5 带电粒子在磁场中的运动 Ch2 习题中的问题讲解
8	4	课堂教学	Ch3 电磁感应 §1 电磁感应定律 §2 动生电动势和感生电动势
9	4	课堂教学	§ 3 互感和自感 Ch3 习题中的问题讲解 期中考试
10	4	课堂教学	Ch4 电磁介质 §1 电介质
11	4	课堂教学	§2 磁介质—分子电流观点 §3 磁介质的磁化规律
12	4	课堂教学	§4 边界条件和磁路定理 §5 电磁场能 Ch4 习题中的问题讲解
13	4	课堂教学	Ch5 电路 §1 恒定电路中的电源 §2 各种导体的导电机制 §3 恒定电路的计算
14	4	课堂教学	§4 暂态过程 §5 交流电概述 §6 交流电路中的元件 §7 矢量图解法
15	4	课堂教学	§8 复数解法 §9 交流电功率 §10 谐振电路 §11 交流电桥 §12 变压器原理 §13 三相交流电
16	4	课堂教学	Ch6 麦克斯韦电磁理论介绍 Ch5 习题中的问题讲解 复习

Shantou University

Module Description for Undergraduate Courses

COURSE TITLE: Optics

COURSE CODE: PHY2060A

CREDIT VALUE: 3

CONTACT HOURS: 48

PRE-REQUISITE none

DEPARTMENT/UNIT: Department of Physics

VERSION: 20240731- PHY2060A

COURSE COORDINATOR: (Signature and Seal)

APPROVER: (Signature and Seal)

APPROVE DATE: 20240731

Shantou University Faculty of Science

July 2024

1. Course Description

(1) Nature of the Course

Optics is a compulsory fundamental course for students majoring in Optoelectronic Information Science and Engineering, Microelectronics, and Physics.

(2) Course Content

As an indispensable discipline within General Physics, this course provides a thorough and systematic exploration of optical phenomena such as interference, diffraction, polarization, and light–matter interaction, covering both foundational theories and modern applications.

The course elaborates on interference patterns, diffraction principles, the properties of polarized light, and the basic mechanisms of light interacting with matter. By integrating classical experiments with modern technological examples, it enables students to develop a deep understanding of general methodologies for solving optical problems.

Special emphasis is placed on the wide applications of optics in scientific research, industry, and practical technologies—particularly advanced optical technologies and equipment independently developed in China, such as innovative polarization techniques in quantum communication satellites. These examples aim to broaden students' scientific and technological perspectives while strengthening practical competency and innovative thinking.

(3) Course Objectives

Upon completing this course, students should be able to:

1. Understand the objective nature of light through the historical development of optics.
2. Master the wave nature and propagation characteristics of light, and understand the fundamental principles and laws governing interference, diffraction, and polarization, as well as their basic applications in scientific research and industry.
3. Construct basic physical models for interference, diffraction, and polarization according to specific problems, and solve and analyze the corresponding intensity distributions.
4. Master the Planck radiation formula, the concept of energy quanta, the photoelectric effect, Einstein's photon hypothesis, and the fundamental ideas of wave–particle duality.

This course provides essential theoretical foundations and application-oriented training for undergraduate students in Optoelectronic Information Science and Engineering, Microelectronics, and Physics. It strongly supports key expected learning outcomes of these programs, including:

3.1 Mastery of fundamental theories and professional knowledge in physics, optoelectronics, and information science;

5.1 Ability to conduct research based on scientific principles and methodologies.

2. Intended Learning Outcomes

The expected learning outcomes of this course are summarized as follows:

Knowledge Unit	Key Knowledge Points	Initial Level	Required Level	Expected Learning Outcomes
1. Introduction	1.1 History of Optics	L1	L2 L5	Describe the historical development of optics.
	1.2 Basic Laws of Light Propagation	L1	L4	Apply the basic laws of light propagation to analyze and solve reflection, refraction, and total internal reflection problems.
2. Interference of Light	2.1 Description of Light Waves, Superposition, and Coherence Conditions	L1	L4 L5	Apply wave superposition and coherence conditions to compute and analyze interference patterns from two point sources.

	2.2 Division-of-Wavefront Interference and Spatial Coherence	L1	L4	Use the principles of division-of-wavefront interference to analyze fringe distributions and fringe shifts.
	2.3 Division-of-Amplitude Interference and Temporal Coherence	L1	L4	Apply division-of-amplitude interference to analyze precise thickness measurements and related problems.
	2.4 Multiple-Beam Interference and Fabry–Perot Interferometer	L1	L2	Describe the operating principles of a Fabry–Perot interferometer.
	2.5 Introduction to Thin-Film Optics (Optional)	L1	L2	Describe the applications of thin-film optics.
3. Diffraction of Light	3.1 Diffraction Phenomena and the Huygens–Fresnel Principle	L1	L3 L4	Describe diffraction phenomena and the physical picture of the Huygens–Fresnel principle. Apply Huygens' construction to analyze light-propagation problems.
	3.2 Fresnel Diffraction by a Circular Aperture	L1	L3	Apply Fresnel diffraction of a circular aperture to solve relevant problems.
	3.3 Fraunhofer Diffraction by a Single Slit	L1	L3	Apply Fraunhofer diffraction of a single slit to solve relevant problems.
	3.4 Fraunhofer Diffraction by a Circular Aperture and Resolving Power of Imaging Instruments	L1	L3	Use Fraunhofer diffraction to compute the resolving power of imaging instruments.
	3.5 Fraunhofer Diffraction by Multiple Slits and Gratings	L1	L3	Compute amplitude and intensity distributions for multi-slit Fraunhofer diffraction and gratings.
	3.6 Bragg Condition of a Spatial Grating	L1	L3	Compute and analyze the Bragg condition for spatial gratings.
	3.7 Holography (Optional)	L1	L2	Explain the principles of holography.
4. Polarization of Light	4.1 Natural Light and Polarized Light	L1	L4 L5	Distinguish and compare natural light and different types of polarized light.
	4.2 Reflection and Refraction at Interfaces of Isotropic Media	L1	L3	Apply laws of reflection and refraction at isotropic-medium interfaces to solve optical problems.
	4.3 Propagation in Anisotropic Media — Basics of Crystal Optics	L1	L3	Use propagation laws in anisotropic media to solve related problems.
	4.4 Uniaxial Crystals	L1	L3	Apply graphical methods to analyze light propagation in uniaxial crystals.
	4.5 Circular Polarization and System Analysis of Monochromatic Polarized Light	L1	L4	Distinguish and compare circularly polarized and linearly polarized light.

	4.6 Interference of Linearly Polarized Light	L1	L4	Apply interference principles to analyze interference phenomena of polarized light.
	4.7 Optical Activity	L1	L3	Use optical activity to explain the Faraday rotation effect.
5. Light–Matter Interaction and Quantum Nature of Light	5.1 Light Absorption	L1	L2	Explain the phenomenon of light absorption.
	5.2 Dispersion	L1	L2	Explain dispersion phenomena.
	5.3 Scattering	L1	L2	Explain scattering phenomena.
	5.4 Radiation Theory	L1	L2	Explain the basic concepts of radiation theory.
	5.5 Photoelectric Effect	L1	L2	Explain the phenomena and principles of the photoelectric effect.
	5.6 Wave–Particle Duality of Light	L1	L2 L5	Explain the concept of wave–particle duality.

3. Pre-requisit

None

4. Textbooks and Other Learning Resources

(1) Required Textbooks

Optics, edited by Chen Min, Zhao Fuli, and Dong Jianwen, Higher Education Press.

(2) Recommended Textbooks:

None.

(3) Course Website:

Course Website:

https://my.stu.edu.cn/

5. Teaching and Learning Activities

Teaching Segment	Lectures (Theory)	Exercise Classes	Lab Reports	Seminars	Online Learning	Total
Hours (In-class)	48					48
Hours (Out-of-class)		36		12	48	96

Basis for Out-of-class Workload Calculation:

As this course is a core foundational course with a comparatively heavy content load and a certain level of difficulty, students are expected to complete approximately 3 hours of tutorial exercises per week (around 12 assignments), 3 hours of review and online learning per week, and 1 hour of seminar discussion per week (around 12 sessions).

6. Assessment Scheme

Assessment Component	Description of Assessment Content and Methods	Weight
Continuous Assessment	Class participation, homework, and reflective tasks	40%
Final Examination	Final closed-book exam	60%

7. Course Schedule

Week	Hour	Teaching format	Teaching Method	Teaching content
1	3	Lecture	Lecture & “Rain Classroom” platform	Brief history of optics; scope and methods of optical research.
2	3	Lecture	Lecture & “Rain Classroom” platform	Description of light waves and their mathematical foundations.
3	3	Lecture	Lecture & “Rain Class-room” platform	Superposition of light waves and conditions for coherence.
4	3	Lecture	Lecture & “Rain Classroom” platform	Wavefront-division two-beam interference; spatial coherence.
5	3	Lecture	Lecture & “Rain Classroom” platform	Amplitude-division two-beam interference; temporal coherence.
6	3	Lecture	Lecture & “Rain Classroom” platform	Amplitude-division multiple-beam interference; Fabry–Perot interferometer; introduction to thin-film optics.
7	3	Lecture	Lecture & “Rain Classroom” platform	Optical diffraction phenomena; Huygens–Fresnel principle; Fresnel diffraction by a circular aperture and zone plates
8	3	Lecture	Lecture & “Rain Classroom” platform	Fraunhofer diffraction by a single slit; Fraunhofer diffraction by a circular aperture and resolution of imaging instruments.
9	3	Lecture	Lecture & “Rain Classroom” platform	Fraunhofer diffraction by multi-slit gratings.

10	3	Lecture	Lecture & “Rain Classroom” platform	Bragg condition for volume gratings; holography.
11	3	Lecture	Lecture & “Rain Classroom” platform	Natural and polarized light.
12	3	Lecture	Lecture & “Rain Classroom” platform	Light propagation in anisotropic media—fundamentals of crystal optics; uniaxial crystals.
13	3	Lecture	Lecture & “Rain Classroom” platform	Circular polarization and system analysis of circularly polarized monochromatic light.
14	3	Lecture	Lecture & “Rain Classroom” platform	Interference of linearly polarized light; optical rotation.
15	3	Lecture	Lecture & “Rain Classroom” platform	Light absorption; dispersion; scattering.
16	3	Lecture	Lecture & “Rain Classroom” platform	Radiation theory; photoelectric effect; wave–particle duality. Course summary.

汕头大学本科教学

课程教学大纲

课　程　名（COURSE TITLE）：	光学
课程代码（COURSE CODE）：	PHY2060A
学　　　分（CREDIT VALUE）：	3
课内课时（CONTACT OURS）：	48
先修课要求（PRE-REQUISIT）	无
开课单位（DEPARTMENT/UNIT）：	物理学系
版　　　本（VERSION）：	20240731- PHY2060A
课程负责人（COURSE COORDINATOR）：	(签章)
审　核　人（APPROVER）：	(签章)
审核日期（APPROVE DATE）：	20240731

汕头大学理学院

2024 年 7 月

1、课程简介 （Course Description）

（1）课程性质

光学（Optics）是物理学系光电信息科学与工程专业、微电子方向、物理学专业的必修专业基础课。

（2）课程内容

本课程作为普通物理学中不可或缺的重要学科，深入系统地探索了光的干涉、衍射、偏振及光与物质相互作用等现象，涵盖了从基础理论到现代应用的全方位内容。本课程不仅详细阐述了光的干涉现象、衍射规律、偏振光的特性以及光与物质相互作用的基本原理，还通过经典实验与现代技术案例相结合的方式，使学生深刻理解并掌握处理光学问题的一般方法。同时，课程特别强调了光学在科研、生产及实践中的广泛应用，特别是我国自主研发的先进光学技术及设备，如量子卫星中偏振技术的创新应用，旨在拓宽学生的科技视野，增强其实践能力和创新意识。此外，本课程还注重培养学生的家国情怀、民族自信与文化自信，通过介绍我国在光学领域的成就与挑战，激发学生的爱国情怀与责任感，促进其科学素养与人文情怀的融合发展。

（3）课程教学目标

学完本课程后，学生应能够：

① 通过了解光学的发展历史，特别是我国古代光学的成就，学习认识光的客观存在，培养学生辩证唯物主义世界观。

② 初步了解光学在我国自主研发的先进技术及设备中的应用，培养学生的家国情怀，增强学生的民族自信、文化自信。

③ 掌握光的波动性质及其传播特性，掌握光的干涉、衍射、偏振等现象的基本原理和规律，初步了解它们在科研、生产实践上的应用。

④ 根据具体问题建立基本的光学干涉、衍射、偏振物理模型，并求解及分析对应的光强分布。

⑤ 掌握普朗克辐射公式和能量子、光电效应及爱因斯坦的光子假设、波粒二象性等基本概念及原理。

本课程为光电信息科学与工程专业、微电子方向和物理专业学术型本科人才培养提供专业理论与应用研究能力的培养，高度支撑这些专业本科人才培养方案中的毕业要求指标点：1.坚定的理想信念；2.正确价值观和社会责任感；3.1 掌

握物理学、光电子学和信息学的基础理论和专业知识；5.1 具备基于科学原理和方法进行研究的能力。

2、预期学习结果 （Intended Learning Outcomes）

知识单元	知识点	初始程度	要求程度	预期学习结果
1. 绪论	1.1 光学发展史	L1	L2 L5	复述光学的发展过程 思政：详细介绍我国古代光学的成就，增强学生的民族自豪感和自信心
	1.2 光线传播的基本规律	L1	L4	使用光线传播的基本规律解决及分析反射、折射、全反射等光学传播问题。
2.光的干涉	2.1 光波的描述、叠加和相干光的条件	L1	L4 L5	应用光波的叠加和相干条件计算并分析两个点光源的干涉现象 思政：光的性质与唯物主义的关系，培养学生辩证唯物主义思想
	2.2 分波面双光束干涉空间相干性	L1	L4	利用分波面双光束干涉原理解决并分析干涉条纹分布及位移等问题
	2.3 分振幅双光束干涉时间相干性	L1	L4	利用分振幅双光束干涉原理解决并分析精密测量厚度等问题
	2.4 分振幅多光束干涉法布里-珀罗干涉仪	L1	L2	复述法布里-珀罗干涉仪的原理
	*2.5 薄膜光学简介	L1	L2	复述薄膜光学的应用
3.光的衍射	3.1 光的衍射现象 惠更斯-菲涅耳原理	L1	L3 L4	描述光的衍射现象及惠更斯-菲涅耳原理的物理图像 应用惠更斯原理作图解决并分析光的传播问题
	3.2 圆孔的菲涅耳衍射	L1	L3	应用圆孔的菲涅耳衍射解决相关问题
	3.3 单缝夫琅禾费衍射	L1	L3	应用单缝夫琅禾费衍射解决相关问题
	3.4 圆孔夫琅禾费衍射 成像仪器的分辨本领	L1	L3	应用夫琅禾费衍射计算成像仪器的分辨率本领
	3.5 多缝的夫琅禾费衍射光栅	L1	L3	能够计算多缝的夫琅禾费衍射的振幅分布与强度分布
	3.6 空间光栅布拉格条件	L1	L3	能够计算空间光栅布拉格条件
	*3.7 全息照相	L1	L2	阐释全息照相原理
4.光的偏振	4.1 自然光和偏振光	L1	L4 L5	能够分辨和比较自然光、各种偏振光的区别

				思政：介绍我国量子信息技术的发展，重点介绍偏振光在我国墨子号量子卫星中的应用，增强学生的民族自信
	4.2 光在各向同性介质界面上反射与折射	L1	L3	使用光在各向同性介质界面上反射与折射规律解决光的反射与折射问题
	4.3 光在各向异性介质中的传播——晶体光学基础	L1	L3	使用光在各向异性介质中的传播规律解决相关问题
	4.4 单轴晶体	L1	L3	利用作图法解决光在单轴晶体里的传播问题
	4.5 圆偏振与圆偏振单色偏振光的系统分析	L1	L4	能够分辨和比较圆偏振与线偏振光的区别
	4.6 线偏振光的干涉	L1	L4	运用光的干涉原理解决并分析偏振光的干涉问题
	4.7 旋光性	L1	L3	利用旋光性解释法拉第旋光效应
5. 光与物质的相互作用、光的量子性	5.1 光的吸收	L1	L2	阐释光的吸收现象
	5.2 光的色散	L1	L2	阐释光的色散现象
	5.3 光的散射	L1	L2	阐释光的散射现象
	5.4 光辐射理论	L1	L2	阐释光辐射理论
	5.5 光电效应	L1	L2	阐释光电效应的现象与原理
	5.6 光的波粒二象性	L1	L2 L5	阐释光的波粒二象性 思政环节：从辩证唯物主义角度看待光学理论的螺旋式上升发展，培养学生辩证唯物主义思想。

3、先修要求 （Pre-requisite）

无

4、教材及其他教学资源 （Textbooks and Other Learning Resources）

（1）指定教材：

《光学》，陈敏/赵福利/董建文 编著，高等教育出版社

（2）推荐教材：

无

（3）课程网站：

https://my.stu.edu.cn/

5、主要教学环节 （Teaching and Learning Activities）

教学环节	理论课（小时）	习题课（小时）	实验（小时）	研讨（小时）	社会实践（小时）	项目（小时）	在线学习（小时）	期中测试（小时）	合计
课内	48	0	0	0	0	0	0	0	48
课外	0	36	0	12	0	0	48	0	96

课外课时计算依据：本课程为专业基础课，内容较多且有一定的难度，预计每周课内学时3小时，需要学生课外完成习题练习3小时(约12次作业)，课外复习3小时(在线学习)，研讨1小时（约12次）。

6、课程考核 （Assessment Scheme）

考核项目	考核内容和考试方法简介	权重%
平时成绩	包括课堂参与、课后作业及思考	40
期末考核	期末闭卷考试	60

7、学习进度 （Course Schedule）

周次	教学时数	教学形式	教学方法	教 学 内 容
1	3	课堂教学	课堂讲授 雨课堂	光学发展简史 光学的研究内容和方法 思政环节：详细介绍我国古代光学的成就，增强学生的民族自豪感和自信心。 光线传播的基本规律
2	3	课堂教学	课堂讲授 雨课堂	光波的描述及其数学基础
3	3	课堂教学	课堂讲授 雨课堂	光波的叠加和相干光的条件
4	3	课堂教学	课堂讲授 雨课堂	分波面双光束干涉 空间相干性
5	3	课堂教学	课堂讲授 雨课堂	分振幅双光束干涉 时间相干性
6	3	课堂教学	课堂讲授 雨课堂	分振幅多光束干涉 法布里-珀罗干涉仪 薄膜光学简介

7	3	课堂 教学	课堂讲授 雨课堂	光的衍射现象 惠更斯-菲涅耳原理 圆孔的菲涅耳衍射波带片
8	3	课堂 教学	课堂讲授 雨课堂	单缝夫琅禾费衍射 圆孔的夫琅禾费衍射成像仪器的分辨本领
9	3	课堂 教学	课堂讲授 雨课堂	多缝的夫琅禾费衍射光栅
10	3	课堂 教学	课堂讲授 雨课堂	空间光栅布拉格条件 全息照相
11	3	课堂 教学	课堂讲授 雨课堂	自然光和偏振光 思政环节：介绍我国量子信息技术的发展，重点介绍偏振光在我国墨子号量子卫星中的应用，增强学生的民族自信。 光在各向同性介质界面上反射与折射
12	3	课堂 教学	课堂讲授 雨课堂	光在各向异性介质中的传播——晶体光学基础 单轴晶体
13	3	课堂 教学	课堂讲授 雨课堂	圆偏振与圆偏振单色偏振光的系统分析
14	3	课堂 教学	课堂讲授 雨课堂	线偏振光的干涉 旋光性
15	3	课堂 教学	课堂讲授 雨课堂	光的吸收 光的色散 光的散射
16	3	课堂 教学	课堂讲授 雨课堂	光辐射理论 光电效应 光的波粒二象性 光学总结 思政环节：通过介绍光在麦克斯韦方程组统一下的电磁波理论框架下再次遇到瓶颈，科学家们因此进一步发现了光的量子性，体现了事物的螺旋式上升发展，培养学生辩证唯物主义思想。

Shantou University

Module Description for Undergraduate Courses

COURSE TITLE：	Thermal Physics
COURSE CODE：	PHY2021A
CREDIT VALUE：	2
CONTACT HOURS：	32
PRE-REQUISITE	none
DEPARTMENT/UNIT：	Department of Physics
VERSION：	2024
COURSE COORDINATOR：	(Signature and Seal)
APPROVER：	(Signature and Seal)
APPROVE DATE：	

Shantou University Faculty of Science

January 2024

1. Course Description

Thermal Physics constitutes an essential component of General Physics.It investigates all phenomena related to heat and reveals their underlying physical nature.Historically, breakthroughs in thermal physics directly contributed to the First Industrial Revolution, dramatically enhancing productive capacity and reshaping social relations, thereby driving profound transformations in human society. As one of the most fundamental compulsory courses for physics majors, this module covers:

- the basic concepts of thermal physics,
- the states of matter and their equilibrium properties,
- statistical distribution laws of thermal equilibrium,
- the First Law of Thermodynamics,
- the Second Law of Thermodynamics,
- and an introduction to non-equilibrium processes.

Upon completing this course, students should be able to:

1. **Approach scientific questions from a materialist and dialectical perspective**, forming a rigorous and objective worldview.
2. **Cultivate a sense of social responsibility and commitment**, developing openness to exploration, willingness to contribute, and confidence in scientific and cultural systems.
3. **Use the molecular kinetic theory as a starting point** to understand macroscopic physical phenomena through statistical laws.
4. **Apply the First Law of Thermodynamics** to analyze work, heat transfer, and efficiency in thermodynamic processes.
5. **Master and utilize the concept of entropy** to determine the direction of natural processes.
6. **Gain introductory knowledge of emerging interdisciplinary fields** related to thermal physics.

2. Intended Learning Outcomes

Training Objectives	Knowledge Units / Competencies Standards	Initial Level	Target Level	Expected Learning Outcomes
Introduction	Objects of Study in Thermal Physics	L1	L3	Describe the characteristic features of the phenomena studied in thermal physics and the methods used to investigate them.
	Macroscopic and Microscopic Descriptions of Thermodynamic Systems	L1	L3	Use macroscopic quantities and microscopic variables to characterize a thermodynamic system.
Temperature	State Variables in Equilibrium	L1	L4	Identify thermal equilibrium and distinguish different state variables
	Zeroth Law of Thermodynamics and Temperature	L1	L3	Explain the concepts of thermal equilibrium and temperature.
	Establishment of Temperature Scales	L1	L3	Describe the definition and construction of temperature scales.

	Equation of State for an Ideal Gas	L1	L4	Present and interpret the ideal gas equation of state.
First Law of Thermodynamics	Processes of Thermodynamic Systems	L1	L4	Present typical processes undergone by thermodynamic systems.
	Work	L1	L4	Analyze the physical nature of work in thermodynamic processes.
	Internal Energy, Heat, and Joule's Experiment on the Mechanical Equivalent of Heat	L1	L4	Define internal energy and heat, and describe Joule's experiment and its improvements.
	First Law of Thermodynamics	L1	L5	Evaluate energy conversion in thermodynamic processes using the First Law.
	Internal Energy, Heat Capacity, and Enthalpy of an Ideal Gas	L1	L4 L3	Analyze work and heat transfer in isochoric, isobaric, isothermal, adiabatic, and polytropic processes of an ideal gas.
	Cyclic Processes	L1	L4	Analyze forward and reverse cycles of ideal gases and determine the efficiency of a thermodynamic cycle.
Second Law of Thermodynamics	Second Law of Thermodynamics	L1	L4	Analyze the equivalence between the two classical statements of the Second Law.
	Irreversibility of Macroscopic Processes	L1	L3	Illustrate the irreversibility of real macroscopic processes from a microscopic perspective.
	Carnot Cycle	L1	L4	Analyze the four stages of the Carnot cycle.
	Carnot's Theorem	L1	L4 L5	Evaluate the efficiency of the Carnot cycle in light of Carnot's theorem.
	Thermodynamic Temperature Scale	L1	L3	Apply the Second Law to interpret the definition of the thermodynamic temperature scale.
	Entropy and the Second Law	L1	L4	Analyze the relation between entropy and the Second Law, and identify the principle of entropy increase.
Kinetic Theory of Gases	Basic Concepts of the Kinetic Theory of Molecules	L1	L3	Explain the fundamental assumptions of the kinetic theory of gases.
	Pressure of an Ideal Gas	L1	L3	Apply the kinetic theory to give a microscopic interpretation of gas pressure.

	Microscopic Meaning of Temperature	L1	L3	Explain that temperature reflects the macroscopic manifestation of the average kinetic energy of a large number of molecules in thermal motion.
	Maxwell Speed Distribution Law	L1	L4 L4 L5 L5	Understand the concept of a distribution function, analyze the Maxwell speed distribution, and evaluate the three characteristic speeds.
	Boltzmann Distribution Law	L1	L4	Analyze the Boltzmann density distribution law
	Equipartition Theorem of Energy	L1	L3 L4	Determine degrees of freedom and master the equipartition theorem for estimating average molecular energy
	Internal Energy and Molar Heat Capacity of an Ideal Gas	L1	L4	Analyze the internal energy and molar heat capacity of ideal gases.
	Relationship Between Kinetic Theory and the Laws of Thermodynamics	L1	L4	Analyze the connections between kinetic theory and the fundamental laws of thermodynamics.
Transport Processes in Gases	Mean Free Path of Gas Molecules	L1	L3	Apply the concepts of mean free path and collision frequency to describe molecular motion in dilute gases
	Viscosity	L1	L3	Explain the microscopic origin of viscosity in gases
	Thermal Conduction	L1	L3	Explain the microscopic mechanism underlying heat conduction in gases.
	Diffusion	L1	L3	Explain the microscopic mechanism responsible for diffusion phenomena in gases.
Solids and Liquids	Van der Waals Equation	L1	L3	Apply the van der Waals equation to describe the behavior of real gases.
	Joule–Thomson Effect	L1	L3	Explain the microscopic mechanism of the Joule–Thomson effect.
	Crystalline Solids	L1	L3	Describe the macroscopic characteristics of crystals
	Liquids	L1	L3	Explain the microscopic structure of liquids and the origin of surface tension.
	Capillary Phenomena and Capillary Formula	L1	L3	Apply the principles of capillarity and the capillary rise formula to analyze relevant physical phenomena.

Phase Tra Phase Transitions nsitions	General Concepts of Phases and Phase Transitions	L1	L4	Distinguish the concepts of phase and phase transition.
	Evaporation, Boiling, and Saturated Vapor Pressure	L1	L4	Analyze evaporation, boiling, and saturated vapor pressure.
	Liquid–Vapor Phase Diagram	L1	L4	Analyze the liquid–vapor phase diagram.
	van der Waals Isotherms	L1	L3	Describe van der Waals isotherms.
	Clausius–Clapeyron Equation	L1	L4	Determine relations among thermodynamic variables using the Clausius–Clapeyron equation.
	Gas Liquefaction and Low Temperatures	L1	L3	Explain gas liquefaction and low-temperature behavior.
	Solid–Liquid / Solid–Gas Transitions and Triple Point	L1	L3	Explain phase transitions and the triple point.
	p–V–T Surface of Real Substances	L1	L3	Describe the p–V–T surface for real substances.

3. Pre-requisit

None

4. Textbooks and Other Learning Resources

Recommended References

- Huang, S.-Q. *Thermal Physics Course*, 4th ed. Higher Education Press.
- Li, C., and Zhang, L.-Y. *Thermal Physics*, 3rd ed. Higher Education Press.
- Zhao, K.-H., and Luo, W.-Y. *New Concept Physics Course: Thermal Physics*, 2nd ed. Higher Education Press.
- Qin, Y.-H. *Thermal Physics*, 2nd ed. Higher Education Press.
- Zhao, K.-H. *Qualitative and Semi-Quantitative Physics*. Higher Education Press.
- Wu, X., et al. *The Source of Civilization: Physics*. Shanghai Science & Technology Press.
- Gamow, George. *One Two Three… Infinity: Facts and Speculations of Science*. Science Press edition (Chinese translation by Bao Yong-ning; original English version retained in reference list).

5. Teaching and Learning Activities

Teaching Segment	Lectures (Theory)	Exercise Classes	Laboratory Work	Seminars	Social Practice	Project Work	Online Learning Others	Mid-Term Exam	Total
Hours (In-class)	30	0	0	2	0	0	0	0	32
Hours (Out-of-class)	6	24	0	6	0	6	0	0	42

7. Assessment Scheme

Assessment item	Description / Assessment criteria	Weight
Coursework	Coursework and reflection	40%
Final Examination	A closed-book final exam	60%

7. Course Schedule

Week	Hour	Teaching format	Teaching content
1	2	Lecture	Introduction; scope of thermal physics; macroscopic and microscopic descriptions of thermodynamic systems
2	2	Lecture	Variables of equilibrium states; the zeroth law of thermodynamics and temperature; establishment of temperature scales
3	2	Lecture	Equation of state of an ideal gas; thermodynamic processes; work, internal energy, and heat; Joule's mechanical equivalent of heat
4	2	Lecture	First law of thermodynamics; internal energy, heat capacity, and enthalpy of ideal gases; typical thermodynamic processes
5	2	Lecture	Applications of the first law of thermodynamics to typical processes
6	2	Lecture	Cyclic processes
7	2	Lecture	Second law of thermodynamics; irreversibility of real processes
8	2	Lecture	Carnot cycle and Carnot theorem
9	2	Lecture	Thermodynamic temperature scale; the second law and entropy; free energy
10	2	Lecture	Kinetic theory of gases; microscopic interpretation of pressure and temperature
11	2	Lecture	Distribution functions; Maxwell distribution of molecular speeds
12	2	Lecture	Boltzmann distribution; equipartition theorem; internal energy and molar heat capacity
13	2	Lecture	Mean free path; transport phenomena

14	2	Lecture	van der Waals equation; Joule–Thomson effect; crystalline solids
15	2	Lecture	Liquids; capillarity; phases and phase transitions; saturated vapor pressure
16	2	Lecture	Clausius–Clapeyron equation; liquefaction; p–V–T surfaces

汕头大学本科教学
课程教学大纲

课程名（COURSE TITLE）：	热学
课程代码（COURSE CODE）：	PHY2021A
学分（CREDIT VALUE）：	2
课内课时（CONTACT HOURS）：	32
先修课要求（PRE-REQUISITE）	
开课单位（DEPARTMENT/UNIT）：	物理系
版本（VERSION）：	2024
课程负责人（COURSE COORDINATOR）：	(签章)
审核人（APPROVER）：	(签章)
审核日期（APPROVE DATE）：	

汕头大学理学院

2024 年 1 月

1. 课程简介（Course Description）

热学是普通物理学的一个组成部分，其研究对象是与热有关的一切现象及其物理本质。在人类历史上，正是对热学研究取得的突破促成了第一次工业革命，极大地提高了社会生产力，深刻地改变了生产关系，从而推动了人类社会形态发生了变革。热学是物理学专业最重要的必修基础课之一，本课程的内容是热学基本概念和物质聚集态、热平衡态的统计分布律、热力学第一定律、热力学第二定律、非平衡过程等。学完本课程后学生应能够：

1. 能从唯物的、辩证的角度去看待科学问题；
2. 培养学生的家国情怀，勇于探索、乐于奉献的精神，树立制度自信和文化自信；
3. 由分子动理论出发，运用统计规律理解宏观物理现象；
4. 运用热力学第一定律分析热力学系统过程的做功、热交换和效率问题；
5. 掌握并运用熵的概念，分析自然过程的方向；
6. 了解与热学相关的诸多新兴交叉学科。

2. 预期学习结果（Intended Learning Outcomes）

本课程的预期学习结果如下表：

知识单元	知识点	初始程度	要求程度	预期学习结果
引言	热学研究对象	L1	L3	说明热学研究对象特征及研究方法
	热力学系统的宏观描述和微观描述	L1	L3	使用宏观量和微观量分别描述热力学系统
温度	平衡态状态参量	L1	L4	识别平衡态，分解状态参量 思政：通过平衡态引入《劝学》，培养文化自信
	热力学第零定律和温度	L1	L3	说明热平衡和温度的含义
	温标的建立	L1	L3	说明温标的定义 思政：观看抗议期间的体温检测的视频，培养家国情怀
	理想气体物态方程	L1	L4	展示理想气体物态方程
热力学第一定律	热力学系统的过程	L1	L4	展示热力学系统的典型过程
	功	L1	L4	分析热力学系统中功的本质
	内能热量焦耳热功当量实验	L1	L4 L4	确定内能和热量的概念 展现焦耳实验及其改进
	热力学第一定律	L1	L5	评价热力学过程中的能量转换过程 思政：介绍β衰变“能量失窃案”，培养家国情怀
	理想气体的内能、热容和焓	L1	L4 L3	分析理想气体的内能、热容量 计算化学反应热和生成焓
	热力学第一定律对几种典型过程的应用	L1	L4	分析理想气体的等容、等压、等温、绝热、多方等过程中的功与热关系
	循环过程	L1	L4	分析理想气体的正循环和逆循环过程，并确定循环效率 思政：介绍涉及循环的“天问一号”，培养家国情怀
热力学第二定律	热力学第二定律	L1	L4	分析热力学第二定律两种表述的等价性
	实际宏观过程的不可逆性	L1	L3	从微观角度展示不可逆性
	卡诺循环	L1	L4	分析卡诺循环的四个组成环节

	卡诺定理	L1	L4 L5	评价卡诺循环效率
	热力学温标	L1	L3	应用热力学第二定律理解热力学温标
	熵与热力学第二定律	L1	L4 L4	分析熵与热力学第二定律的关系 确定熵增加原理 思政：从熵增加角度说明生命的有限，介绍钟南山、张定宇等的抗疫事迹，培养家国情怀
	自由能	L1	L4	分析热力学过程中的自由能
气体动理论	分子动理论的基本观点	L1	L3	说明分子动理论的基本观点 思政：讲述最美逆行者的故事与举国上下同舟共济的精神风貌，树立制度自信
	理想气体压强	L1	L3	应用分子动理论做出压强的微观解释
	温度的微观实质	L1	L3	说明温度是大量分子热运动动能的宏观表现
	麦克斯韦速率分布律	L1	L4 L4 L5 L5	掌握分布函数的概念 解构麦克斯韦速率分布律 评价三种统计速率 思政：阐释速率分布，培养家国情怀，树立制度自信
	玻尔兹曼分布律	L1	L4	分析玻尔兹曼密度分布律
	能量按自由度均分定理	L1	L3 L4	估算自由度 掌握能量均分定理
	理想气体的内能和摩尔热容	L1	L4	分析理想气体内容和摩尔热容
	气体动理论与热力学定律	L1	L4	分析气体动理论与热力学定律之间的关系
气体内的输运过程	气体分子的平均自由程	L1	L3	应用平均自由程与碰撞频率
	黏性现象	L1	L3	说明气体中黏性现象产生的原因
	热传导现象	L1	L3	说明热传导现象的微观机制
	扩散现象	L1	L3	说明扩散现象的微观机制
实际气体固体液体	范德瓦尔斯方程	L1	L3	应用范德瓦尔斯方程处理实际气体
	焦耳-汤姆孙效应	L1	L3	说明焦耳-汤姆孙效应的微观机制 思政：对比焦耳-汤姆逊效应的发现和同一时期的第一次鸦片战争，树立制度自信，培养家国情怀
	晶体	L1	L3	说明晶体宏观特征等
	液体	L1	L3	说明液体的微观结构和表面张力
	毛细现象及毛细管公式	L1	L3	应用毛细现象及毛细管公式
相变	相和相变的一般概念	L1	L4	辨别相和相变的概念
	蒸发与沸腾饱和蒸气压	L1	L4	分析蒸发与沸腾，饱和蒸气压
	液气二相图	L1	L4	分析液气二相图
	范德瓦尔斯等温线	L1	L3	说明范德瓦尔斯等温线
	克拉珀龙方程	L1	L4	确定理想气体各参量之间的定量关系
	气体的液化低温	L1	L3	说明气体的液化低温
	固液相变固气相变三相点	L1	L3	说明固液相变固气相变三相点
	实际物质的 p-V-T 曲面	L1	L3	说明 p-V-T 曲面

3、先修要求（Pre-requisit）

无

4、教材及其他教学资源（Textbooks and Other Learning Resources）

推荐参考资料

《热学教程（第四版）》黄淑清，高等教育出版社

《热学（第三版）》李椿，章立源，高等教育出版社

《新概念物理教程热学（第二版）》赵凯华、罗蔚茵，高等教育出版社

《热学（第二版）》秦允豪，高等教育出版社

《定性与半定量物理学》赵凯华，高等教育出版社

《文明之源——物理学》吴翔等，上海科技出版社

《从一到无穷大（科学中的事实和臆测）》 G. Gamow 著，暴永宁译，吴伯泽校，科学出版社

3. 主要教学环节（Teaching and Learning Activities）

教学环节	理论课（小时）	习题课（小时）	实验（小时）	研讨（小时）	社会实践（小时）	项目（小时）	在线学习（小时）	期中测试（小时）	合计
课内	30	0	0	2	0	0	0	0	32
课外	6	24	0	6	0	6	0	0	42

4. 课程考核（Assessment Scheme）

考核项目	考核内容和考试方法简介	权重
平时成绩	课后作业及思考	40%
考试	期末闭卷考试	60%

5. 学习进度（Course Schedule）

周次	教学时数	教学形式	教学内容
1	2	课堂教学	引言，热学研究对象，热力学系统的宏观描述和微观描述
2	2	课堂教学	平衡态状态参量，热力学第零定律和温度，温标的建立
3	2	课堂教学	理想气体物态方程，热力学系统过程，功，内能，热量 焦耳热功当量实验
4	2	课堂教学	热力学第一定律，理想气体的内能、热容和焓，几种典型过程

5	2	课堂教学	热力学第一定律在几种典型过程中的应用
6	2	课堂教学	循环过程
7	2	课堂教学	热力学第二定律，实际过程的不可逆性
8	2	课堂教学	卡诺循环和卡诺定理
9	2	课堂教学	热力学温标，热力学第二定律与熵，自由能
10	2	课堂教学	气体动理论，压强和温度的实质
11	2	课堂教学	分布函数，麦克斯韦速率分布律
12	2	课堂教学	玻尔兹曼分布律，能量均分定理，内能和摩尔热容
13	2	课堂教学	分子平均自由程，输运现象
14	2	课堂教学	范德瓦尔斯方程，焦耳-汤姆孙效应，晶体
15	2	课堂教学	液体，毛细现象，相和相变，饱和蒸气压
16	2	课堂教学	克拉珀龙方程，液化，p-V-T 曲面等

Shantou University

Module Description for Undergraduate Courses

COURSE TITLE：	Solidstate Physics
COURSE CODE：	PHY3003B
CREDIT VALUE：	4
CONTACT HOURS：	64
PRE-REQUISITE	Quantum Mechanics 1 or University Physics III
DEPARTMENT/UNIT：	Department of Physics
VERSION：	2nd
COURSE COORDINATOR：	(Signature and Seal)
APPROVER：	(Signature and Seal)
APPROVE DATE：	

Shantou University Faculty of Science

December2023

1. Course Description

Solid State Physics investigates the intrinsic physical processes, phenomena, and laws governing condensed matter, as well as the resulting macroscopic properties. It is a core theoretical Lecture within programmes in physics, materials science, and electronic devices. Through this course, students will acquire fundamental concepts, characteristic phenomena, and theoretical methods related to crystal structures, lattice dynamics, electronic band theory, and solid-state properties. They will develop the essential theoretical foundation needed to understand and analyse the physical behaviour of crystalline materials. The course also aims to train students in applying knowledge from prerequisite modules to address selected physical problems in solids—complex many-body systems. Students are expected to appreciate how macroscopic physical quantities can be derived from microscopic or first-principles considerations. In this process, they enhance their understanding of previously learned material, deepen their ability to apply it, and gradually comprehend the distinctive features, research methods, and logical structure of the subject. This course serves as an extension of earlier modules, and its theoretical framework forms an essential foundation for subsequent lectures on optoelectronic materials and devices. It constitutes a highly important component of the curriculum designed to meet the programme's training objectives.

2. Intended Learning Outcomes

Training Objectives	Knowledge Units / Competencies Standards	Initial Level	Target Level	Expected Learning Outcomes
CC1 Crystal Structure	Description of crystal structures; symmetry operations in crystals; reciprocal lattice; crystal diffraction; bonding and classification of crystals; crystal defects.	L1	L3	1. Apply the concepts of unit cell and Bravais lattice to describe real crystal structures, demonstrating understanding of unit cells, crystallographic directions, and crystallographic planes. 2. Classify symmetry operations and identify symmetry elements in crystal structures. 3. Use macroscopic symmetry considerations to explain selected physical properties of crystals. 4. Construct reciprocal vectors and reciprocal lattices, and explain their relation to the direct lattice. 5. Explain Bragg diffraction, compute geometric structure factors, and apply Bragg's law to analyze X-ray diffraction phenomena. 6. Summarize major types of crystal bonding and characterize their features. 7. Summarize major types of crystal bonding and characterize their features. 8. Demonstrate foundational understanding of major types of crystal defects and their characteristics. 9. Appreciate the scientific spirit and dedication exemplified by Cheng Kaijia, particularly his encouragement toward young researchers.

CC2 Lattice Dynamics	Dynamics of one-dimensional atomic chains and three-dimensional lattices; basic theory of lattice vibrations; thermal properties of lattices.	L1	L3	1. Understand the theoretical methods for lattice vibrations, including the harmonic approximation, normal-mode description, equations of motion, physical meaning of lattice waves, dispersion relations, and boundary conditions. 2. Visualize and interpret lattice waves, and connect them to frequency–wave-vector relations in reciprocal space. 3. Understand the concept of phonons and the principles of phonon-mode measurements; provide examples of inelastic scattering processes involving particles and crystals. 4. Compute phonon density of states and lattice vibrational energy; calculate lattice heat capacity within the Einstein and Debye models. 5. Understand the coupling between optical phonons and electromagnetic waves, the concept of polaritons, and their dispersion. 6. Qualitatively explain temperature effects on selected thermo-mechanical properties of solids. 7. Appreciate the scientific values of skepticism, rigor, and innovation.
CC3 Electronic Band Theory	Electron wavefunctions and band structures in periodic potentials; semiclassical electron dynamics and motion in external fields.	L1	L3	1. Demonstrate understanding of lattice translational symmetry, Bloch's theorem, and Bloch waves. 2. Describe the plane-wave method, nearly-free-electron approximation, and tight-binding approximation, and apply them to compute electronic bands of simple lattices. 3. Interpret band diagrams in reciprocal space and estimate density of states from dispersion relations. 4. Demonstrate understanding of semiclassical approximation for Bloch electrons, including wave packets, electron velocity, effective mass, and acceleration under external fields. 5. Use semiclassical equations of motion to analyze electron dynamics; explain features such as Landau levels, magnetoresistance, and Hall effect; relate band characteristics to electrical conduction. 6. Display understanding of the Kronig–Penney model and the concept of superlattices. 7. Appreciate scientific responsibility,and the spirit of innovation.

CC4 Theory of Metals	Electronic statistics and heat capacity in solids; free-electron gas model; Boltzmann equation; electrical transport, electron-phonon interaction, plasmons, and quasiparticles.	L1	L3	1. Explain features of the Fermi–Dirac distribution and estimate electronic energy, heat capacity, Fermi energy, and Fermi surfaces. 2. Apply the free-electron gas model to compute the above physical quantities in metals. 3. Relate nonequilibrium electron distribution in reciprocal space to electrical conductivity. 4. Demonstrate unDemonstrate understanding of the Boltzmann equation and relaxation-time approximation; estimate DC conductivity under specified conditions; discuss limitations of the electron-gas model and the effect of electron–phonon interactions. 5. Understand thermionic emission and the mechanism of contact potential difference. 6. Understand plasma oscillations, plasmons, quasiparticles, and Coulomb screening in metals. 7. Appreciate the role of physics in scientific and technological progress.
CC5 Introduction to Optical Properties of Solids	Optical parameters and Kramers–Kronig relations; optical absorption mechanisms and electronic transitions.	L1	L2	1. Demonstrate understanding of optical parameters and their interrelations. 2. Explain main mechanisms of optical absorption and their connection to electronic band structures.

CC6 Magnetism in Solids	Diamagnetism, paramagnetism, ferromagnetism, and antiferromagnetism of solids; Carrier-induced magnetism; Exchange interaction; Spin transport.	L1	L2	1. Demonstrate understanding of lattice translational symmetry, Bloch's theorem, and Bloch waves. 2. Describe the plane-wave method, nearly-free-electron approximation, and tight-binding approximation, and apply them to compute electronic bands of simple lattices.
CC7 Optional Topics	Selected emerging topics such as low-dimensional materials, superconductivity, and other frontier topics.	L1	L2	Recognize how foundational concepts of solid-state physics apply to advanced and frontier research domains.
CA2.1.2 Scientific Literacy	Understanding the influence of the natural world and human activities on nature; using scientific knowledge to identify problems and draw evidence-based conclusions.	L2	L3	Understanding the influence of the natural world and human activities on nature; using scientific knowledge to identify problems and draw evidence-based conclusions.

CA2.2.1 Critical Thinking	Analyzing problems, identifying conflicting viewpoints and logical fallacies, selecting logical arguments and solutions; inductively validating hypotheses and conclusions through theory and evidence.	L2	L3	Students discuss the limitations, logical gaps, and resolutions involved in establishing the theoretical framework of this course, particularly in foundational models and approximations.
CA2.2.2 Systems Thinking	Analyzing system concepts, properties, relationships, and structures; exploring system functions and behaviors; recognizing interactions among internal elements and between the system and its environment; applying holistic, structural, hierarchical, multidimensional, and dynamic thinking.	L2	L3	Students discuss the interconnections among different components of the course's theoretical system, and explain the logical refinement, coherence, and enrichment of the knowledge structure.
Innovative Thinking	Approaching and handling problems from multiple perspectives; applying divergent, lateral, reverse, associative, and visual thinking.	L2	L3	Students discuss how limitations or logical inconsistencies in established models or approximations were identified and how corresponding solutions were developed during the evolution of the course's theoretical system.

CA2.4.1 Identifying and Formulating Problems	Analyzing and summarizing valuable problems; scientifically and accurately articulating them.	L2	L3	Students select solid-state-physics–related real-world phenomena and formulate the underlying scientific problems with precision.
CA2.4.3 Model Building	Identifying key issues requiring verification; forming hypotheses; simplifying complex systems through assumptions; selecting and using conceptual, qualitative, and quantitative models and simulations.	L2	L3	Students demonstrate an understanding of model construction and quantification in solid-state physics, and explain the rationale and applicability of different models.
CA4.1.3 Understanding Societal Requirements for the Optoelectronics Major	A broad theoretical foundation and strong adaptability; close relevance to modern high technology.	L2	L3	Students use the learned knowledge of solid-state physics to analyze problems in daily life and advanced technologies, and identify the intrinsic links between contemporary technological development and solid-state physics.

3. Pre-requisit

Quantum Mechanics 1 or *University Physics III*

4. Textbooks and Other Learning Resources

Required Textbooks

Hu An & Zhang Weiyi, *Solid State Physics*, Higher Education Press, 2nd Edition, 2011 (National "11th Five-Year" Planning Textbook for Higher Education).

Online course on the Chinese MOOC platform "iCourse" (www.icourse.com):*Solid State Physics*, taught by Li Dan, Beijing Jiaotong University.

Recommended Textbooks

Huang Kun, *Solid State Physics*, Higher Education Press.

Lu Dong & Jiang Ping (Eds.), *Solid State Physics*, Higher Education Press, 1st Edition, January 2011 (National "11th Five-Year" Planning Textbook for Higher Education).

Yan Shousheng, *Fundamentals of Solid State Physics*, Peking University Press.

Charles Kittel, *Introduction to Solid State Physics*
(Chinese translation: *固体物理导论*, by C. Kittel, Chemical Industry Press, 1st Beijing Edition, August 2015).

Duan Chen (Chief Editor), *Guided Study and Complete Solutions to Exercises in Solid State Physics*, China Times Economic Publishing House.

Video course on Bilibili: *Solid State Physics* by Hu An.

5. Teaching and Learning Activities

Teaching Segment	Lectures (Theory)	Tutorial	Laboratory	Seminar	Social Pratice	Project	Online Learning	Other	Total
Hours (In-class)	54	8	0	2	0	0	0	0	64
Hours (Out-of-class)	54	64	0	6	0	0	60	0	184

Intended Learning Outcomes	Teaching Content	Implementation Strategies	Recommended Teaching Strategies
1. Apply the concepts of unit cells and Bravais lattices to describe real crystal structures, demonstrating an understanding of unit cells, crystal directions, and crystal planes. 2. Demonstrate an understanding of symmetry operations in crystal structures and their classification. 3. Use macroscopic symmetry considerations to explain selected physical properties of crystals.	Description of Crystal Structures; Symmetry in Crystal Structures; Reciprocal Lattices; Crystal Structure Diffraction; Crystal Bonding and Classification; Crystal Defects	In-person lectures supplemented by online learning	Lecturing, directed questioning, discussion, and guided exercises

4. Explain the construction of reciprocal vectors and reciprocal lattices, and describe their relationship to the direct lattice. 5. Demonstrate an understanding of Bragg diffraction; compute geometric structure factors and analyze X-ray diffraction phenomena using Bragg's law. 6. Outline the fundamental types of crystal bonding and their main characteristics. 7. Estimate the internal energy and selected mechanical quantities of crystals using interatomic potentials and structural parameters. 8. Demonstrate an understanding of the basic types of crystal defects and their characteristic features.			
1. Understand the basic theoretical methods for lattice vibrations in one-dimensional atomic chains and three-dimensional crystals, including the harmonic approximation, normal-mode description, formulation of equations of motion, the physical meaning of lattice-wave solutions, dispersion relations, and boundary conditions. 2. Sketch lattice-wave patterns and describe their characteristics, explaining their relationship to the frequency-wavevector relations in reciprocal space. 3. Demonstrate an understanding of the phonon concept and the principles ofphonon-mode measurements, and illustrate examples of inelastic scattering processes between particles and crystals. 4. Calculate the phonon density of states and determine lattice-wave energies and crystal lattice heat capacities under the Einstein model and the Debyemodel.	Fundamentals of Lattice Dynamics in 1D Atomic Chains and 3D Crystals; Thermal Properties of Crystals	In-person lectures supplemented by online learning	Lecturing, directed questioning, discussion, and guided exercises

5. Understand the coupling between optical lattice waves and electromagneticwaves, and explain the concepts of polaritons and their dispersion. 6. Illustrate, in a qualitative manner, the temperature dependence of selected thermo-mechanical properties of solids.			
1. Demonstrate an understanding of lattice translational symmetry, Bloch's theorem, and the properties of Bloch waves. 2. Describe the plane-wave method, the nearly free-electron approximation, and the tight-binding approximation for calculating electronic band structures; compute the band structures of simple lattices using these approaches. 3. Explain the meaning and features of band diagrams in reciprocal space, and estimate the electronic density of states using dispersion relations. 4. Demonstrate an understanding of the semiclassical approximation for Bloch-electrons, including wave packets, electron velocity, effective mass, and acceleration under external fields. 5. Apply semiclassical equations of motion to solve simple electron dynamics problems, and describe characteristic electronic motions in constant electric and magnetic fields (such as Landau levels, magnetoresistance, and the Halleffect), demonstrating the connection between band-structure features and electronic transport properties. 6. Demonstrate an understanding of the Kronig-Penney model and the concept of superlattices. 7. Discuss the limitations of band theory and selected extensions.	Electronic Wavefunctions and Energy Bands in Periodic Potentials Semiclassical Electrons in Crystals and Charge Transport in External Fields	In-person lectures supplemented by online learning	Lecturing, directed questioning, discussion, and guided exercises

1. Explain the characteristics and significance of the Fermi-Dirac distribution,and describe methods for estimating the energy, heat capacity, Fermi energy,and Fermi surface of band-electron systems in reciprocal space. 2. Apply the free-electron gas model to calculate the above physical quantities for metals. 3. Explain the relationship between nonequilibrium electronic distribution functions in reciprocal space and electrical conductivity. 4. Demonstrate an understanding of the Boltzmann transport equation and the relaxation-time approximation, and estimate the DC electrical conductivity of metals under specific conditions; describe the limitations of the electron-gas model and the influence of electron-phonon interactions on transport. 5. Explain the mechanisms of thermionic emission and contact potential differences. 6. Demonstrate an understanding of plasma oscillations, plasmons, quasiparticles, and Coulomb screening in metals.	Electronic Statistics and Heat Capacity in Crystals Free-Electron Gas Model Boltzmann Transport Equation; Electrical Conduction in Metals; Electron–Phonon Interaction; Plasmons and Quasiparticles	In-person lectures supplemented by online learning	Lecturing, directed questioning, discussion, and guided exercises
1. Demonstrate an understanding of the meaning and interrelations of optical parameters in solids. 2. Explain the major mechanisms of optical absorption in solids and their connections to electronic band structures.	Optical parameters and the Kramers–Kronig (K–K) relations. Mechanisms of optical absorption and electronic transitions.	In-person lectures	Lecturing, directed questioning, discussion, and guided exercises
1. Demonstrate an understanding of various magnetic phenomena, concepts, and theoretical models.	Diamagnetism, paramagnetism, ferromagnetism, and antiferromagnetism in solids.	In-person lectures	Lecturing, directed questioning, discussion

2. Explain the mechanisms of exchange interactions and selected spin-transportphenomena.	Carrier magnetism. Exchange interactions. Spin transport.		
Recognize how acquired knowledge is applied in certain advanced or frontier research areas.	Topical introductions (selected according to teaching progress).	In-class seminars and lectures.	Lecturing
Perceive the historical development of solid-state physics, its profound impact on human progress, and how physics enables the understanding and transformation of solids.	scientific literacy	In-person lectures and extra-curricular learning	Integrated into lectures and discussions.
Discuss the limitations, logical fallacies, and remedies associated with some fundamental models or approximations in the development of this course's theoretical framework.	Critical thinking	In-person lectures and extra-curricular learning	Integrated into lectures and discussions.
Discuss the interrelations among different components of the theoretical system developed in this course, illustrating the completion, rationality, and enrichment of the knowledge structure.	Systemic thinking	In-person lectures and extra-curricular learning	Integrated into lectures and discussions.
Discuss how limitations and logical flaws in models or approximations are identified and how corresponding solutions are developed.	Innovative thinking	In-person lectures and extra-curricular learning	Integrated into lectures and discussions.
Select real-world phenomena related to solid-state physics and express the corresponding problems clearly and accurately	Problem identification and Formulation	In-person lectures and extra-curricular learning	Discussion, Investigative Assignment
Demonstrate an understanding of the establishment and quantitative formulation of models used in solid-state physics, explaining their rationality and applicability.	Model Construction	In-person lectures and extra-curricular learning	Integrated into lectures and discussions.
Use knowledge of solid-state physics to analyze real-life and technological issues, identifying the intrinsic links between modern high technologies and solid-state physics.	Understanding societal requirements for optoelectronics majors	Extracurricular activities	Discussion, Investigative Assignment

7. Assessment Scheme

Course: Solid-State Physics Course Code: PHY3003B Course Type: Theoretical / Compulsory In-class / Out-of-class Hours: 64 / 184

Assessment item	Assessment Content & Methods	Weight

Exercises	Post-class assignments and reflective questions	20%
Class Participation	Including participation, responses, questions, and group discussions	20%
Examinations	Mid-term and final closed-book examinations	30% each

Assessment Item	**Main Content (Knowledge Units / Points)**	**Relevant Intended Learning Outcomes (ILOs)**	**Weight**
Exercises	All knowledge units	See corresponding ILOs in the syllabus (8 + 6 + 7 + 6 + 2 + 2 points)	20%
Class Participation	All knowledge units	See corresponding ILOs in the syllabus (8 + 6 + 7 + 6 + 2 + 2 points)	20%
Examinations	All knowledge units	See corresponding ILOs in the syllabus (8 + 6 + 7 + 6 + 2 + 2 points)	60%

Course: ***Solid State Physics***

Assessment Items: Examinations, Exercises, and Class Participation

Assessment Methods: Closed-book examination, practice-based discussion

Weighting: (60 + 20 + 20)%

Intended Learning Outcomes	**Below Expectation**	**Meeting Expectation**	**Exceeding Expectation**
See the ILOs under the syllabus knowledge section (total: 8 + 6 + 7 + 6 + 2 + 2 points)	The student shows confusion regarding basic concepts, demonstrates major misunderstandings of principles and methods, and mixes up core ideas. Explanations of key concepts and logical reasoning are unclear.	The student demonstrates correct understanding and application of key concepts. Reasoning is generally coherent, though a few points may remain incomplete or weak. Explanations of core concepts and logical reasoning are correct and complete.	The student demonstrates solid and well-structured understanding of concepts, applies knowledge independently, and provides deeper analytical or evidence-based judgments. Explanations of key ideas and logical reasoning are correct, complete, and insightful.

7. Course Schedule

Week	**Hour**	**Teaching format**	**Teaching content**
1	2	Lecture + Online Learning	Chapter 1: Crystal Structure Introduction; Bravais lattices; basis and lattice points; primitive vectors; primitive cell; lattice vectors; translational periodicity; composite lattices; examples of crystal structures. Reading assignments, conceptual questions, and discussion-based exercises. Instructor note: Introduction to Cheng Kaijia (scientist, national dedication).

2	2	Lecture + Online Learning	Unit cell; crystal directions; crystal planes; Wigner–Seitz cell; reciprocal lattice and its characteristics. Reading assignments, conceptual and discussion problem
3	2	Lecture + Online Learning	Crystal symmetry; symmetry operations; crystal systems and Bravais-lattice classification. Reading assignments, conceptual and discussion exercises.
4	2	Lecture + Online Learning	Bragg diffraction and Bragg condition; Laue equations; geometric structure factor. Reading assignments; conceptual/discussion questions; computational exercises. Short scientific story: W.L. Bragg (encouraging young scientific creativity).
5	2	Lecture + Online Learning	Problem-solving session. Reading assignment.
6	2	Lecture + Online Learning	Bonding in solids and crystal defects. Major types of bonding and their characteristics. Calculation of cohesive energy and mechanical parameters (Part I). Bonding in solids and crystal defects. Major types of bonding and their characteristics. Calculation of cohesive energy and mechanical parameters (Part I).
7	2	Lecture + Online Learning	Cohesive energy and mechanical parameters (Part II); defects and their main categories; demonstration. Reading assignments and discussion-based exercises.
8	2	Lecture + Online Learning	Problem-solving session. Chapter 2: Lattice Dynamics Basic concepts; vibrations in a one-dimensional atomic chain. Reading assignments; conceptual/discussion questions. Emphasis on scientific spirit: skepticism, rigor, and innovation.
9	2	Lecture + Online Learning	Harmonic approximation; analysis of normal modes. Reading assignments and computational exercises.
10	2	Lecture + Online Learning	Extension to three-dimensional lattices; phonons and phonon density of states; quantum theory of lattice heat capacity. Reading assignments, discussion problems, and computational exercises
11	2	Lecture + Online Learning	Coupling between optical waves and electromagnetic waves; polaritons and dispersion; thermal expansion and equations of state. Reading assignments on thermal conductivity and computational tasks. Scientific biographies: Huang Kun, Yang Zhenning, and Deng Jiaxian (national pride & scientific legacy).

12	2	Lecture	Discussion of exercises; Assigning reading materials and calculation exercises after class.
13	2	Lecture + Online Learning	Chapter 3: Electronic Band Theory Bloch theorem and Bloch waves; Semiconductors, microchips, and band structure (technological relevance). Reading assignments and computational exercises.
14	2	Lecture + Online Learning	Brillouin zones and determination of electron wavevectors; k·p method. Reading assignments and discussion exercises.
15	2	Lecture + Online Learning	Plane-wave method; nearly-free-electron approximation (Part I). Reading assignments and computational problems.
16	2	Lecture + Online Learning	Nearly-free-electron approximation (Part II); characteristics and representations of energy bands. Reading assignments and computational tasks.
17	2	Lecture + Online Learning	Tight-binding approximation; orthogonal plane-wave and pseudopotential methods (introduction). Reading assignments and computational exercises.
18	2	Lecture + Online Learning	Density of states and the Fermi surface; problem-solving session. Reading assignments and computational tasks.
19	2	Lecture + Online Learning	Semiclassical electron dynamics in crystals under electric and magnetic fields; wave packets and group velocity. Reading assignments and exercises.
20	2	Lecture + Online Learning	Effective mass; semiclassical motion in a uniform electric field; electrical conductivity in metals. Reading assignments and computational tasks.
21	2	Lecture + Online Learning	Electronic motion in solids; semiclassical dynamics under constant magnetic fields; Landau levels. Reading assignments and computational problems.
22	2	Lecture + Online Learning	Hall effect and magnetoresistance; problem-solving session. Reading assignments and computational exercises. Brief history of Hall-effect research (scientific innovation).
23	2	Lecture + Online Learning	Chapter 4: Free-Electron Theory of Metals Drude free-electron model; Fermi statistics and electronic heat capacity; Fermi surface and the physics of metals. Reading assignments and discussion tasks.

24	2	Lecture + Online Learning	Fermi-surface determination; distribution function in k-space. Reading assignments and computational exercises.
25	2	Lecture + Online Learning	Boltzmann equation; dc conductivity formula. Reading assignments and computational tasks.
26	2	Lecture + Online Learning	Two major scattering mechanisms; thermionic emission; contact potential difference. Reading assignments and computational exercises.
27	2	Lecture	Plasma oscillation; plasmons; quasiparticles; Coulomb screening. Problem-solving session. Reading assignments and computational exercises.
28	2	Lecture	Chapter 5: Optical Properties of Solids Optical parameters and Kramers–Kronig relations. Reading assignments and computational exercises.
29	2	Lecture	Optical absorption mechanisms; electronic transitions and excitons. Problem-solving session. Discussion of exercises; Assigning reading materials and calculation exercises after class.
30	2	Lecture	Atomic magnetism and dia-/paramagnetism; carrier magnetism. Assign after-class reading materials, conceptual and discussion questions, and calculation exercises.
31	2	Lecture	Ferromagnetism and antiferromagnetism; exchange interaction; spin-dependent transport. Reading assignments and computational tasks. National science context: China’s advantage in rare-earth materials.
32	2	Lecture	Special topics (depending on teaching progress); course summary.
17-18		Outside Classroom	Review, consolidation, Q&A, and final examinations.

汕头大学本科教学

课程教学大纲

课　程　名（COURSE TITLE）：	固体物理
课程代码（COURSE CODE）：	**PHY3003B**
学　　　分（CREDIT VALUE）：	4
课内课时（CONTACT OURS）：	64
先修课要求（PRE-REQUISIT）	量子力学或大学物理 3.
开课单位（DEPARTMENT/UNIT）：	物理系
版　　　本（VERSION）：	2^{nd}
课程负责人（COURSE COORDINATOR）：	(签章)
审　核　人（APPROVER）：	(签章)
审核日期（APPROVE DATE）：	

汕头大学理学院

2023 年 12 月

1、课程简介 （Course Description）

固体物理学研究固态物质内在的各种物理过程、现象、规律及其相应的宏观物性，是物理学、材料和器件专业的一门核心理论课程。通过该课程的学习，使学生掌握关于晶体结构、晶格动力学、电子能带和固体物性等方面的基本概念、现象和一些理论方法，具备理解分析晶相物质物理性能的基本理论知识。培养学生利用先修课程的知识来解决固体这种多体系统中的部分物理问题的能力；体会到从微观或第一性物理原理出发，推算得到一些宏观物理量的过程。在此过程中提升学生对已学知识的理解和应用能力，并逐步领悟课程的特点、基本研究方法和理论结果的合理性。该课程的学习是以前课程的延伸，得到的理论知识也是后续有关光电材料和器件课程的基础，是专业培养目标相应课程体系中非常重要的一个环节。

2、预期学习结果 （Intended Learning Outcomes）

培养目标（知识单元/能力标准）	知识点/能力标准	初始熟练程度	要求熟练程度	预期学习结果
CC1晶体结构	晶体结构的描述； 晶体结构的对称性； 倒易点阵； 晶体结构衍射； 晶体的结合与分类； 缺陷。	L1	L3	1应用元胞和布拉菲格子（点阵）的概念说明实际晶体结构，展现出对单胞、晶向和晶面概念的理解。 2展现对晶体结构对称操作的理解和分类。 3 利用宏观对称性说明晶体的一些物理性能。 4说明倒易矢量和点阵的构造方法及与正格子的关系。

				5 展示对Bragg衍射知识的理解，计算散射的几何结构因子。应用Bragg公式分析X射线衍射现象。 6 概述晶体结合的基本类型及其特点。 7 利用势能和结构参数估算晶体内能和一些力学量。 8展现对晶体结构缺陷的基本类型及其特点的初步了解。 9 展现程开甲先生爱国奉献精神、鼓励年轻人的科研勇气。
CC2晶格动力学	一维原子链和三维晶格振动动力学基本理论； 晶格热学性质。	L1	L3	1理解原子链和三维晶格振动的基本理论方法，包括简谐近似、简正模式描写、运动方程建立、格波解的物理含义、色散关系和边界条件的确定。 2勾画格波图像和特点，说明它与倒空间中频率-波矢关系的联系。 3 理解声子概念和声子模测量原理，举例说明一些粒子与晶体非弹性散射过程。 4计算晶格振动的声子谱密度，在爱因斯坦模型和德拜模型下计算格波能量和晶体的晶格比热容。 5理解光学波与电磁波的耦合现象、极化激元及其

				色散的概念 6举例定性说明一些固体力热学性能的温度效应。 7体会质疑、严谨和创新的科学精神。
CC3电子能带理论	周期势场中的电子波函数和能带； 晶体中电子的准经典近似和外场下电子的运动。	L1	L3	1 展现对晶格平移对称性与布洛赫定理和布洛赫波关系的理解， 2陈述平面波法、近自由电子近似和紧束缚近似计算电子能带的方法和主要结果。使用这些方法计算一些简单晶格的能带。 3 说明倒空间中能带图的含义和特点，利用色散关系估算能态密度。 4 展示对布洛赫（能带）电子准经典近似的理解，包括波包、电子速度、有效质量和外场下加速度的含义和关系。 5 准经典近似条件下，利用动力学方程解决简单的电子运动问题，说明恒定电场和磁场下能带电子的一些运动特点（朗道能级、磁阻和Hall效应），展现对固体能带特征与导电性能关系的理解。 6 展现对克龙尼克-潘尼问题及超晶格概念的了解。

				7 讨论能带论的局限性和一些延伸。 8了解体会民族自信、家国情怀、科学家的时代担当；开拓与创新的科学精神。
CC4 金属电子论	晶体中能带电子的统计分布和热容； 自由电子气模型； Boltzman方程和金属的电输运、电声作用、等离激元与准电子。	L1	L3	1 阐释费米分布函数的特点和意义，说明对能带电子体系的能量、比热容、费米能级和倒空间费米面的估算方法。 2 应用自由电子气模型，计算金属中上述各个物理量。 3 理解倒空间中电子非平衡分布函数与电导的关系。 4 展现对Boltzman方程和弛豫时间近似的理解，特定条件下估算金属直流电导率。说明电子气模型的局限性以及电子-声子相互作用对电导的影响。 5 理解热电子发射和接触电势差的机理。 6理解金属中的等离子体振荡、等离激元、准电子和库伦屏蔽概念。 7体会**科学的进步与力量。**

CC5 固体光学性质简介	光学参数与K-K关系； 光吸收机制及电子的跃迁；	L1	L2	1 展示对固体光学参数的含义及相互关系的理解； 2 陈述固体光吸收的主要机制和与能带之间的关联；
CC6 固体磁性	固体的抗磁、顺磁、铁磁和反铁磁性； 载流子磁性； 交换作用； 自旋输运	L1	L2	1 展示对各种磁性的现象、概念及其理论模型的理解； 2 陈述交换作用和一些自旋输运现象的机制。 3 介绍我国在稀土方面的资源和技术优势，显示国家自豪感。
CC7 专题简介（选用）	新热点问题或低维材料或超导。	L1	L2	觉察到已学知识在某些深入或前沿研究领域的应用。
CA2.1.2科学素养	理解自然世界和人类活动对自然世界的影响；运用科学知识，明确问题并做出具有证据的结论	L2	L3	觉察到固体物理学的发展过程及对人类进步带来的巨大影响，以及物理学是如何来认识和改造固体的各种特性。
CA2.2.1批判性思维	分析问题，识别有矛盾的观点和逻辑谬误，选择逻辑论点和解决方法；归纳理论和事实验证假设与结论	L2	L3	讨论该课程理论体系的建立和发展过程中一些基础模型或近似的局限性、逻辑的谬误和解决方法。
CA2.2.2系统性思维	分析系统概念、性质、关系和结构，探究系统的功能和行为，识别系统内部各要素之间以及系统与外部环境间的联	L2	L3	讨论该课程理论体系的建立和发展过程中各部分之间的联系，说明知识结构和理论的完善化、合

	系；应用整体性、结构性、主次性、立体性、动态性等思维方式进行思维			理性和丰富化过程。
CA2.2.3创新性思维	选择多角度、多侧面地看待和处理问题，实施发散思维、侧向思维、逆向思维、联想思维和形象思维	L2	L3	讨论该课程理论体系的建立和发展过程中如何发现一些模型或近似的局限性、逻辑的谬误，并据此采用的解决方法。
CA2.4.1发现问题和表述问题	分析并归纳有价值的问题，科学准确地表述问题	L2	L3	选择现实中的一些固体物理相关现象的问题，准确地表达问题。
CA2.4.3建立模型	选择需要验证的关键问题，建立需要测试的假设；应用假设简化复杂的系统和环境，选择并应用概念性和定性模型，选择并应用定量模型与模拟；	L2	L3	展示对固体物理学基本理论体系建立和解决问题所用到的相关模型的建立和量化过程的理解。说明模型的合理性和适用范围。
CA4.1.3理解社会对光电子专业要求	宽广的理论基础和强大的专业适应性，与当今高科技结合紧密；	L2	L3	使用已学固体物理学知识分析现实生活和科技中的一些问题，识别当今高科技及其发展与固体物理学之间的一些必然联系。

3、先修要求 （Pre-requisit）

《量子力学》或《大学物理 3》

4、教材及其他教学资源 （Textbooks and Other Learning Resources）

课程教材

《固体物理学》 胡安，章维益，高等教育出版社，2011 年第 2 版，

（普通高等教育“十一五”国家级规划教材）

中国 mooc 平台爱课程，www.icourse.com,北方交通大学《固体物理学》李丹主讲。

推荐参考资料

《固体物理学》 黄昆著 高等教育出版社

陆栋 将平 编 《固体物理学》 高等教育出版社 2011.1 第 1 版

（普通高等教育“十一五”国家级规划教材）

《固体物理基础》阎守胜编著 北京大学出版社

《Introduction to solid state physics》 Charles Kittel （《固体物理导论》，C. 基泰尔 著，化学工业出版社，2015,8 北京第 1 版）

《固体物理学全程导学及习题全解》 段晨等主审 中国时代经济出版社

哔哩哔哩网站：胡安主讲《固体物理》视频。

5、主要教学环节 （Teaching and Learning Activities）

理论课（小时）		习题课（小时）		实验（小时）		研讨（小时）		社会实践（小时）		项目（小时）		在线学习（小时）		其他（小时）	
课内	课外	课内	课外	课内	课外	课内	课外	课内	课外	课内	课外	课内	课外	课内	课外
54	54	8	64	无	无	2	6	无	无	无	无	0	60	无	0

预期学习结果（ILO）	教学内容（知识单元/点）	实现环节(课内、实验等）	建议采用的教学策略
1 应用元胞和布拉菲格子（点阵）的概念说明实际晶体结构，展现出对单胞、晶向和晶面概念的理解。 2 展现对晶体结构对称操作的理解和分类。 3 利用宏观对称性说明晶体的一些物理性能。 4 说明倒易矢量和点阵的构造方法及与正格子的关系。 5 展示对 Bragg 衍射知识的理解，计算散射的几何结构因子。应用 Bragg 公式分析 X 射线衍射现象。 6 概述晶体结合的基本类型及其特点。 7 利用势能和结构参数估算晶体内能和一些力学量。 8 展现对晶体结构缺陷的基本类型及其特点	晶体结构的描述； 晶体结构的对称性； 倒易点阵； 晶体结构衍射； 晶体的结合与分类； 缺陷。	课内教学+网上学习	讲授，提问，讨论，练习。

的初步了解。			
1理解原子链和三维晶格振动的基本理论方法，包括简谐近似、简正模式描写、运动方程建立、格波解的物理含义、色散关系和边界条件的确定。 2勾画格波图像和特点，说明它与倒空间中频率-波矢关系的联系。 3 理解声子概念和声子模测量原理，举例说明一些粒子与晶体非弹性散射过程。 4计算晶格振动的声子谱密度，在爱因斯坦模型和德拜模型下计算格波能量和晶体的晶格比热容。 5理解光学波与电磁波的耦合现象、极化激元及其色散的概念 6举例定性说明一些固体力热学性能的温度效应。	一维原子链和三维晶格振动动力学基本理论； 晶格热学性质。	课内教学+网上学习	讲授，提问，讨论，练习。
1 展现对晶格平移对称性与布洛赫定理和布洛赫波关系的理解， 2陈述平面波法、近自由电子近似和紧束缚近似计算电子能带的方法和	周期势场中的电子波函数和能带； 晶体中电子的准经典近似和外场下电子的运动。	课内教学+网上学习	讲授，提问，讨论，练习。

主要结果。使用这些方法计算一些简单晶格的能带。 3 说明倒空间中能带图的含义和特点，利用色散关系估算能态密度。 4 展示对布洛赫（能带）电子准经典近似的理解，包括波包、电子速度、有效质量和外场下加速度的含义和关系。 5 准经典近似条件下，利用动力学方程解决简单的电子运动问题，说明恒定电场和磁场下能带电子的一些运动特点（朗道能级，磁阻和Hall效应），展现对固体能带特征与导电性能关系的理解。 6 展现对克龙尼克-潘尼问题及超晶格概念的了解。 7 讨论能带论的局限性和一些延伸。			
1 阐释费米分布函数的特点和意义，说明对能带电子体系的能量、比热容、费米能级和倒空间费米面的估算方法。 2 应用自由电子气模型，计算金属中上述各个物理量。	晶体中电子的统计分布和热容； 自由电子气模型； Boltzman 方程和金属的电输运、电声作用、等离激元与准电子。	课内教学+网上学习	讲授，提问，讨论，练习。

3 理解倒空间中电子非平衡分布函数与电导的关系。 4 展现对Boltzman方程和弛豫时间近似的理解，特定条件下估算金属直流电导率。说明电子气模型的局限性以及电子-声子相互作用对电导的影响。 5 理解热电子发射和接触电势差的机理。 6 理解金属中的等离子体振荡、等离激元、准电子和库伦屏蔽概念。			
1 展示对固体光学参数的含义及相互关系的理解； 2 陈述固体光吸收的主要机制和与能带之间的关联；	光学参数与K-K关系； 光吸收机制及电子的跃迁；	课内教学	讲授，提问，讨论，练习。
1 展示对各种磁性的现象、概念及其理论模型的理解； 2 陈述交换作用和一些自旋输运现象的机制。	固体的抗磁、顺磁、铁磁和反铁磁性； 载流子磁性； 交换作用； 自旋输运。	课内教学	讲授，提问，讨论
觉察到已学知识在某些深入或前沿研究领域的应用。	专题简介（据具体教学进度选用）	课内研讨	讲授。
觉察到固体物理学的发展过程及对人类进步带来的巨大影响，以及物理学是如何来认识和改造固体的各种	科学素养	课内教学、课外学习	穿插在讲授和讨论中

特性。			
讨论该课程理论体系的建立和发展过程中一些基础模型或近似的局限性、逻辑的谬误和解决方法。	批判性思维	课内教学、课外学习	穿插在讲授，提问和讨论中
讨论该课程理论体系的建立和发展过程中各部分之间的联系，说明知识结构和理论的完善化、合理性和丰富化过程。	系统性思维	课内教学、课外学习	穿插在讲授和讨论中
讨论该课程理论体系的建立和发展过程中如何发现一些模型或近似的局限性、逻辑的谬误，并据此采用的解决方法。	创新性思维	课内教学、课外学习	穿插在讲授和讨论中
选择现实中的一些固体物理相关现象的问题，准确地表达问题。	发现问题和表述问题	课内教学、课外学习	提问，讨论，调查性作业
展示对固体物理学基本理论体系建立和解决问题所用到的相关模型的建立和量化过程的理解。说明模型的合理性和适用范围。	建立模型	课内教学、课外学习	穿插在讲授和讨论中
使用已学固体物理学知识分析现实生活和科技中的一些问题，识别当今高科技及其发展与固体物理学之间的一些必然联系。	理解社会对光电子专业要求	课外活动	讨论，调查性作业

6、 课程考核 （Assessment Scheme）

课程：固体物理　课程代码：PHY3003B 课程性质：理论/必修　课内/外学时:64/184

考核项目	考核内容和考试方法简介	权重

练习	课后作业及思考	20%
课堂参与	包括课堂参与、发言、提问及分组讨论	20%
考试	期中和期末闭卷考试	各占 30%

考核项目	主要内容（知识单元/点）	相关的预期学习结果（ILO）	权重%
练习	所有知识单元	见大纲知识部分的 ILO,共 8+6+7+6+2+2 点内容	20
课堂参与	所有知识单元	见大纲知识部分的 ILO,共 8+6+7+6+2+2 点内容	20
考试	所有知识单元	见大纲知识部分的 ILO,共 8+6+7+6+2+2 点内容	60

课程考核项目评估标准

课程：固体物理 考核项目：考试、练习和课堂参与 **考核方式：**闭卷考试、练习训练和提问讨论　　**考核权重：**（60+20+20）%

预期学习结果	低于期望	符合期望	超越期望
见大纲知识部分的 ILO,共 8+6+7+6+2+2 点内容	对课程知识体系有所了解,识别部分概念和理论方法,但答题过程显示学生的基本概念混乱,对大部分知识点的理解和知识应用不正确和思路混乱。 陈述问题概念和逻辑思维混乱。	答题过程显示学生的概念基本准确、对大部分知识点的理解和知识应用基本正确,逻辑和思路比较清晰完整,但少部分知识点生疏，应用出错。 陈述问题概念和逻辑思维基本正确、完整。	答题过程显示学生的概念理解正确、对绝大部分知识点的理解和知识运用严谨正确,逻辑和思路清晰完整,完全达到预期学习效果。 陈述问题概念和逻辑思维正确、完整。对问题有比较深入的分析和有依据的判断。

7、 学习进度 （Course Schedule）

课次	教学时数	教学形式	教　学　内　容
1	2	课堂教学+线上学习	Ch1 晶体结构 绪论；布拉菲格子；基元（格点）；基矢；原胞；格矢；平移周期性；复式格子；晶体实例。 选用教材与程开甲先生（爱国奉献精神）；布置课后阅读内容、概念性和讨论性课后练习
2	2	课堂教学+线上学习	晶胞；晶向；晶面；W-S 原胞；倒格子及其特点。 布置课后阅读内容、概念性和讨论性课后练习。
3	2	课堂教学+线上学习	晶体的对称性；对称操作；晶系和格子分类； 布置课后阅读内容、概念性和讨论性课后练习
4	2	课堂教学+线上学习	Bragg 衍射及公式，劳厄方程；几何结构因子。 小 Bragg 介绍（鼓励年轻人的科研勇气）；布置课后阅读内容、概念性和讨论性问题、课后计算练习。
5	2	课堂教学	习题讨论课； 布置课后阅读内容。
6	2	课堂教学+线上学习	固体的结合及缺陷 几种主要结合方式及特点。 结合能及力学参数计算 1；
7	2	课堂教学+线上学习	结合能及力学参数计算 2；缺陷及主要类型；演示。 布置课后阅读内容、概念性和讨论性课后练习。
8	2	课堂教学+线上学习	习题讨论课 Ch2 晶格动力学 概念；一维原子链的振动问题 振动问题引入（质疑、严谨和创新的科学精神）；布置课后阅读内容、概念性和讨论性课后练习。

9	2	课堂教学+线上学习	简谐近似及简正振动模式的分析。 布置课后阅读内容、概念性和讨论性问题、课后计算练习。
10	2	课堂教学+线上学习	结果对三维晶格的推广；声子及其模式密度；晶格热容的量子理论。 布置课后阅读内容、概念性和讨论性问题、课后计算练习。
11	2	课堂教学+线上学习	光学波与电磁波的耦合现象、极化激元及其色散； 热膨胀及固体物态方程； 黄昆杨振宁邓稼先先生介绍（民族自信，家国情怀）；布置课后阅读内容（热导率）、概念性和讨论性问题、课后计算练习。
12	2	课堂教学	习题讨论课； 布置课后阅读内容课后计算练习。
13	2	课堂教学+线上学习	Ch3 电子能带理论 Bloch 定理及 Bloch 波； 半导体、芯片与能带（时代担当）；布置课后阅读内容、概念性和讨论性问题、课后计算练习。
14	2	课堂教学+线上学习	布里渊区与电子波矢的确定；K-P 问题； 布置课后阅读内容、概念性和讨论性问题。
15	2	课堂教学+线上学习	平面波法；近自由电子近似 1； 布置课后阅读内容、概念性和讨论性问题、课后计算练习。
16	2	课堂教学+线上学习	近自由电子近似 2；能带特点及表示； 布置课后阅读内容、概念性和讨论性问题、课后计算练习。
17	2	课堂教学+线上学习	紧束缚近似；正交平面波与赝势法介绍； 布置课后阅读内容、概念性和讨论性问题、课后计算练习。
18	2	课堂教学+线上学习	能态密度和费米面；习题讨论课； 布置课后阅读内容、课后计算练习。
19	2	课堂教学+线上	晶体中电子在电场和磁场中的运动 准经典运动；波包、电子速度（群速）。 布置课后阅读内容、概念性和讨论性问题、课后计算练习

		学习	
20	2	课堂教学+线上学习	有效质量；恒定电场下电子的准经典运动；金属电导率； 布置课后阅读内容、概念性和讨论性问题、课后计算练习。
21	2	课堂教学+线上学习	固体的能带电子运动特点；恒定磁场中的电子运动；朗道能级； 布置课后阅读内容、概念性和讨论性问题、课后计算练习。
22	2	课堂教学+线上学习	Hall 效应与磁阻； 习题讨论课。 Hall 效应研究的发展（开拓与创新的科学精神）；布置课后阅读内容、课后计算练习。
23	2	课堂教学+线上学习	Ch4 金属电子论 Drude 自由电子气模型；费米统计与能带电子热容；金属电子热容和费米面。（科学的进步与力量） 布置课后阅读内容、概念性和讨论性问题、课后计算练习。
24	2	课堂教学+线上学习	费米面测定与 K 空间态分布函数。 布置课后阅读内容、概念性和讨论性问题、课后计算练习
25	2	课堂教学+线上学习	Boltzmann equation；直流电导率公式； 布置课后阅读内容、概念性和讨论性问题、课后计算练习。
26	2	课堂教学+线上学习	二种主要散射机制；热电子发射和接触电势差的机理； 布置课后阅读内容、概念性和讨论性问题、课后计算练习。
27	2	课堂教学	等离子体振荡、等离激元、准电子和库伦屏蔽。 习题讨论课。 布置课后阅读内容、课后计算练习。
28	2	课堂教学	Ch5固体光学性能 光学参数与K-K关系介绍； 布置课后阅读内容、课后计算练习。
29	2	课堂教学	光吸收机制及电子的跃迁与激子； 习题讨论。 布置课后阅读内容、课后计算练习。
30	2	课堂	Ch6 固体磁性 原子磁性与固体抗顺磁性；

		教学	载流子磁性； 布置课后阅读内容、概念性和讨论性问题、课后计算练习。
31	2	课堂教学	铁磁性与反铁磁性； 中国稀土优势介绍（国家自豪感） 交换作用； 自旋相关输运。 布置课后计算。
32	2	课堂教学	专题介绍（根据具体教学进度而定）；课程总结。
17-18周		课外学习	复习、总结、答疑和考试。

Shantou University
Module Description for Undergraduate Courses

COURSE TITLE:	Semiconductor Physics
COURSE CODE:	PHY3015A
CREDIT VALUE:	2
CONTACT HOURS:	32
PRE-REQUISITE	Calculus B-I, Calculus B-II, University Physics III, Solidstate Physics I
DEPARTMENT/UNIT:	Department of Physics
VERSION:	20240731-PHY3015A
COURSE COORDINATOR:	Xu Congkang (Signature and Seal)
APPROVER:	Chi Lingfei (Signature and Seal)
APPROVE DATE:	20240731

Shantou University Faculty of Science
July 2024

1. Course Description

(1) Nature of the Course

Semiconductor Physics is a professional elective course offered to students majoring in Optoelectronic Information Science and Engineering, Microelectronics, and Physics.

(2) Course Content

Knowledge of semiconductor physics and semiconductor devices forms the foundation of modern integrated circuit design and fabrication. As a core course I the field of microelectronics, Semiconductor Physics covers fundamental concept from quantum mechanics, solid-state physics, semiconductor materials, and semiconductor device physics.

The course is composed of two main parts:

1. Fundamentals of Semiconductor Science and Technology

This part introduces the historical development of semiconductor science and technology, the classification of semiconductor materials, and the crystalstructures and energy band properties of common semiconductors. Building onthis foundation, it covers semiconductor material physics, focusing onequilibrium and non-equilibrium semiconductors and carrier transport phenomena.

2. Introduction to Semiconductor Device Physics

This part provides the foundational concepts of device physics, including the basic structure of homojunction pn junctions and pn-junction diodes, preparing students for further study of more advanced semiconductor devices

(3) Course Objectives

Upon completing this course, students will be able to:

1. Cultivate a well-grounded sense of academic and cultural confidence through examples of pioneering scientists, fostering an awareness of scientific responsibility and an alignment between personal aspirations and national development.

2. Demonstrate scientific rigor, perseverance, and collaborative competence, along with a constructive and ethical approach to academic work, while developing an international perspective relevant to the semiconductor field.

This course contributes significantly to the development of theoretical foundations and applied research competence for undergraduate students in Optoelectronic Information Science and Engineering and Physics. It strongly supports the following graduation requirement indicators:

3.2 Ability to learn and understand complex professional theories

4.2 Ability to design and optimize basic optoelectronic systems, optical information processing systems, and optoelectronic devices

6.1 Ability to identify, articulate, and analyze scientific and engineering problems in the optoelectronics field through literature research and to draw effective conclusions

2. Intended Learning Outcomes

Training Objectives	Knowledge Units / Competencies Standards	Initial Level	Target Level	Expected Learning Outcomes
Semiconductors and Integrated Circuits	1. Historical discovery of semiconductors; development of integrated circuits; origins and evolution of information technology. 2. Classification of solids; historical development and	L1	L3	1. Explain the relationship between modern information technology, integrated-circuit development, and advances in semiconductor science and technology. 2. Describe the historical progression of scientific understanding of

	major applications of semiconductor materials. 3. Spatial lattices; defects and impurities in crystals. 4. Growth of semiconductor single crystals. 5. Integrated-circuit fabrication processes.			semiconductor materials. 3. Identify spatial crystal structures and recognize the formation and characteristics of defects and impurities. 4. Illustrate the growth mechanisms of semiconductor single crystals and outline basic IC fabrication processes. 5. Understand the importance of semiconductor ICs and chips for national economic development and technological security; recognize current technological gaps between China and technologically advanced countries. 6. Understand the challenges in advanced lithography; explain why extreme precision in component integration is crucial; cultivate a spirit of precision, professional dedication, and technological responsibility. 7. Gain awareness of China's early semiconductor research through examples such as Lin Lanying's contributions, appreciating the historical development of the field and the commitment of pioneering scientists.
Foundations of Solid-State Quantum Theory	1. Allowed bands and forbidden gaps (bandgap). Supplement: Typical band structures of common semiconductors; energy-band diagrams of Si and GaAs. 2. Electrical conduction in solids. 3. Three-dimensional band extension. 4. Density of states (DOS). 5. Introduction to statistical mechanics. 6. Distribution functions in statistical mechanics.	L1	L3	1. Explain the formation and characteristics of electronic bands. 2. Sketch energy-band diagrams of Si, Ge, and GaAs, and distinguish direct-gap and indirect-gap semiconductors. 3. Compute the density of states in typical cases. 4. Apply statistical-mechanical distribution functions to calculate representative electron distributions. 5. Appreciate how early semiconductor research in China was established through the contribution of pioneering scientists, exemplified by Professor Huang Kun.
Semiconductors in Equilibrium	1. Charge carriers in semiconductors. 2. Impurity atoms and their energy levels. 3. Extrinsic (non-intrinsic) semiconductors. 4. Statistical distribution of donors and acceptors. 5. Carrier concentration in doped semiconductors. 6. Position of the Fermi level.	L1	L3	1. Describe types and characteristics of carriers in semiconductors. 2. Estimate ionization energies of dopants and locate donor/acceptor levels. 3. Compute carrier concentrations in doped semiconductors. 4. Solve problems involving the relation between doping levels and the Fermi energy.

	7. In-class exercises.			5. Estimate how the Fermi level shifts with temperature and doping concentration.
Carrier Transport & Excess Carriers	1. Drift motion of carriers. 2. Carrier diffusion. 3. Impurity concentration distribution and the Einstein relation. 4. Hall effect and (selected topic) quantum Hall effect.	L1	L3	1. Explain drift motion under an electric field, the physical essence of mobility, and diffusion under concentration gradients. 2. Compute impurity concentration distributions and demonstrate the Einstein relation. 3. Apply the Hall effect to interpret contemporary condensed-matter phenomena. 4.Introduce the development history of companies like Huawei and SMIC, and compares them with Japanese and South Korean semiconductor companies.
Excess Carriers in Non-Equilibrium Semiconductors	1. Carrier generation and recombination. 2. Properties of excess carriers. 3. Bipolar transport processes. 4. Quasi-Fermi levels. 5. Surface effects (selected topic).	L1	L3	1. Analyze various mechanisms of carrier generation and recombination. 2. Summarize and classify the properties of excess carriers. 3. Formulate the bipolar transport equations and interpret their solutions under special conditions. 4. Investigate surface effects and their major physical implications.
pn Junction Physics	1. Basic structure of the pn junction. 2. Zero-bias (thermal-equilibrium) pn junction. 3. Reverse-bias behavior. 4. Non-uniformly doped pn junctions (selected: varactor diode).	L1	L2	1. Identify the basic structure of a pn junction. 2. Analyze the characteristics of a pn junction under thermal equilibrium. 3. Compare the electrical behavior of reverse-bias and zero-bias pn junctions and summarize key features of the reverse-bias response.
pn Junction Diode	1. I–V characteristics of a pn diode. 2. Small-signal model of the pn diode. 3. Generation–recombination current. 4. Junction breakdown. 5. Tunnel diode (selected topic).			1. Explain the operating mechanism of pn diodes. 2. Provide examples of key device applications based on pn junctions. 3. Understand, through industrial case studies such as solid-state lighting.
Critical Thinking	Analyze problems, identify contradictions or logical fallacies, evaluate arguments, and validate conclusions with theory and evidence.	L1	L4	1. Explain the interconnected development of semiconductor materials, semiconductor physics, semiconductor devices, IC engineering, and information technology.

				2. Discuss misconceptions in the historical development of semiconductor science and how correct understanding was established.
Problem Discovery & Formulation	Analyze and summarize valuable scientific problems; articulate problems accurately using scientific language.	L1	L2	1. Identify fundamental semiconductor-physics issues underlying emerging semiconductor devices. 2. Explain semiconductor-related phenomena encountered in daily life. 3. Recognize the physical essence of a given problem.
Model Construction	Identify key problems requiring verification, formulate hypotheses, simplify complex systems, and construct qualitative/quantitative models.	L1	L2	1. Apply carrier-transport models. 2. Select appropriate mathematical descriptions for representative problems. 3. Use bipolar transport equations. 4. Solve quantitative carrier-transport problems in typical scenarios.
Communication Skills	Group discussion and collaborative task completion.	L1	L2	1. Present one's viewpoint clearly. 2. Select appropriate modes of expression. 3. Revise and refine viewpoints when necessary.
Information Retrieval Skills	Use library tools (online databases, search engines, digital libraries) to locate and obtain information.	L1	L2	1. Select appropriate sources of information. 2. Acquire information efficiently. 3. Use retrieved information effectively.

3. Pre-requisit

Calculus B-I, Calculus B-II, University Physics III, Solidstate Physics I

4. Textbooks and Other Learning Resources

Textbook:

Neamen, Donald A. *Semiconductor Physics and Devices*.

Translated by Zhao Yiqiang et al., 4th ed., Electronics Industry Press, 2013.

(Series: Foreign Electronics and Communication Textbooks)

Recommended References

1) Liu, Enke, et al. *Semiconductor Physics.*
6th ed., Electronics Industry Press, 2003.

2) Qian, Youhua, et al. *Semiconductor Physics.*
1st ed., Higher Education Press, 1999.

3) Huang, Kun, and Han, Ruqi. *Fundamentals of Semiconductor Physics.*

4) Sze, S. M. *Physics and Technology of Semiconductor Devices.*
Translated by Wang Yangyuan et al.

5) Neamen, Donald A. *An Introduction to Semiconductor Devices.* Tsinghua University Press, March 2009. (Series: Excellent Textbooks from Foreign Universities – Microelectronics Series)

Course website`

my.stu.edu.cn

5. Teaching and Learning Activities

Teaching Segment	Lectures (Theory)	Tutorial Session	Experi-ment	Seminar	Social Pratice	Project	Online Learning	Other	Total
Hours (In-class)	30	2	0	0	0	0	0	0	32
Hours (Out-of-class)	32	28	0	16	0	0	0	4	80

7. Assessment Scheme

Assessment item	Assessment Components and Methods	Weight
Exercises, Discussions, and Questions	Homework and reflective assignments; class participation including presentations, questions, and contributions; responses in group discussions.	30%
Final Examination	Final Open-Book Exam	70%

7. Course Schedule

Week	Hours	Teaching Format	Teaching Methods	Teaching Content
1	2	Lecture	Lecture, Class Discussion	Introduction: Semiconductor and Integrated Circuits — History, IC development, manufacturing, China's semiconductor development
2	2	Lecture	Lecture, Class Discussion	Chapter 1: Solid Crystal Structures and Development of Semiconductor Materials 1.0 Overview; 1.1 Semiconductor materials; 1.2 Types of solids; 1.3 Crystal lattice; 1.4 Diamond structure; 1.5 Atomic valence bonds; 1.6 Defects and impurities in solids (Dialectical principle); 1.7 Growth of single-crystal semiconductors; IC manufacturing process
3	2	Lecture	Lecture, Class Discussion	Chapter 3: Introduction to Solid Quantum Theory (4 hrs) 3.0 Overview;

				3.1 Allowed and forbidden energy bands; Supplement: Energy band diagrams of common semiconductors, Si and GaAs (Application of dialectical principle); 3.2 Electrical conduction in solids; 3.3 Three-dimensional extension
4	2	Lecture	Lecture, Class Discussion	3.4 Density of states; 3.5 Statistical mechanics; 3.6 Summary
5	2	Lecture	Lecture, Class Discussion	Chapter 4: Equilibrium Semiconductors (5 hrs) 4.1 Charge carriers in semiconductors; 4.2 Doping atoms and energy levels; 4.3 Non-intrinsic semiconductors
6	2	Lecture	Lecture, Class Discussion	4.4 Statistical distribution of donors and acceptors; 4.5 Charge neutrality
7	2	Lecture	Lecture, Class Discussion	4.6 Fermi level position
8	2	Lecture	Lecture, Class Discussion	Chapter 5: Carrier Transport Phenomena (5 hrs) 5.0 Overview; 5.1 Drift motion of carriers
9	2	Lecture	Lecture, Class Discussion	5.2 Carrier diffusion
10	2	Lecture	Lecture, Class Discussion	5.3 Impurity gradient distribution; 5.4 Hall effect (optional); 5.5 Summary
11	2	Lecture	Lecture, Class Discussion	Chapter 6: Non-equilibrium Excess Carriers in Semiconductors (6 hrs) 6.0 Overview; 6.1 Generation and recombination of carriers (Contradictory theory)
12	2	Lecture	Lecture, Class Discussion	6.2 Properties of excess carriers; 6.3 Bipolar transport process (Equation establishment) (Contradictory theory)
13	2	Lecture	Lecture, Class Discussion	6.3 Bipolar transport process (Examples and applications); 6.4 Quasi-Fermi level; Summary

14	2	Lecture	Lecture, Class Discussion	Chapter 7: PN Junction (4 hrs) 7.0 Overview; 7.1 Basic structure of PN junction; 7.2 Zero bias
15	2	Lecture	Lecture, Class Discussion	7.3 Reverse bias; 7.4 Junction breakdown; 7.5 Non-uniformly doped PN junction (optional); 7.6 Summary
16	2	Lecture	Lecture, Class Discussion	Chapter 8: PN Junction Diodes 8.0 Overview; 8.1 PN junction current; 8.2 Generation-recombination current and high injection (Dialectical principle); 8.3 Small-signal model of PN junction; 8.6 Summary

汕头大学本科教学

课程教学大纲

课　程　名（COURSE TITLE）：	半导体物理学
课程代码（COURSE CODE）：	PHY3015A
学　　　分（CREDIT VALUE）：	2
课内课时（CONTACT OURS）：	32
先修课要求（PRE-REQUISIT）	微积分 B-I，微积分 B-II、大学物理 3、固体物理 1
开课单位（DEPARTMENT/UNIT）：	物理学系
版　　　本（VERSION）：	20240731-PHY3015A
课程负责人（COURSE COORDINATOR）：	徐从康　(签章)
审　核　人（APPROVER）：	池凌飞(签章)
审核日期（APPROVE DATE）：	20240731

汕头大学　理学院

2024 年　7　月

1. 课程简介 （Course Description）

（1）课程性质

半导体物理学（Semiconductor Physics）是物理学系光电信息科学与工程专业、微电子方向、物理学专业的专业选修课。

（2）课程内容

半导体物理和器件的相关知识是现代集成电路设计和制造的基础。半导体物理学是微电子技术领域的基础课程，课程涵盖量子力学、固体物理、半导体材料物理以及半导体器件物理。主要包括两部分：第一部分讲授半导体科学和技术的发展、半导体材料分类以及常见半导体的晶体结构和能带；在此基础上讲授半导体材料物理，主要讨论平衡态和非平衡态半导体以及载流子输运现象；第二部分介绍半导体器件物理入门，主要讲授介绍同质 pn 结基本结构和 pn 结二极管，为学习其它半导体器件打下一个基础。

（3）课程教学目标

学完本课程后，学生应能够：

① 对中国当前的半导体产业和技术有较为深入的认识，明白解决"卡脖子"环节对我国的产业结构发展的必要性和迫切性。

② 通过老一辈科学家的事例，建立制度自信、道路自信和文化自信，胸怀祖国，科技报国，将个人追求与国家发展结合起来。

③ 培养迎难而上、开拓进取、求真务实的科学精神和团结协作、宽厚待人的公民品格，具有一定的国际视野。

本课程为光电信息科学与工程专业和物理学专业学术型本科人才培养提供专业理论与应用研究能力的培养，高度支撑该专业本科人才培养方案中的毕业要求指标点：3.2 具备对专业复杂理论的学习和理解能力；4.2 具备对基础光电系统、光信息处理系统、光电子器件的设计与优化能力；6.1 具备识别、表达、通过文献研究分析光电领域的科学问题和工程问题，并获得有效结论的能力。

2. 预期学习结果 （Intended Learning Outcomes）

培养目标 知识单元		知识点/能力标准	初始程度	要求程度	预期学习结果
知识	半导体与集成电路 固体晶体结构和半导体材料的发展	1.半导体发现的历史，集成电路的发展，信息技术的开始和发展 2.固体类型，半导体材料发展历史和主要应用 3.空间晶格，晶体中的缺陷与杂质 4.半导体单晶材料的生长 5.集成电路制造工艺	L1	L3	1.解释当今的信息技术发展与集成电路的发展、半导体科学和技术的发展关系； 2.阐述历史上对半导体材料性能的认识过程； 3.确认空间晶体结构，确认晶体中的缺陷与杂质的形成和特点 4.举例说明半导体单晶材料的生长机制，理解集成电路制造工艺 5.半导体集成电路和芯片对国家经济社会发展和保障国家安全稳定的重要性，当前我国核心技术、制造设备等环节与西方发达国家的差距。激励学生奋发图强，为我国半导体事业贡献自己的力

知识					量。 6.重点阐述光刻环节被卡脖子的现状，光刻机原理并不复杂，但要制造出光刻机需要各部件以精度极高的方式组装到一起，鼓励学生要精益求精，敬业爱岗，激发学生爱国主义，产业报国的情怀。 7.介绍林兰英的材料制备技术，展现我国半导体技术发展历程，让学生体会到老一辈科学家的拳拳报国心，激发学生爱国主义精神，树立家国情怀，将个人追求与国家发展联系起来。
能力	固体量子理论初步	1.允带与禁带；补充：常见半导体材料的能带图，硅和砷化镓的能带图 2.固体中电的传导 3.三维扩展； 4.状态密度； 5.统计力学简介； 6.统计力学（分布函数）	L1	L3	1.说明能带的形成以及特点, 2.勾画 Si,Ge; GaAs 等的能带图，了解直接带隙半导体和间接带隙半导体能带特点 3.计算状态密度 4.应用统计力学，计算典型电子分布 5.黄昆先生在英国留学时已经是一名出色的物理学家，可以在英国获得很好的生活条件。但学成后毅然回国，全力投入祖国的半导体建设中，为我国的半导体行业打下一个良好的基础。通过与俄罗斯半导体行业的发展做对比，让学生体会到以黄昆先生为代表的老一辈科学家对国家做出的杰出贡献。
	平衡状态下的半导体	1.半导体中的载流子； 2.掺杂原子与能级； 3.非本征半导体； 4.施主和受主的统计学分布 5.掺杂半导体的载流子浓度； 6.费米能级的位置 7.课堂练习	L1	L3	1.说明半导体中载流子类型和特点 2.计算掺杂原子电离能大小，估算施主与受主能级位置 3.计算掺杂半导体的载流子浓度值 4.解决费米能级与掺杂水平的关系问题 5.估算费米能级随温度以及掺杂浓度的变化趋势
	载流子输运与过剩载流子现象	1.载流子的漂移运动 2.载流子扩散 3.杂质浓度分布与爱因斯坦关系 4.霍尔效应，量子霍尔效应（选讲）	L1	L3	1.说明电场作用下，载流子的漂移运动规律，说明迁移率的本质以及浓度梯度下载流子的扩散规律 2.计算杂质浓度分布，展示爱因斯坦关系 3.应用霍尔效应，解释最新发现的物理现象 4.介绍华为、中芯等发展历程，同时与日韩半导体企业做对比，让

					学生体会到拥有一个独立的、强大的祖国，是中国半导体产业发展的坚实后盾，日韩半导体企业在很大程度上是被美国扶持起来的，又轮番被美国资本收割，只有做到独立自主，才有可能发展。体现了我国的制度优越性，激发家国情怀。
	半导体中的非平衡过剩载流子	1.载流子的产生与复合 2.过剩载流子的性质 3.双极输运过程 4.准费米能级 5.表面效应（选讲）；	L1	L3	1.分析载流子的产生与复合的各种机制 2.归纳过剩载流子的性质 3.确定双极输运方程并区别各种特殊情况下的解的意义 4.探究表面效应以及重要影响
	pn 结	1.pn 结的基本结构 2.零偏（热平衡）pn 结 3.反偏 4.非均匀掺杂 pn 结（选讲变容二极管）	L1	L2	1.确定 pn 结的基本机构 2.分析热平衡 pn 结的特性 3.对比反偏 pn 结与零偏 pn 结并归纳反偏特性
	pn 结二极管	1.pn 节二极管电流电压特性 2.pn 节小信号模型 3.产生-复合电流 4.结击穿 5.隧道二极管（选讲）			1.阐释 pn 结二极管的工作原理 2.举例说明 pn 结二极管的主要应用（器件） 3.融入我国的 LED 照明和光伏产业从无到有，再到独占鳌头的历程。激发家国情怀和民族自豪感。
	批判性思维	分析问题，识别有矛盾的观点和逻辑谬误，选择逻辑论点和解决方法；归纳理论和事实验证假设与结论；	L1	L4	1.说明半导体材料、半导体物理和半导体器件以及 IC 电路和信息技术的发展关系 2.讨论半导体材料和半导体物理发展过程中某些认识的谬误和建立正确认识的过程。
	发现问题和表述问题	分析并归纳有价值的问题，科学准确地表述问题；	L1	L2	1.找到新的半导体器件背后的半导体物理问题 2.解释身边与半导体物理现象相关的问题 3.确认问题的物理本质
	建立模型	选择需要验证的关键问题，制定假设；应用假设简化复杂的系统和环境，制定定性和定量模型	L1	L2	1.应用载流子输运模型 2.选择问题的典型数学描述 3.利用双极输运方程 4.解决典型情况下的载流子定量输运
	交流能力	分组讨论及完成任务	L1	L2	1.说明自己的观点 2.选择适合的表述方式 3.修改不恰当的观点
	查询资料	应用图书馆工具（在线检索、数据库、搜索引擎等）检索并获取信息	L2	L2	1.选择合适的信息来源 2.实行快速有效获取信息 3.使用有效信息

3. 先修要求 （Pre-requisit）

微积分 B-I，微积分 B-II、大学物理 3、固体物理 1

4. 教材及其他教学资源 （Textbooks and Other Learning Resources）

（1）指定教材：

《半导体物理与器件》【美】Donald A. Neamen 著 赵毅强 等译，电子工业出版社 2013 年 8 月 第四版（国外电子与通信教材系列）

（2）推荐教材：

①《半导体物理学》刘恩科等著，电子工业出版社 2003 第 6 版
②《半导体物理》钱佑华等著 高等教育出版社 1999 第 1 版
③《半导体物理基础》黄昆 韩汝琦
④《半导体器件 物理与工艺》(美)施敏(S.M.Sze)著，王阳元等译
⑤《半导体器件导论》An Introduction to Semiconductor Devices. Donald A. Neamen 清华大学出版社 2009.3（国外大学优秀教材-微电子系列）

（3）课程网站：

https://my.stu.edu.cn/

5. 主要教学环节 （Teaching and Learning Activities）

理论课（小时）		习题课（小时）		实验（小时）		研讨（小时）		社会实践（小时）		项目（小时）		在线学习（小时）		其他（小时）	
课内	课外	课内	课外	课内	课外	课内	课外	课内	课外	课内	课外	课内	课外	课内	课外
30	32	2	28	0	0	0	0	0	0	0	0	0	0	0	4

6. 课程考核 （Assessment Scheme）

考核项目	考核内容和考试方法简介	权重
练习、讨论、提问	课后作业及思考；课堂参与、发言、提问；分组讨论回答问题。	30%
期末考试	期末闭卷考试	70%

7. 学习进度 （Course Schedule）

周次	教学时数	教学形式	教学方法	教　学　内　容
1	2	课堂教学	课堂讲授 课堂讨论	绪论 半导体与集成电路 历史，集成电路，制造;中国的半导体发展
2	2	课堂教学	课堂讲授 课堂讨论	第 1 章 固体晶体结构和半导体材料的发展 1.0 概述，1.1 半导体材料；1.2 固体类型；1.3 空间晶格；1.4 金刚石结构；1.5 原子价键；1.6 固体中的缺陷与杂质（辩证法原理）；1.7 半导体单晶材料的生长；集成电路制造工艺过程
3	2	课堂教学	课堂讲授 课堂讨论	第 3 章固体量子理论初步 （4 学时） 3.0 概述； 3.1 允带与禁带；补充：常见半导体材料的能带图，硅和砷化镓的能带图（辩证法的应用） 3.2 固体中电的传导 3.3 三维扩展；
4	2	课堂教学	课堂讲授 课堂讨论	3.4 状态密度函数； 3.5 统计力学； 3.6 小结
5	2	课堂教学	课堂讲授 课堂讨论	第 4 章 平衡半导体（5 学时） 4.1 半导体中的载流子； 4.2 掺杂原子与能级； 4.3 非本征半导体；
6	2	课堂教学	课堂讲授 课堂讨论	4.4 施主和受主的统计学分布； 4.5 电中性状态；
7	2	课堂教学	课堂讲授 课堂讨论	4.6 费米能级的位置 第五章 载流子输运现象（5 学时） 5.0 概述 5.1 载流子的漂移运动；
8	2	课堂教学	课堂讲授 课堂讨论	5.2 载流子扩散；
9	2	课堂教学	课堂讲授 课堂讨论	5.3 杂质梯度分布 5.4 霍尔效应（选讲） 5.5 小结
10	2	课堂教学	课堂讲授 课堂讨论	第 6 章 半导体中的非平衡过剩载流子 （6 学时） 6.0 概述 6.1 载流子的产生与复合；（矛盾理论）
11	2	课堂教学	课堂讲授 课堂讨论	6.2 过剩载流子的性质； 6.3 双极输运过程（方程的建立）（矛盾理论）
12	2	课堂教学	课堂讲授 课堂讨论	6.3 双极输运过程（例题和应用） 6.4 准费米能级； 小结
13	2	课堂教学	课堂讲授 课堂讨论	第 7 章 pn 结 （4 学时） 7.0 概述 7.1 pn 结的基本结构； 7.2 零偏

14	2	课堂教学	课堂讲授 课堂讨论	7.3 反偏 7.4 结击穿 7.5 非均匀掺杂 pn 结（选讲） 7.6 小结
15	2	课堂教学	课堂讲授 课堂讨论	第 8 章 pn 结二极管 8.0 概述 8.1 pn 结电流 8.2 产生-复合电流和大注入（辩证法原理）；
16	2	课堂教学	课堂讲授 课堂讨论	8.2 产生-复合电流和大注入 8.3 pn 结的小信号模型 8.6 小结

Shantou University

Module Description for Undergraduate Courses

COURSE TITLE:	Optoelectronic Thin Film Technology
COURSE CODE:	PHY4006A
CREDIT VALUE:	2
CONTACT HOURS:	32
PRE-REQUISITE	none
DEPARTMENT/UNIT:	Department of Physics
VERSION:	202406-PHY4006A
COURSE COORDINATOR:	Lin Shunhui (Signature and Seal)
APPROVER:	Chi Lingfei (Signature and Seal)
APPROVE DATE:	20240731

Shantou University Faculty of Science

July 2024

1. Course Description

(1) Course Nature

Opto-Electronic Thin Film Technology is a specialized elective course for students in the programme *Optoelectronic Information Science and Engineering*, and it also serves as a general elective within the Physics major.

(2) Course Contant

This course introduces the fundamental physical principles underlying the fabrication of opto-electronic thin films, including vacuum technology, gas discharge, and low-temperature plasma physics. Building upon these foundations, the course focuses on typical physical vapor deposition (PVD) and chemical vapor deposition (CVD) techniques for opto-electronic thin-film materials, thin-film growth mechanisms and structural models, as well as commonly used structural analysis and compositional characterization methods.

The objective of the course is to enable students to master the principles and techniques of thin-film preparation, to become familiar with thin-film characterization approaches, and to gain an understanding of the applications and current developments in opto-electronic thin-film materials

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(3) Course Objectives

Upon successful completion of the course, students will be able to:

1. Demonstrate understanding of vacuum technologies relevant to the preparation of opto-electronic thin films.
2. Explain the fundamentals of gas discharge and low-temperature plasma physics.
3. Apply physical vapor deposition techniques for thin-film fabrication.
4. Apply chemical vapor deposition techniques and describe thin-film growth processes and structural models.
5. Utilize common structural analysis methods, compositional characterization techniques, and optical/electronic performance measurements for thin-film materials.

This course contributes to the academic training of undergraduate students in Optoelectronic Information Science and Engineering and Physics, supporting key programme learning outcomes in the areas of:

– commitment to professional integrity and scientific values;
– social responsibility;
– mastery of fundamental theories in physics, optoelectronics, and information science (Outcome 3.1);
– ability to conduct research based on scientific principles and methodologies (Outcome 5.1).

2. Intended Learning Outcomes

Training Objectives	Knowledge Units / Competencies Standards	Initial Level	Target Level	Expected Learning Outcomes
Fundamentals of Vacuum Technology	(1) Overview: history of thin-film research, thin-film preparation, characterization, properties, and applications.	L0	L1	(1) Able to recall and describe the historical development of thin-film preparation and characterization techniques.

	(2) Molecular velocity distribution, collision frequency, pressure, molecular flux, Knudsen equation. (3) Gas-flow regimes, concepts of conductance, pumping speed. (4) Vacuum systems and vacuum pump fundamentals. (5) Vacuum measurement techniques.	L1	L2	(2) Understand molecular velocity distribution, collision frequency, pressure, molecular flux, and the Knudsen equation.
			L3	(3) Demonstrate understanding of gas-flow regimes, conductance, and vacuum pumping speed.
			L3	(4) Demonstrate understanding of vacuum systems and pump operating principles.
			L4	(5) Summarize the structure of vacuum systems.
			L3	(6) Estimate the ultimate vacuum of cryogenic adsorption pumps.
			L2	(7) Understand the principles of vacuum-measurement techniques.
			L3	(8) Estimate measurement errors for vacuum gauges.
Physical Vapor Deposition (I): Evaporation Method	(1) Equilibrium vapor pressure, particle emission rate and energy, evaporation rate. (2) Deposition characteristics: deposition rate, sticking coefficient, film uniformity and purity. (3) Common evaporation-coating systems. (4) Examples: Al film, Ni–Cr film, TCO film. (5) Factors affecting film formation: deposition rate, substrate temperature.	L1	L2	(1) Understand equilibrium vapor pressure, particle emission rate and energy, and evaporation rate.
			L3	(2) Estimate equilibrium vapor pressure.
			L5	(3) Determine whether a substance undergoes evaporation or sublimation.
			L3-L4	(4) Explain the principles and differences among common evaporation systems.
			L3	(5) Demonstrate understanding of how deposition rate and substrate temperature affect evaporation coating.
Physical Vapor Deposition (I): Plasma Fundamentals	(1) Fundamentals of low-pressure gas discharge: collisions, excitation, ionization, motion of charged particles. (2) DC glow discharge: V–A characteristics,	L1	L2-L3	(1) Understand collision laws, excitation/ionization, and transport of charged particles. (2) Understand characteristics of low-pressure DC discharges.

	breakdown voltage, Paschen's law. (3) Low-temperature plasma: Debye length, plasma oscillations, sheath, plasma chemistry. (4) RF discharge			(3) Demonstrate understanding of Debye length, plasma oscillations, and plasma sheath.
			L3	(4) Estimate plasma sheath thickness.
			L2	(5) Understand the application of plasma chemistry in film deposition. (6) Understand RF discharge principles.
			L4	(7) Distinguish DC and RF discharges.
Physical Vapor Deposition (II): Sputtering & Other PVD Methods	(1) Gas glow-discharge physics: gas discharge, low-temp plasma, RF discharge, magnetron discharge. (2) Sputtering phenomena: sputtering mechanism, threshold, sputtering yield. (3) Sputtering systems: RF sputtering, magnetron sputtering. (4) Examples: ITO film, Y–Ba–Cu–O superconducting film. (5) Overview of other PVD methods.	L1	L3	(1) Demonstrate understanding of gas, cold plasma discharge, RF discharge, and magnetron glow discharge. (2) Demonstrate understanding of sputtering mechanism, threshold, and yield. (3) Demonstrate understanding of RF and magnetron sputtering systems. (4) Demonstrate understanding of sputtering processes for ITO and Y-Ba-Cu-O film (5) Demonstrate understanding of other PVD technologies.
			L3-L4	(6) Explain differences and applicable ranges of magnetron vs. conventional sputtering.
			L2	(7) Understand the role of presputtering.
			L3	(8) Calculate target-surface compositions after presputtering.
			L4	(9) Summarize differences between sputtering and evaporation in preserving film composition.
Chemical Vapor Deposition (CVD)	(1) Chemical vapor deposition (CVD) of thin films:	L1	L2	(1) Understand CVD technology and reaction types.

	Types of CVD reactions (2) Thermodynamics of CVD processes: Gibbs free-energy changes of chemical reactions; calculation of chemical equilibrium (3) CVD equipment: High-temperature and low-temperature CVD; atmospheric-pressure and low-pressure CVD; metal–organic CVD (MOCVD); laser-assisted CVD (4) Plasma-enhanced chemical vapor deposition (PECVD) (5) Examples of CVD technologies: Preparation of SiO_2, Si_3N_4, a-Si:H, and a-C:H thin films			(2) Understanding the change in Gibbs Free Energy (ΔG) for a chemical reaction and its relationship with the reaction spontaneity/direction.
			L3-L4	(2) Calculate free-energy changes and determine reaction direction.
			L3	(3) Demonstrate understanding of various CVD systems. (4) Demonstrate understanding of PECVD.
			L4	(5) Summarize characteristics and differences among CVD techniques.
Thin-Film Growth and Structure	(1) Thin-film growth and nucleation theory. (2) Amorphous films. (3) Epitaxial growth.	L1	L3	(1) Demonstrate understanding of nucleation and growth. (2) Demonstrate understanding of amorphous-film preparation and properties. (3) Demonstrate understanding of epitaxial growth.
Dry Etching	(1) Dry etching (2) Plasma etching (3) Reactive ion etching (RIE) (4) Reactive ion beam–assisted etching (RIBE) (5) Photo-assisted dry etching	L1	L2	(1) Understand dry etching, plasma etching, RIE, ion-beam-assisted etching, and photo-assisted etching
			L3	(2) Explain differences, characteristics, and advantages/limitations of various etching technologies.
Characterization Methods of Thin-Film Materials	(1) Film-thickness measurement methods: optical interference, profilometer/step measurement, gravimetric method, quartz crystal microbalance/suspension method, ellipsometry, optical absorption spectroscopy. (2) Measurement of thin-film optical constants: spectroscopic ellipsometry, optical absorption spectroscopy.	L1	L2	(1) Understand the principles of film-thickness measurement methods such as optical interference, profilometer, gravimetric method, and suspension method.
			L3	(2) Explain the principles of spectroscopic ellipsometry and optical absorption spectroscopy.
			L2	(3) Understand fundamental principles of IR, Raman, UV, and ellipsometric methods for

	(3) Structural-state characterization: fundamental principles of infrared (IR) spectroscopy, Raman spectroscopy, UV spectroscopy, and ellipsometry; analysis of application examples. (4) Structural-analysis methods: scanning electron microscopy (SEM), transmission electron microscopy (TEM), scanning probe microscopy (SPM), X-ray diffraction (XRD). (5) Compositional-analysis methods: infrared spectroscopy, Raman spectroscopy, X-ray energy-dispersive spectroscopy (EDS), Auger electron spectroscopy (AES), X-ray photoelectron spectroscopy (XPS), Rutherford backscattering spectroscopy (RBS), secondary ion mass spectrometry (SIMS).			structural-state characterization.
			L3-L4	(4) Apply theoretical knowledge to perform preliminary analysis of IR spectra, Raman spectra, and ellipsometric spectra.
			L2-L3	(5) Understand the basic principles of SEM, TEM, SPM, and XRD, and describe their characteristics and differences.
			L4-L5	(6) Perform preliminary analysis of SEM images and XRD patterns and determine thin-film structural features.
			L2-L3	(7) Understand the principles of IR, Raman, EDS, AES, XPS, RBS, and SIMS, and explain their differences and application ranges.
			L4-L5	(8) Perform preliminary analysis of IR spectra, EDS spectra, and XPS spectra to determine film composition.

3. Pre-requisit

None

4. Textbooks and Other Learning Resources

(1) Designated textbooks

None

(2) Recommended Textbook

① Tang Weizhong, *Principles, Techniques, and Applications of Thin Film Material Preparation,* 2nd Edition, Metallurgical Industry Press, January 2003.

② *Vacuum Deposition Technology,* Li Xuedan, Wan Yingchao, Jiang Xiangqi, Du Yuancheng, Zhejiang University Press, 1994.

(3) Recommended References

① A simple method for the determination of the optical constants n, k and the thickness of a weakly absorbing film（*Manifacier*）

② Determination of surface roughness and optical constants of inhomogeneousamorphous silicon films（*R Swanepoel*）

③ Critical investigation of the infrared-transmission-data analysis of hydrogenated amorphous silicon alloys（*PhysRevB.46.2078*）

④ Optical dielectric function of hydrogenated amorphous silicon （*PhysRevB.38.10623*）

(4) Online Resources

https://my.stu.edu.cn/
CNKI：https://kns.cnki.net/kns8s/?classid=YSTT4HG0

5. Teaching and Learning Activities

Teaching Segment	Lectures (Theory)	Exercise	Homework	Research	Seminar	Extracurricular Reading	Project Work	Total
Hours (In-class)	30	0	0	0	2	0	0	32
Hours (Out-of-class)	32	0	12	0	0	20	0	64

Basis for Calculating Out-of-Class Workload:
Out-of-class workload arrangement:
(1) Students are expected to spend 1 hour on pre-class preparation and 1 hour on post-class review each week, totaling 32 hours per semester.
(2) Homework assignments require 12 hours per semester (6 assignments, 2 hours per assignment).
(3) As the course content is closely related to future work in optoelectronic information, students need to read relevant literature; therefore, 20 hours of out-of-class reading are assigned per semester.
Total out-of-class workload: 64 hours per semester.

7. Assessment Scheme

Assessment item	Description / Assessment criteria	Weight
Class Attendance	Classroom attendance rate	10%
Classroom Discussion	Including participation, in-class comments, questions, and discussions	15%
After-class Exercises	In-class Participation and Engagement: Includes active listening and Homework assignments, reflective questions, and in-class quizzes	20%
Final Examination	Closed-Book Written Examination	55%

7. Course Schedule

Week	Hour	Teaching format	Teaching Methods	Teaching content
1	2	Lecture	Lectures, Rain Classroom, Attendance, Tests, Interactive Discussion	**Introduction:** (1) History of thin-film research (2) Overview of thin-film preparation, characterization, measurement, and applications 1-1 Concepts of vacuum and pressure; Maxwell distribution of molecular speeds; three characteristic molecular speeds 1-2 Gas pressure and mean free path of gas molecules 1-3 Collision frequency, molecular flux, Knudsen equation

2	2	Lecture	Lectures, Rain Classroom, Attendance, Tests, Interactive Discussion	1-4 Gas flow regimes, flow channels, pumping speed in vacuum 1-5 Vacuum systems and vacuum pumps 1-6 Vacuum measurement techniques: measurement errors, thermocouple gauges, Pirani gauges, ionization gauges, thin-film vacuum gauges
3	2	Lecture	Lectures, Rain Classroom, Attendance, Tests, Interactive Discussion	2-1 Overview of evaporation deposition 2-2 Evaporation characteristics: saturated vapor pressure, material evaporation rate; evaporation of compounds and alloys 2-3 Deposition characteristics: deposition rate and sticking coefficient, thickness uniformity and purity 2-4 Factors influencing evaporation deposition: deposition rate, substrate temperature, substrate cleaning
4	2	Lecture	Lectures, Rain Classroom, Attendance, Tests, Interactive Discussion	2-5 Common evaporation deposition equipment: resistance heating sources, RF heating sources, electron-beam heating sources, arc evaporation systems, laser heating, hollow-cathode evaporation sources 2-6 Examples of evaporation coating: aluminum film, Ni-Cr film, transparent conductive films
5	2	Lecture	Lectures, Rain Classroom, Attendance, Tests, Interactive Discussion	3-1 Basics of low-temperature plasma physics: particle collision laws, excitation and ionization of gas atoms by electrons, motion characteristics of charged particles in gases 3-2 Low-pressure gas DC discharge: breakdown voltage, Paschen's law
6	2	Lecture	Lectures, Rain Classroom, Attendance, Tests, Interactive Discussion	3-3 Characteristics of low-temperature plasma: plasma sheath, plasma potential distribution and discharge regions, plasma chemistry, RF discharge 4-1 Sputtering phenomena and mechanisms; sputtering yield
7	2	Lecture	Lectures, Rain Classroom, Attendance, Tests, Interactive Discussion	4-2 Sputtering of alloys and compounds: self-compensation effect 4-3 Sputtering deposition equipment: DC sputtering, RF sputtering, magnetron sputtering, reactive sputtering, sputter ion plating, ion-beam sputtering, ion plating
8	2	Lecture	Lectures, Rain Classroom, Attendance, Tests, Interactive Discussion	4-4 Examples of sputtering deposition: Ta and TaN thin films, ITO transparent conductive films, Y-Ba-Cu-O superconducting films, diamond-like carbon (DLC) films and sputtering methods Rain Classroom unit quiz 5-1 Reaction types in chemical vapor deposition (CVD)
9	2	Lecture	Lectures, Rain Classroom, Attendance, Tests, Interactive Discussion	5-2 Thermodynamics of the CVD process: Gibbs free-energy change of reactions, equilibrium calculations 5-3 CVD equipment: high-temperature and low-temperature CVD, atmospheric-pressure and low-pressure CVD, laser-assisted CVD, metal-organic CVD

10	2	Lecture	Lectures, Rain Classroom, Attendance, Tests, Interactive Discussion	5-5 Plasma-enhanced chemical vapor deposition (PECVD) 5-4 Examples of CVD: fabrication of SiO_2, Si_3N_4, a-Si:H, a-C:H thin films
11	2	Lecture	Lectures, Rain Classroom, Attendance, Tests, Interactive Discussion	6-1 Overview of thin-film growth and nucleation theory 6-2 Amorphous thin films 6-3 Overview of epitaxial growth
12	2	Lecture	Lectures, Rain Classroom, Attendance, Tests, Interactive Discussion	7-1 Dry etching 7-2 Plasma etching 7-3 Reactive ion etching (RIE), reactive ion-beam assisted etching 7-5 Photo-assisted dry etching Rain Classroom unit quiz
13	2	Lecture	Lectures, Rain Classroom, Attendance, Tests, Interactive Discussion	8-1 Measurement of film adhesion 8-2 Film thickness measurement techniques 8-3 Characterization of thin-film chemical structure: (1) Fundamentals of IR and Raman spectroscopy Example: infrared absorption analysis of a-Si:H films
14	2	Lecture	Lectures, Rain Classroom, Attendance, Tests, Interactive Discussion	(2) Ellipsometric spectroscopy Example: ellipsometric spectral analysis of a-Si:H films (3) Principles of UV spectroscopy
15	2	Lecture	Lectures, Rain Classroom, Attendance, Tests, Interactive Discussion	8-4 Structural characterization of thin films: SEM, TEM, SPM, X-ray diffraction; brief introduction to electron diffraction analysis
16	2	Lecture	Lectures, Rain Classroom, Attendance, Tests, Interactive Discussion	8-5 Compositional analysis of thin films: EDX, AES, XPS, RBS, SIMS Rain Classroom unit quiz Final exam review

汕头大学本科教学

课程教学大纲

课　程　名（COURSE TITLE）：	光电子薄膜技术
课程代码（COURSE CODE）：	PHY4006A
学　　　分（CREDIT VALUE）：	2
课内课时（CONTACT OURS）：	32
先修课要求（PRE-REQUISIT）	无
开课单位（DEPARTMENT/UNIT）：	物理学系
版　　　本（VERSION）：	202406-PHY4006A
课程负责人（COURSE COORDINATOR）：	林舜辉　(签章)
审　核　人（APPROVER）：	池凌飞(签章)
审核日期（APPROVE DATE）：	20240731

汕头大学理学院

2024 年 7 月

1、课程简介 （Course Description）

（1）课程性质

光电子薄膜技术（Opto-Electronic Thin Film Technology）是物理学系光电信息科学与工程专业的专业选修课，也是物理学专业的公共选修课。

（2）课程内容

光电子薄膜技术课程在介绍光电子薄膜材料制备技术所涉及的真空技术、气体放电和低温等离子体物理基础知识的基础上，着重介绍典型的光电子薄膜材料的物理气相、化学气相沉积技术，薄膜的生长和薄膜结构模型，以及常用的结构分析技术和成份表征方法。本课程的教学目的与任务是使学生掌握光电子薄膜材料的制备技术及其基本原理和薄膜材料的分析方法，了解光电子薄膜材料的应用及发展前沿。

（3）课程教学目标

学完本课程后，学生应能够：

① 通过介绍我国改革开放以来在电子信息产业方面取得的伟大成就，培养学生的民族自豪感；坚定中国特色社会主义道路自信、理论自信、制度自信、文化自信；厚植爱国主义情怀，具有强国志、报国行。

② 掌握光电子薄膜材料制备技术涉及的真空技术；

③ 掌握气体放电和低温等离子体物理基础知识；

④ 掌握制备光电子薄膜材料的物理气相沉积技术；

⑤ 掌握光电子薄膜材料的化学气相沉积技术、薄膜的生长和结构模型；

⑥ 掌握常用的薄膜结构分析、成份表征和光电性能测试方法。

本课程为光电信息科学与工程专业和物理专业学术型本科人才提供专业理论与应用研究能力的培养，高度支撑相关专业本科人才培养方案中的毕业要求指标点：1.坚定的理想信念、2.正确价值观和社会责任感、3.1 掌握物理学、光电子学和信息学的基础理论和专业知识；5.1 具备基于科学原理和方法进行研究的能力。

2、预期学习结果 （Intended Learning Outcomes）

知识单元	知识点	初始熟练程度	要求熟练程度	相关学习结果
薄膜制备的真空技术基础	（1）绪论:薄膜研究的历史 、薄膜的制备、检测、表征和应用概述； （2）气体分子运动速率及其分布、气体分子碰撞频率、压强、气体分子的通量、克努森方程； （3）气体的流动状态、流导的概念、真空的抽速； （4）真空系统及真空泵简介； （5）真空的测量技术。	L0	L1	（1）能够记住并描述薄膜制备检测技术的发展史；
		L1	L2	（2）理解气体分子运动速率及其分布、气体分子碰撞频率、压强、气体分子的通量、克努森方程；
			L3	（3）展现对气体的流动状态、流导、真空的抽速等概念的理解；
			L3	（4）展现对真空系统及真空泵工作原理的理解；
			L4	（5）总结真空系统的结构；
			L3	（6）能够计算低温吸附泵的极限

				真空；
			L2	（7）理解真空的测量技术原理；
			L3	（8）能够估算真空测量的误差。
				思政元素：介绍我国改革开放以来在电子信息产业方面取得的伟大成就，培养学生的民族自豪感。
				思政元素：让学生懂得推进全面建成小康社会、全面深化改革、全面依法治国、全面从严治党对国家实现现代化强国的重要性。
薄膜的物理气相沉积（I）蒸发法	（1）平衡蒸气压、蒸发粒子的速率和能量、蒸发速率； （2）沉积特性:沉积速率与凝结系数、膜厚均匀性和纯度； （3）常用蒸发镀膜装置； （4）蒸发镀膜实例:铝膜、镍-铬膜、透明导电膜； （5）影响蒸镀膜的因素:沉积速率、衬底温度。	L1	L2	（1）理解平衡蒸气压、蒸发粒子的速率和能量、蒸发速率等概念；
			L3	（2）能够熟练估算平衡蒸气压；
			L5	（3）能够判断物质的蒸发和升华；
			L3-L4	（4）理解并能说明常用蒸发镀膜装置的原理和功能的区别；
			L3	（5）展现对沉积速率、衬底温度影响蒸镀膜的因素的理解；
薄膜的物理气相沉积方法（I）等离子体物理基础	（1）低气压气体放电基础：粒子间的碰撞规律、原子的激发和电离、带电粒子在气体中的运动特征； （2）低气压气体直流放电:伏安特性、击穿电压、帕邢定律； （3）低温等离子体的特征：德拜长度、等离子体振荡、等离子体鞘层、等离子体化学； （4）高频放电。	L1	L2-L3	（1）理解粒子间的碰撞规律、原子的激发和电离、带电粒子在气体中的运动特征； （2）理解低气压气体直流放电特性:伏安特性、击穿电压、帕邢定律； （3）展现对低温等离子体的特征：德拜长度、等离子体振荡、等离子体鞘层的理解；
			L3	（4）估算等离子体鞘层厚度；
			L2	（5）理解对等离子体化学在薄膜制备中的应用； （6）理解高频放电的原理；
			L4	（7）能够区别直流放电和高频放电的不同。
薄膜的物理气相沉积方法（II）溅射法及其他PVD方法	（1）气体辉光放电的物理基础：气体放电与低温等离子体、射频放电、磁控辉光放电； （2）物质的溅射现象、溅射机理、溅射阀值、溅射产额； （3）溅射沉积装置:射频溅射、磁控溅射； （4）溅射镀膜实例:ITO透明导电膜、Y-Ba-Cu-O超导薄膜； （5）其他的物理气相沉积技术简介	L1	L3	（1）展现对气体放电与低温等离子体、射频放电、磁控辉光放电的理解； （2）展现对物质的溅射现象、溅射机理、溅射阀值、溅射产额的理解； （3）展现对射频溅射、磁控溅射沉积装置工作原理的理解； （4）展现对 ITO 透明导电膜、Y-Ba-Cu-O 超导薄膜溅射镀膜方法的理解； （5）展现对其他相关物理气相沉积技术的理解；
			L3-L4	（6）能够说明磁控溅射和普通溅射的区别及其适用范围；
			L2	（7）能够理解预溅射的作用；

			L3	（8）能够说明自补偿原理，并计算预溅射后靶材表面的成分；
			L4	（9）概述溅射法镀膜和蒸发镀膜在保持薄膜化学成分方面的区别。
				思政元素：以大面积优质 ITO 薄膜、以及大面积平板示器原来必须依赖进口的卡脖子技术，到现在能够自主生产，乃至完成镀膜设备自主设计生产的突破，引导学生坚定中国特色社会主义道路自信、理论自信、制度自信、文化自信。
薄膜的化学气相沉积	（1）薄膜的化学气相沉积：化学气相沉积反应类型； （2）化学气相沉积反应过程的热力学：化学反应的自由能变化、化学反应平衡的计算； （3）化学气相沉积装置:高温和低温 CVD、常压和低压 CVD、金属有机化合物 CVD、激光辅助 CVD； （4）等离子体辅助化学汽相沉积（PECVD）技术； （5）化学气相沉积技术实例: SiO_2、Si_3N_4、a-Si:H 和 a-C:H 薄膜的制备。	L1	L2	（1）理解化学气相沉积技术和化学气相沉积反应类型； （2）理解化学反应的自由能变化和反应进行方向的关系；
			L3-L4	（2）计算自由能变化，辨别化学反应进行的方向；
			L3	（3）展现对高温和低温 CVD、常压和低压 CVD、金属有机化合物 CVD、激光辅助 CVD 薄膜沉积技术的理解； （4）展现对等离子体辅助化学汽相沉积技术的理解；
			L4	（5）总结各种 CVD 方法的特点和区别；
				思政元素：通过介绍我国科学家赵忠贤教授在高温超导材料研究的突出贡献，激发学生的使命担当和思想自觉。
				思政元素：以我国太阳能产业为例，介绍我国在生态环境保护方面取得的伟大成就及对世界的杰出贡献。厚植学生的爱国主义情怀，具有强国志、报国行。
薄膜的生长过程和薄膜结构	（1）薄膜生长过程及形核理论概述； （2）非晶薄膜； （3）薄膜的外延生长概述；	L1	L3	（1）展现对薄膜生长过程及形核理论的理解； （2）展现对非晶薄膜的制备方法、生长过程和基本特性的理解； （3）展现对薄膜外延生长的理解。
薄膜的干法刻蚀	（1）干法刻蚀； （2）等离子体刻蚀； （3）反应离子刻蚀； （4）反应离子束辅助刻蚀 （5）光辅助干法刻蚀。	L1	L2	（1）理解干法刻蚀技术、等离子体刻蚀技术、反应离子刻蚀技术、反应离子束辅助刻蚀技术、光辅助干法刻蚀技术的原理；
			L3	（2）能够说明不同刻蚀技术的特点和它们之间的区别及优缺点。
				思政元素：介绍我国在半导体技术方面取得的成就以及与西方国家的差距、中美贸易战的本质以及美国为首的西方的技术封锁对我国

				的影响，说明“核心技术是要不来的，要靠我们自己”。
				思政元素：强调举国体制集中力量办大事的制度优势，培育学生的政治意识、大局意识、核心意识和看齐意识。
薄膜材料的表征方法	（1）膜厚测量法:光干涉法、台阶测试仪、称重法、悬浮法、椭圆偏振法、光吸收谱法； （2）薄膜光学常数的测试方法：椭偏光谱法、光吸收谱法 （3）薄膜结构态表征：红外与拉曼光谱、紫外光谱、椭偏光谱的基本原理，应用实例剖析； （4）薄膜结构的分析方法：扫描电子显微镜、透射电子显微镜、扫描探针显微镜、X-射线衍射； （5）薄膜成分的分析方法：红外光谱、喇曼光谱、X 射线能量色散谱、俄歇电子能谱、X 射线光电子能谱、卢瑟福背散射谱、二次离子质谱。	L1	L2	（1）理解膜厚测量法:光干涉法、台阶测试仪、称重法、悬浮法的原理；
			L3	（2）能够说明椭偏光谱法、光吸收谱法的原理；
			L2	（3）理解薄膜结构态表征方法：红外与拉曼光谱、紫外光谱、椭偏光谱法的基本原理；
			L3-L4	（4）能够应用相关理论知识对红外与拉曼光谱和椭偏光谱进行初步的分析；
			L2-L3	（5）理解薄膜结构的分析方法：扫描电子显微镜、透射电子显微镜、扫描探针显微镜、X-射线衍射的基本原理；并说明各种方法的特点和区别；
			L4-L5	（6）具备初步分析扫描电子显微镜像、X-射线衍射谱的能力，并判断薄膜的结构；
			L2-L3	（7）理解薄膜成分的分析方法：红外光谱、喇曼光谱、X 射线能量色散谱、俄歇电子能谱、X 射线光电子能谱、卢瑟福背散射谱、二次离子质谱的原理；说明它们的区别和应用范围；
			L4-L5	（8）能够初步分析红外光谱、X 射线能量色散谱、X 射线光电子能谱，并判断薄膜的成分。

3、先修要求 （Pre-requisit）

无

4、教材及其他教学资源 （Textbooks and Other Learning Resources）

（1）指定教材

无

（2）推荐教材

① 唐伟忠 著《薄膜材料制备原理、技术及应用》，冶金工业出版社，2003 年 1 月第二版

②《真空沉积技术》，李学丹、万英超、姜详祺、杜元成，浙江大学出版社，1994

（3）参考文献示例

① A simple method for the determination of the optical constants n, k and the thickness of a weakly absorbing film（Manifacier）

② Determination of surface roughness and optical constants of inhomogeneousamorphous silicon films（R Swanepoel）

③ Critical investigation of the infrared-transmission-data analysis of hydrogenated amorphous silicon alloys（PhysRevB.46.2078）

④ Optical dielectric function of hydrogenated amorphous silicon（PhysRevB.38.10623）

（4）课程网站

https://my.stu.edu.cn/

CNKI 中国知网--中国学术期刊：https://kns.cnki.net/kns8s/?classid=YSTT4HG0

5、 主要教学环节 （Teaching and Learning Activities）

教学环节	理论学习（小时）	习题课（小时）	作业（小时）	实验（小时）	研讨（小时）	课外阅读（小时）	项目（小时）	在线学习（小时）	合计
课内	30	0	0	0	2	0	0	0	32
课外	32	0	12	0	0	20	0	0	64

课外课时计算依据：课外课时安排：（1）每周课前预习1小时、课后复习1小时，共32学时/学期；（2）课后作业需12小时/学期（2小时/次×6次作业)；（3）本课程的教学内容与学生毕业从事的光电信息方面的工作联系较为紧密，需要阅读相关文献资料，故安排课外阅读20小时/学期；共计64小时/学期。

6、课程考核 （Assessment Scheme）

考核项目	考核内容和考试方法简介	权重
课堂考勤	课堂出勤率	10%
课堂讨论	包括课堂参与、发言、提问及讨论	15%
课后练习	课后作业、思考题及课堂测试	20%
期末考试	期末闭卷考试	55%

7、学习进度 （Course Schedule）

周次	教学时数	教学形式	教学方法	教 学 内 容
1	2	课堂教学	课堂讲授、雨课堂、考勤、测试、弹幕互动	绪论: (1)薄膜研究的历史 (2）薄膜的制备、检测、表征和应用概述 1-1 真空与压强的概念、麦克斯韦气体分子速率分布函数、气体分子的三个特征速率 1-2 气体的压强和气体分子的平均自由程 1-3 气体分子的碰撞频率、气体分子的通量、克努森方程
2	2	课堂教学	课堂讲授、雨课堂、考勤、测试、弹幕互动	1-4 气体的流动状态、流道、真空的抽速 1-5 真空系统及真空泵 1-6 真空的测量技术：真空测量误差、热偶真空规、皮拉尼真空规、电离真空规、薄膜真空规
3	2	课堂教学	课堂讲授、雨课堂、考勤、测试、弹幕互动	2-1 蒸发镀膜概述 2-2 蒸发特性: 饱和蒸汽压、物质的蒸发速率 化合物和合金的蒸发 2-3 沉积特性:沉积速率与凝结系数、膜厚均匀性和纯度 2-4 影响蒸镀膜的因素：沉积速率、衬底温度及基片的净化
4	2	课堂教学	课堂讲授、雨课堂、考勤、测试、弹幕互动	2-5 常用蒸发镀膜装置：电阻加热源、高频加热源、电子束加热源、电弧蒸发装置、激光束加热、空心阴极蒸发装置 2-6 蒸发镀膜实例：铝膜、镍-铬膜、透明导电膜 雨课堂单元测试
5	2	课堂教学	课堂讲授、雨课堂、考勤、测试、弹幕互动	3-1 低温等离子体的物理基础：粒子间的碰撞规律、电子碰撞气体原子的激发和电离、带电粒子在气体中的运动特征 3-2 低气压气体直流放电：击穿电压、帕邢定律
6	2	课堂教学	课堂讲授、雨课堂、考勤、测试、弹幕互动	3-3 低温等离子体的特征：等离子体鞘层、等离子体电位分布及放电区域划分、等离子体化学、射频放电 4-1 物质的溅射现象及机理；溅射产额
7	2	课堂教学	课堂讲授、雨课堂、考勤、测试、弹幕互动	4-2 合金和化合物的溅射：自补偿效应 4-3 溅射沉积装置: 直流溅射、射频溅射、磁控溅射、反应溅射、溅射离子镀、离子束溅射、离子镀
8	2	课堂教学	课堂讲授、雨课堂、考勤、测试、弹幕互动	4-4 溅射镀膜实例: 纯钽与氮化钽薄膜、ITO 透明导电膜、Y-Ba-Cu-O 超导薄膜、类金刚石薄膜的应用及溅射制备方法 雨课堂单元测试 5-1 化学气相沉积的反应类型
9	2	课堂教学	课堂讲授、雨课堂、考勤、测试、弹幕互动	5-2 化学气相沉积过程的热力学：化学反应的自由能变化、化学反应平衡的计算 5-3 化学气相沉积装置：高温和低温 CVD、常压和低压 CVD、激光辅助 CVD、金属有机化合物 CVD

10	2	课堂教学	课堂讲授、雨课堂、考勤、测试、弹幕互动	5-5 等离子体辅助化学汽相沉积(PECVD)技术 5-4 化学气相沉积实例：SiO_2、Si_3N_4、a-Si:H 和 a-C:H 薄膜的制备
11	2	课堂教学	课堂讲授、雨课堂、考勤、测试、弹幕互动	6-1 薄膜生长过程及形核理论概述 6-2 非晶薄膜 6-3 薄膜的外延生长概述
12	2	课堂教学	课堂讲授、雨课堂、考勤、测试、弹幕互动	7-1 干法刻蚀 7-2 等离子刻蚀 7-3 反应离子刻蚀、反应离子束辅助刻蚀 7-5 光辅助干法刻蚀 雨课堂单元测试
13	2	课堂教学	课堂讲授、雨课堂、考勤、测试、弹幕互动	8-1 薄膜附着力的测量方法 8-2 薄膜厚度测量技术 8-3 薄膜化学结构态的表征 （1）红外与拉曼光谱的基本原理 实例：a-Si:H 薄膜的红外吸收谱分析
14	2	课堂教学	课堂讲授、雨课堂、考勤、测试、弹幕互动	（2）椭偏光谱 实例：a-Si:H 薄膜的椭偏光谱分析 （3）紫外光谱的原理
15	2	课堂教学	课堂讲授、雨课堂、考勤、测试、弹幕互动	8-4 薄膜结构的分析方法：扫描电子显微镜、透射电子显微镜、扫描探针显微镜、X-射线衍射方法，电子衍射分析方法简述
16	2	课堂教学	课堂讲授、雨课堂、考勤、测试、弹幕互动	8-5 薄膜成分的分析：X射线能量色散谱(EDX)、俄歇电子能谱(AES)、X射线光电子能谱（XPS）、卢瑟福背散射谱(RBS)、二次离子质谱 雨课堂单元测试 期末考试复习

Shantou University

Module Description for Undergraduate Courses

COURSE TITLE:	Physics of optoelectronic material
COURSE CODE:	PHY3004A
CREDIT VALUE:	2
CONTACT HOURS:	32
PRE-REQUISITE	none
DEPARTMENT/UNIT:	Department of Physics
VERSION:	
COURSE COORDINATOR:	Ma Wenhui (Signature and Seal)
APPROVER:	Chi Lingfei (Signature and Seal)
APPROVE DATE:	20240731

Shantou University Faculty of Science

July 2024

1. Course Description

Materials constitute the fundamental basis for the development and application of various optoelectronic functional structures and devices. Through this course, students will gain a comprehensive understanding of the basic physical principles underlying mechanical, electrical, thermal, optical, and magnetic effects in materials; the key parameters used to characterize these physical properties; and the factors that determine or influence them.

The course emphasizes the explanation of fundamental concepts in materials physics and the construction of clear physical pictures. It provides a systematic introduction to charge-transport mechanisms in different types of materials, dielectric polarization mechanisms, piezoelectricity, pyroelectricity, ferroelectricity and other multifunctional effects, light–matter interactions, and nonlinear optical materials. The scientific modes of thinking conveyed in this course—including epistemology and methodology—play an important role in shaping students' worldview, values, and scientific literacy.

An essential educational goal of the course is to strengthen students' awareness of the fundamental physical issues underlying current technological bottlenecks ("critical chokepoints") in optoelectronic materials, thereby fostering motivation for learning, cultural confidence, and a sense of responsibility. Beginning with basic theory and progressing step by step, the course also aims to cultivate critical thinking and a rigorous, truth-seeking scientific spirit, ultimately enabling students to acquire foundational capabilities in scientific research and technological development.

Upon successful completion of the course and the establishment of corresponding physical models and conceptual frameworks, students should be able to::

1. Approach scientific problems from a materialist and dialectical perspective, developing an exploratory and inquisitive mindset.
2. Demonstrate critical thinking: identify contradictions and logical fallacies, analyze and synthesize theoretical arguments, and evaluate hypotheses using empirical evidence.
3. Understand and describe conduction mechanisms in various classes of materials.
4. Explain dielectric polarization mechanisms and analyze relaxation phenomena in dielectric materials.
5. Understand piezoelectric, pyroelectric, and ferroelectric effects, as well as general electromechanical and thermoelectric coupling behaviors.
6. Analyze interactions between solids and light, and understand transparent ceramics and their electro-optic effects.

2. Intended Learning Outcomes

Training Objectives	Knowledge Units / Competencies Standards	Initial Level	Target Level	Expected Learning Outcomes
1. Electrical Conductivity	1.1 Conductivity of Pure Metals	L2	L4	Analyze the fundamental origins of electrical resistance in pure metals and identify the key factors influencing resistivity.
	1.2 Conductivity of Solid Solutions	L2	L4	Analyze the mechanisms governing conductivity modulation in solid-solution systems.

	1.3 Ionic Conductivity	L2	L4	Analyze ionic conduction mechanisms and perform relevant formula derivations; understand fast-ion conductors and their applications.
	1.4 Semiconductor Conductivity and Doping	L2	L4	Analyze why donor and acceptor doping in semiconductors modifies their electrical behavior. **[Civic Education]:** Connect semiconductor research in China to the cultivation of scientific commitment and technological responsibility.
	1.5 Superconductivity	L1	L3/L5	Understand superconductivity, related materials, and applications. **[Civic Education]:** Discuss the discovery of high-temperature superconductivity as an example of scientific literacy and rigor.
2. Fundamentals of Dielectrics	2.1 Polarization Mechanisms	L1	L3	Understand the microscopic mechanisms of dielectric polarization.
	2.2 Complex Permittivity	L2	L4/L5	Analyze dielectric relaxation and complex permittivity. **[Civic Education]:** Introduce Debye relaxation as an example of viewing scientific problems from a materialist and dialectical perspective.
3. Ferroelectricity and Piezoelectricity	3.1 Ferroelectric Crystals	L1	L3	Understand ferroelectricity and the corresponding crystal structures.
	3.2 Spontaneous Polarization and Curie Transition	L2	L4/L5	Analyze ferroelectric phase transitions and understand the fundamental thermal properties of related materials. **[Civic Education]:** Review the origins of ferroelectricity as an illustration of scientific methodology.
	3.3 Piezoelectric Effect	L1	L4	Perform calculations of the direct and inverse piezoelectric effects.
	3.4 Electrostriction	L1	L4	Perform calculations of electrostriction; understand basic concepts of elasticity in materials and compute spontaneous strain.

	3.5 Piezoelectric Ceramics	L2	L4 L4	Analyze the structure and properties of piezoelectric ceramics. **[Civic Education]:** Discuss the development of piezoelectric ceramics to promote a spirit of scientific exploration.
4. Optical Ceramics	4.1 Light–Matter Interaction	L2	L4 L4	Analyze the interaction between light and solids.
	4.2 Transparent Ceramics	L2	L4 L4	Analyze the mechanisms underlying optical transparency in ceramics. **[Civic Education]:** Use porosity and its effect on transparency to illustrate hypothesis testing with theory and empirical evidence.
	4.3 Electro-Optic Effects in Ceramics	L2	L3	Understand linear and quadratic electro-optic effects.
5. Infrared Sensing and Detection Materials	5.1 Pyroelectric Materials	L2	L4 L4	Analyze the temperature dependence of spontaneous polarization and its modulation by external fields. **[Civic Education]:** Examine pyroelectric effects above the Curie temperature to cultivate critical thinking and the ability to identify contradictory viewpoints.

3. Pre-requisit

None

4. Textbooks and Other Learning Resources

Recommended References

Tian Shi (Ed.), *Physical Properties of Materials*, Beihang University Press.

5. Teaching and Learning Activities

Teaching Segment	Lectures (Theory)	Exercise	Laboratory Work	Research	Social Practice	Project Work	Online Learning Others	Mid-Term Exam	Total
Hours (In-class)	32	0	0		0	0	0	0	32
Hours (Out-of-class)		48	0	16	0		0	0	64

7. Assessment Scheme

Assessment item	Description / Assessment criteria	Weight
Coursework	In-class Participation and Engagement: Includes active listening and answering questions during lectures. Assignments and Research/Investigation: Includes outside practice, exercises, and related Research/Fact-finding tasks.	60%
Final Examination	Closed-Book Written Examination: Consists of Short Answer Questions and Analytical Questions (Duration: 120 minutes).	40%

7. Course Schedule

Week	Hour	Teaching format	Teaching content
1	2	Lecture	Electrical resistance in pure metals and the factors influencing resistivity
2	2	Lecture & Discussion	Electrical conductivity of metallic solid solutions
3	2	Lecture	Conduction mechanisms in ionic crystals
4	2	Lecture	Fast-ion conductors and their applications
5	2	Lecture	(1) Semiconductor conductivity and doping; (2) Superconductivity, related materials, and applications
6	2	Lecture	Microscopic mechanisms of dielectric polarization
7	2	Lecture	Dielectric relaxation and complex permittivity
8	2	Lecture	Ferroelectricity and related crystal structures
9	2	Lecture	Ferroelectric phase transitions and basic thermal properties of relevant materials
10	2	Lecture	Calculation of direct and inverse piezoelectric effects
11	2	Lecture	Electrostriction and calculation of spontaneous strain
12	2	Lecture	Fundamental concepts of elasticity in materials
13	2	Lecture & Discussion	Structure and properties of piezoelectric ceramics
14	2	Lecture	Interaction of light with solids; mechanisms of optical transparency in ceramics
15	2	Lecture & Discussion	Electro-optic effects in ceramics and their applications
16	2	Lecture	Pyroelectric effect and its modulation by external fields

汕头大学本科教学

课程教学大纲

课程名（COURSE TITLE）：	光电材料物理
课程代码（COURSE CODE）：	PHY3004A
学分（CREDIT VALUE）：	2
课内课时（CONTACT HOURS）：	32
先修课要求（PRE-REQUISITE）	无
开课单位（DEPARTMENT/UNIT）：	物理学系
版本（VERSION）：	
课程负责人（COURSE COORDINATOR）：	马文辉 (签章)
审核人（APPROVER）：	池凌飞(签章)
审核日期（APPROVE DATE）：	20240731

汕头大学理学院

2024 年 06 月

1、课程简介（Course Description）

材料是各种光电功能结构和器件开发和应用的物质基础。通过本课程的学习，学生能充分地认识和了解材料的弹性、电、热、光、磁等各种物理效应的基本原理，表征材料相关物理性质的主要参量，以及影响和决定这些物理参量的关键因素。本课程重视材料物理基本概念的讲解和物理图象的描述，系统地介绍各种材料的电导机制、材料的介电极化机制、压电、热释电、铁电等多功能材料、材料和光的相互作用以及非线性材料等内容。所体现的科学的思维方式以及认识论和方法论对世界观、价值观、人生观和素质能力等的培养有着重要的意义。本课程的思政培养目标是使学生充分认识到光电材料领域 “卡脖子”的物理问题，激发学生的学习热情和爱国情怀，增强文化自信；同时从基本理论出发，循序渐进地培养学生的批判性思维能力和实事求是的科学精神，进而使学生具备一定的科学研究和技术开发能力。通过学习材料物理的基本概念和知识并建立起相应的物理图象,学生应能够：

1. 能从唯物的、辩证的角度去看待科学问题；培养学生的家国情怀和勇于探索的精神。
2. 批判性思维：分析识别有矛盾的观点和逻辑谬误，归纳理论和事实验证假设。
3. 掌握各种材料的导电机制;
4. 掌握电介质的极化机制并分析介质的弛豫行为;
5. 掌握压电、热释电、铁电等力-热-电耦合行为;
6. 分析固体与光的相互作用，掌握透明陶瓷及其电光效应。

2、预期学习结果（Intended Learning Outcomes）

本课程的预期学习结果如下表：

知识单元	知识点	初始程度	要求程度	预期学习结果
1. 导电性	1.1 纯金属的电导	L2	L4	分析纯金属中产生电阻的根本原因，掌握电阻率的影响因素
	1.2 固溶体的电导	L2	L4	分析固溶体的电导调控机制
	1.3 离子电导	L2	L4	分析离子的电导机制并进行相关公式推导，掌握快离子导体及其应用
	1.4 半导体的电导与掺杂	L2	L4	分析为何半导体的施主和受主掺杂能改变其电导行为 思政：从我国半导体研究的发展历程谈起，主张家国情怀、科技报国
	1.5 超导电性	L1	L3 L5	掌握超导电性，相关材料及应用 思政：由高温超导的发现谈科学素养
2. 电介质初步	2.1 极化的机制	L1	L3	掌握电介质极化的微观机制
	2.2 复介电常数	L2	L4 L5	分析介质弛豫和复介电常数 思政：介绍德拜弛豫的研究--从唯物的、辩证的角度去看待科学问题
3. 铁电与压电	3.1 铁电晶体	L1	L3	掌握铁电性及相关晶体结构
	3.2 自发极化与居里相变	L2	L4	分析铁电相变过程，并掌握相关材料的基本热学性质

			L5	思政：铁电性起源的回顾——科学方法论
	3.3 压电效应	L1	L4	计算正、逆压电效应
	3.4 电致伸缩	L1	L4	计算电致伸缩效应，掌握材料弹性的基本概念，计算自发应变
	3.5 压电陶瓷	L2	L4 L4	分析压电陶瓷的结构与性质 思政：压电陶瓷的研发--主张勇于探索精神
4. 光学陶瓷	4.1 光与固体	L2	L4 L4	分析光与固体的相互作用
	4.2 透明陶瓷	L2	L4 L4	分析陶瓷的透光性机理 思政：气孔如何影响透光性--归纳理论和事实验证假设。
	4.3 陶瓷的电光效应	L2	L3	掌握线性和二次电光效应
5. 红外传感与探测材料	5.1 热释电体	L2	L4 L4	分析自发极化的温度效应及其外场调控 思政：居里温度以上的热释电效应--培养批判性思维，分析识别有矛盾的观点

3、先修要求（Pre-requisite）

无

4、教材及其他教学资源（Textbooks and Other Learning Resources）

指定教材：

田莳编著，材料物理性能，北京航空航天大学出版社.

5、主要教学环节（Teaching and Learning Activities）

教学环节	理论课（小时）	练 习（小时）	实验（小时）	调 研（小时）	社会实践（小时）	项目（小时）	在线学习（小时）	期中测试（小时）	合计
课内	32	0	0		0	0	0	0	32
课外		48	0	16	0		0	0	64

6、课程考核（Assessment Scheme）

考核项目	考核内容和考试方法简介	权重
平时练习	听课及回答问题，课外练习及相关调研	60%
期末考试	闭卷笔试（简答题、分析题），时间 120 分钟	40%

7、学习进度（Course Schedule）

周次	教学时数	教学形式	教学内容
1	2	课堂讲授	纯金属中的电阻及其影响因素
2	2	课堂讲授、研讨	金属固溶体的电导
3	2	课堂讲授	离子晶体的电导机制
4	2	课堂讲授	快离子导体及其应用
5	2	课堂讲授	(1) 半导体的电导与掺杂；(2) 超导现象，相关材料及其应用
6	2	课堂讲授	电介质极化的微观机制
7	2	课堂讲授	介质弛豫和复介电常数
8	2	课堂讲授	铁电性及相关晶体结构
9	2	课堂讲授	铁电相变过程，相关材料的基本热学性质

10	2	课堂讲授	正、逆压电效应的计算
11	2	课堂讲授	电致伸缩效应，自发应变的计算
12	2	课堂讲授	材料弹性的基本概念
13	2	课堂讲授、研讨	压电陶瓷的结构与性质
14	2	课堂讲授	光与固体的相互作用，陶瓷的透光性机理
15	2	课堂讲授、研讨	陶瓷的电光效应及其应用
16	2	课堂讲授	热释电效应及其外场调控

Shantou University

Module Description for Undergraduate Courses

COURSE TITLE:	Atomic Physics
COURSE CODE:	PHY2080A
CREDIT VALUE:	3
CONTACT HOURS:	48
PRE-REQUISITE	Optics, Electromagnetism
DEPARTMENT/UNIT:	Department of Physics
VERSION:	20240731-PHY2080A
COURSE COORDINATOR:	(Signature and Seal)
APPROVER:	Chi Lingfei (Signature and Seal)
APPROVE DATE:	20240731

Shantou University Faculty of Science

July 2024

1. Course Description

Atomic Physics belongs to the domain of general physics and is an important foundational course in the physics curriculum, following Mechanics, Electromagnetism, and Optics. This course begins with experimental observations and introduces key modern physical concepts and principles concerning the microscopic world. Using the framework of quantum mechanics, together with selected classical concepts, it explains the fundamental problems and essential topics of atomic physics and explores the structure of atoms and the laws governing their motion.

This course provides the foundation for subsequent courses such as Quantum Mechanics, Solid State Physics, and Modern Physics Experiments, and is a compulsory course for undergraduate physics majors. It prepares students for academic development in Atomic Physics, Nuclear Physics, and Quantum Technology.

As a required course under the Shantou University Physics major training program, its main content includes:

The basic properties of atoms, atomic energy levels and radiation, an introduction to quantum mechanics, alkali metal atoms and electron spin, multi-electron atoms, atoms in magnetic fields, atomic shell structure, X-rays, molecular structure and molecular spectra, atomic nuclei, and elementary particles.

Through this course, students are expected to:

1. Build a solid physical understanding and conceptual framework of the microscopic world; master the structure, spectra, motion laws, and research methods of atoms; and gain introductory knowledge of molecular physics, nuclear physics, and high-energy physics. Students should be able to acquire the basic methods for studying atomic physics, understand how to analyze experimental results, construct physical models, and ultimately develop theoretical frameworks.
2. Develop the ability to analyze and solve problems, as well as the capability to construct theoretical models based on experimental observations, through the study of key experimental phenomena and the progressive development of theoretical systems. Students should also develop a dialectical materialist worldview, a rigorous and pragmatic scientific attitude, and a spirit of innovation and exploration.

The learning objectives of this course correspond to the following graduation requirement indicators in the Physics major training program:

3.1 Mastery of fundamental theories and core knowledge of physics;

5.1 Ability to conduct research based on scientific principles and methodologies;

6.1 Research and engineering ability to solve scientific problems.

2. Intended Learning Outcomes

Knowledge Unit	Key Knowledge Points	Initial Level	Required Level	Expected Learning Outcomes
1. Basic Properties of Atoms	1.1 Atomic Mass and Size 1.2 Nuclear Structure of the Atom 1.3 Isotopes	L1	L3	1. Summarize the research scope and methods of atomic physics. 2. Summarize the historical development of atomic physics, nuclear physics, and particle physics. 3. Summarize the background leading to the proposal of the nuclear model of the atom. 4. Explain the microscopic dimensions and size of atoms.

				5. Describe the nuclear model of the atom (Rutherford model). 6. Explain the differences between the Thomson model and the Rutherford model, and understand Rutherford scattering theory.
2. Atomic Energy Levels and Radiation	2.1 Spectra — One of the Important Approaches to Studying Atomic Structure 2.2 Spectra of Hydrogen and General Features of Atomic Spectra 2.3 Bohr's Theory of the Hydrogen Atom and Universal Atomic Regularities 2.4 Spectra of Hydrogen-like Ions 2.5 Franck–Hertz Experiment and Atomic Energy Levels 2.6 Quantization Rules 2.7 Elliptical Electron Orbits and Relativistic Effects in Hydrogen 2.8 Stern–Gerlach Experiment and Space Quantization 2.9 Atomic Excitation, Radiation, and Laser Principles 2.10 Correspondence Principle and the Status of Bohr's Theory	L1	L3	1. Explain the regularities and spectral series of the hydrogen atom. 2. Apply Bohr's atomic model and theory to explain the structure and spectral regularities of hydrogen and hydrogen-like ions; be able to draw energy-level transition diagrams. 3. Understand the Sommerfeld quantization condition and the elliptical-orbit model of electrons. 4. Understand the principles and conclusions of the Franck–Hertz experiment and the Stern–Gerlach experiment. 5. Summarize the limitations of Bohr's hydrogen-atom model.
3. Introduction to Quantum Mechanics	3.1 Wave–Particle Duality 3.2 Uncertainty Relations 3.3 Wavefunction and Its Physical Meaning 3.4 Schrödinger Equation 3.5 Several Simple Quantum Examples 3.6 Quantum Mechanical Description of the Hydrogen Atom	L1	L3	1. Understand the meaning and properties of matter waves. 2. Explain the Heisenberg uncertainty principle. 3. Understand the physical meaning of the wavefunction. 4. Summarize the role of the Schrödinger equation in quantum mechanics and the conclusions obtained from applying it to the hydrogen atom.
	4.1 Spectra of Alkali-Metal Atoms	L1	L3	1. Understand the spectral laws of alkali-metal

4. Alkali-Metal Atoms and Electron Spin	4.2 Core Polarization and Orbital Penetration 4.3 Fine Structure of Alkali-Metal Spectra 4.4 Spin–Orbit Interaction 4.5 Selection Rules for Single-Electron Transitions 4.6 Fine Structure of Hydrogen and the Lamb Shift			atoms and the effects of core polarization and orbital penetration on their spectra. 2. Understand electron spin and the meaning of the spin quantum number. 3. Compute the interaction between electron spin and orbital motion. 4. Apply the physical origin of fine-structure splitting in alkali-metal spectra. 5. Use spectroscopic notation for single-electron atomic states.
5. Multi-Electron Atoms	5.1 Spectra and Energy Levels of Helium and Group-II Elements 5.2 Atomic States with Two Electrons 5.3 Pauli Principle and Identical Electrons 5.4 General Laws of Complex Atomic Spectra 5.5 Universal Selection Rules for Radiative Transitions 5.6 Example of Atomic Excitation and Radiation — He–Ne Laser	L1	L3	1. Use the general laws and analytical methods for spectra of two-valence-electron atoms. 2. Draw atomic energy-level transition diagrams. 3. Understand the two coupling schemes of two-electron systems and explain physical laws using the vector model of the atom (mainly LS coupling). 4. Describe the Pauli principle and universal selection rules for radiative transitions, and apply them to problem-solving. 5. Understand atomic excitation, radiation processes, and the basic principles of lasers.
6. Atoms in Magnetic Fields	6.1 Atomic Magnetic Moments 6.2 Effects of External Magnetic Fields 6.3 Results of the Stern–Gerlach Experiment 6.4 Paramagnetic Resonance 6.5 Zeeman Effect	L1	L3	1. Understand atomic magnetic moments. 2. Identify and explain the interaction between atoms and magnetic fields. 3. Describe the four quantum numbers that specify electronic motion in atoms. 4. Understand the Stern–Gerlach experiment and analyze its results. 5. Explain the Zeeman effect (normal and anomalous) and its significance.

	6.6 Diamagnetism, Paramagnetism, and Ferromagnetism			6. Apply the Zeeman effect to solve practical problems. 7. Understand diamagnetism, paramagnetism, and ferromagnetism.
7. Atomic Shell Structure	7.1 Periodic Variation of Element Properties 7.2 Electronic Shell Structure 7.3 Ground-State Electron Configurations	L1	L2	1. Summarize the structure of the periodic table. 2. Understand Bohr's physical explanation of the periodic table. 3. Understand and apply electron-filling principles in atomic shells, and use shell structure to explain the periodicity of elemental properties. 4. Identify ground-state electron configurations and term symbols. 5. Summarize the origin of level interleaving during electron filling.
8. X-Rays	8.1 Generation of X-Rays and Measurement of Wavelength and Intensity 8.2 Emission Spectra of X-Rays 8.3 Inner-Shell Atomic Energy Levels Related to X-Rays 8.4 X-Ray Absorption 8.5 Compton Effect 8.6 X-Ray Diffraction in Crystals	L1	L2	1. Understand the properties of X-rays. 2. Understand the formation mechanisms and features of the continuous and characteristic spectra of X-rays. 3. Understand energy-level structures associated with inner shells. 4. Understand mechanisms of X-ray absorption and the features of absorption spectra. 5. Summarize the cause of the Compton effect. 6. Understand X-ray diffraction.
9. Molecular Structure and Molecular Spectra	9.1 Molecular Bonding 9.2 Molecular Spectra and Molecular Energy Levels 9.3 Electronic States of Diatomic Molecules 9.4 Vibrational Spectra of Diatomic Molecules 9.5 Rotational Structure of Diatomic Spectra and Determination of Molecular Constants	L1	L2	1. Provide examples of major types of chemical bonds. 2. Summarize general laws of molecular energy levels and molecular spectra; write the spectroscopic notation for electronic states of diatomic molecules.

	9.6 Raman Scattering			
	9.7 Brief Description of Polyatomic Molecules			
10. Atomic Nuclei	10.1 Basic Properties of Atomic Nuclei	L1	L2	1. Summarize the general properties of nuclei. 2. Explain the laws and categories of radioactive decay. 3. Explain mechanisms and classifications of nuclear reactions.
	10.2 Radioactive Decay			
	10.3 Interaction of Radiation with Matter and Applications of Radioactivity			
	10.4 Nuclear Forces			
	10.5 Nuclear Structure Models			
	10.6 Nuclear Reactions			
	10.7 Nuclear Fission and Nuclear Energy			
	10.8 Nuclear Fusion and Prospects of Nuclear-Energy Utilization			
11. Elementary Particles (Self-Study)	11.1 Interactions of Elementary Particles	L1	L2	1. Summarize electromagnetic interaction and weak interaction among the four fundamental interactions. 2. Summarize classifications of elementary particles. 3. Understand conservation laws and symmetry principles.
	11.2 Observation of Particles			
	11.3 Conservation Laws and Symmetry Principles			
	11.4 Resonant States			
	11.5 Classification of Hadrons and the Quark Model			
	11.6 Electromagnetic Interaction			
	11.7 Weak Interaction			

3. Pre-requisit

Optics, Electromagnetism

4. Textbooks and Other Learning Resources

Required Textbooks

Chu Shenglin, *Atomic Physics*, 2nd Edition, Higher Education Press, 2022.

Recommended Textbooks

[1] Yang Fujia, *Atomic Physics*, 5th Edition, Higher Education Press, 2019

[2] Cui Hongbin, *Atomic Physics*, 2nd Edition, University of Science and Technology of China Press, 2012

[3] Richard P. Feynman, *The Feynman Lectures on Physics III*

[4] Christopher J. Foot, *Atomic Physics,* 2023

Online Resources

my.stu.edu.cn

5. Teaching and Learning Activities

Note:

The original table did not include the out-of-class hours due to an omission. However, the detailed description following the table specifies the distribution of out-of-class study hours. Therefore, the translated table adopts the allocation stated in the descriptive text.

Teaching Segment	Lectures (Theory)	Exercise Classes	Laboratory Work	Seminars	Social Practice	Project Work	Online Learning	Mid-Term Test	Total
Hours (In-class)	48	0	0	0	0	0	0	0	48
Hours (Out-of-class)	72	20	0	0	0	0	4	0	96

The content of this course is abstract. Classroom teaching alone cannot ensure full comprehension, and students must engage in self-study outside class. The ratio of self-study hours to classroom hours is 2:1, amounting to 96 hours of self-study. Among these, 72 hours are allocated to theoretical study, 20 hours to completing exercises, and 4 hours to literature review, discussions, and related activities.

6. Assessment Scheme

Assessment item	Description	Weight
Exercises, Discussions, and Questions	After-class exercises and reflection; classroom participation, speaking, and questioning. Evaluation Criteria: After-class exercises: Are basic concepts and reasoning clear? Are formulas used correctly? Is the logic complete? Classroom participation, speaking, questioning: Is the student attentive in class? Do they actively participate in discussions or raise questions? Do they proactively search for and prepare relevant materials?	40%
Final Examination	Closed-book final exam	60%

Continuous Assessment:

Attendance, class participation, speaking, and questioning: 20%, evaluated by the instructor

Course exercises: 20%, evaluated jointly by the instructor and teaching assistant

Final Examination:

The exam assesses students' mastery of the course's fundamental concepts, physical models, and methods, including topics such as atomic spectral lines, atomic states, drawing energy-level transition diagrams, Zeeman effect, etc.

7. Course Schedule

Week	Hour	Teaching format	Teaching content
1	3	Lecture	Introduction; atomic mass and size; nuclear model of the atom; isotopes
2	3	Lecture	Spectra and atomic spectra; hydrogen atomic spectrum; Bohr model of the hydrogen atom; general properties of atoms; hydrogen-like ion spectra
3	3	Lecture	Franck–Hertz experiment; atomic energy levels; quantization rule; elliptical electron orbits; relativistic corrections to hydrogen energy levels; Stern–Gerlach experiment; space quantization; atomic excitation and radiation; correspondence principle
4	3	Lecture	Wave–particle duality; uncertainty relation; wavefunction and its physical meaning; Schrödinger equation
5	3	Lecture	One-dimensional infinite potential well; harmonic oscillator
6	3	Lecture	Schrödinger equation and wavefunctions of the hydrogen atom
7	3	Lecture	Spectra of alkali-metal atoms; atomic core polarization; orbital penetration; fine structure of alkali-metal atomic spectra
8	3	Lecture	Spin–orbit interaction; selection rules for single-electron radiative transitions; fine structure of hydrogen spectra
9	3	Lecture	Group-II atomic spectra and energy levels; two-valence-electron atomic states; Pauli principle; equivalent electrons
10	3	Lecture	Regularities of complex atomic spectra; selection rules for radiative transitions; He–Ne laser
11	3	Lecture	Atomic magnetic moment; interaction of atoms with external magnetic fields; results of the Stern–Gerlach experiment
12	3	Lecture	Electron paramagnetic resonance; Zeeman effect; diamagnetism; paramagnetism; ferromagnetism
13	3	Lecture	Periodic table; periodic variations of elemental properties; electronic shell structure; ground-state electron configurations
14	3	Lecture	Ionic bonds; covalent bonds; molecular spectra; molecular energy levels; electronic states of diatomic molecules; vibrational spectra
15	3	Lecture	X-ray production and detection; continuous spectrum; characteristic spectrum; X-ray-related atomic energy levels; X-ray absorption; Compton effect; X-ray crystal diffraction
16	3	Lecture	Properties of atomic nuclei; nuclear decay; applications of radioactivity; nuclear structure models; nuclear fission; nuclear fusion; atomic energy

汕头大学本科教学

课程教学大纲

课程名（COURSE TITLE）：	原子物理学
课程代码（COURSE CODE）：	PHY2080A
学分（CREDIT VALUE）：	3
课内课时（CONTACT HOURS）：	48
先修课要求（PRE-REQUISITE）	光学、电磁学
开课单位（DEPARTMENT/UNIT）：	物理学系
版本（VERSION）：	20240731-PHY2080A
课程负责人（COURSE COORDINATOR）：	王志诚 (签章)
审核人（APPROVER）：	池凌飞(签章)
审核日期（APPROVE DATE）：	20240731

汕头大学理学院

2024 年 7 月

1、课程简介（Course Description）

原子物理学（Atomic Physics）属于普通物理学的范畴，是物理学专业继力学、电磁学和光学等课程的又一门重要基础课程。本课程从物理实验结果出发，引进近代物理关于微观世界的重要概念和原理，用微观粒子服从的量子力学理论并结合一些经典物理概念，阐明原子物理的基本问题和基本内容，探讨原子的结构及其运动规律。本课程是量子力学、固体物理、近代物理实验等课程的基础，是物理学专业本科生必修课程之一。通过本课程，将为原子物理、原子核物理、量子技术等领域培养物理学专业学术型人才奠定基础。

本课程属于汕头大学物理学专业人才培养方案的专业必修模块课程，主要内容包含原子的基本状况、原子的能级和辐射、量子力学初步、碱金属原子和电子自旋、多电子原子、在磁场中的原子、原子的壳层结构、X 射线、分子结构和分子光谱、原子核、基本粒子。通过本课程的学习，学生应能够：

（1）坚定中国特色社会主义道路，使学生树立坚定的理想信念；

（2）培养和树立正确的价值观和社会责任感；

（3）建立丰富的微观世界的物理图像和物理概念，熟练掌握原子的结构、光谱、运动规律和研究方法，初步了解分子物理、原子核物理以及高能物理的基本知识；使学生能够掌握研究原子物理问题的基本方法，明确如何由分析物理实验结果出发、建立物理模型，进而建立物理理论体系的过程。

（4）通过对重要实验现象以及理论体系逐步完善过程的分析，具备分析问题、解决问题的能力，以及从实验结果出发建立理论模型的能力。同时还应具备辩证唯物主义世界观和严谨求实的科学态度以及开拓创新的探索精神。

本课程目标对应物理学专业人才培养方案毕业要求指标点：1.坚定的理想信念；2.正确价值观和社会责任感；3.1 掌握物理学的基础理论和专业知识；5.1 具备基于科学原理和方法进行研究的能力；6.1 解决问题的研究和工程能力。

2、预期学习结果（Intended Learning Outcomes）

<table>
<tr><th>知识单元</th><th>知识点</th><th>初始程度</th><th>要求程度</th><th>预期学习结果</th></tr>
<tr><td rowspan="3">1. 原子的基本状况</td><td>1.1 原子的质量和大小</td><td rowspan="3">L1</td><td rowspan="3">L3</td><td rowspan="3">1. 概括原子物理学的研究内容和研究方法。
2. 概括原子物理学、原子核物理、粒子物理的发展史。
3. 概括原子核式结构产生的背景。
4. 解释原子的微观尺寸和大小。
5. 说明原子的核式结构模型-卢瑟福模型。
6. 说明对汤姆孙模型和卢瑟福模型的区别的理解，理解对卢瑟福散射理论。

思政：卢瑟福在科学上取得了伟大的成就，还培养了许多杰出科学家；汤姆逊利用创造性思维提出假说和物理模型的科学研究方法发现了电子，这些事迹体</td></tr>
<tr><td>1.2 原子的核式结构</td></tr>
<tr><td>1.3 同位素</td></tr>
</table>

				现了科学家们严谨的科学态度和精神，契而不舍、实事求是的科学情感态度与价值观。通过这些科学家的故事培养学生良好的学术道德和实事求是的精神。
2. 原子的能级和辐射	2.1 光谱——研究原子结构的重要途径之一 2.2 氢原子的光谱和原子光谱的一般情况 2.3 玻尔的氢原子理论和关于原子的普遍规律 2.4 类氢离子的光谱 2.5 弗兰克-赫兹实验与原子能级 2.6 量子化通则 2.7 电子的椭圆轨道与氢原子的能量的相对论效应 2.8 施特恩-格拉赫实验与原子空间取向量子化 2.9 原子的激发与辐射 激光原理 2.10 对应原理与玻尔理论的地位	L1	L3	1. 解释氢原子光谱的规律和线系。 2. 应用玻尔的原子模型及原子理论，并运用该理论来解释氢原子和类氢离子的结构及其光谱规律，能熟练画出能级跃迁图。 3. 理解索末非量子化条件和电子的椭圆轨道理论。 4. 理解夫兰克-赫兹和史特恩-盖拉赫两个实验原理及其结论。 5. 总结与概括玻尔氢原子理论的局限性。 思政：介绍 FAST 系统在高科技领域的影响和对中国制造技术向信息化、极限化和绿色化的方向发展产生的影响。强调创新意识，勉励学生勇于创新，不断提高自己的能力和水平，奉献社会。
3. 量子力学初步	3.1 物质的二象性 3.2 不确定关系 3.3 波函数及其物理意义 3.4 薛定谔波动方程 3.5 量子力学问题的几个简例 3.6 量子力学对氢原子的描述	L1	L4	1. 理解物质波的意义及其性质。 2. 说明海森堡不确定原理。 3. 理解波函数的物理意义。 4. 概述薛定谔方程在量子力学中的地位和用薛定谔方程解决氢原子问题所得到的结论。 思政：量子力学的建立是普朗克、德布罗意、爱因斯坦、玻尔、海森堡、薛定谔和狄拉克等人打破固有思维，冲破经典理论束缚，在实践中建立起来的理论，量子力学的发展推动了现代高新技术的发展。在课堂上向学生介绍量子力学的发展历程，激发学生的创新意识，培养学生的创造性思维。创新是一个民族进步的灵魂，中华名族的伟大复兴将在一代青年的奋斗中变为现实。 思政：通过物质的波粒二象性引导学生用辩证的方法看待问题，主张唯物主义认识论，厚植爱国主义情怀，具有强国志、报国行，为营造民主、文明、和谐国家做贡献。
4. 碱金属原子和电子自旋	4.1 碱金属原子的光谱 4.2 原子实的极化和轨道的贯穿 4.3 碱金属原子光谱的精细结构 4.4 电子自旋同轨道运动的相互作用 4.5 单电子辐射跃迁的选择定则 4.6 氢原子光谱的精细结构与兰姆位移	L1	L3	1. 理解碱金属光谱规律，了解原子实极化和轨道贯穿对光谱的影响。 2. 理解掌握电子自旋与自旋量子数的意义。 3. 计算电子自旋与轨道运动的相互作用。 4. 应用碱金属原子光谱的精细结构形成的物理本质。 5. 使用但电子原子态的符号描述。

<table>
<tr><td rowspan="6">5. 多电子原子</td><td>5.1 氦及周期系第二族元素的光谱和能级</td><td rowspan="6">L1</td><td rowspan="6">L3</td><td rowspan="6">1. 使用两个价电子原子光谱的一般规律及其分析方法。
2. 作图画出原子能级跃迁图。
3. 理解两个电子耦合的两种方法，能够用原子的矢量模型（主要是 LS 耦合）解释一些物理规律。
4. 说明泡利原理和辐射跃迁的普适选择定则，并能够用于分析问题。
5. 理解原子的激发与辐射的规律以及基本的激光原理。

思政：以激光器的诞生和国内在激光领域的发展与研究向学生传播先进文化和科技，鼓励学生勇于创新，不断提高工作能力和水平，奉献社会。</td></tr>
<tr><td>5.2 具有两个电子的原子态</td></tr>
<tr><td>5.3 泡利原理和同科电子</td></tr>
<tr><td>5.4 复杂原子光谱的一般规律</td></tr>
<tr><td>5.5 辐射跃迁的普适选择定则</td></tr>
<tr><td>5.6 原子的激发和辐射跃迁的一个实例——氦氖激光器</td></tr>
<tr><td rowspan="6">6. 在磁场中的原子</td><td>6.1 原子的磁矩</td><td rowspan="6">L1</td><td rowspan="6">L3</td><td rowspan="6">1. 理解原子磁矩。
2. 发现并说明磁场对原子的相互作用。
3. 说明描述原子的电子运动状态的四个量子数。
4. 理解施特恩-格拉赫实验的思想，能分析施特恩-格拉赫实验的结果。
5. 说明塞曼效应（包括正常塞曼效应和反常塞曼效应）的内容及意义
6. 应用塞曼效应相关知识解决一些实际问题。
7. 理解原子的抗磁性、顺磁性和铁磁性。</td></tr>
<tr><td>6.2 外磁场对原子的作用</td></tr>
<tr><td>6.3 施特恩-格拉赫实验的结果</td></tr>
<tr><td>6.4 顺磁共振</td></tr>
<tr><td>6.5 塞曼效应</td></tr>
<tr><td>6.6 抗磁性、顺磁性和铁磁性</td></tr>
<tr><td rowspan="3">7. 原子的壳层结构</td><td>7.1 元素性质的周期性变化</td><td rowspan="3">L1</td><td rowspan="3">L2</td><td rowspan="3">1. 总结元素周期表的结构。
2. 理解玻尔对元素周期表的物理解释。
3. 理解并掌握电子填充原子壳层的原则，能够通过原子的壳层结构解释元素具有周期性的内在根源。
4. 辨别原子基态的电子组态及其原子态符号。
5. 概括电子填充时出现能级交错的原因。</td></tr>
<tr><td>7.2 原子的电子壳层结构</td></tr>
<tr><td>7.3 原子基态的电子组态</td></tr>
<tr><td rowspan="6">8.X 射线</td><td>8.1 X 射线的产生及其波长、强度的测量</td><td rowspan="6">L1</td><td rowspan="6">L2</td><td rowspan="6">1. 理解 X 射线的性质。
2. 理解 X 射线包括连续谱和标识谱的产生机制和特征。
3. 理解与原子内壳层有关的能级结构。
4. 理解 X 射线吸收的机制和吸收谱的特点。
5. 总结康普顿效应产生的原因。
6. 理解 X 射线衍射。

思政：介绍北京正负电子对撞机在 X 射线激发发光实验和 X 光激发荧光光谱分析等方面的研究，通过建造对撞机的时代背景培养学生具有政治意识、大局意识、核心意识、看齐意识。</td></tr>
<tr><td>8.2 X 射线的发射谱</td></tr>
<tr><td>8.3 同 X 射线有关的原子能级</td></tr>
<tr><td>8.4 X 射线的吸收</td></tr>
<tr><td>8.5 康普顿效应</td></tr>
<tr><td>8.6 X 射线在晶体中的衍射</td></tr>
<tr><td rowspan="4">9. 分子结构和分子光谱</td><td>9.1 分子的键联</td><td rowspan="4">L1</td><td rowspan="4">L2</td><td rowspan="4">1. 举例分子形成的几种主要化学键。
2. 概括分子能级和分子光谱的一般规律，并能够用符号写出双原子分子电子态的表示式。</td></tr>
<tr><td>9.2 分子光谱和分子能级</td></tr>
<tr><td>9.3 双原子分子的电子态</td></tr>
<tr><td>9.4 双原子分子的振动光谱</td></tr>
</table>

	9.5 双原子分子光谱的转动结构和分子常量的测定 9.6 组合散射（拉曼效应） 9.7 多原子分子简述			3. 理解双原子分子光谱的转动结构。
10.原子核	10.1 原子核的基本性质 10.2 原子核的放射衰变 10.3 射线同实物的相互作用核放射性的应用 10.4 核力 10.5 原子核结构模型 10.6 原子核反应 10.7 原子核裂变和原子能 10.8 原子核的聚变和原子能利用的展望	L1	L2	1. 概括原子核的一般性质。 2. 说明原子核的放射性衰变规律和分类。 3. 说明原子核反应的机制和类型。 思政：介绍原子核聚变利用前景和一些相关装置，以及我国在实现可控核聚变的贡献和成果，鼓励学生勇于创新，为国奉献。结合改革开放成就，让学生懂得推进全面建成小康社会、全面深化改革、全面依法治国、全面从严治党队国家实现现代化强国的重要性。 思政：介绍全超导托卡马克核聚变实验装置(EAST)及其在国际核聚变研究领域占有的重要地位。通过了解当代科学家在科技领域取得成就及国家发展需求，激发学生们社会责任和历史使命感。
11.基本粒子（自学）	11.1 基本粒子核粒子的相互作用 11.2 粒子的观测 11.3 守恒定律核对称原理 11.4 共振态 11.5 强子分类和层子模型 11.6 关于电磁相互作用 11.7 弱相互作用	L1	L2	1. 总结物质的四种相互作用中的电磁相互作用和弱相互作用。 2. 概括基本粒子的分类。 3. 理解守恒律和对称原理。 思政：通过杨振宁和李政道先生因大胆提出“宇称不守恒”而获得了华人的第一个诺贝尔物理学奖的故事，激励学生“大胆假设，小心求证”，培养学生探索未知、追求真理、勇攀科学高峰的责任感和使命感。

3、先修要求（Pre-requisite）

光学、电磁学

4、教材及其他教学资源（Textbooks and Other Learning Resources）

指定教材：

《原子物理学》，第二版，褚圣麟 编，高等教育出版社，2022 年

参考书目：

[1]《原子物理学》，第五版，杨福家 编，高等教育出版社，2019 年

[2]《原子物理学》，第二版，崔宏滨 编，中国科学技术大学出版社，2012 年

[3]《The Feynman Lectures on Physics III》Richard P. Feynman

[4]《Atomic Physics》，Christopher J. Foot，2023 年

网络资源

my.stu.edu.cn

5、主要教学环节（Teaching and Learning Activities）

教学环节	理论课（小时）	习题课（小时）	实验（小时）	研讨（小时）	社会实践（小	项目（小时）	在线学习（小	期中测试（小	合计

					时）		时）	时）	
课内	48	0	0	0	0	0	0	0	48
课外	0	0	0	0	0	0	0	0	0

本课程内容较抽象，只进行课堂教学，学生无法全部理解课程内容，学生需要在课堂教学环节之外进行自学。自学环节课时与课堂教学课时比例为 2:1，即自学环节为 96 学时，其中理论内容学习 72 课时，完成习题 20 学时，查阅资料、讨论等 4 学时。

6、课程考核（Assessment Scheme）

考核项目	考核内容和考试方法简介	权重
练习、讨论、提问	课后作业及思考；课堂参与、发言、提问 评判标准： 课后作业：解题过程中基本概念和思路是否清晰？公式使用是否正确？逻辑方面是否完整？ 课堂参与、发言、提问：是否认真听课？是否积极参与讨论或提出问题？是否会积极查询准备资料？	40%
期末考试	期末闭卷考试	60%

本课程考核由课程平时学习表现和期末考试两部分组成，其中平时学习表现评分占比为40%，期末考试评分占比60%。

平时学习表现：出勤、课堂参与程度、发言、提问等占比20%，由教师评定；课程习题占比20%，由教师和助教共同评定。

期末考试：主要考察学生是否掌握本课程基本概念、物理模型和方法等内容，如原子谱线、原子态、画出能级跃迁图、塞曼效应等。

7、学习进度（Course Schedule）

周次	教学时数	教学形式	教学内容
1	3	课堂教学	绪论、原子的质量和大小、原子的核式结构、同位素
2	3	课堂教学	光谱和原子光谱、氢原子光谱、玻尔氢原子理论、原子的普遍规律、类氢离子光谱
3	3	课堂教学	弗兰克-赫兹实验、原子能级、量子化通则、电子的椭圆轨道、氢原子能量的相对论效应、施特恩-格拉赫实验、原子空间取向量子化、原子的激发与辐射、对应原理
4	3	课堂教学	波粒二象性、不确定关系、波函数及其物理意义、薛定谔波动方程
5	3	课堂教学	一维无限深势阱、简谐振子
6	3	课堂教学	氢原子的薛定谔方程和波函数
7	3	课堂教学	碱金属原子的光谱、原子实的极化、轨道贯穿、碱金属原子光谱精细结构
8	3	课堂教学	电子自旋同轨道运动的相互作用、单电子辐射跃迁的选择定则、氢原子光谱的精细结构

9	3	课堂教学	第二族元素的光谱和能级、两个价电子的原子态、泡利原理、同科电子
10	3	课堂教学	复杂原子光谱的规律、跃迁辐射的选择定则、氦氖激光器
11	3	课堂教学	原子的磁矩、外磁场对原子的作用、施特恩-格拉赫实验的结果
12	3	课堂教学	顺磁共振、塞曼效应、抗磁性、顺磁性、铁磁性
13	3	课堂教学	元素周期表、元素性质的周期性变化、电子壳层结构、原子基态的电子组态
14	3	课堂教学	X 射线产生及测量、连续谱、标识谱、X 射线有关的原子能级、X 射线吸收、康普顿效应、X 射线晶体衍射
15	3	课堂教学	离子键、共价键、分子光谱、分子能级、双原子分子的电子态、振动光谱
16	3	课堂教学	原子核的性质、衰变、放射性的应用、原子核结构模型、核裂变、核聚变、原子能

Shantou University
Module Description for Undergraduate Courses

COURSE TITLE:	Structure and properties
COURSE CODE:	PHY2013A
CREDIT VALUE:	2
CONTACT HOURS:	32
PRE-REQUISITE	None
DEPARTMENT/UNIT:	Department of Physics
VERSION:	20240731-PHY2013A
COURSE COORDINATOR:	(Signature and Seal)
APPROVER:	Chi Lingfei (Signature and Seal)
APPROVE DATE:	20240731

Shantou University　　Faculty of Science
July 2024

1. Course Description

(1) Nature of the Course

Structure and Properties is an elective course offered to students majoring in Optoelectronic Information Science and Engineering, Optoelectronic Information Science and Engineering (Microelectronics Track), and Physics. The interplay and integration among physics, chemistry, and materials science permeate nearly all areas of optical, electronic, and information technologies. From microelectronics to hydrogen energy, a central thread running through modern high-tech development is the intriguing relationship between structure and properties in the material world.

From diamond to graphite, fullerenes, carbon nanotubes, and finally graphene, the dramatic diversity in physical properties arises from variations in structure. This course introduces the fundamental structures of matter at multiple levels—from atoms to molecules to crystals—and explores their connections to macroscopic properties. It emphasizes the nature of chemical bonding, its influence on structure and performance, and the fundamental concepts of symmetry operations and point groups in molecules and crystals.

While delivering core knowledge, the course also briefly presents frontier progress and recent research achievements in related fields. The scientific methodology, epistemology, and ways of thinking conveyed herein play an important role in shaping students' worldview, values, cultural literacy, competencies, and knowledge structure. Upon completion, students will understand how foundational disciplines such as physics and chemistry intersect with engineering applications, while simultaneously cultivating research capability and scientific curiosity.

(2) Course Content

The main topics include:Atoms and molecules、Chemical bonding and molecular orbital theory、Symmetry and physical properties、Surfaces and interfaces、Selected frontier topics

(3) Course Objectives

① Approach scientific problems from a materialist and dialectical perspective; cultivate a spirit of exploration and the capacity for critical thinking, including the ability to analyze and identify contradictory viewpoints and logical fallacies, and to formulate and test hypotheses through the induction of theory and empirical evidence.
② Attain a solid understanding of atomic structure, chemical bonding, and molecular orbital theory.
③ Master molecular point groups and crystal point groups, and learn how to determine polarity and optical activity based on symmetry.
④ Understand the structural and property characteristics of quasicrystals, amorphous alloys, and ceramics, as well as the working principles of hydrogen-storage alloys and shape-memory alloys.
⑤ Understand surface structure and surface tension, surface adsorption and wetting, and gain a basic grasp of thin films and nanostructures.

This course provides essential theoretical foundations and research training that support the academic development of students in Optoelectronic Information Science and Engineering, Optoelectronic Information Science and Engineering (Microelectronics Track), and Physics. It strongly supports the fulfillment of the following graduation requirement indicators:" 3.2 Ability to learn and understand complex theories in the discipline 5.1 Ability to conduct research based on scientific principles and methodologies 6.1 Ability to identify, express, and analyze scientific and engineering problems in optoelectronics through literature research and to draw effective conclusions"

2. Intended Learning Outcomes

Training Objectives	Knowledge Units / Competencies Standards	Initial Level	Target Level	Expected Learning Outcomes
1. Atoms and Molecules	1.1 Atomic Structure	L1	L3	Master the structures of hydrogen and multi-electron atoms.
	1.2 Elements and Compounds	L2	L4	Master oxidation states, ionization energy, and electronegativity of elemental atoms.
	1.3 Spectra and Energy Spectra	L2	L4	Understand atomic spectra and electron energy spectra.
	Research on atomic structure as an example of scientific exploration.			
2. Chemical Bonding and Molecular Orbital Theory	2.1 Molecular Orbitals	L1	L3	Master molecular orbitals, energy-level ordering, hybrid orbitals, conjugation, and delocalized bonding.
	2.2 Bonding Types and Interactions	L2	L3	Understand ionic bonds, coordination bonds, hydrogen bonds, and van der Waals forces.
	Discovery of conjugation in benzene—scientific inquiry from a dialectical and materialist perspective.			
3. Symmetry and Physical Properties	3.1 Molecular Symmetry	L2	L3	Master symmetry elements and symmetry operations.
	3.2 Point Groups (Molecules)	L3	L4	Determine molecular point groups.
	3.3 Crystal Symmetry	L1	L4	Determine crystal point groups.
	3.4 Symmetry and Polarity	L3	L4	Determine polarity based on molecular/crystal symmetry.
	3.5 Symmetry and optical activity	L3	L4	Determination of optical activity based on the symmetry of molecules and crystals
	Using symmetry analysis to cultivate critical thinking and recognize logical contradictions.			
4. Special Topics and Frontiers	4.1 Quasicrystals and Amorphous Alloys	L2	L4	Compare structures and physical properties of quasicrystals and amorphous alloys.

	4.2 Ceramics	L1	L3	Master the structures and property characteristics of ceramics; understand frontier research in optoelectronic ceramics.
	4.3 Shape-Memory and Hydrogen-Storage Alloys	L2	L3	Master working principles of hydrogen-storage alloys and the mechanisms of shape-memory effect and martensitic transformation.
	Development of shape-memory alloys in China and international progress—scientific responsibility and global perspective.			
5. Surfaces and Interfaces	5.1 Surfaces	L2	L3	Master surface structure, surface tension, and surface adsorption.
	5.2 Interfaces	L1	L2	Understand interfacial wetting, thin films, and nanostructures.

3. Pre-requisit

None.

4. Textbooks and Other Learning Resources

Required Textbooks
None.

Recommended Textbooks
Structure and Properties, edited by Zhou Gongdu, Higher Education Press, 2009.
Course Website:
my.stu.edu.cn

5. Teaching and Learning Activities

Teaching Segment	Lectures (Theory)	Practice Hours	Experi-ment Classes	Research	Social Pratice	Project Work	Online Learning	Midterm Exam	Total
Hours (In-class)	32	0	0	0	0	0	0	0	32
Hours (Out-of-class)	32	16	0	16	0	0	0	0	64

Basis for Out-of-Class Workload calculation:

As a professional course that covers topics at the technological frontier, the content load is substantial and requires a certain amount of independent literature review.

The course includes 2 hours of in-class instruction per week. Students are expected to spend approximately 1 hour on pre-class preparation and 1 hour on post-class review each week. Completion of each assignment requires roughly 2 hours (with approximately 8 assignments in total). An additional 1 hour per week is expected for reading supplementary materials.

7. Assessment Scheme

Assessment item	Assessment criteria	Weight	Description
Continuous Assessment	Class Attendance	10%	A deduction of **3%** for each unexcused absence, until this component reaches zero.
	Class Participation	20%	A deduction of **4%** for each failure to participate in in-class discussions, until this component reaches zero.
	Assignment Submission	10%	A deduction of **3%** for each missing assignment, until this component reaches zero.
	Assignment Quality	10%	Evaluated based on the completeness, accuracy, and overall quality of the submitted work.
Final Examination	Final Open-Book Exam	50%	Grading follows the established scoring criteria for the final examination.

Note:

The final examination is open-book. It is designed to evaluate whether students have gained an accurate understanding of atomic and molecular structures, chemical bonding and molecular orbital theory, as well as symmetry and physical properties. The exam also assesses scientific modes of thinking—including analysis, synthesis, reasoning, and analogy—and evaluates the student's ability to apply these concepts to analyze and resolve problems concerning the relationship between the fundamental structure of matter and its macroscopic properties.

7. Course Schedule

Week	Hour	Teaching format	Teaching content
1	2	Lecture	Hydrogen atom and multi-electron atomic structures Oxidation states, ionization energies Introduction to atomic spectra and electron energy spectra
2	2	Lecture	Electronegativity; introduction to molecular orbital theory (I) **Assignment:** Problem set assigned
3	2	Lecture	Introduction to molecular orbital theory (II) **Assignment:** Problem set assigned
4	2	Lecture	Hybrid orbitals, conjugation, and delocalized bonding Pedagogical emphasis: fostering a scientific, evidence-based understanding of bonding concepts
5	2	Lecture	Ionic bonds, coordination bonds, hydrogen bonds, van der Waals interactions
6	2	Lecture	Molecular symmetry elements and symmetry operations Pedagogical emphasis: cultivating a sense of scientific responsibility Assignment: Problem set assigned

7	2	Lecture	Molecular point groups (I) Pedagogical emphasis: encouraging curiosity and exploratory thinking in scientific inquiry Assignment: Problem set assigned
8	2	Lecture	Molecular point groups (II) **Assignment:** Problem set assigned
9	2	Lecture	Crystal point groups (I) Pedagogical emphasis: reinforcing scientific reasoning and materialist methodology*
10	2	Lecture	Crystal point groups (II); brief introduction to space groups
11	2	Lecture	Determining macroscopic polarity from symmetry Pedagogical emphasis: strengthening analytical thinking and evidence-based reasoning Assignment: Problem set assigned
12	2	Lecture	Determining optical activity from molecular and crystal symmetry **Assignment:** Problem set assigned
13	2	Lecture	Structures and physical properties of quasicrystals and amorphous alloys Pedagogical emphasis: developing scientific literacy and the ability to draw evidence-based conclusions Assignment: Problem set assigned
14	2	Lecture	Topics in optical and electronic ceramics Pedagogical emphasis: connecting materials science to societal and technological development
15	2	Lecture	Shape-memory effect and martensitic transformations; working principles of hydrogen-storage alloys Pedagogical emphasis: cultivating a rigorous scientific worldview
16	2	Lecture	Surface structure, surface tension, surface adsorption; interfacial wetting; thin films and nanostructures *Pedagogical emphasis:* fostering scientific responsibility and practical problem-solving mindset

汕头大学本科教学

课程教学大纲

课程名（COURSE TITLE）：	结构与物性
课程代码（COURSE CODE）：	PHY2013A
学分（CREDIT VALUE）：	2
课内课时（CONTACT HOURS）：	32
先修课要求（PRE-REQUISITE）	无
开课单位（DEPARTMENT/UNIT）：	物理学系
版本（VERSION）：	20240731-PHY2013A
课程负责人（COURSE COORDINATOR）：	马文辉(签章)
审核人（APPROVER）：	池凌飞(签章)
审核日期（APPROVE DATE）：	20240731

汕头大学理学院

2024 年 7 月

1、课程简介（Course Description）

（1）课程性质

结构与物性（Structure and Properties）是光电信息科学与工程专业、光电信息科学与工程（微电子方向）专业、物理学专业的选修课。物理、化学和材料科学等的交叉和融合几乎遍及光、电和信息技术的各个领域。从微电子到氢能源，现代高新科技的一条主线是物质世界中结构与性质之间神奇而有趣的联系。从金刚石到石墨、球碳、碳纳米管再到石墨烯，丰富的物性差异缘于其结构的变化。本课程拟分别从原子、分子到晶体多层次地介绍物质的基本结构并探讨其与宏观性质的关系，着重介绍化学键的本质及其对物质的结构和性能的影响，以及物质中分子和晶体的对称操作和点群等基本概念。在基本知识传授的同时也将简要介绍相关领域的前沿和最新科研成果。所体现的科学的思维方式以及认识论和方法论对人才的世界观、价值观和人生观，文化修炼、素质和能力的培养以及知识构成有着重要的意义。学完本课程后学生能够认识到物理和化学等基础学问是如何与相关工程应用交叉和融合的, 同时培养了学生的科研能力和兴趣。

（2）课程内容

本课程主要内容：原子和分子、化学键与分子轨道理论、对称性与物性、表面与界面、若干前沿专题

（3）课程目标

① 从唯物的、辩证的角度去看待科学问题；培养学生勇于探索的精神，批判性思维: 分析识别有矛盾的观点和逻辑谬误，归纳理论和事实验证假设。
② 掌握原子结构、化学键与分子轨道理论；
③ 掌握分子点群和晶体的点群, 以及如何由对称性判断极性和旋光性;
④ 掌握准晶、非晶态合金和陶瓷的结构与物性特点，以及储氢合金、形状记忆合金等的工作原理；
⑤ 掌握表面结构与表面张力，表面吸附与润湿，认识薄膜与纳米结构。

本课程为支持光电信息科学与工程专业、光电信息科学与工程专业（微电子方向）和物理学专业学术型人才培养提供专业理论与研究能力培养，高度支撑上述专业毕业要求指标点 “1. 坚定的理想信念，2. 正确价值观和社会责任感，3.2 具备对专业复杂理论的学习和理解能力，5.1 具备基于科学原理和方法进行研究的能力，6.1 具备识别、表达、通过文献研究分析光电领域的科学问题和工程问题，并获得有效结论的能力。”

2、预期学习结果（Intended Learning Outcomes）

本课程的预期学习结果如下表：

<table>
<tr><th>知识单元</th><th>知识点</th><th>初始
程度</th><th>要求
程度</th><th>预期学习结果</th></tr>
<tr><td rowspan="2">1.原子和分子</td><td>1.1 原子结构</td><td>L1</td><td>L3</td><td>掌握氢原子和多电子原子结构</td></tr>
<tr><td colspan="4">课程思政：科学家在原子结构等方面的研究--主张勇于探索精神</td></tr>
</table>

	1.2 元素与化合物	L2	L4	掌握元素原子的氧化态,电离能和电负性
	1.3 光谱与能谱	L2	L4	认识原子光谱与电子能谱
2.化学键与分子轨道理论	2.1 分子轨道	L1	L3	掌握分子轨道及其能级排布，杂化轨道，共轭效应，离域键
	课程思政：介绍苯环中共轭效应的研究发现--从唯物的、辩证的角度去看待科学问题			
	2.2 键型混杂	L2	L3	认识离子键,配位键,氢键和范德华力等,
	课程思政：通过人们对范德华力的认识历程说明应主张唯物主义认识论			
3.对称性与物性	3.1 分子的对称性	L2	L3	掌握分子的对称元素与对称操作
	课程思政：通过分子对称性的介绍说明如何通过归纳理论和事实验证假设。			
	3.2 点群	L3	L4	判别分子所属的点群
	3.3 晶体的对称性	L1	L4	判别晶体所属的点群
	3.4 对称性与极性	L3	L4	由分子和晶体的对称性判定极性
	课程思政：通过对称性判断极性培养批判性思维，分析识别有矛盾的观点和逻辑谬误			
	3.5 对称性与旋光	L3	L4	由分子和晶体的对称性判定旋光性
4.专题与前沿	4.1 准晶与非晶态合金	L2	L4	比较准晶与非晶态合金两者的结构与物性特点
	课程思政：由准晶的发现谈科学素养,运用科学知识，明确问题并做出具有证据的结论。			
	4.2 陶瓷	L1	L3	掌握陶瓷的结构与物性特点，了解光电陶瓷相关研究的前沿
	课程思政：光电陶瓷的工程应用——科技报国、大国工匠			
	4.3 形状记忆，储氢合金	L2	L3	掌握储氢合金的工作原理 掌握形状记忆效应与马氏体结构相变
	课程思政：我国形状记忆合金的发展史以及国际相关研究的最新动态——家国情怀、国际视野			
5. 表面和界面	5.1 表面	L2	L3	掌握表面结构、表面张力以及表面吸附
	5.2 界面	L1	L2	认识界面浸润,薄膜与纳米结构

3、先修要求（Pre-requisite）

无

4、教材及其他教学资源（Textbooks and Other Learning Resources）

指定教材：

无

推荐参考资料

《结构与物性》，周公度，高等教育出版社，2009.5.

网络资源

my.stu.edu.cn

5. 主要教学环节（Teaching and Learning Activities）

教学环节	理论学习（小时）	练习（小时）	实验（小时）	调研（小时）	社会实践（小时）	项目（小时）	在线学习（小时）	期中测试（小时）	合计
课内	32	0	0		0	0	0	0	32
课外	32	16	0	16	0		0	0	64

课外课时计算依据：

本课程为涉及技术前沿的专业课程，内容较多，需要一定的课外文献调研，预计每周课内学时2小时，需要学生课外预习1小时，课外复习1小时，课外完成每次作业需2小时（约8次作业），1小时用于阅读课外资料。

6. 课程考核（Assessment Scheme）

考核项目	考核内容	权重	评定标准
平时学习表现	课堂出勤率	10%	无故缺勤一次扣 3% 扣完为止
	课堂参与程度	20%	不参加课堂讨论一次扣 4%，扣完为止
	作业缴交情况	10%	缺交作业 1 次扣 3%，扣完为止
	作业完成情况	10%	根据作业完成妥善度及准确率酌情给分
考试	期末开卷考试	50%	评卷评分标准

说明：期末开卷考试，主要考察学生是否能够正确掌握原子和分子结构、化学键与分子轨道理论、对称性与物性、掌握分析、综合、推理类比等科学思维方法，运用所学知识分析和解决物质的基本结构与宏观性质的关系问题。

7. 学习进度（Course Schedule）

周次	教学时数	教学形式	教学内容
1	2	课堂讲授	氢原子和多电子原子结构 元素的氧化态，电离能 简介原子光谱与电子能谱
2	2	课堂讲授	元素的电负性，分子轨道理论初步 1 作业：布置课后练习题
3	2	课堂讲授	分子轨道理论初步 2 作业：布置课后练习题
4	2	课堂讲授	杂化轨道，共轭效应，离域键 主张唯物主义认识论
5	2	课堂讲授	离子键,配位键,氢键,范德华力等
6	2	课堂讲授	分子的对称元素与对称操作 主张奉献精神 作业：布置课后练习题
7	2	课堂讲授	分子点群 I 主张勇于探索精神 作业：布置课后练习题
8	2	课堂讲授、研讨	分子点群 II 作业：布置课后练习题
9	2	课堂讲授	晶体的点群 I 主张唯物主义认识论

10	2	课堂讲授	晶体的点群 II，简述空间群
11	2	课堂讲授	由宏观对称性判断极性 主张唯物主义认识论 作业：布置课后练习题
12	2	课堂讲授	由宏观对称性判断旋光性 作业：布置课后练习题
13	2	课堂讲授、研讨	准晶与非晶态合金的结构与物性 支持家国情怀 作业：布置课后练习题
14	2	课堂讲授	光电陶瓷相关专题 主张文化自信
15	2	课堂讲授	形状记忆效应与马氏体相变,介绍储氢合金的工作原理 主张唯物主义认识论
16	2	课堂讲授	表面结构与表面张力,表面吸附，界面润湿,薄膜与纳米结构 主张奉献精神

Shantou University

Module Description for Undergraduate Courses

COURSE TITLE: Information optics

COURSE CODE: PHY3014B

CREDIT VALUE: 3

CONTACT HOURS: 48

PRE-REQUISITE Optics, Advance Calculus

DEPARTMENT/UNIT: Department of Physics

VERSION: 20240731- PHY3014B

谢向生

COURSE COORDINATOR: (Signature and Seal)

池凌[illegible]

APPROVER: (Signature and Seal)

APPROVE DATE: 20240731

Shantou University Faculty of Science

July 2024

1. Course Description

(1) Nature of the Course

Information Optics is a specialized elective course for students majoring in Optoelectronic Information Science and Engineering as well as Physics. Information optics is an emerging discipline that has developed over the past four decades. Building upon holography, optical transfer functions, and lasers, it diverges from traditional classical wave optics and has evolved into an optical science that integrates applied optics, computer science, and information science.

(2) Course Content

The course covers the fundamental concepts and principles of information optics, with emphasis on scalar diffraction theory, transfer functions of optical imaging systems, fundamental theories of holography, and the principles and methods of spatial filtering. It also introduces developments in major frontier areas of information optics and provides extended training in simulation and modeling techniques based on MATLAB.

(3) Course Objectives

The course aims to cultivate students' physical intuition, physical reasoning, and ability to connect theory with practical applications. Through optical information processing techniques, it broadens students' methodological tools and innovative perspectives for applying theoretical knowledge to practice, improving their ability to solve real-world problems. It lays the theoretical and methodological foundation for academic research and modern technological applications in optical information processing. Upon completing the course, students should be able to:

1. Master scientific methodologies used in scientific research and engineering practice;
2. Construct general models and analytical methods in information optics;
3. Acquire the core knowledge of optical information theory;
4. Understand, analyze, and evaluate key issues in novel optical imaging techniques.

This course provides essential theoretical and applied research training for academic-oriented undergraduates in Optoelectronic Information Science and Engineering and Physics. It strongly supports the following graduation requirement indicators for these majors: "3.2 Capability to learn and understand complex professional theories; 5.3 Demonstration of innovative awareness in research/design/development processes."

2. Intended Learning Outcomes

The intended learning outcomes of this course are summarized in the table below.

Knowledge Unit	Key Knowledge Points	Initial Level	Required Level	Expected Learning Outcomes
Mathematical Foundations of Fourier Transform	Physical background of Fourier transform; mastery of the mathematical forms and physical meaning of Fourier transform, convolution, and autocorrelation; common mathematical functions	L2	L3	Demonstrate the application of frequently used mathematical functions
			L3	Demonstrate understanding and application of the physical meaning of Fourier transform
			L4	Analyze the physical meaning of convolution and interpret mathematical results
			L3	Demonstrate understanding of the physical meaning of correlation
Scalar Wave Diffraction Theory	Fresnel diffraction theory; Fraunhofer diffraction	L2	L3	Demonstrate the derivation and application of Fresnel diffraction formulas

			L4	Understand the relationship between Fresnel and Fraunhofer diffraction, and master Fourier-transform-based analysis and classification of Fraunhofer diffraction
Mathematical Descriptions of Lenses and Their Physical Meaning	Physical structure and mathematical description of lenses	L1	L3	Master mathematical expressions of lenses and the conditions for the thin-lens approximation.
	Transform properties of lenses	L0	L3	Illustrate the optical path when a lens performs Fourier transform.
			L3	Advanced Topics, Fundamentals, Design Strategies, and Practical Applications of Metasurfaces.
Transfer Function of Optical Imaging Systems	Image-quality analysis of imaging systems	L0	L4	Master various image-quality analysis methods and compare their advantages and suitable contexts.
	Point spread function of a lens	L1	L3	Master the form of the single-lens point spread function and understand the Rayleigh and Abbe criteria.
	Coherent and incoherent transfer functions	L1	L4	Distinguish the computation methods of coherent and incoherent transfer functions for a single lens and a 4f system.
	Line spread function and edge spread function	L1	L5	Master the physical meaning and computation of LSF and ESF, and critically evaluate their physical and practical accuracy.
Partially Coherent Light Theory	Optical coherence processes	L1	L2	Form self-consistent understanding of optical coherence.
	Spatial coherence	L1	L3	Understand the origin of spatial coherence, theoretical computation, and experimental testing methods.
	Temporal coherence	L1	L3	Master the origin, theoretical calculation, and testing methods of temporal coherence.
	Van Cittert–Zernike theorem	L1	L3	Master the theoretical derivation and applications of the VCZ theorem; understand astronomical telescopes and their performance.
Optical Holography	Concepts of holography; inline and off-axis holography; 3D applications	L1	L2	Demonstrate theoretical and experimental methods of inline holography
			L3	Demonstrate understanding of holographic concepts
			L3	Demonstrate theoretical and experimental methods of off-axis holography

			L4	Present understanding of glasses-free 3D technologies and compare various 3D imaging techniques

Note:

Training objectives refer to Level-3 knowledge units and competency indicators in the program curriculum standards. Knowledge points and sub-level indicators correspond to specific skills within these units. The “initial proficiency level” describes students’ expected level before taking the course, and the “required proficiency level” describes the expected level after completing the course.

3. Pre-requisit

Optics, Advance Calculus

4. Textbooks and Other Learning Resources

Required Textbooks

Su Xianyu & Li Jitao, *Information Optics* (2nd Edition), Science Press, June 2011.

Recommended Textbooks

1. Yu Xiangyang, *Information Optics*, Sun Yat-sen University Press, September 2015.
2. Li Junchang & Xiong Bingheng, *Tutorial of Information Optics*, Science Press, 2011.
3. Joseph Goodman, *Introduction to Fourier Optics*, W. H. Freeman, May 2017.
4. Qian Xiaofan, *Digital Laboratory of Information Optics* (Matlab Edition), Science Press, May 2015.

Course Websites

http://my.stu.edu.cn

https://coursehome.zhihuishu.com/courseHome/1000050596#teachTeam

*Course materials are subject to change.

5. Teaching and Learning Activities

Teaching Segment	Lectures (Theory)	Exercise Classes	Laboratory Work	Seminars	Social Practice	Project Work	Online Learning	Mid-Term Test	Total
Hours (In-class)	44	4	0	0	0	0	0	0	48
Hours (Out-of-class)	10	46	0	10	0	10	20	0	96

Basis for Out-of-class Study Hours:

This is a senior-level theoretical course with extensive content and relatively high difficulty. Students are expected to spend 3 hours per week in class, 1 hour on preview, and 2 hours on review (including online study and online seminars). Completing each assignment requires approximately 2.5 hours (around 14 assignments in total), with an additional 0.5 hour allocated for the simulation project.

6. Assessment Scheme

Assessment item	Description	Weight
Continuous Assessment	Attendance, homework, in-class quizzes, summaries, or simulation projects	40%

Final Examination	Open-book final exam	60%

7. Course Schedule

Week	Hour	Teaching format	Teaching content
1	3	Lecture	Chapter 1: Linear System Analysis Introduction to common mathematical functions and their applications
2	3	Lecture	Chapter 1: Linear System Analysis Mathematical and physical significance of Fourier transform, convolution, and autocorrelation Homework: Assigned exercises Discussion: What is the most essential mathematical tool in information science? How can we memorize these mathematical tools conceptually and physically?
3	3	Lecture	Chapter 2 Scalar Diffraction Theory 一. Historical introduction 二. Kirchhoff scalar diffraction theory Discussion: With so many diffraction theories, how can we distinguish them?
4	3	Lecture	Chapter 2 Scalar Diffraction Theory 一. Fresnel diffraction theory 二. Applications of Fresnel diffraction 三. MATLAB simulation Discussion: What should we pay attention to when simulating theoretical models?
5	3	Lecture	Chapter 2 Scalar Diffraction Theory 一. Fraunhofer diffraction: principles, applications, and simulations 二. Frontier introduction: speckle autocorrelation and focal-field measurement Homework: Assign after-class exercises Discussion: Which has broader applicability, Fresnel or Fraunhofer?
6	3	Lecture	Chapter 2 Scalar Diffraction Theory 一. Transform properties of lenses 二. Frontier introduction: principles, design, and applications of metasurfaces (metalenses) Homework: Assign after-class exercises Discussion: Why are lenses so important?
7	3	Lecture	Chapter 3 Transfer Function of Optical Imaging Systems 一. Image-quality analysis methods 二. Point spread function of lenses 三. Frontier introduction: diffractive optical elements and their design

			Discussion: How is the optical transfer function related to system functions in electronic information systems?
8	3	Lecture	Chapter 3 Transfer Function of Optical Imaging Systems 一. Coherent transfer function 二. Incoherent transfer function 三. Frontier introduction: optical super-resolution imaging Discussion: What are the diffraction limit and super-resolution?
9	3	Lecture	Chapter 3 Transfer Function of Optical Imaging Systems 一. Common optical path systems: single-lens imaging and 4f system 二. Frontier introduction: holographic fabrication of photonic crystals Discussion: What role does the Fourier transform play in imaging system analysis?
10	3	Lecture	Practice session: explanation and analysis of homework examples; independent design of project report.
11	3	Lecture	Chapter 3 Transfer Function of Optical Imaging Systems 一. Linear representation of optical imaging systems 二. Comparison of coherent and incoherent imaging systems 三. Frontier introduction: measurement methods for line spread function (LSF) and point spread function (PSF) Homework: Assign after-class exercises Discussion: Are the calculations of LSF and edge spread function (ESF) rigorous?
12	3	Lecture	Chapter 4 Partial Coherence Theory 一. Additional physical principles of optical coherence 二. Spatial coherence 三. Frontier introduction: scattering imaging background and methods Discussion: Is partially coherent light common?
13	3	Lecture	Chapter 4 Partial Coherence Theory 一. Interference of quasi-monochromatic light 二. Comparison of temporal and spatial coherence 三. Frontier introduction: vector diffraction theory and optical-field control Discussion: How can partial-coherence theory be simplified?
14	3	Lecture	Chapter 4 Partial Coherence Theory 一. Van Cittert–Zernike theorem 二. Frontier introduction: near-field scanning optical microscopy and wavefront-optimization methods Homework: Assign after-class exercises Discussion: Where is the van Cittert–Zernike theorem applied?

15	3	Lecture	Chapter 5 Optical Holography 一．Overview of holography 二．Physical process and mathematical significance of inline (on-axis) holography 三．Frontier introduction: glasses-free 3D imaging Discussion: What are the application scenarios of holography?
16	3	Lecture	Chapter 5 Optical Holography 一．Physical process and mathematical significance of off-axis holography Final Review

汕头大学本科教学

课程教学大纲

课　程　名（COURSE TITLE）： 信息光学

课程代码（COURSE CODE）： PHY3014B

学　　　分（CREDIT VALUE）： 3

课内课时（CONTACT OURS）： 48

先修课要求（PRE-REQUISIT） 光学、高等微积分

开课单位（DEPARTMENT/UNIT）： 物理学系

版　　　本（VERSION）： 20240731- PHY3014B

课程负责人（COURSE COORDINATOR）： 谢向生 (签章)

审　核　人（APPROVER）： [illegible] (签章)

审核日期（APPROVE DATE）： 20240731

汕头大学理学院

2024 年 7 月

1、课程简介 （Course Description）

（1）课程性质：信息光学（information optics）是光电信息科学与工程专业和物理学专业的专业选修课。信息光学是近 40 年发展起来的一门新兴学科，它是在全息术、光学传递函数和激光的基础上，从传统的、经典的波动光学中脱颖而出的，是应用光学、计算机和信息科学相结合而发展起来的一门光学科学。

（2）课程内容：本课程包括信息光学中的基本概念、基本原理，重点理解标量衍射理论、光学成像系统的传递函数、全息基础理论和空间滤波的原理和方法，介绍信息光学各主要前沿领域的发展，拓展学习基于 matlab 的信息光学模拟仿真方法。

（3）课程目标：重点培养学生的物理思想、物理思维和理论联系实际能力，结合光学信息处理技术，开拓学生理论用于实践的方法和创新思路，提高学生解决实际问题的能力。为从事光学信息处理的学术和近代光学信息处理技术的应用研究打下基础。学完本课程后学生应能够：

1）正确认识我国科技实力，树立“四个自信”，自觉地将个人追求与国 家需要相结合；

2）掌握科学研究和工程技术中的科学方法论

3）建立信息光学的一般模型和分析方法；

4）掌握光学信息论方法的核心知识；

5）理解新型光学成像方法的若干关键问题，并对其进行分析和评价

本课程为光电信息科学与工程专业和物理学专业学术型本科人才培养提供专业理论与应用研究能力培养，高度支撑该专业本科人才培养方案中的毕业要求指标点“1.坚定的理想信念、2.正确价值观和社会责任感、3.2 具备对专业复杂理论的学习和理解能力、5.3 在研究/设计/开发过程中体现创新意识”。

2、预期学习结果 （Intended Learning Outcomes）

本课程的预期学习结果为：

知识单元	知识点	初始程度	要求程度	预期学习结果
傅里叶变换对应的数学基础	傅里叶变换的物理背景、掌握傅里叶变换、卷积和自相关的数学形式和物理意义、掌握常见的数学函数	L2	L3	展现集中常用的数学函数的应用
			L3	展现对傅里叶变换的物理意义的理解和应用
			L4	展现对卷积的物理意义的理解和数学结果分析
			L3	展现对相关的物理意义的理解 思政元素：可靠性与有效性的关系所体现出来的辩证关系
标量波衍射理论	菲涅耳衍射理论、夫琅禾费衍射	L2	L3	展示对菲涅尔衍射的推导过程和菲涅尔衍射公式的应用

			L4	理解菲涅尔衍射与夫琅禾费衍射的关系，掌握夫琅禾费的傅里叶变换的分析和归类 思政元素：展示基于 matlab 的仿真实验，介绍基于标量衍射理论的多种模拟仿真内容——实践是检验理论的唯一标准，要求大家实事求是，追求真理。
透镜的数学表达及其物理意义	透镜物理结构和数学描述	L1	L3	掌握透镜的数学表达式，薄透镜近似的条件 思政元素：我国在计算成像、微纳光电子器件等通信事业的发展，主张我国社会主义制度，科技报国使命担当
	透镜的变换作用	L0	L3	图解透镜作为傅里叶变换时的光路情况 思政元素：空间带宽积中，空域与空间频域分辨率之间的辩证关系
			L3	前沿介绍，超透镜原理、设计及应用 思政元素：超透镜的发明和运用——科学方法论
光学成像系统的传递函数	成像系统的像质分析	L0	L4	掌握各种成像系统的像质分析方法，对比各种像质分析方法 思政元素：讨论各种像质分析方法的优缺点和适用场合，主张我国社会主义制度
	透镜的点扩散函数	L1	L3	掌握单透镜点扩散函数的形式，理解瑞利判据和阿贝判据 思政元素：理解了物理极限的"重要性",延伸其文化内涵,增强民族自豪感和投身国防建设的强烈信念.
	相干和非相干传递函数	L1	L4	区分单透镜和 4f 系统的相干和非相干传递函数的计算方法
	线扩散函数和刃边扩散函数	L1	L5	掌握线扩散函数和刃边扩散函数的物理意义和计算方法，批判其物理和应用的准确性。 思政元素：不要迷信权威,敢于质疑,坚持科学的实事求是的精神
部分相干光理论	光相干物理过程	L1	L2	形成光相干概念的自我理解 思政元素：文化自信,对中华民族的优秀文明成果的了解,对中华优秀传统文化和社会主义先进文化的

<table>
<tr><td rowspan="4"></td><td></td><td></td><td></td><td>传播和弘扬;</td></tr>
<tr><td>空间相干性</td><td>L1</td><td>L3</td><td>掌握空间相干性产生的原因，理论计算方法及实验测试方法
思政元素：化繁为简，抓住主要矛盾，逐一攻克</td></tr>
<tr><td>时间相干性</td><td>L1</td><td>L3</td><td>掌握时间相干性产生的原因，理论计算方法及实验测试方法</td></tr>
<tr><td>范西特-泽尼克定理</td><td>L1</td><td>L3</td><td>掌握范西特-泽尼克定理的理论推导和应用，了解天文望远系统及望远系统的主要性能
思政元素：军事上为什么提高成像分辨率——爱国主义</td></tr>
<tr><td rowspan="4">光学全息</td><td rowspan="4">全息概念、同轴全息、离轴全息、3d 应用</td><td rowspan="4">L1</td><td>L2</td><td>展示对全息概念的理解</td></tr>
<tr><td>L3</td><td>展示同轴全息的理论和实验方法</td></tr>
<tr><td>L3</td><td>展示离轴全息的理论和实验方法</td></tr>
<tr><td>L4</td><td>展示裸眼 3d 技术的前沿理解，比较各种 3d 成像技术
思政元素：中外全息技术对比——制度自信和家国情怀</td></tr>
</table>

表注：培养目标指专业培养标准中的知识单元和能力培养第三级（x.x.x）标准；知识点是专业培养标准中该知识单元所包含的知识点，x.x.x 级以下的能力标准指专业培养标准中比第三级能力标准 x.x.x 进一步分解的能力标准；初始熟练程度指学生学习本课程之前在该知识单元或第三级能力标准所具备的熟练程度；要求熟练程度指学生学完本课程之后在该知识单元或第三级能力标准所应该具备的熟练程度

3、先修要求 （Pre-requisit）

光学

高等微积分

4、教材及其他教学资源 （Textbooks and Other Learning Resources）

课程教材

苏显渝 李继陶著《信息光学（第二版）》科学出版社出版，2011 年 6 月，

推荐参考资料

1. 余向阳，《信息光学》 中山大学出版社 2015 年 9 月；
2. 李俊昌、熊秉衡，《信息光学教程》科学出版社出版的图书，2011 年；
3. Joseph Goodman，《傅里叶光学概论 Introduction to Fourier Optics》W. H. Freeman 出版社，2017 年 5 月；
4. 钱晓凡，《信息光学数字实验室(Matlab 版) 》，科学出版社，2015 年 5 月

课程网站：

http://my.stu.edu.cn

https://coursehome.zhihuishu.com/courseHome/1000050596#teachTeam

* Course materials are subject to change.

5、主要教学环节 （Teaching and Learning Activities）

教学环节	理论课（小时）	习题课（小时）	实验（小时）	研讨（小时）	社会实践（小时）	项目（小时）	在线学习（小时）	期中测试（小时）	合计
课内	44	4	0	0	0	0	0	0	48
课外	10	46	0	10	0	10	20	0	96

课外课时计算依据:

本课程为高年级理论课，内容较多且难度大，预计每周课内学时 3 小时，需要学生课外预习 1 小时，课外复习 2 小时(含在线学习和线上研讨)，课外完成每次作业需 2.5 小时(约 14 次作业)，0.5 小时用于仿真项目。

6、课程考核 （Assessment Scheme）

考核项目	考核内容和考试方法简介	权重
平时成绩	考勤、作业、课堂测试、小结或模拟项目等	40%
考试	期末开卷考试	60%

7、学习进度 （Course Schedule）

周次	教学时数	教学形式	教　学　内　容
1	3	课堂教学	第一章 线性系统分析 介绍常见的数学函数及其应用
2	3	课堂教学	第一章 线性系统分析 一．傅里叶变换、卷积和自相关的数学和物理意义 作业: 布置课后练习题 讨论: 信息科学方面最重要的数学工具是什么？如何去记忆这些数学工具的概念和物理图像？
3	3	课堂教学	第二章 标量衍射理论 一．历史介绍 二．基尔霍夫标量衍射理论； 讨论: 这么多衍射理论，如何区分？

4	3	课堂教学	第二章 标量衍射理论 一．菲涅尔衍射理论 二．菲涅尔衍射理论和应用 三. Matlab 仿真 讨论: 从理论的仿真主要需要注意什么？
5	3	课堂教学	第二章 标量衍射理论 一．夫琅禾费衍射及其应用和仿真 二．科学前沿介绍，散斑自相关和焦场测量 作业: 布置课后练习题 讨论: 菲涅尔和夫琅禾费哪个具有更好的普适性？
6	3	课堂教学	第二章 标量衍射理论 一．透镜的变换性质 二．科学前沿介绍，超透镜原理、设计及应用 作业: 布置课后练习题 讨论: 透镜为什么这么重要？
7	3	课堂教学	第三章 光学成像系统的传递函数 一．成像系统的像质分析方法 二．透镜点扩散函数 三．科学前沿介绍，衍射光学元器件及其设计 讨论: 光学的传递函数跟电子信息的系统函数有何关联？
8	3	课堂教学	第三章 光学成像系统的传递函数 一．相干传递函数 二．非相干传递函数 三．科学前沿介绍，光学超分辨成像技术 讨论: 什么是衍射极限和超分辨？
9	3	课堂教学	第三章 光学成像系统的传递函数 一．透镜最常用的光路系统，单透镜成像和 4f 系统 二．科学前沿介绍，光子晶体的全息制备术 讨论: 傅里叶变换在成像系统分析中的作用？
10	3	课堂教学	1.作业例题讲解分析，讨论。自主设计项目报告
11	3	课堂教学	第三章 光学成像系统的传递函数 一．光学成像系统的线性表达 二．相干与非相干成像系统比较。 三．科学前沿介绍，线扩散函数和点扩散函数的测量方法 作业: 布置课后练习题 讨论: 线扩散函数和刃边扩散函数的计算是否严谨？
12	3	课堂教学	第四章 部分相干光理论 一．补充光学相干过程的物理原理 二．空间相干性。 三．科学前沿介绍，散射成像背景及方法 讨论: 部分相干光是否常见？

13	4	课堂教学	第四章 部分相干光理论 一．准单色光的干涉 二．时间相干性和空间相干性比较 三．科学前沿介绍，矢量衍射理论及光场调控 讨论：部分相干光理论如何简化？
14	3	课堂教学	第四章 部分相干光理论 一．范西特-泽尼克定理 二．科学前沿介绍，近场扫描光学显微及其波前调控优化 作业：布置课后练习题 讨论：范泽尼克定理哪里有应用？
15	3	课堂教学	第五章 光学全息 一．全息概述 二．同轴全息的物理过程和数学符号意义。 四．科学前沿介绍，裸眼 3d 成像技术 讨论：全息有哪些应用场景？
16	3	课堂教学	第五章 光学全息 三．离轴全息的物理过程和数学符号意义。 总复习

Shantou University

Module Description for Undergraduate Courses

COURSE TITLE:	Physics in English
COURSE CODE:	PHY3007A
CREDIT VALUE:	2
CONTACT HOURS:	32
PRE-REQUISITE	None
DEPARTMENT/UNIT:	Department of Physics
VERSION:	20240731-PHY3007A
COURSE COORDINATOR:	Liu Chaoping (Signature and Seal)
APPROVER:	Chi Lingfei (Signature and Seal)
APPROVE DATE:	20240731

Shantou University Faculty of Science

July 2024

1. Course Description

(1) Nature of the Course

Physics in English is a compulsory course specially designed by the Department of Physics at Shantou University for undergraduate students majoring in physics and related disciplines. Through 32 hours of systematic instruction, the course aims to enhance students' overall proficiency in scientific English and strengthen their scientific literacy. Closely aligned with core physics knowledge, the course covers essential vocabulary and terminology in mechanics, electromagnetism, optics, thermodynamics, and quantum mechanics, while also offering training in reading and translating English literature in cutting-edge areas of physics. It is suitable for students majoring in Physics, Optoelectronic Science and Engineering, and Microelectronics Science and Engineering.

(2) Course Content

The course integrates theory with practice through lectures, discussions, hands-on activities, and case analyses. Students will learn the fundamental structure and writing techniques of academic papers, including key elements of the abstract, introduction, methodology, results and discussion, and conclusion. The course also includes oral presentations and discussion sessions to develop students' spoken communication, logical reasoning, and cross-cultural communication skills, thereby preparing them for future participation in international academic conferences and research collaborations.

In addition, the course emphasizes the cultivation of students' overall competencies by introducing international developments in physics, research ethics, and academic integrity. These components aim to strengthen students' sense of social responsibility, foster sound values, and broaden their global outlook. Through guided engagement in research topic selection, literature reviews, and academic writing, the course encourages innovative thinking, strengthens research abilities, and nurtures problem-solving skills and teamwork. In short, *Physics in English* integrates language learning, disciplinary knowledge, and holistic development, providing solid support for students' future academic and professional pursuits.

(3) Course Objectives

Upon completing this course, students should be able to:

1. Develop a sense of commitment and social responsibility, along with sound values and an international outlook.
2. Master core vocabulary and terminology in physics.
3. Apply techniques for reading and translating English literature in frontier areas of physics.
4. Understand and employ the basic structure and writing methods of academicpapers.
5. Demonstrate fundamental oral communication, logical reasoning, and cross-cultural communication skills in English.
6. Understand research ethics and academic integrity.

Achievement of these learning outcomes plays a key role in strengthening students'professional English competence and global perspective across the three undergraduate programs in the Department of Physics--Physics, Optoelectronic Information Science and Engineering, and Microelectronics Science and Technology.

Correspondence to Graduation Requirements

This course contributes to the following graduation requirement indicators in the Physics Training Program:

3.1 Mastery of fundamental theories and professional knowledge in physics.

6.1 Research and engineering problem-solving ability.

8.2 Communication skills and international vision.

2. Intended Learning Outcomes

Knowledge Unit	Key Knowledge Points	Initial Level	Target Level	Expected Learning Outcomes
Foundations of Physics-related Academic English	Professional vocabulary and terminology	L1	L3	Students will be able to accurately understand and use physics-related professional vocabulary and terminology in academic communication.
	Overview of physics literature	L1	L3	Students will be able to read and summarize the main content of English-language physics literature and identify key information.
Reading and Translation of Professional Literature	Techniques for reading academic literature	L1	L4	Students will be able to efficiently read and comprehend English-language physics literature, extract relevant information, and conduct preliminary analysis. *Civic literacy component: Introducing the scientific contributions of Professor Yang Zhenning to foster confidence in cultural heritage.*
	Translation practice	L1	L2	Students will be able to independently complete preliminary translations of physics-related English literature and perform basic self-editing. *Civic literacy component: Introducing renowned Chinese translators to cultivate a sense of national responsibility.*
Academic Writing and Oral Presentation	Academic paper writing	L1	L6	Students will be able to write English academic papers or research reports that follow accepted academic conventions.
	Oral presentation and discussion	L1	L6	Students will demonstrate effective oral communication skills and engage in academic discussions in settings such as international conferences or seminars. *Civic literacy component: Introducing the achievements of Nobel laureate Tu Youyou to cultivate a sense of national responsibility.*

Comprehensive Competence Development	Research ethics and academic integrity	L1	L4	Students will adhere to principles of academic integrity, respect others' scholarly contributions, and uphold ethical standards in scientific research.
	Innovative thinking and research ability	L1	L3	Students will demonstrate independent thinking, solve basic physics-related problems, and begin developing research and innovation capabilities.

3. Pre-requisit

None.

4. Textbooks and Other Learning Resources

Recommended References

Zhong, Haiyang, et al. *A Concise Course in Physics English.* Tsinghua University Press, 2022.

5. Teaching and Learning Activities

Teaching Segment	Lectures (Theory)	Practice Hours	Seminar	Social Pratice	Project Work	Online Learning	Midterm Exam	Total
Hours (In-class)	30	0	2	0	0	0	0	32
Hours (Out-of-class)	6	0	6	0	6	0	0	18

7. Assessment Scheme

Assessment item	Assessment criteria	Weight
Continuous Assessment	Homework and Reflection	50%
Final Examination	Final Open-Book Exam	50%

7. Course Schedule

Week	Hour	Teaching format	Teaching content
1	2	Lecture	Importance of Physics in English; course overview; international developments and frontier trends in physics; academic integrity and research ethics.
2	2	Lecture	Professional vocabulary in core areas: mechanics, electromagnetism, optics, thermodynamics, and quantum mechanics.

3	2	Lecture	Vocabulary related to experimental techniques and equipment.
4	2	Lecture	Vocabulary for mathematical tools used in physics.
5	2	Lecture	Selected readings from English-language physics journal articles.
6	2	Lecture	Translation techniques and practice: translating abstracts, introductions, and conclusions.
7	2	Lecture	Group discussion (1): literature interpretation and exchange of viewpoints.
8	2	Lecture	Group discussion (2): literature interpretation and exchange of viewpoints.
9	2	Lecture	Structure of academic papers.
10	2	Lecture	Writing techniques for abstracts, introductions, methods, results and discussion, and conclusions.
11	2	Lecture	Citation conventions and reference management; writing workshop for hands-on practice and feedback.
12	2	Lecture	Oral presentation skills: structure, language use, and slide design.
13	2	Lecture	Mock academic conference: group presentations on professional topics and Q&A; cross-cultural communication skills and preparation for international academic conferences.
14	2	Lecture	English interface and operation of commonly used research software (e.g., Origin); introduction and discussion of advanced experimental techniques in English.
15	2	Lecture	Research topic selection and English writing of literature reviews; introduction to innovative thinking: critical thinking and problem-solving strategies; manuscript submission process and overview of international journals.
16	2	Lecture	Course summary and individual learning reflection; introduction to international exchange opportunities in physics; guidance on future study and career development.

汕头大学本科教学

课程教学大纲

课程名（COURSE TITLE）：	专业英语
课程代码（COURSE CODE）：	PHY3007A
学分（CREDIT VALUE）：	2
课内课时（CONTACT HOURS）：	32
先修课要求（PRE-REQUISITE）	无
开课单位（DEPARTMENT/UNIT）：	物理学系
版本（VERSION）：	20240731-PHY3007A
课程负责人（COURSE COORDINATOR）：	刘超平 (签章)
审核人（APPROVER）：	池凌飞(签章)
审核日期（APPROVE DATE）：	20240731

汕头大学理学院

2024 年 7 月

1、课程简介（Course Description）

课程性质

专业英语（Physics in English）是汕头大学物理系为物理学等相关专业本科生精心设计的必修课程，旨在通过32学时的系统学习，全面提升学生的专业英语综合能力及科学素养。课程紧密结合物理学专业知识，不仅涵盖了力学、电磁学、光学、热学及量子力学等基础领域的专业词汇与术语，还深入探讨了物理学前沿领域的英文文献阅读与翻译技巧，适合于物理学、光电科学与工程、微电子科学与技术等相关专业。

课程内容

在课程内容上，本课程注重理论与实践相结合，通过讲授、讨论、实践及案例分析等多种教学方法，引导学生掌握学术论文的基本结构与写作技巧，包括摘要、引言、方法、结果与讨论、结论等部分的撰写要点。同时，课程还设置了口头报告与讨论环节，旨在锻炼学生的口头表达、逻辑思维及跨文化交流能力，为日后参与国际学术会议及科研合作打下坚实基础。此外，本课程还强调对学生综合素质的培养，通过介绍物理学领域的国际发展动态、科研伦理与学术诚信等内容，增强学生的社会责任感、正确的价值观及国际视野。同时，通过引导学生参与科研选题、文献综述及论文撰写等实践活动，激发学生的创新思维与研究能力，培养其解决复杂问题的能力及团队合作精神。总之，《专业英语》课程是一门集语言学习、专业知识传授与综合素质培养于一体的综合性课程，将为学生的未来学术研究与职业发展提供有力支持。

课程教学目标

学完本课程后学生应能够：

（1）能从唯物的、辩证的角度去看待科学问题；

（2）培养学生的家国情怀，勇于探索、增强学生的社会责任感、正确的价值观及国际视野；

（3）掌握物理学专业的专业词汇与术语；

（4）掌握并运用物理学前沿领域的英文文献阅读与翻译技巧；

（5）掌握学术论文的基本结构与写作技巧；

（6）具备基本的英文口头表达、逻辑思维及跨文化交流能力；

（7）了解科研伦理与学术诚信。

以上教学目标的完成对物理系三个本科专业（物理学、光电信息科学与工程、微电子科学与技术）专业英语的应用能力及国际视野的培养十分关键。

本课程目标对应物理学专业人才培养方案毕业要求指标点：1.坚定的理想信念；2.正确价值观和社会责任感；3.1掌握物理学的基础理论和专业知识；6.1解决问题的研究和工程能力；8.2具有交流能力与国际视野。

2、预期学习结果（Intended Learning Outcomes）

本课程的预期学习结果如下表：

知识单元	知识点	初始程度	要求程度	预期学习结果
物理学专业英语基础	专业词汇与术语	L1	L3	能够准确理解和运用物理学专业词汇与术语进行学术交流。
	物理学文献概述	L1	L3	能够阅读并概述物理学英文文献的主要内容，识别其关键信息。
专业文献阅读与翻译	文献阅读技巧	L1	L4	能够高效地阅读并理解物理学英文文献，提取所需信息并进行初步分析。 思政：通过介绍物理大师杨振宁先生，培养文化自信
	翻译实践	L1	L2	能够独立完成物理学英文文献的初步翻译工作，并进行自我校对。 思政：通过介绍中国著名的翻译家，培养家国情怀
学术写作与口头报告	学术论文写作	L1	L6	能够撰写符合学术规范的物理学英文论文或研究报告。
	口头报告与讨论	L1	L6	具备良好的口头表达能力和沟通技巧，能够在国际学术会议或研讨会上进行有效交流。 思政：介绍伟大科学家屠呦呦先生，培养家国情怀
综合素质培养	科研伦理与学术诚信	L1	L4	能够在科研活动中坚持诚信原则，尊重他人成果，维护学术界的良好风气。
	创新思维与研究能力	L1	L3	能够独立思考并解决物理学问题，具备初步的研究能力和创新精神。 思政：讲述新中国取得的伟大科学成就，树立制度自信

3、先修要求（Pre-requisit）

无

4、教材及其他教学资源（Textbooks and Other Learning Resources）

推荐参考资料

《物理学专业英语简明教程》仲海洋等，清华大学出版社，2022 年

3、主要教学环节（Teaching and Learning Activities）

教学环节	理论课（小时）	习题课（小时）	实验（小时）	研讨（小时）	社会实践（小时）	项目（小时）	在线学习（小时）	期中测试（小时）	合计
课内	30	0	0	2	0	0	0	0	32
课外	6	0	0	6	0	6	0	0	18

4、课程考核（Assessment Scheme）

考核项目	考核内容和考试方法简介	权重
平时成绩	课后作业及思考	50%
考试	期末闭卷考试	50%

5、学习进度（Course Schedule）

周次	教学时数	教学形式	教学内容
1	2	课堂教学	物理学专业英语的重要性及课程简介，国际物理学发展概况与前沿动态，学术诚信与科研伦理
2	2	课堂教学	力学、电磁学、光学、热学、量子力学等基础领域专业词汇
3	2	课堂教学	实验技术与设备名称
4	2	课堂教学	数学工具在物理中的应用词汇
5	2	课堂教学	精选物理学领域英文期刊论文阅读
6	2	课堂教学	翻译技巧与实践：摘要、引言、结论等部分的翻译
7	2	课堂教学	小组讨论（1）：文献解读与观点交流
8	2	课堂教学	小组讨论（2）：文献解读与观点交流
9	2	课堂教学	学术论文基本结构讲解
10	2	课堂教学	摘要、引言、方法、结果与讨论、结论的写作技巧
11	2	课堂教学	引用规范与参考文献管理；写作工作坊：实战演练与反馈
12	2	课堂教学	口头报告技巧：结构安排、语言表达、PPT 制作
13	2	课堂教学	模拟学术会议：学生分组进行专业主题报告与 Q&A 跨文化交流技巧：国际学术会议准备与参与
14	2	课堂教学	科研常用软件（如 Origin）的英文界面与操作指南 先进实验技术的英文介绍与讨论
15	2	课堂教学	科研选题与文献综述的英语撰写 创新思维方法介绍：批判性思维、问题解决策略 科研论文投稿流程与国际期刊介绍
16	2	课堂教学	课程总结与个人学习反思 物理学领域国际交流机会介绍 未来学习与职业规划建议

Shantou University

Module Description for Undergraduate Courses

COURSE TITLE: Fundamentals of Computational Physics

COURSE CODE: PHY3026A

CREDIT VALUE: 2

CONTACT HOURS: 32

PRE-REQUISITE Calculus B1, Calculus B2,
Linear algebra, Mathematical methods of Physics

DEPARTMENT/UNIT: Department of Physics

VERSION: 20240731-PHY3023A

COURSE COORDINATOR: 胡师林 (Signature and Seal)

APPROVER: Chi Lingfei (Signature and Seal)

APPROVE DATE: 20240731

Shantou University Faculty of Science

July 2024

1. Course Description

(1) Nature of the Course

Fundamentals of Computational Physics is a core course within the professional foundation module of the Physics major. Computational physics constitutes a crucial branch of modern physics and, together with experimental physics and theoretical physics, forms the complete framework of the discipline. It employs appropriate mathematical techniques and computer-based numerical algorithms to simulate physical problems and perform quantitative analysis. As such, it is inherently interdisciplinary, integrating physics, mathematics, and computer science.

This course plays a significant role in deepening students' understanding of quantum mechanics, electrodynamics, and thermodynamics & statistical physics.

(2) Course Content

The course covers:

- the historical development of computational physics;
- the MATLAB programming language;
- numerical differentiation and integration;
- numerical solutions of algebraic equations and systems;
- numerical methods for ordinary differential equations.

(3) Course Objectives

The course aims to equip students with the ability to model and simulate physical problems by applying mathematical techniques and modern computational tools. It cultivates logical thinking, reasoning, and modeling skills, and provides a solid foundation for academically oriented undergraduates in physics. Meanwhile, the scientific methodology and reflective thinking embedded in the course help students develop sound scientific attitudes and values. The objectives include:

1. Explaining the development of computational physics in China and its important contributions to national defense and economic growth—for example, to the "Two Bombs, One Satellite" program and the establishment of national supercomputing centers.
2. Mastering finite-difference–type numerical differentiation methods and performing numerical differentiation; applying Newton–Cotes and composite numerical integration methods.
3. Mastering common numerical techniques for solving linear and nonlinear equations and performing curve fitting; using MATLAB to implement numerical solutions to linear/nonlinear systems and perform curve fitting.
4. Mastering numerical methods for solving ordinary differential equations; choosing appropriate MATLAB commands to solve ODEs and visualize their solutions.

2. Intended Learning Outcomes

The intended learning outcomes of this course are summarized in the table below.

Knowledge Unit	Key Knowledge Points	Initial Level	Required Level	Expected Learning Outcomes
1: History of Computational Physics and Programming Software	1.1 Origin and Development of Computational Physics	L1	L3	Demonstrate a correct understanding of the role of computational physics within the broader discipline of physics. Describe the historical development of computational physics and explain its significant contributions to national defense and economic development.
	1.2 Programming Software	L1	L3	Explain commonly used programming software and their respective advantages.

	1.3 MATLAB Operating Interface	L1	L3	Demonstrate familiarity with the MATLAB interface and perform mathematical calculations using the editor.
	1.4 MATLAB Programming Rules	L1	L3	Use MATLAB to write simple mathematical scripts and obtain correct numerical results.
2: Computational Errors and Visualization	2.1 Errors	L1	L3	Explain the sources and definitions of computational errors.
	2.2 Methods of Minimizing Error Impact	L1	L3	Reduce computational error through step-size optimization and appropriate numerical methods.
	2.3 Visualization of Computational Results	L1	L4	Use MATLAB to produce 2D plots and 3D visualizations.
3: Numerical Differentiation and Integration	3.1 Numerical Differentiation	L1	L3	Explain the principle of finite-difference numerical differentiation and perform calculations using MATLAB.
	3.2 Numerical Integration	L1	L4	Explain the Newton–Cotes formula and composite numerical integration; compare these methods and use MATLAB integration commands.
	3.3 Applications of Numerical Calculus in Physics	L1	L3	Use MATLAB to compute energy levels in a one-dimensional quantum well and the electric potential distribution of a charged ring.
4: Numerical Solutions of Equations and Curve Fitting	4.1 Numerical Solutions of Linear Equations	L1	L3	Explain the principles of direct methods and iterative methods; solve linear systems using MATLAB matrix division.
	4.2 Numerical Solutions of Single-Variable Nonlinear Equations	L1	L4	Explain the bisection method and secant method, compare their efficiencies, and use MATLAB commands for nonlinear equation solving.
	4.3 Numerical Solutions of Nonlinear Systems and Function Minimization	L1	L3	Explain Newton's method, gradient descent, and the golden-section method; apply MATLAB commands to solve nonlinear systems and perform minimization.
	4.4 Curve Fitting	L1	L3	Describe the principles of least-squares fitting and methods for polynomial and nonlinear curve fitting; use MATLAB to fit thermistor temperature–resistance data.
5: Solving Ordinary	5.1 Basic Concepts and Runge–Kutta Method	L1	L3	Explain the basic concepts of ODEs and PDEs, describe the idea

Differential Equations				of the Runge–Kutta method, and solve ODEs using MATLAB.
	5.2 Initial-Value Problems for ODE Systems	L1	L3	Describe the computation process of the fourth-order Runge–Kutta method and use MATLAB to solve physical examples.
	5.3 MATLAB Commands for Solving ODEs	L1	L4	Select appropriate MATLAB ODE commands and apply them to physical problems.
	5.4 Boundary-Value Problems and Shooting Method	L1	L3	Explain the principles of boundary-value problem solving and the steps of the shooting method; use MATLAB to compute electric potential generated by charge distributions.
	5.5 Eigenvalue Problems	L1	L3	Explain the definition of eigenvalues and use MATLAB to compute string vibration modes and the 1D Schrödinger equation.

3. Pre-requisit

Calculus B1, Calculus B2, Linear algebra, Mathematical methods of Physics

4. Textbooks and Other Learning Resources

Required Textbooks

Fundamentals of Computational Physics, edited by Dong Qingrui, Science Press (1st Edition, 2022).

Recommended Textbooks

Computational Physics, edited by Liu Jinyuan, Science Press (2nd Edition, 2021).

Course Website

my.stu.edu.cn

5. Teaching and Learning Activities

Teaching Segment	Lectures (Theory)	Exercise Classes	Laboratory Work	Seminars	Social Practice	Project Work	Online Learning	Mid-Term Test	Total
Hours (In-class)	32	0	0	0	0	0	0	0	32
Hours (Out-of-class)	32	32	0	0	0	0	0	0	64

Because this course covers a substantial amount of computational methods and programming content, students are expected to strengthen their proficiency in programming outside of class. The ratio between out-of-class study hours and in-class teaching hours is 2:1, corresponding to 64 hours of out-of-class work (32 hours for theoretical study and 32 hours for problem-solving).

6. Assessment Scheme

Assessment item	Description	Weight

Project Exercises	Attendance, in-class responses, and homework assignments	45%
Mid-term Test	None	0%
Final Examination	Open-book exam	55%

The final grade consists of continuous assessment (45%) and the final examination (55%).

Continuous assessment:

Attendance, class participation, and responses: 20%, evaluated by the instructor.

Homework assignments: 25%, evaluated jointly by the instructor and teaching assistant.

Final examination:

The exam primarily evaluates students' ability to construct physical models, apply analytical and reasoning methods, and use Matlab programming to solve physical problems.

7. Course Schedule

Week	Hour	Teaching format	Teaching content
1	2	Lecture	Origins and development of computational physics; commonly used programming languages and tools, including the close connection between computational physics and the development of computers; introduction to Fortran, Matlab, and the plotting software Origin.
2	2	Lecture	Fundamentals of Matlab programming: Matlab interface, mathematical operations and data storage, data formats, operators, and writing rules.
3	2	Lecture	Fundamentals of Matlab programming: program editing, function files, data input and output, and program debugging.
4	2	Lecture	Computational errors and visualization: sources of computational errors, methods to reduce errors, and visualization of computational results.
5	2	Lecture	Numerical differentiation: finite-difference numerical differentiation, Euler method for differentiation, central difference formulas, and Matlab commands for numerical differentiation.
6	2	Lecture	Numerical integration: Newton–Cotes formulas, composite integration methods, and Matlab commands for numerical integration.
7	2	Lecture	Applications of numerical differentiation and integration in physics: energy levels of a one-dimensional quantum well and the electric potential distribution of a charged ring.
8	2	Lecture	Numerical solutions to linear algebraic equations and single-variable nonlinear equations: direct and iterative methods, Matlab matrix division for solving linear systems, and the bisection method.
9	2	Lecture	Numerical methods for single-variable nonlinear equations: secant method and Matlab commands for nonlinear equation solving.
10	2	Lecture	Numerical solutions to nonlinear systems and function minimization: Newton's method, gradient descent, golden-section search, and relevant Matlab commands.

11	2	Lecture	Curve fitting: least-squares method, polynomial fitting, nonlinear curve fitting, and fitting of thermistor temperature characteristics.
12	2	Lecture	Fundamentals of differential equations and Runge–Kutta methods: ODEs, PDEs, concepts of Runge–Kutta methods, and second- and higher-order schemes.
13	2	Lecture	Initial-value problems for systems of ODEs: fourth-order Runge–Kutta method and applications in physical examples.
14	2	Lecture	Matlab commands for solving ODEs: commonly used commands, steps for invoking solvers, and solving physics examples.
15	2	Lecture	Boundary-value problems and the shooting method: basic ideas for solving BVPs, steps of the shooting method, and numerical solutions of electric potential generated by spatial charge distributions.
16	2	Lecture	Eigenvalue problems: criteria for verifying eigenvalue validity, solving vibrating-string problems, and the one-dimensional Schrödinger equation.

汕头大学本科教学

课程教学大纲

课程名（COURSE TITLE）：	计算物理基础
课程代码（COURSE CODE）：	PHY3026A
学分（CREDIT VALUE）：	2
课内课时（CONTACT HOURS）：	32
先修课要求（PRE-REQUISITE）	微积分 B-I、微积分 B-II、线性代数、数学物理方法
开课单位（DEPARTMENT/UNIT）：	物理学系
版本（VERSION）：	20240731-PHY3023A
课程负责人（COURSE COORDINATOR）：	胡师林 (签章)
审核人（APPROVER）：	池凌飞(签章)
审核日期（APPROVE DATE）：	20240731

汕头大学理学院

2024 年 7 月

1、课程简介（Course Description）

（1）课程性质

计算物理基础（Fundamentals of Computational Physics）是物理学专业人才培养方案的专业基础模块课程。计算物理是物理学的一个极为重要分支，它与实验物理学、理论物理学共同组成了物理学的整体。计算物理采用合适的数学计算方法，借助计算机对物理问题进行数值模拟和归纳分析，因此它是融合了物理学、数学和计算机科学的综合课程。本课程对于深入理解量子力学、电动力学、热力学统计物理等课程内容具有重要意义。

（2）课程内容

本课程主要内容包括：计算物理学的历史、Matlab 编程语言、数值微分和积分、方程组的数值求解和常微分方程的求解。

（3）课程目标

本课程的教学目的旨在以现代计算机为工具，运用数学方法编程实现对物理问题的数值模拟，培养学生的逻辑思维能力和推理能力，提升学生的建模能力，为培养物理学专业学术型本科人才奠定坚实的基础。同时，本课程包含的科学思辨能力和方法论对于学生树立正确的科学态度和价值观具有重要的意义。主要体现在：

① 坚定中国特色社会主义道路自信、理论自信、制度自信和文化自信。

② 阐述计算物理学在我国的发展历程以及计算物理学对“两弹一星”、国家超级计算中心等国防、经济生产的重要贡献。

③ 掌握差商型数值微分方法并能够进行数值微分计算，应用牛顿-科茨方法和复化积分方法进行数值积分计算。

④ 掌握线性方程组、非线性方程（组）的常用数值解法和曲线拟合方法，能够采用 Matlab 编程语言实现对线性方程组、非线性方程组的求解和曲线拟合。

⑤ 掌握常微分方程的数值求解方法，能够选择 Matlab 指令求解常微分方程，并实现对微分方程的解进行可视化。

本课程目标对应物理学专业人才培养方案毕业要求指标点：1.坚定的理想信念；2 正确价值观和社会责任感；3.3 掌握专业理论知识及复杂理论的学习能力；4.2 掌握专业工具和实验技巧；5.3 具备创新思维和研究能力；6.2 解决问题的研究和工程能力。

2、预期学习结果（Intended Learning Outcomes）

本课程的预期学习结果如下表：

知识单元	知识点	初始程度	要求程度	预期学习结果
1.计算物理学的历史和编程软件	1.1 计算物理学的起源和发展	L1	L3	1.展现对计算物理学在物理学定位的正确理解。 2. 能够陈述计算物理学的发展历程和计算物理对国防和国民经济生产的重要贡献。 思政元素：介绍我国“两弹一星”的伟大成就，国家各超级计算中心的发展历程，阐述我国集中力量办大事的制

				度优势和科学家的奉献精神，培养学生的政治意识和大局意识。 思政元素：阐述我国拥有自主知识产权的计算物理软件的发展现状，引导学生树立追求科技进步的精神。
	1.2 计算机编程软件	L1	L3	能够阐释常用的编程软件及其优点。
	1.3 Matlab 的操作界面	L1	L3	熟悉 Matlab 的操作界面，并能够利用编辑窗口进行数学表达式计算。
	1.4 Matlab 编程的规则	L1	L3	能够利用Matlab软件对简单的数学运算编程并得到正确的结果。
2.计算结果的误差和可视化	2.1 误差	L1	L3	能够说明误差的来源和定义
	2.2 误差危害的防止措施	L1	L3	能够在编程中利用计算步长的优化和选取合适的数值计算方法降低误差。 思政元素：通过分析计算误差的来源并提出解决方案，提升学生精益求精的科学素养。
	2.3 计算结果的可视化	L1	L4	能够利用Matlab对计算数据进行二维曲线绘图、三维空间绘图。
3.数值微分与数值积分	3.1 数值微分	L1	L3	能够说明差商型数值微分计算原理，并利用 Matlab 数值微分指令进行计算。 思政元素：我国古代科学家在数学微积分计算方面的重要贡献，如割圆术。
	3.2 数值积分	L1	L4	能够阐释牛顿-科茨数值积分方法和复化积分方法，比较上述两种方法的差异，并能够选择 Matlab 相关的积分指令进行数值积分运算。 思政元素：介绍牛顿-科茨数值积分方法的发展历程，引导学生树立追求科学发展的精神。
	3.3 数值微积分在物理学计算中的运用	L1	L3	能够利用Matlab编程实现物理学中一维量子势阱中能级的计算和带电圆环空间电势分布的计算。
4.方程（组）的数值求解与曲线拟合	4.1 线性方程组的数值解法	L1	L3	能够说明直接法和迭代法的原理，并能利用Matlab软件的矩阵除法计算线性代数方程组。 思政元素：我国古代科学家对代数方程和方程组求解取得的成就，如天元术、四元术。
	4.2 单变量非线性方程的数值解法	L1	L4	能够说明对分法和弦割法的计算过程，对比以上两种方法的计算效率，并选择Matlab软件的指令实现非线性方程的计算。
	4.3 非线性方程组的数值解法和求解函数极小值	L1	L3	能够阐释牛顿迭代法、梯度下降法、黄金分割法的原理，并采用相应的 Matlab 软件的指令对非线性方程组进行计算和函数极小值的求解。 思政元素：中国科学技术大学科学家在量子计算机研发取得的成就和量子

				计算机求解代数方程组的优势。
	4.4 曲线拟合	L1	L3	能够陈述最小二乘法的原理和多项式曲线拟合、非线性曲线拟合的方法，并利用Matlab软件实现对半导体热敏电阻温度曲线的拟合。 思政元素：介绍最小二乘法的历史和现状，培养学生的批判性思维。
5.常微分方程的求解	5.1 微分方程的基本概念和龙格-库塔法	L1	L3	能够说明常微分方程和偏微分方程的基本概念以及龙-格库塔法的基本思想，并能够利用相应的 Matlab 指令计算微分方程。 思政元素：我国科学家在微分方程求解方面取得的重要成就，如辛算法、有限元方法。
	5.2 常微分方程组初值问题的求解	L1	L3	能够陈述四阶龙格-库塔法的计算过程并基于Matlab软件对物理实例进行计算。 思政元素：介绍我国在常微分方程组求解方面计算软件的发展。
	5.3 数值求解常微分方程的 Matlab 指令	L1	L4	能够选择常见的 Matlab 指令，并利用指令对物理实例进行计算。
	5.4 边值问题和打靶法	L1	L3	能够说明求解边值问题的基本思想和打靶法的步骤，并基于打靶法利用Matlab 编程实现电荷分布在空间产生电势的数值计算。
	5.5 本征值方程	L1	L3	能够说明本征值的标准，并利用Matlab 编程实现物理学中弦的振动问题和一维薛定谔方程的计算。 思政元素：我国科学家在本征值方程计算方面的重要贡献。

3、先修要求（Pre-requisite）

微积分 B-I、微积分 B-II、线性代数、数理方法

4、教材及其他教学资源（Textbooks and Other Learning Resources）

指定教材： 《计算物理学基础》，董庆瑞编著，科学出版社 （2022 年第一版）

推荐教材： 《计算物理学》，刘金远编著，科学出版社 （2021 年 第二版）

课程网站： my.stu.edu.cn

5、主要教学环节（Teaching and Learning Activities）

教学环节	理论课（小时）	习题课（小时）	实验（小时）	研讨（小时）	社会实践（小时）	项目（小时）	在线学习（小时）	期中测试（小时）	合计
课内	32	0	0	0	0	0	0	0	32
课外	32	32	0	0	0	0	0	0	64

本课程内容较多，包含了计算方法和编程知识，因此需要在课堂教学环节之外进行加强编程操作。课外课时与课堂教学课时比例为2:1，即课外学习环节为学时64，其中理论内容学习学时32，完成习题学时32。

6、课程考核（Assessment Scheme）

考核项目	考核内容和考试方法简介	权重
项目练习	考勤、课堂提问和回答、课外作业。	45%
期中测试	无	0%
期末考试	开卷考试	55%

本课程考核由课程平时学习表现和期末考试两部分组成，其中平时学习表现评分占比为45%，期末考试评分占比55%。

平时学习表现：出勤、课堂参与程度、提问等占比20%，由教师评定；课程习题占比25%，由教师和助教共同评定。

期末考试：主要考察学生是否能够基于物理问题进行物理模型的构建，掌握分析、推理等科学思维方法，并应用Matlab编程语言解决物理问题。

7、学习进度（Course Schedule）

周次	教学时数	教学形式	教学内容
1	2	课堂教学	计算物理学的起源和发展、常用的编程语言和工具，内容包括：计算物理学与计算机发展的紧密联系、Fortran 和 Matlab 编程语言以及绘图软件 Origin 的介绍。 思政元素：我国两弹一星的伟大成就。 思政元素：我国自主研发超级计算机的历程。 思政元素：我国拥有自主知识产权的计算物理软件的介绍。
2	2	课堂教学	Matlab 编程基础，内容包括：Matlab 的操作界面的介绍、数学运算和数据存储、数据格式和算符的定义和书写规则。
3	2	课堂教学	Matlab 编程基础，内容包括：编辑程序、函数文件、数据输入与输出以及程序的调试。
4	2	课堂教学	计算结果的误差和可视化，内容包括：计算误差的来源和防止措施、计算结果的可视化。 思政元素：通过分析计算误差的来源并提出解决方案，提升学生精益求精的科学素养。
5	2	课堂教学	数值微分，内容包括：差商型数值微分、微分的欧拉方法、中心差商公式和 Matlab 软件的数值微分指令。 思政元素：我国古代科学家在数学微积分计算方面的重要贡献，如割圆术。

6	2	课堂教学	数值积分，内容包括：牛顿-科茨数值积分方法、复化积分方法和 Matlab 软件的数值积分指令。 思政元素：介绍牛顿-科茨数值积分方法的发展历程，引导学生树立追求科学发展的精神。
7	2	课堂教学	数值微分和数值积分在物理学中的应用，内容包括：量子力学中一维量子势阱中能级计算和带电圆环空间电势分布的计算。
8	2	课堂教学	线性代数方程组的数值求解方法和单变量非线性方程的数值解法，内容包括：直接法和迭代法、Matlab 软件的矩阵除法计算线性代数方程组和对分法。 思政元素：我国古代科学家对代数方程和方程组求解取得的成就，如天元术、四元术。
9	2	课堂教学	单变量非线性方程的数值解法，内容包括：弦割法、求解非线性方程的 Matlab 软件的指令。
10	2	课堂教学	非线性方程组的数值解法和求解函数极小值，内容包括：牛顿迭代法、梯度下降法、黄金分割法和对应的 Matlab 软件的指令。 思政元素：中国科学技术大学科学家在量子计算机研发取得的成就和量子计算机求解代数方程组的优势。
11	2	课堂教学	曲线拟合，内容包括：最小二乘法、多项式曲线拟合、非线性曲线拟合和半导体热敏电阻温度曲线的拟合。 思政元素：介绍最小二乘法的发展历史，培养学生的批判性思维。
12	2	课堂教学	微分方程的基本概念和龙格-库塔法，内容包括：常微分方程、偏微分方程、龙-格库塔法的基本思想和二阶、高阶龙格-库塔法。 思政元素：我国科学家在微分方程求解方面取得的重要成就，如辛算法、有限元方法。
13	2	课堂教学	常微分方程组初值问题的求解，内容包括：四阶龙格-库塔法和物理实例的应用。 思政元素：介绍我国在常微分方程组求解方面计算软件的发展。
14	2	课堂教学	数值求解常微分方程的 Matlab 指令，内容包括：常见的 Matlab 指令、调用指令的步骤、采用指令求解物理实例。
15	2	课堂教学	边值问题和打靶法，内容包括：求解边值问题的基本思想、打靶法的步骤、电荷分布在空间产生电势的数值求解。
16	2	课堂教学	本征值方程，内容包括：本征值是否合理的标准、求解弦的振动问题和一维薛定谔方程。 思政元素：我国科学家在本征值方程求解方面的重要贡献。

Shantou University

Module Description for Undergraduate Courses

COURSE TITLE:	Mathematical methods of Physics
COURSE CODE:	PHY2090
CREDIT VALUE:	3
CONTACT HOURS:	48
PRE-REQUISITE	Calculus B1, Calculus B2, Advance Calculus
DEPARTMENT/UNIT:	Department of Physics
VERSION:	20240731-PHY2090
COURSE COORDINATOR:	Li Kun (Signature and Seal)
APPROVER:	Chi Lingfei (Signature and Seal)
APPROVE DATE:	20240731

Shantou University Faculty of Science

July 2024

1. Course Description

(1) Nature of the Course

Mathematical Methods of Physics is a fundamental core course for Physics majors and an elective course for the Optoelectronic Information Science and Engineering program. The course consists of two major components: *Complex Variable Functions* and *Mathematical Physics Equations*.

The section on *complex variable functions*—particularly Fourier transforms and Laplace transforms—provides essential mathematical foundations not only for the subsequent section on mathematical physics equations but also for many other physics courses.

The section on *mathematical physics equations* serves as a bridge between mathematics and the more complex physical processes encountered beyond introductory physics courses. It introduces students to elementary methods of mathematical modeling and, more importantly, enables them to master analytic techniques for solving various types of partial differential equations (PDEs), i.e., mathematical physics equations. This prepares students for advanced courses such as quantum mechanics and electrodynamics, and lays a solid foundation for using mathematical tools to analyze a broad range of complex physical phenomena.

(2) Course Contents

The main contents of the course include: complex numbers and complex variable functions, residues and applications, Laplace transforms, Fourier transforms, the one-dimensional wave equation on a finite interval, one-dimensional transport problems, series solutions of second-order linear ordinary differential equations, special functions, the Laplace equation, and the Helmholtz equation.

(3) Course Objectives

Through this course, students are expected not only to understand and become familiar with the concepts and techniques of mathematical methods but also to further cultivate rational thinking and logical reasoning, strengthen their perseverance in overcoming difficulties and achieving goals, acquire the capability to contribute to national development, and enhance their sense of patriotism. The specific objectives are as follows:

1. Master the fundamental theories and methods of complex variable functions, including basic concepts, properties of analytic functions, differentiation and integration techniques for complex functions, as well as Laplace and Fourier transforms.
2. Learn the formulation and solution of several common types of mathematical physics equations, gain a preliminary understanding of the characteristics and applications of special functions, and acquire initial experience in applying mathematical physics equations to practical physical problems.
3. Enhance theoretical thinking and strengthen the ability to analyze and solve problems, thereby laying the foundation for subsequent physics courses.

This course corresponds to the following graduation requirement indicators in the training program for Physics and Optoelectronic Information Science majors:

1. Mastery of basic theories and professional knowledge in physics (optoelectronics and microelectronics);
2. Ability to conduct research based on scientific principles and methods.

2. Intended Learning Outcomes

The intended learning outcomes of this course are summarized in the table below.

Knowledge Unit	Key Knowledge Points	Initial Level	Required Level	Expected Learning Outcomes
Complex Numbers and Complex Functions	1. Concept and properties of complex numbers	L1	L3	1. Understand the concept and meaning of complex numbers and the complex plane.

	2. Calculations involving complex functions			2. Recognize the multivalued nature of complex functions. 3. Become familiar with elementary computations involving complex numbers. 4. Broaden mathematical perspectives.
Differentiation and Integration of Complex Functions	1. Limits, continuity, and analyticity of complex functions 2. Integration of complex functions and the Cauchy theorem	L1	L3	1. Understand the analytic properties of complex functions. 2. Gain familiarity with complex integration and the Cauchy theorem. 3. Appreciate the elegance of mathematical reasoning.
Power Series of Complex Functions	1. Power series of complex functions and their convergence 2. Taylor series expansion and Laurent series expansion	L1	L3	1. Understand the convergence properties of power series for complex functions. 2. Learn to perform series expansions of complex functions, including Taylor and Laurent expansions. 3. Appreciate the unity and coherence of mathematical structures.
Residues and Their Applications	Residue theorem and applications	L1	L3	1. Master the residue theorem. 2. Apply residues to evaluate real integrals. 3. Appreciate the simplicity and power of mathematical techniques.
Laplace Transform and Applications	Properties of the Laplace transform	L1	L3	1. Master the concept of the Laplace transform. 2. Learn the inversion of the Laplace transform. 3. Apply the Laplace transform in problem-solving. 4. Recognize the practical relevance of mathematical tools.
Fourier Series and Integral Transforms	Properties and methods of Fourier series and integral transforms	L1	L3	1. Master the concepts of Fourier series and Fourier integral transforms. 2. Learn to perform Fourier series expansions and Fourier transforms.
Wave Equation on a Finite One-Dimensional Interval	1. Formulation of boundary-value problems for the wave equation 2. Method of separation of variables 3. Fourier series expansion 4. Treatment of nonhomogeneous boundary conditions	L1	L3	1. Demonstrate understanding of the nature of boundary-value problems. 2. Correctly interpret the method of separation of variables. 3. Understand eigenfunctions and eigenvalues. 4. Use separation of variables to solve homogeneous partial differential equations.

				5. Explain the purpose of Fourier expansions and the steps for solving PDEs with nonhomogeneous boundary conditions. 6. Strengthen analytical clarity in mathematical physics.
One-Dimensional Transport Problems	1. Formulation of boundary-value problems for transport equations 2. Solution methods for transport equations	L1	L3	1. Describe the differences between wave and transport boundary-value problems. 2. Understand periodic extension methods for nonperiodic boundary conditions. 3. Cultivate analytical thinking through modeling examples.
Series Solutions of Second-Order Linear ODEs	1. Series solutions near an ordinary point 2. Series solutions near a regular singular point	L1	L3	1. Distinguish between ordinary points and regular singular points. 2. Use series-expansion methods to solve second-order linear ODEs near ordinary points. 3. Understand the procedure for solving second-order linear ODEs near regular singular points. 4. Develop disciplined problem-solving habits.
Special Functions	1. Legendre functions (polynomials) 2. Cylindrical functions 3. Bessel functions	L1	L3	1. Explain the motivation for introducing special functions. 2. Understand recurrence relations. 3. Understand orthogonality and completeness of basis functions. 4. Recognize the historical development of special functions through scientific case studies.
Solutions of the Laplace Equation	1. Solutions in Cartesian coordinates 2. Solutions in spherical coordinates 3. Solutions in cylindrical coordinates	L1	L3	1. Justify the choice of coordinate systems when solving the Laplace equation. 2. Analyze symmetry using boundary conditions. 3. Explain the major steps in solving the Laplace equation. 4. Apply separation of variables to solve the Laplace equation. 5. Develop self-discipline through sustained analytical practice.
Solutions of the Helmholtz Equation	1. Solutions in spherical coordinates 2. Solutions in cylindrical coordinates	L1	L3	1. Distinguish between steady-state and nonsteady-state physical problems. 2. Demonstrate understanding of the separation-of-variables method for the Helmholtz equation. 3. Develop creativity and analytical ability for scientific problem-solving.

3. Pre-requisit

Calculus B1, Calculus B2, Advance Calculus

4. Textbooks and Other Learning Resources

Required Textbooks

Lin Fumin, *Concise Course in Mathematical Methods for Physics*, Peking University Press , First Edition (2008)

Recommended Textbooks

Lu Quankang & Zhao Huifen, *Mathematical Methods for Physics* (Second Edition, "21st Century Textbook Series"), Higher Education Press (First printing in 2003; reprinted in 2018)

Gu Qiao (Germany), *Mathematical Methods for Physics*, Science Press (First Edition 2012; 13th printing of the Second Edition in 2021). (Note: This book does not include complex analysis.)

5. Teaching and Learning Activities

Teaching Segment	Lectures (Theory)	Exercise Classes	Laboratory Work	Seminars	Social Practice	Project Work	Online Learning Others	Mid-Term Test	Total
Hours (In-class)	48	0	0	0	0	0	0	0	48
Hours (Out-of-class)	54	32	0	0	0	0	0	0	96

6. Assessment Scheme

Assessment item	Description	Weight
Project-Based Tasks	Homework assignments, attendance, and in-class Q&A.	40%
Midterm Test	None.	0%
Final Examination		60%

7. Course Schedule

Week	Hour	Teaching format	Teaching content
1	3	Classroom Teaching	Complex numbers and complex functions: complex plane, regions and boundaries, elementary complex functions, multivalued functions.
2	3	Classroom Teaching	Calculus of complex functions: limits and continuity, analyticity.
3	3	Classroom Teaching	Integrals of complex functions, Cauchy's theorem and integral formula; Chapter 3: power series of complex functions—power series and convergence, Taylor series, Laurent series.

4	3	Classroom Teaching	Chapter 4: residues and applications—residue theorem, evaluation of real integrals using residues.
5	3	Classroom Teaching	Chapter 5: Laplace transform and applications—Laplace transform, inverse transform, applications.
6	3	Classroom Teaching	Chapter 6: Fourier series and integral transforms—Fourier series.
7	3	Classroom Teaching	Fourier integral transform, δ-function and its Fourier transform; Chapter 7: wave equation on a finite interval—formulation of boundary-value problems.
8	3	Classroom Teaching	Separation of variables, Fourier-series method.
9	3	Classroom Teaching	Non-homogeneous boundary conditions, damped wave problems; Chapter 8: one-dimensional transport problem—formulation of the boundary-value problem.
10	3	Classroom Teaching	Solutions to transport problems on a finite interval and on an infinite interval.
11	3	Classroom Teaching	Chapter 9: series solutions of second-order linear ODEs—series near ordinary points, series near regular singular points.
12	3	Classroom Teaching	Chapter 10: Legendre polynomials—definition, main properties, associated Legendre polynomials.
13	3	Classroom Teaching	Chapter 11: Bessel functions—definition and main properties; Chapter 12: modified Bessel equations—imaginary-order Bessel equation, spherical Bessel equation.
14	3	Classroom Teaching	Chapter 13: Laplace equation—solutions in Cartesian coordinates and spherical coordinates.
15	3	Classroom Teaching	Solutions in cylindrical coordinates; Chapter 14: Helmholtz equation—solutions in spherical and cylindrical coordinates.
16	3	Classroom Teaching	Course review and summary.

汕头大学本科教学

课程教学大纲

课程名（COURSE TITLE）：	数理方法
课程代码（COURSE CODE）：	PHY2090
学分（CREDIT VALUE）：	3
课内课时（CONTACT HOURS）：	48
先修课要求（PRE-REQUISITE）	微积分 B-I、微积分 B-II，高等微积分
开课单位（DEPARTMENT/UNIT）：	物理学系
版本（VERSION）：	20240731-PHY2090
课程负责人（COURSE COORDINATOR）：	李昆 (签章)
审核人（APPROVER）：	池凌飞(签章)
审核日期（APPROVE DATE）：	20240731

汕头大学理学院

2024 年 7 月

1、课程简介（Course Description）

（1） 课程性质

数理方法（Mathematical methods of physics）是物理学专业的专业基础课程，也是光电信息科学与工程专业的选修课程，包含“复变函数”和“数学物理方程”两部分。“复变函数”部分，尤其是其中的傅里叶变换和拉普拉斯变换，不但为“数学物理方程”部分而且为其它物理课程提供了重要的数学基础。“数学物理方程”部分则为比前期基础物理课程中涉及的更为复杂的一些物理过程搭建物理和数学之间的桥梁。它不但能帮助学生了解简单的数学建模方法，尤为重要的是能帮助学生掌握不同类型偏微分方程（即数学物理方程）解析求解法，为下一步量子力学、电动力学等课程的学习提供必要的数学准备，也为学生以数学手段分析更广阔而复杂的物理现象打下良好基础。

（2）课程内容

本课程主要内容：复数与复变函数、留数及应用、拉普拉斯变换、傅里叶变换、一维有限区间中的波动方程、一维输运问题、二阶线性常微分方程的级数解法、特殊函数、拉普拉斯方程、亥姆霍兹方程。

（3）课程目标

通过对本课程的学习，学生们应该不但能够了解和熟悉“数理方法”的概念和技巧，而且能够进一步培养出纯理性思维和逻辑推理方法，磨练和坚定克服困难达成目的的意志和信念，掌握为国家的发展做贡献的本领，并提高爱国情怀，具体目标如下：

① 坚定中国特色社会主义道路自信、理论自信、制度自信和文化自信
② 掌握复变函数的基本理论和方法，包含复变函数的基本概念、解析函数的性质、复变函数微分积分方法以及拉普拉斯和傅里叶变换等。
③ 学会几种常见类型数学物理方程的建立和求解方法，了解并初步掌握特殊函数的特点和应用，并初步学会用数学物理方程解决实际物理问题。
④ 通过课程学习提高学生的理论思维能力，增强分析问题和解决问题的能力，为后续其它物理课程的学习打下基础。

本课程目标对应物理学、光电信息科学专业人才培养方案毕业要求指标点：1. 坚定的理想信念；2 正确价值观和社会责任感；3.1 掌握物理学（光电子学和微电子学）的基础理论和专业知识；5.1 具备基于科学原理和方法进行研究的能力。

2、预期学习结果（Intended Learning Outcomes）

本课程的预期学习结果如下表：

知识单元	知识点	初始程度	要求程度	预期学习结果
复数与复变函数	1. 复数的概念和特性 2. 复变函数的计算	L1	L3	1. 理解复数和复平面的概念和内涵 2. 了解复变函数的多值性 3. 熟悉复数的初等计算 4. 扩展对数学的视野

复变函数微积分	1. 复变函数的极限、连续 和解析性；2. 复变函数的积分和柯西定理	L1	L3	1. 了解复变函数的解析特性； 2. 了解复数的积分和柯西定理； 3. 领略数学之美
复变函数的幂级数展开	1、复变函数的幂级数及其收敛性；2. 泰勒级数展开和罗朗级数展开。	L1	L3	1. 了解复变函数的收敛性； 2. 学会对复变函数进行级数展开，包括泰勒级数和罗朗级数展开； 3. 了解数学的统一性；
留数及其应用	留数定理和应用	L1	L3	1. 留数定理； 2. 应用留数计算实变积分； 3. 了解数学的简洁美
拉普拉斯变换及其应用	拉普拉斯变换的特性	L1	L3	1. 掌握拉普拉斯变换的概念 2. 学会拉普拉斯变换的反演 3. 掌握拉普拉斯变换的应用 4. 领略数学的实际应用
傅里叶级数和积分变换	傅里叶级数和积分变换的特性和方法	L1	L3	1. 掌握傅里叶级数和积分变换的概念 2. 学会进行傅里叶级数和积分变换
一维有限区间中的波动方程	1. 波动定解问题的建立 2. 分离变量法 3. 傅里叶级数展开法 4. 非齐次边界条件的处理	L1	L3	1. 展现对定解问题内涵的理解 2. 展现对分离变量法的正确理解 3. 展现对本征函数及本征值的理解 4. 利用分离变量法求解(齐次)偏微分方程 5. 说明进行傅里叶级数展开的目的， 以及求解具有非齐次边界条件偏微分方程的步骤 6. 讲好中国故事，引导学生坚定的中国特色社会主义到了自信
一维输运问题	1. 输运定解问题的建立 2. 输运问题的解法	L1	L3	1. 说明波动定解问题与输运定解问题的区别 2. 展现对非周期性边界条件进行周期性延拓的理解 3. 介绍中国科学家事迹，强调爱国情怀
二阶线性常微分方程的级数解法	1. 在常点邻域中的级数解法 2. 在正则奇点邻域中的级数解法	L1	L3	1. 说明常点与正则奇点的区别 2. 利用级数展开法在常点邻域中求解二阶线性常微分方程 3. 说明在正则奇点邻域中求解二阶线性常微分方程的步骤 4. 爱岗敬业，培养努力学习的习

				惯，在平凡中铸就伟大
特殊函数	1. 勒让德函数(多项式) 2. 柱函数 3. 贝塞耳函数	L1	L3	1．说明引入的特殊函数目的 2．展现对递推关系的理解 3．展现对正交完备基的理解 4．介绍相关科学及历史人物的故事，理解科学发展的继承性
拉普拉斯方程的求解	1. 直角坐标中的解 2. 球坐标中的解 3. 柱坐标中的解	L1	L3	1．说明在求解拉普拉斯方程过程中选择不同坐标系的原因 2．利用给定边界条件进行对称性分析 3．说明求解拉普拉斯方程的主要步骤 4．利用分离变量法求解拉普拉斯方程 5．引导学生克制自己的惰性，向著名的科学家学习
赫姆霍兹方程的求解	1. 球坐标中的解法 2. 柱坐标中的解	L1	L3	1．说明稳态和非稳态物理问题的区别 2．展现对分离变量法在求解赫姆霍兹 3．强调勇于创新的精神，不断提升能力，为中国的发展贡献聪明才智

3、先修要求（Pre-requisite）

微积分 B-I、微积分 B-II，高等微积分

4、教材及其他教学资源（Textbooks and Other Learning Resources）

指定教材：

《数学物理方法简明教程》，林福民 编著，北京大学出版社 （2008 年第一版）

推荐教材：

《数学物理方法》第二版面向 21 世纪教材，陆全康、赵蕙芬 编著，高度教育出版社 （2003 年第一次印刷，2018 年重印）

《数学物理方法》，【德】顾樵 编著，科学出版社（2012 年第一版，2021 年第二十三次印刷）（注：没有复变函数）

5、主要教学环节（Teaching and Learning Activities）

教学环节	理论课（小时）	习题课（小时）	实验（小时）	研讨（小时）	社会实践（小时）	项目（小时）	在线学习（小时）	期中测试（小时）	合计
课内	48	0	无	无	无	无	无	无	48
课外	54	32	无	无	无	无	无	无	96

6、课程考核（Assessment Scheme）

考核项目	考核内容和考试方法简介	权重
项目练习	课后作业；考勤；课堂提问及回答。	40%
期中测试	无	0%
期末考试	开卷考试	60%

7、学习进度（Course Schedule）

周次	教学时数	教学形式	教学内容
1	3	课堂教学	复数与复变函数。内容包括： 复数和复平面，复平面区域和边界，初等复变函数，复变函数的多值性。
2	3	课堂教学	复变函数微积分。内容包括： 复变函数的极限和连续性，复变函数的解析性。
3	3	课堂教学	复变函数积分，柯西定理和积分公式。 第三章 复变函数的幂级数展开。内容包括：复变函数项幂级数及其收敛性，泰勒级数展开，罗朗级数展开。
4	3	课堂教学	第四章 留数及其应用。内容包括：留数定理，应用留数计算实变积分。
5	3	课堂教学	第五章 拉普拉斯变换及其应用。内容包括：拉普拉斯变换，拉普拉斯变换的反演，拉普拉斯变换的应用。

6	3	课堂教学	第六章 傅里叶级数和积分变换。内容包括：傅里叶级数。
7	3	课堂教学	傅里叶积分变换，δ函数及其傅里叶变换 第七章 一维有限区间中的波动方程。内容包括：定解问题的建立。
8	3	课堂教学	分离变量法，傅里叶级数展开法。
9	3	课堂教学	非齐次边界条件的处理，阻尼波动问题。 第八章 一维输运问题。内容包括：一维输运定解问题的建立。
10	3	课堂教学	一维有限区间中输运问题的解法， 一维无限区间中输运问题的解法。
11	3	课堂教学	第九章 二阶线性常微分方程的级数解法。内容包括： 在常点邻域中的级数解法， 在正则奇点邻域中的级数解法。
12	3	课堂教学	第十章 勒让德多项式。内容包括： 勒让德多项式的定义， 勒让德多项式的重要性质， 缔合勒让德多项式。
13	3	课堂教学	第十一章 柱函数。内容包括： 柱函数的定义及其重要性质。 第十二章 变形贝塞耳方程。内容包括： 虚宗量贝塞耳方程， 球贝塞耳方程。
14	3	课堂教学	第十三章 拉普拉斯方程。内容包括： 直角坐标中拉普拉斯方程的解法， 球坐标中拉普拉斯方程的解法。
15	3	课堂教学	柱坐标中拉普拉斯方程的解法。 第十四章 亥姆赫兹方程。内容包括：球坐标中亥姆赫兹方程的解法，柱坐标中亥姆赫兹方程的解法。
16	3	课堂教学	课程总结复习

Shantou University

Module Description for Undergraduate Courses

COURSE TITLE:	Graduation Practice and social practice
COURSE CODE:	PHY4100B
CREDIT VALUE:	6
CONTACT HOURS:	0
PRE-REQUISITE	None
DEPARTMENT/UNIT:	Department of Physics
VERSION:	20240731-PHY4100B
COURSE COORDINATOR:	迪凌 (Signature and Seal)
APPROVER:	Li Pengcheng (Signature and Seal)
APPROVE DATE:	20240731

Shantou University Faculty of Science

July 2024

1. Course Description

(1) Nature of the Course

Graduation Internship and Social Practice is a compulsory course for students majoring in Optoelectronic Information Science and Engineering, Optoelectronic Information Science and Engineering (Microelectronics Track), and Physics. This course serves as a comprehensive practical training after students have largely completed their major coursework. Its aim is to expose students to real working environments, enabling them to integrate theoretical knowledge with practical tasks, identify problems in real work settings, analyze them, and develop solutions. Through this process, students enhance their ability to apply theory to practice and improve their problem-solving skills.

Through social practice activities, students experience corporate cultures that are fundamentally different from the university environment and gain insight into industry demands for talent. This helps guide students toward aligning their personal development with societal needs. Social practice also cultivates students' social awareness and sense of responsibility, strengthens their team spirit and collaboration skills, and enhances communication abilities—important qualities for nurturing research-oriented talents capable of contributing to national and societal needs.

(2) Course Content

This course primarily consists of social practice activities, generally scheduled during the summer of the third academic year and the winter of the fourth academic year. Students may participate in a 6–8-week internship (depending on the arrangement of the internship base) at designated practical training bases or internship institutions organized by the department. The internship position must be relevant to the student's major. Students may also independently contact enterprises or institutions related to their major to arrange an internship.

Students who independently arrange internships must submit the "Student Application Form for Self-Arranged Internship Placement" to the department before the internship and may proceed only after obtaining approval from the program director or internship supervisor. The specific internship tasks are determined through consultation between the internship base and the supervising instructor.

(3) Course Objectives

① To apply theoretical knowledge to real work scenarios, thereby deepening and consolidating mastery of the learned theories;

② To acquire relevant professional knowledge not covered in classroom teaching and expand the scope of disciplinary understanding;

③ To understand corporate culture and develop the ability to analyze and solve problems in the interaction between enterprises and society, thereby improving students' social adaptability and competitiveness;

④ To develop interpersonal skills and strengthen students' sense of professionalism.

This course supports the cultivation of academic-oriented talents in Optoelectronic Information Science and Engineering, Optoelectronic Information Science and Engineering (Microelectronics Track), and Physics. It strongly contributes to the fulfillment of graduation requirement indicators, including:

"3.3 Ability to acquire knowledge necessary for work in related professional fields; 5.2 Ability to design experiments, analyze data, and interpret results; 6.2 Ability to design engineering solutions to basic optoelectronic problems (Physics: ability to study and optimize application-related problems based on fundamental physics); 7.1 Ability to assume roles as individuals, members, or leaders in multidisciplinary teams; 8.1 Ability to communicate effectively with industry professionals and the public regarding scientific and engineering issues."

2. Intended Learning Outcomes

Knowledge Unit	Key Knowledge Points	Initial Level	Required Level	Expected Learning Outcomes
Professional Knowledge and Ability Application	Critical Thinking Ability	L3	L4	Accurately compare the encountered problems
	Analytical Ability	L3	L4	Conduct scientific reasoning on encountered problems
	Action Competence	L2	L4	Select the appropriate time to complete assigned tasks
Ability to analyze and solve problems encountered in enterprise practice	Ability to Raise and State Problems	L1	L3	Explain problems encountered in practice
	Problem-Analysis and Problem-Solving Ability	L1	L3	Use professional knowledge to solve practical problems
	Internship Report Writing Ability	L2	L4	Summarize the internship process, outcomes, and propose constructive suggestions
Development of comprehensive competencies	Teamwork Ability	L2	L4	Demonstrate collaborative spirit and respond to team-work requirements
	Organizational Ability	L2	L4	Deconstruct tasks and organize effective collaboration
	Communication and Expression Ability	L2	L4	Deconstruct tasks and organize collaboration; present issues concisely and respond to others accurately
	Adaptability	L2	L4	Demonstrate adaptability by deconstructing unexpected issues and selecting appropriate solutions
Service and Practice Ability Development	Practical Ability	L2	L5	Apply professional knowledge appropriately in real-world tasks and take initiative in fulfilling internship responsibilities
	Service Spirit	L2	L5	Cultivate enthusiasm and awareness for serving society

3. Pre-requisit

None

4. Teaching and Learning Activities

Teaching Segment	Social Practice	Total
Hours (In-class)	0	0
Hours (Out-of-class)	⩾240	⩾240

Basis for calculating out-of-class hours:

Based on 5 practice days per week and 8 hours per day, the weekly off-campus practice time amounts to 40 hours.

Given that students complete 6–8 weeks of internship, the minimum required hours for off-campus social practice are therefore 240 hours.

6. Assessment Scheme

Assessment Content	**Weight**	**Evaluator**
Overall performance, professional qualities, and abilities	33%	Host organization (with official seal required)
Attendance records provided by the company, overall performance, internship diary and internship report, learning gains, etc.	67%	Instructor

Note: The assessment shall follow the Shantou University Student Internship Performance Evaluation Form, and grades are assigned on a 5-point scale.

7. Course Schedule

Week	**Hour**	**Teaching format**	**Teaching content**
		Internship Orientation Meeting	The internship coordinator introduces the overview of each internship base, the main internship tasks, the number of available positions, and the start and end dates of the internship. Safety instructions for internship activities are also provided.
		Allocation of Internship Units	Based on students' preferences and the willingness of internship units to accept interns, internship placements are confirmed through mutual selection. Relevant internship documents are prepared. Applications from students who independently secure internship units are reviewed.
1-6	240	Independent Practice	Under the supervision of the internship instructor and the host organization, students conduct practical training. For off-campus internship bases or group internships (more than 4 students), the internship instructor must visit the site at least once during the internship to assess students' progress.
		Submission of Internship Materials	After completing the internship, students must submit the Internship Attendance Sheet and the Internship Performance Evaluation Form (both stamped with the host organization's official seal), the internship diary, and the internship report within the specified deadline. Students who independently arranged their internship must additionally submit a Letter of Acceptance from the Internship Unit (with official seal).
		Grade Evaluation	After collecting all internship materials, the internship instructor evaluates student performance based on the submitted documents.

Note: Since internship duration requirements vary across host organizations, the schedule is presented based on the minimum requirement of a 6-week internship.

B 是

汕头大学本科教学
课程教学大纲

课程名（COURSE TITLE）：	毕业实习与社会实践
课程代码（COURSE CODE）：	PHY4100B
学分（CREDIT VALUE）：	6
课内课时（CONTACT OURS）：	0
先修课要求（PRE-REQUISIT）	无
开课单位（DEPARTMENT/UNIT）：	物理学系
版本（VERSION）：	20240731-PHY4100B
课程负责人（COURSE COORDINATOR）：	池凌飞(签章)
审核人（APPROVER）：	李鹏程(签章)
审核日期（APPROVE DATE）：	20240731

汕头大学理学院

2024 年 7 月

1. 课程简介（Course Description）

（1）课程性质

“毕业实习与社会实践（Graduation Internship and Social Practice）”是光电信息科学与工程专业、光电信息科学与工程专业（微电子方向）和物理学专业的必修课。社会实践是学生在基本完成专业学习之后的综合实习，目的是让学生体验真实的工作场景，将所学知识与实际工作相结合，在工作中发现问题、分析问题和解决问题，从而提高学生理论联系实际和解决问题的能力。通过社会实践活动，可以让学生体验到与学校截然不同的企业文化，了解行业对人才的需求，从而促使学生自觉地向满足社会需求的方向发展。社会实践活动还培养了学生的社会意识和责任感，培养学生协作精神和团队意识，提高团队合作和沟通能力，有助于培养满足国家和社会需要的研究型人才。

（2）课程内容

本课程主要内容为社会实践，一般安排在大学三年级暑假和大学四年级寒假进行。学生可以在专业的组织下前往专业的实践教学基地、实习基地进行为期6~8周的实习（视实习基地安排而定），实习岗位需与专业相关，也可以自行联系与专业相关的企事业单位实习。自行联系实习单位的学生需在实习前向专业提交《学生自行联系实习单位申请表》，获得专业主任或实习指导教师同意后，方可按计划实习。实习具体内容由实习基地与指导教师协商后确定。

（3）课程目标

①认同和拥护我国的社会主义制度，胸怀家国情怀，能树立将个人追求与国家重大需求相结合，实现人生价值的信念；

② 学生能将所学理论知识应用到实际工作中，从而加深和巩固所学的理论知识；

③ 学生了解和掌握课堂上未涉及的相关专业知识，拓宽专业知识面；

④ 学生了解企业文化，在企业和社会的互动中培养分析问题和解决问题的能力，提高学生社会适应能力和社会竞争力；

⑤ 学生学会处理人与人之间的关系，增强学生的职业意识。

本课程为光电信息科学与工程专业、光电信息科学与工程专业（微电子方向）和物理学专业学术型人才培养提供研究能力培养，高度支撑上述专业毕业要求指标点“1. 坚定的理想信念，2. 正确价值观和社会责任感，3.3 具备通过学习获得相近专业领域工作的能力，5.2 具备设计实验、分析与解释数据的能力，6.2 具备设计光电领域基本工程问题解决方案的能力（物理学专业为：具备从物理基础出发，对物理学及相关领域中的应用问题研究与优化能力),7.1 能在多学科背景团队中承担个体、成员及负责人角色，8.1 具备就专业的科学与工程问题与业界同行、社会公众进行有效沟通和交流的能力”。

2. 预期学习结果（Intended Learning Outcomes）

本课程的预期学习结果如下表：

知识单元	知识点	初始程度	要求程度	预期学习结果
专业知识和能力运用	思辨能力	L3	L4	对遇到的问题进行准确的比较
	分析能力	L3	L4	对遇到的问题进行科学的推理
	行动能力	L2	L4	选择正确的时间完成工作
企业实践中实践分析，解决问题的能力	提出、阐述问题的能力	L1	L3	说明实践中的问题
	分析、解决问题的能力	L1	L3	运用专业知识解决实践中的问题
	实践报告撰写能力	L2	L4	概述实习过程、实习收获，提出对策建议
综合能力培养	团队合作能力	L2	L4	富有协作精神，能呼应团队协作要求
	组织能力	L2	L4	解构任务并组织协作
	表达、沟通能力	L2	L4	简明扼要地说明问题，迅速准确地回应别人的问题
	应变能力	L2	L4	解构突发问题，选择恰当的处理方法
服务和实践能力培养	实践能力	L2	L5	将专业知识正确地应用于实践中积极主动完成实践岗位职责
	服务精神	L2	L5	树立服务社会的热情与意识

3. 先修要求（Pre-requisit）

无

4. 主要教学环节（Teaching and Learning Activities）

教学环节	社会实践（小时）	合计
课内	0	0
课外	≥240	≥240

课外课时计算依据：

按每周实践5天，每天8小时计算，每周课外实践40小时。学生实习周数为6~8周，所以课外社会实践最低应完成240小时。

5.课程考核（Assessment Scheme）

考核内容	权重	评定人
综合表现、素质与能力等	33%	用人单位（需加盖单位公章）
企业提供的考勤记录、综合表现、实习日记与实习报告、实践收获等	67%	教师

说明：分数评定使用《汕头大学学生实习成绩鉴定表》，以5分制评定。

6. 学习进度（Course Schedule）

周次	教学时数	教学形式	教学内容
		实习动员会	实习动员会，实习负责教师介绍各实习基地概况、主要实习工作、接收人数、实习起止时间等信息，并进行实习安全教育
		分配实习单位	根据学生意愿和实习单位接收意愿，双向确定实习单位和对应的实习学生，准备相应的实习材料。 审核自行联系实习单位学生申请。
1~6	240	自主实践	在实习指导教师和实习单位指导下，开展实践活动 对于外地实习基地或集体实习（人数>4 人）单位的学生，实习期间实习指导教师必须至少实地拜访一次，了解学生实习情况
		提交实习材料	学生在实习完成后规定的期限内提交实习考勤表、实习成绩鉴定表（以上两份材料均需实习单位加盖公章）、实习日记和实习报告；自行联系实习单位的学生除上述材料外，还需提交《实习单位接收函》（加盖单位公章）
		成绩评定	收齐学生实习材料后，实习指导教师根据提交的实习材料进行成绩评定

注：因各实习单位要求的实习时长不一致，学习进度以实习 6 周的最低要求填写。

Shantou University

Module Description for Undergraduate Courses

COURSE TITLE: Graduation Thesis

COURSE CODE: PHY4200A

CREDIT VALUE: 10

CONTACT HOURS: 0

PRE-REQUISITE None

DEPARTMENT/UNIT: Department of Physics

VERSION: 20240731-PHY4200C

COURSE COORDINATOR: (Signature and Seal)

APPROVER: Li Pengcheng (Signature and Seal)

APPROVE DATE: 20240731

Shantou University Faculty of Science

July 2024

1. Course Description

(1) Nature of the Course

Graduation Thesis is a compulsory course for students majoring in Optoelectronic Information Science and Engineering, Optoelectronic Information Science and Engineering (Microelectronics), and Physics.

The graduation thesis constitutes a crucial component of higher education. It evaluates students' ability to apply the knowledge and skills acquired during their undergraduate studies in an integrated manner, and serves as a comprehensive assessment of their research competence and innovative thinking.

Students are required to select a research topic relevant to their major and possessing academic or practical value. By consulting the literature, collecting data, conducting experiments, performing analysis, and examining theoretical models, students investigate the topic in depth and ultimately produce a well-structured, clearly argued, and rigorously supported academic thesis.

This process assesses students' mastery of disciplinary knowledge, ability to apply professional skills, competence in information retrieval, academic writing, and scholarly communication. It is an important evaluation of the overall outcomes of undergraduate training. Through this course, students receive comprehensive training and develop into research-oriented talents.

(2) Course Content

This course follows the Shantou University Undergraduate Graduation Thesis (Design) Regulations and consists of the stages of topic selection, proposal, writing, and thesis defense, with a total duration of approximately 18 weeks. The main components include:

① Based on students' knowledge foundation and required competencies, teachers propose thesis topics that involve integrated training, are appropriately challenging, have sufficient workload, and possess theoretical or practical significance. Topics are formulated according to the instructor's research field, academic interests, or industry needs. After departmental discussion and approval by the department chair, the topics are released to students for selection.

② After choosing a topic, students work under the guidance of their supervisors to conduct literature searches, design a feasible research plan, and complete preparatory tasks such as the thesis proposal.

③ Under the supervisor's guidance, students independently complete the research tasks required for the thesis, including but not limited to experiments, modelling, simulations, computational analysis, and data processing.

④ Students independently write the thesis, maintain timely communication with the supervisor during the writing process, revise continuously based on feedback, and complete plagiarism checks.

⑤ Upon approval by the thesis reviewer, students participate in the department-organized thesis defense and finalize the thesis according to the suggestions of the defense committee.

(3) Course Objectives

① To master the scientific methodology commonly used in academic research and engineering practice.

② To develop reductive thinking and critical thinking skills.

③ To strengthen the ability to connect theory with practice and to enhance data-processing and analytical skills, enabling students to solve general engineering problems.

This course serves as a core component in cultivating research capabilities for students in Optoelectronic Information Science and Engineering, Optoelectronic Information Science and Engineering (Microelectronics), and Physics. It strongly supports the corresponding program learning outcomes, including:

3.3 ability to acquire knowledge for employment in related fields;

5.2 ability to design experiments and analyze and interpret data;

6.2 ability to design solutions to basic engineering problems in optoelectronics (for Physics: ability to study and optimize application problems in physics-based fields);

8.1 ability to communicate effectively with peers and the public regarding scientific and engineering issues.”

2. Intended Learning Outcomes

The intended learning outcomes of this course are listed in the table below:

Knowledge Unit	Key Knowledge Points	Initial Level	Required Level	Expected Learning Outcomes
Topic Selection and Research Design	Identifying a topic and articulating its significance	L1	L2	Explain the significance and value of the topic and justify the choice of research topic.
	Writing a literature review	L1	L2	Describe the background and current status of the research field.
	Formulating research questions and hypotheses	L1	L4	Outline the research questions and propose research hypotheses.
	Determining research methods	L1	L6	Design appropriate research methods.
	Research ethics and academic norms	L0	L2	Identify basic research ethics and academic norms.
Thesis Writing and Structure	Thesis structure and writing conventions	L1	L3	Apply correct thesis structure and writing conventions.
	Writing the abstract and introduction	L1	L4	Summarize the research significance, background, and main work of the thesis.
	Presenting and discussing research results	L1	L5	Summarize the main methods used and evaluate the research results.
	Writing conclusions and recommendations	L1	L4	Summarize the main conclusions and provide suggestions based on the research work.
	Citation and referencing conventions	L1	L3	Apply correct citation and referencing rules.
Thesis Defense	Preparation and rehearsal	L1	L3	Demonstrate familiarity with the thesis content during defense preparation.
	Defense strategies and techniques	L1	L3	Apply appropriate defense strategies and techniques.

3. Pre-requisit

None

4. Teaching and Learning Activities

Teaching Segment	Lectures (Theory)	Homework	Experiments	Seminars	Reading	Project	Online Learning	Total
Hours (In-class)	0	0	0	0	0	0	0	0
Hours (Out-of-class)	45	0	100	20	45	0	30	240

Basis for calculating out-of-class hours:

Approximately 5 hours of reading and 1 hour of discussion with the supervisor are required during the topic-selection stage. After the topic is confirmed, students need more than 60 hours of independent theoretical study (including online learning) and about 3 hours of discussion with the supervisor. During the research phase, students must complete approximately 100 hours of experimental work (including simulations) and data analysis, plus about 15 hours of discussion with the supervisor, as well as 50 hours of out-of-class study. During the thesis-writing stage, about 2 hours of supervisor consultation and 5 hours of additional study are required.

5. Assessment Scheme

The thesis work is conducted in the following sequence: proposal, mid-term assessment, plagiarism check, thesis review, and defense. Students are not allowed to proceed to the next stage unless the previous stage is successfully completed.

Thesis Proposal:

The student, under the guidance of the supervisor, conducts a careful literature review and designs a reasonable research plan. The student then writes a review-style proposal, which is checked and approved by the supervisor.

Mid-term Assessment:

Students report the current progress of their research according to the research methods outlined in the proposal. For projects that do not meet expected progress, students must explain the reasons in detail and propose corrective measures. The supervisor is responsible for reviewing this assessment.

Thesis Completion and Plagiarism Check:

After the main work of the research is completed, students introduce their research and present conclusions. The undergraduate thesis must be written following specific formatting and academic standards. At least one plagiarism check must be conducted before the submission deadline, and the plagiarism rate must not exceed 30%.

Thesis Review:

Students submit the compiled thesis to the supervisor for review. The supervisor grades the thesis and provides personalized comments, which are then submitted to the defense group leader. The leader forwards the thesis to reviewers, who provide a score and review comments that are submitted to the defense committee.

Thesis Defense:

All undergraduate theses require a defense; grades are not assigned without defense participation. The defense is conducted under the leadership of the department thesis defense committee and is divided into two stages:

① Group Defense: Several defense groups are set up under the department, responsible for conducting defense sessions and performing initial selection of outstanding theses.

② Outstanding Thesis Defense: The department defense committee identifies outstanding theses based on the defense performance and finalizes all thesis grades.

Thesis Review Criteria:

1. Significance and practical value of the chosen topic.

2. Student's understanding of the research progress, mastery of literature, and ability to summarize prior studies.
3. Foundation in theory, professional knowledge, basic research methods and skills, independent work capability, novel insights, originality, and the completeness of the thesis work.
4. Compliance with academic norms, clarity of written expression, authenticity of materials, reasonableness of conclusions, conceptual clarity, and rigor of analysis.
5. Defense performance and whether the thesis meets bachelor-level requirements.

Thesis Defense Scoring Considerations:

1. Nature, difficulty, weight, and comprehensive training involved in the thesis.
2. Thesis quality, academic value, and originality.
3. Accuracy and correctness of oral presentation and answers during the defense.
4. Work attitude.

Grading:

The final grade is comprehensively determined by the defense committee based on inputs from the supervisor, review panel, and defense group. A five-level grading system is applied.

Recommended Grading Scale:

- Excellent: Average score $\geqslant$ 4.5
- Good: 3.5 $\leqslant$ Average score < 4.5
- Medium: 2.5 $\leqslant$ Average score < 3.5
- Pass: 1.5 $\leqslant$ Average score < 2.5
- Fail: Average score < 1.5

Plagiarism may lower the evaluation level; severe cases result in a failing grade.

Reference Standards for Thesis Comments:

- Excellent: Clear and innovative arguments, logical structure, thorough reasoning, sufficient materials, appropriate methodology, accurate narrative, fluent language.
- Good: Clear arguments, logical structure, adequate materials, sound reasoning, correct methodology, accurate narrative, fluent language; has innovation but with minor defects.
- Medium: Relatively clear arguments, reasonable structure, adequate materials, fairly thorough reasoning, appropriate methods, relatively accurate narrative, fluent language; has some innovation but noticeable defects.
- Pass: Arguments and structure are acceptable but materials are insufficient, reasoning incomplete, methods limited, narrative lacks clarity, language is less fluent.
- Fail: Core arguments or main content are plagiarized, unclear, logically inconsistent, or contain factual errors.

6. Course Schedule

Week	Hour	Teaching format	Teaching content	Requirements
1-2	40	Online & On-site Guidance	Topic selection, accept research assignment	Complete topic selection
3-6	80	Online & On-site Guidance	Literature review, preliminary experiments	Complete literature search and organization, explore possible experimental methods
7-8	40	Online & On-site Guidance	Thesis proposal, verification experiments	Complete thesis proposal, report literature review results, and confirm research plan
9-11	60	Online & On-site Guidance	Formal experiments, modeling, or simulation calculations	Obtain intermediate results for the thesis

12	20	Online & On-site Guidance	Mid-term report	Complete mid-term report and improve thesis work according to supervisor's feedback
13-16	60	Online & On-site Guidance	Formal experiments, modeling, or simulation calculations	Obtain main results of the thesis
17	20	Online & On-site Guidance	Thesis writing and revisions	Complete thesis, revise according to supervisor's feedback, and pass thesis review
18	20	On-site Defense	Thesis defense	Complete thesis defense

汕头大学本科教学

课程教学大纲

课程名（COURSE TITLE）：	毕业论文
课程代码（COURSE CODE）：	PHY4200A
学分（CREDIT VALUE）：	10
课内课时（CONTACT OURS）：	0
先修课要求（PRE-REQUISIT）	无
开课单位（DEPARTMENT/UNIT）：	物理学系
版本（VERSION）：	20240731-PHY4200C
课程负责人（COURSE COORDINATOR）：	(签章)
审核人（APPROVER）：	李鹏程(签章)
审核日期（APPROVE DATE）：	20240731

汕头大学理学院

2024 年 7 月

1. 课程简介（Course Description）

（1）课程性质

“毕业论文（Graduation Thesis）”是光电信息科学与工程专业、光电信息科学与工程专业（微电子方向）和物理学专业的必修课。毕业论文是高等教育中的一个重要环节，它旨在检验学生在本科阶段所学知识和技能的综合运用能力，同时也是对学生研究能力和创新思维的一次全面考核。学生需要选择一个与自己专业相关且具有一定研究价值的题目，通过查阅文献、收集数据、分析实验等方式，深入探讨问题，最终形成一篇结构严谨、观点明确、论证有力的学术论文。通过毕业论文的环节，全面检验学生对专业知识的掌握、专业能力的运用、查阅资料、组织文字、语言表达等素质，是对学生培养成
果的一次重要考核。通过该课程（环节）使学生得到全方位的锻炼，最终成长为研究型人才。

（2）课程内容

本课程以《汕头大学本科毕业论文（设计）工作规程》为规范，包括：选题、开题、撰写、答辩等阶段，总用时约十八周。主要安排下列内容：

① 教师根据本专业学生的知识和能力要求，在体现综合训练前提下，按照难度适当，工作量足够，具有一定理论或应用意义的要求，结合自己的研究领域、兴趣，或根据行业需求拟定，论文选题经集体讨论并由系主任审批后，向学生公布，供学生选择；

② 学生确定选题后，接受指导教师任务，在指导教师的指导下，对相关资料进行检索，设计合理的课题研究方案，完成毕业论文的开题等前期准备工作；

③ 在指导教师的指导下，自主完成论文所需数据工作，包括但不限于实验、建模、模拟计算、数据分析等；

④ 独立完成毕业论文的撰写，此过程中需及时与指导教师进行沟通并进行不断修改，通过查重检查；

⑤ 经论文评阅人同意后，学生参加专业统一组织的毕业论文的答辩，并根据答辩委员会意见最终定稿毕业论文。

（3）课程目标

① 认同和拥护我国的社会主义制度，胸怀家国情怀，能树立将个人追求与国家重大需求相结合，实现人生价值的信念；

② 掌握科学研究和工程技术中的科学方法论；

③ 具备一定的还原性思维和批判性思维能力；

④ 具备较好地理论联系实际能力，较强的数据处理、分析能力，能解决一般的工程问题

本课程为光电信息科学与工程专业、光电信息科学与工程专业（微电子方向）和物理学专业学术型人才培养提供研究能力培养，高度支撑上述专业毕业要求指标点“1. 坚定的理想信念，2. 正确价值观和社会责任感，3.3 具备通过学习获得相近专业领域工作的能力，5.2 具备设计实验、分析与解释数据的能力，6.2 具备设计光电领域基本工程问题解决方案的能力（物理学专业为：

具备从物理基础出发，对物理学及相关领域中的应用问题研究与优化能力），8.1 具备就专业的科学与工程问题与业界同行、社会公众进行有效沟通和交流的能力”。

2. 预期学习结果（Intended Learning Outcomes）

本课程的预期学习结果如下表：

知识单元	知识点	初始程度	要求程度	预期学习结果
选题与研究设计	确定选题与选题意义阐述	L1	L2	说明论文的选题意义和价值，解释选题原因
	撰写文献综述	L1	L2	说明研究领域的背景和现状
	提出研究问题与假设	L1	L4	概述研究问题，提出研究假设
	确定研究方法	L1	L6	能设计研究方法
	研究伦理与规范	L0	L2	能辨别研究伦理和研究规范
论文撰写与设计	论文结构与写作规范	L1	L3	使用正确的论文结构和协作规范
	撰写论文摘要与引言	L1	L4	能概述论文的研究意义、背景和主要工作
	论文结果展示与讨论	L1	L5	能总结论文使用的主要方法，对论文工作及结果进行评价
	论文结论与建议	L1	L4	概述论文的主要结论，说明自己对论文工作的建议
	参考文献引用规范	L1	L3	应用正确的文献应用规范
论文答辩	答辩准备与演练	L1	L3	演示对答辩内容的熟悉程度
	答辩策略与技巧	L1	L3	使用正确的答辩策略与技巧

3. 先修要求（Pre-requisit）

无

4. 主要教学环节（Teaching and Learning Activities）

教学环节	理论学习（小时）	作业（小时）	实验（小时）	研讨（小时）	课外阅读（小时）	项目（小时）	在线学习（小时）	合计
课内	0	0	0	0	0	0	0	0
课外	45	0	100	20	45	0	30	240

课外课时计算依据：

选题环节需要5小时左右课外阅读时间，需要和教师研讨约1小时。选题确定后学生需要60小时以上的课外理论学习时间（含在线学习），与教师研讨约

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3小时。论文进行阶段，学生需完成约100小时的实验（含模拟计算）和数据分析，与教师研讨约15小时，课外学习50小时。论文撰写阶段，需与教师研讨约2小时，课外学习约5小时。

5. 课程考核（Assessment Scheme）

论文工作按开题、中期考核、论文查重、论文评阅和论文答辩顺序完成，中间任一环节没有完成都不得进入下一个环节。

开题报告是学生在指导教师指导下，认真进行文献调研，设计合理的课题研究方法后，撰写的综述性报告，由指导教师负责审核。

中期考核需根据开题报告中确定的课题研究方法，对当前课题进展的汇报，对于进展不及预期的课题，学生需详细说明理由，并给出弥补思路和措施，由指导教师负责审核。

课题主要工作完成后，学生需按照学位论文的要求，对自己的论文课题工作进行介绍，并给出结论。本科毕业论文需按一定的格式和规范撰写，论文需按学校规定期限完成至少一次查重，查重率不得高于 30%。

学生将论文整理成册交指导教师进行评阅，指导教师评阅后需对论文评分并做出个性化评价后交给答辩小组组长，由组长交由评阅人评阅，评阅人出具评分和评阅意见后，上交答辩小组。

答辩：所有毕业论文均需参加答辩，未经答辩不予评定成绩。答辩工作在系答辩委员会领导下进行，分两阶段：

① 小组答辩：系下设若干答辩小组，负责具体答辩工作并完成优秀论文的初选工作。

② 优秀论文答辩：系答辩委员会根据优秀论文答辩过程的具体情况确定优秀论文，并确定所有毕业论文成绩。

论文评阅标准：

① 选题的意义和实用价值；

② 作者对本课题研究进展的了解程度以及对文献资料的掌握及综述能力；

③ 作者的基础理论、专业知识、基本研究方法和技能及独立工作能力、论文的新见解、新观点、论文工作量是否饱满；

④ 论文的规范性及文字表达能力、材料的真实性和结论的合理性、概念清晰与分析严谨的程度；

⑤ 论文答辩情况及是否达到学士学位论文水平要求。

论文答辩评分标准应从四个方面综合考虑：

① 论文的性质、难度、分量、综合训练等情况；

② 论文的质量、价值及有无创造性；

③ 答辩中自述和回答问题的正确程度；

④ 工作态度。

成绩评定：

根据指导教师、评阅小组、答辩小组多方面的意见由答辩委员会综合评定成绩，按五级计分制确定等级。

毕业论文的评分标准：

建议成绩的记分采用五级制，分为优秀、良好、中等、及格、不及格五个等级。

建议成绩的评定请参考平均分及是否发现抄袭等情况得出，评分参考标准为：

优秀：平均分≥4.5；

良好：3.5≤平均分＜4.5；

中等：2.5≤平均分＜3.5；

及格：1.5≤平均分＜2.5；

不及格：平均分＜1.5。

发现抄袭情况时，可视抄袭程度轻重降低相应评价等级，情况严重者评为不及格。

论文评语的参考标准：

优秀：观点明确，观点有创新，思路清晰，结构合理，逻辑性强，材料充分，论证透彻，方法得当，叙述准确，语言流畅。

良好：观点明确，思路清晰，结构合理，逻辑性强，材料充分，论证透彻，方法得当，叙述准确，语言流畅，观点明确并有创新，但其他方面有较明显的缺陷。

中等：观点较明确，思路较清晰，结构较合理，逻辑性较强，材料较充分，论证较透彻，方法较得当，叙述较明确，语言较流畅。观点较明确并有一定创新，但其他方面有明显的缺陷。

及格：观点较明确，思路较清晰，结构较合理，逻辑性较强，材料欠充分，论证欠透彻，方法单一，叙述欠准确，语言欠流畅。

不及格：核心观点抄袭或文章主体抄袭；或论文基本观点不明确；或论文逻辑结构与论文观点不相符；或论文核心内容有常识性错误。

6. 学习进度 （Course Schedule）

周数	教学时数	教学形式	教学内容	要求
1~2	40	线上线下指导	选题、接受课题任务	完成选题
3~6	80	线上线下指导	调研文献，先期实验	完成资料的检索、整理工作，探索可能的实验方法
7~8	40	线上线下指导	开题报告，验证实验	完成开题报告，汇报调研结果和确认研究方案
9~11	60	线上线下指导	正式实验、建模或模拟计算	获得论文阶段性结果

12	20	线上线下指导	中期报告	完成中期报告，并根据导师意见进一步完善论文工作
13~16	60	线上线下指导	正式实验、建模或模拟计算	获得论文的主要结果
17	20	线上线下指导	撰写论文和修改	完成论文，并根据导师意见修改论文，通过论文评阅
18	20	线下答辩	论文答辩	完成论文答辩

Shantou University
Module Description for Undergraduate Courses

COURSE TITLE:	Linear algebra(Engineering)
COURSE CODE:	MAT1802A
CREDIT VALUE:	2
CONTACT HOURS:	32
PRE-REQUISITE	
DEPARTMENT/UNIT:	Department of Mathematics and Computer Science
VERSION:	202402
COURSE COORDINATOR:	(Signature and Seal)
APPROVER:	(Signature and Seal)
APPROVE DATE:	

Shantou University
Faculty of Mathematics and Computer Science
February 2024

1. Course Description

Linear Algebra is one of the core foundational mathematics courses for students in science, engineering, and economics. This course aims to help students master the concepts and operations of determinants, matrices, and vectors; understand linear dependence and independence of vector sets; apply elementary matrix transformations to the solution of linear systems; grasp the fundamental analytical principles of linear equations; and gain an introductory understanding of eigenvalues, eigenvectors, and matrix similarity.The course aims to cultivate rigorous mathematical thinking and logic, and to provide a solid mathematical foundation for advanced discipline-specific courses.

Ideological and Ethical Objectives:

1. Gradually develop sound mathematical reasoning, and acquire foundational knowledge centered on matrices to support further study in related disciplines.
2. Appreciate the beauty and power of mathematics and science, and foster enthusiasm for exploring the unknown with a rigorous scientific spirit..

Knowledge Objectives:

1. Understand the concept and standard forms of determinants, and master their computation methods.
2. Become proficient in the concepts and operations of matrices, elementary matrix transformations, computation of eigenvalues and eigenvectors, and the concepts of vectors and vector sets, including the ability to judge linear dependence / independence.
3. Master the solution methods of general linear systems and apply linear systems to solve problems in simple scenarios.
4. Become proficient in computations related to similar matrices.

Ability Objectives:

1. Develop the ability to use matrices and linear systems to analyze, simplify, and solve basic practical problems.
2. Acquire the ability to compute determinants and eigenvalues, and apply these computations to analyze practical problems.
3. Gain competence in applying concepts related to matrix similarity to solve simple real-world problems.

2. Intended Learning Outcomes

The intended learning outcomes of this course are summarized in the table below.

Intended Learning Outcomes	Teaching Content	Implementation Arrangements	Suggested Teaching Strategies
1. Understand the concept of an n-order determinant. 2. Apply the properties of determinants to compute determinants proficiently. 3. Master the method of cofactor expansion along rows or columns. 4. Apply Cramer's Rule proficiently.	Definitions of 2×2 and 3×3 determinants Permutations and inversion numbers Definition of n-order determinants Properties of determinants Cofactor expansion Cramer's Rule	In-class teaching and after-class exercises	Using narrative explanations and applied examples to guide students in understanding each concept

1. Apply matrix properties to perform matrix operations proficiently. 2. Apply properties of inverse matrices to compute matrix inverses. 3. Understand the method of matrix block decomposition.	Matrix operations Inverse matrices Block matrix method	In-class teaching and after-class exercises	Using narrative explanations and applied examples to guide students in understanding each concept
1. Apply elementary matrix transformations proficiently. 2. Understand the concept and properties of matrix rank. 3. Solve linear systems using row elementary transformations （row operations）.	Elementary matrix transformations Rank of a matrix Solutions of linear systems	In-class teaching and after-class exercises	Using narrative explanations and applied examples to guide students in understanding each concept
1. Understand vector sets and linear combinations. 2. Understand the concept of linear dependence / independence. 3. Understand the rank of a vector set. 4. Gain introductory knowledge of inner product, length (norm), and orthogonality.	Vector sets and linear combinations Linear dependence / independence of vector sets Rank and maximal linearly independent subsets Inner product, vector length, and orthogonality	In-class teaching and after-class exercises	Using narrative explanations and applied examples to guide students in understanding each concept
1. Master the structure of solutions to linear systems. 2. Understand the relation between homogeneous and non-homogeneous systems.	Structure of solutions Relations between homogeneous and non-homogeneous systems	In-class teaching and after-class exercises	Using narrative explanations and applied examples to guide students in understanding each concept
1. Understand the concepts of eigenvalues and eigenvectors. 2. Understand the concept of matrix similarity.	Eigenvalues and eigenvectors of square matrices Similarity of matrices	In-class teaching and after-class exercises	Using narrative explanations and applied examples to guide students in understanding each concept

3. Pre-requisit

None

4. Textbooks and Other Learning Resources

Course Textbook:

Hao Zhifeng (Ed.). *Linear Algebra* (2nd Edition). Peking University Press, 2023.

Recommended References:

[1] Department of Mathematics, Tongji University. Engineering Mathematics: *Linear Algebra*. Higher Education Press, 2014.

[2] Ju Yuma. *Linear Algebra*. Tsinghua University Press, 2002.

[3] Wu Tianyi, Wang Yujie, Qiu Yuwen. *Linear Algebra*. Nankai University Press, 2007.

[4] Lay, D. C. (Author), Liu Shenquan (Translator). *Linear Algebra and Its Applications*. Mechanical Industry Press, 2005.

[5] Larson, R., Edwards, B. H. *Elementary Linear Algebra*. Houghton Mifflin, 2008.

[6] Strang, G. *Introduction to Linear Algebra*. Wellesley–Cambridge Press, 2009.

5. Teaching and Learning Activities

Teaching Segment	Lectures (Theory)	Exercise Classes	Laboratory Work	Seminars	Social Practice	Project Work	Online Learning Others	Others	Total
Hours (In-class)	32								32
Hours (Out-of-class)	32	32							64

6. Assessment Scheme

Assessment item	Description / Assessment criteria	Weight
Continuous Assessment	Attendance, in-class quizzes, integrated exercises, and class participation	20%
Homework	Completion and quality of after-class homework	20%
Final Examination	Closed-book exam	60%

7. Course Schedule

Week	Hour	Teaching format	Teaching content
1	2	Lectures	Determinants: definitions of 2×2 and 3×3 determinants; permutations and inversion numbers; definition of an n-th order determinant. Reading: *Linear Algebra*, Ch. 1. Homework: end-of-chapter exercises.
2	2	Lectures	Determinants: properties and computation; cofactor (row/column) expansion. Reading: Ch. 1. Homework: end-of-chapter exercises.
3	2	Lectures	Determinants: cofactor expansion; Cramer's Rule. Reading: Ch. 1. Homework: end-of-chapter exercises. In-class quiz: determinant calculation.
4	2	Lectures	Matrices: definitions, operations, and special types of matrices. Reading: Ch. 2. Homework: textbook exercises.
5	2	Lectures	Matrices: inverse matrices; block matrices. Reading: Ch. 2. Homework: textbook exercises.
6	2	Lectures	Exercises for Chapters 1 and 2. In-class quiz: matrix multiplication and matrix inversion.
7	2	Lectures	Elementary transformations: elementary row operations and their connection to solving linear systems. Reading: Ch. 3. Homework: textbook exercises.

8	2	Lectures	Elementary transformations: elementary matrices, elementary operations, and matrix rank. Reading: Ch. 3. Homework: textbook exercises. In-class quiz: rank calculation.
9	2	Lectures	Elementary transformations: solutions of linear systems. Reading: Ch. 3. Homework: textbook exercises.
10	2	Lectures	Vectors: vector operations and inner product; linear representation of vectors and its connection to non-homogeneous linear systems. Reading: Ch. 4. Homework: textbook exercises.
11	2	Lectures	Vectors: linear dependence and independence; rank of a vector set; maximal linearly independent subsets. Reading: Ch. 4. Homework: textbook exercises. In-class quiz: determining rank and maximal independent sets.
12	2	Lectures	Linear systems: structure of solutions; relation between homogeneous and non-homogeneous systems. Reading: Ch. 5; independent reading on applications of linear systems. Homework: textbook exercises.
13	2	Lectures	Exercises for Chapters 3, 4, and 5. Comprehensive exercise: solving linear systems.
14	2	Lectures	Eigenvalues and Eigenvectors: computation methods. Reading: Ch. 6. Homework: textbook exercises.
15	2	Lectures	Eigenvalues and Eigenvectors: properties; similar matrices. Reading: Ch. 6. Homework: textbook exercises.
16	2	Lectures	Chapter 6 exercises and final course review. Comprehensive exercise: computing eigenvalues and eigenvectors.

Note:

All discussions are arranged flexibly depending on the instructor's schedule and students' learning progress.

Homework assignments are given at the instructor's discretion according to the actual teaching situation.

汕头大学本科教学

课程教学大纲

课　程　名（COURSE TITLE）：	线性代数
课程代码（COURSE CODE）：	MAT1802A
学　　　分（CREDIT VALUE）：	2
课内课时（CONTACT HOURS）：	32
先修课要求（PRE-REQUISIT）	
开课单位（DEPARTMENT/UNIT）：	数学系
版　　　本（VERSION）：	202402
课程负责人（COURSE COORDINATOR）：	(签章)
审　核　人（APPROVER）：	(签章)
审核日期（APPROVE DATE）：	

汕头大学数学与计算机学院

2024 年 2 月

1. 课程简介 （Course Description）

线性代数（Linear Algebra）是理工类和经济类专业的主要数学基础课程之一。本课程的教学目的是使学生掌握行列式、矩阵、向量相关概念及其运算，向量的线性相关性、矩阵的初等变换方法以及在线性方程组求解中的应用，掌握线性方程组基本分析原理，了解矩阵特征值和特征向量、矩阵相似等内容。塑造学生严密的数学思维，培养学生严谨的逻辑推理能力，为后续专业课学习奠定良好的数学基础。通过介绍我国近现代数学家在计算数学、密码学等领域所做出的突出贡献，引导学生努力学好数学并应用于本专业的实践、服务国家发展战略需求。

思政目标：

（1）确立科技报国的使命担当，具备严谨认真的科学精神以及良好的职业道德修养

（2）逐步具备严密的数学思维，初步掌握以矩阵为核心的一系列数学知识，为后续相关专业课程的学习奠定基础

（3）逐步体会到数学以及科学的魅力，进而产生以严谨的科学态度探索未知世界的热情

知识目标：

（1）理解行列式的概念并熟悉其基本形式，掌握行列式的计算方法

（2）熟练掌握矩阵的概念、运算以及矩阵的初等变换，会计算矩阵的特征值与特征向量，掌握向量、向量组的相关概念，并能够判断向量组的线性相关性

（3）掌握一般线性方程组的解法，并会在简单情景中应用线性方程组解决问题

（4）熟练掌握与相似矩阵相关的计算

能力目标：

（1）具备运用矩阵以及线性方程组分析、简化并解决简单实际问题的能力

（2）具备计算行列式以及矩阵特征值的能力，并能够将其应用的对实际问题的分析之中

（3）具备运用相似矩阵等相关概念解决简单实际问题的能力

2. 预期学习结果 （Intended Learning Outcomes）

预期学习结果（ILO）	教学内容（知识单元/点）	实现环节（课内、实验等）	建议采用的教学策略
1. 理解 n 阶行列式的概念 2. 熟练应用行列式的性质进行行列式计算	二阶与三阶行列式的定义 全排列及其逆序数	课内教学、课外练习	结合文字叙述及应用情景向学生展示教学内容并引导学

3. 掌握行列式的行（列）展开 4. 熟练应用克莱姆法则	n 阶行列式的定义 行列式的性质， 行列式的行（列）展开 克莱姆法则		生理解掌握相关概念
1. 熟练应用矩阵的性质进行矩阵运算 2. 熟练应用逆矩阵的性质求逆矩阵 3. 理解矩阵的分块法	矩阵的运算 逆矩阵 矩阵的分块法	课内教学、课外练习	课堂讲授与课后习题训练相结合，逐步引导学生掌握关键概念以及重要方法
1.熟练应用矩阵初等变换的性质对矩阵进行初等变换 2.理解矩阵的秩及其性质 3.熟练应用矩阵的行初等变换求解线性方程组	矩阵的初等变换 矩阵的秩 线性方程组的解	课内教学、课外练习	结合文字叙述及应用情景向学生展示教学内容并引导学生理解掌握相关概念
1. 理解向量组及其线性组合的概念 2. 理解向量组的线性相关性的概念 3. 理解向量组的秩的概念 4. 了解矢量的内积，长度及正交性的概念	向量组及其线性组合 向量组的线性相关性 向量组的秩和极大无关组 向量的内积，长度及正交性	课内教学、课外练习	课堂讲授与课堂讨论相结合，逐步引导学生掌握关键概念以及重要方法
1.掌握线性方程组的解的结构 2.理解齐次与非齐次线性方程组的关系	线性方程组的解的结构 齐次线性方程组与非齐次线性方程组的关系	课内教学、课外练习	课堂讲授与课堂讨论相结合，逐步引导学生掌握关键概念以及重要方法
1. 理解方阵的特征值及特征向量的概念 2. 理解相似矩阵的概念	方阵的特征值及特征向量 相似矩阵	课内教学、课外练习	课堂讲授与课后习题训练相结合，逐步引导学生掌握关键概念以及重要方法

3. 先修要求 （Pre-requisit）

无

4. 教材及其它教学资源 （Textbooks and Other Learning Resources）

教材

郝志峰主编， 《线性代数》第二版，北京大学出版社， 2023

推荐参考资料

[1] 同济大学数学系，《工程数学线性代数》，高等教育出版社，2014

[2] 居余马，《线性代数》，清华大学出版社，2002

[3] 吴天毅、王玉杰、 邱玉文 ，《线性代数》，南开大学出版社，2007

[4] 莱 (Lay D.C.) (作者), 刘深泉 (译者), 《线性代数及其应用》，机械工业出版社，2005

[5] Larson, R., Edwards, B. H., Elementary Linear Algebra, Houghton Mifflin, 2008

[6] Strang G., Introduction to Linear Algebra, Wellesley-Cambridge press, 2009

5. 主要教学环节 （Teaching and Learning Activities）

理论课（小时）		习题课（小时）		实验（小时）		研讨（小时）		社会实践（小时）		项目（小时）		在线学习（小时）		其他（小时）	
课内	课外	课内	课外	课内	课外	课内	课外	课内	课外	课内	课外	课内	课外	课内	课外
32	32	无	32	无	无	无	无	无	无	无	无	无	无	无	无

6. 课程考核 （Assessment Scheme）

考核项目	**考核内容和考试方法简介**	**权重**
平时成绩	考勤、随堂测验、综合练习及课堂参与情况	20%
作业	课后作业完成情况	20%
期末考试	闭卷考试	60%

7. 学习进度 （Course Schedule）

周次	**教学时数**	**教学形式**	**教　学　内　容**
1	2	课堂教学	行列式：二阶与三阶行列式的定义、全排列及其逆序数的定义、n 阶行列式的定义 **阅读：**《线性代数》第一章 **课后作业：**教材课后练习题

2	2	课堂教学	行列式：行列式的性质及其行列式的计算、行列式的行（列）展开 **阅读：**《线性代数》第一章 **课后作业：**教材课后练习题
3	2	课堂教学	行列式：行列式的行（列）展开、克莱姆法则 **阅读：**《线性代数》第一章 **课后作业：**教材课后练习题 **随堂小测：**行列式的计算
4	2	课堂教学	矩阵：矩阵的概念、矩阵的运算、几类特殊矩阵 **阅读：**《线性代数》第二章 **课后作业：**教材课后练习题
5	2	课堂教学	矩阵：逆矩阵、分块矩阵 **阅读：**《线性代数》第二章 **课后作业：**教材课后练习题
6	2	教学及研讨	第一章和第二章习题课 **随堂小测：**矩阵的乘法运算及求逆
7	2	课堂教学	矩阵的初等变换：矩阵的初等变换及其与消元法求解线性方程组的关系 **阅读：**《线性代数》第三章 **课后作业：**教材课后练习题
8	2	课堂教学	矩阵的初等变换：初等矩阵及其与初等变换的关系、矩阵的秩 **阅读：**《线性代数》第三章 **课后作业：**教材课后练习题 **随堂小测：**矩阵的秩的计算
9	2	课堂教学	矩阵的初等变换：线性方程组的解 **阅读：**《线性代数》第三章 **课后作业：**教材课后练习题
10	2	课堂教学	向量：向量及其线性运算和内积运算、向量的线性表示及其与非齐次线性方程组的关系 **阅读：**《线性代数》第四章 **课后作业：**教材课后练习题
11	2	课堂教学	向量：向量组的线性相关性及其与齐次线性方程组的关系、向量组的秩和极大无关组 **阅读：**《线性代数》第四章 **课后作业：**教材课后练习题 **随堂小测：**向量组的秩和极大无关组的确定
12	2	课堂教学	线性方程组：线性方程组的解的结构、齐次和非齐次线性方程组间的关系 **阅读：**《线性代数》第五章、自学线性方程组的应用 **课后作业：**教材课后练习题

13	2	教学与研讨	第三章、第四章和第五章习题课 **综合练习：**求解线性方程组解
14	2	课堂教学	特征值与特征向量：特征值与特征向量的计算 **阅读：**《线性代数》第六章 **课后作业：**教材课后练习题
15	2	课堂教学	特征值与特征向量：特征值与特征向量的相关性质、相似矩阵 **阅读：**《线性代数》第六章 **课后作业：**教材课后练习题
16	2	教学与研讨	第六章习题课及课程总复习 **综合练习：**特征值与特征向量的计算

注明:

- ◆ 所有课程的讨论依授课教师时间与学生的实际情况酌情实施
- ◆ 每门课程的作业布置由授课教师视实际情况酌情实施

Shantou University

Module Description for Undergraduate Courses

COURSE TITLE:	Calculus B1
COURSE CODE:	MAT1801A
CREDIT VALUE:	4
CONTACT HOURS:	64
PRE-REQUISITE	none
DEPARTMENT/UNIT:	Department of Mathematics and Computer Science
VERSION:	2025.9.5
COURSE COORDINATOR:	Tan Chaoqiang (Signature and Seal)
APPROVER:	Fang Rei (Signature and Seal)
APPROVE DATE:	

Shantou University
Faculty of Mathematics and Computer Science
September 2025

1. Course Description

Calculus B-I is one of the major fundamental general-education courses in university mathematics.

This course enables students to systematically acquire the basic knowledge of calculus and ordinary differential equations (ODEs), the essential theoretical foundations, and commonly used computational techniques. It also emphasizes the development of computational proficiency, abstract thinking, logical reasoning, geometric intuition, and spatial imagination.

Through this training, students gain preliminary experience in applying mathematical analysis to solve practical problems in geometry, mechanics, physics, and related fields, thus laying the necessary foundation for subsequent courses and further studies in mathematics.

Upon completion of the course, students should be able to:

Technical Knowledge Objectives:

1. Understand limits and continuity of functions, and proficiently compute limits; understand the properties of continuity.
2. Understand the concept and meaning of derivatives and differentials, and compute derivatives proficiently.
3. Understand the mean value theorems of differential calculus, and apply L'Hôpital's rule proficiently to compute limits.
4. Compute indefinite integrals proficiently.
5. Compute definite integrals of single-variable functions and apply them proficiently.
6. Apply techniques of calculus to solve practical problems arising in real-world production.

Ability Objectives:

1. Understand abstract mathematical concepts and theories, and demonstrate strong analytical ability.
2. Demonstrate initial competence in applying mathematical methods to solve practical problems.
3. Demonstrate the ability to communicate and collaborate effectively.

2. Intended Learning Outcomes

The intended learning outcomes of this course are summarized in the table below.

Knowledge Unit	Key Knowledge Points	Initial Level	Required Level	Expected Learning Outcomes
Single-variable functions and limits	Single-variable functions; limits of sequences; limits of functions; limit laws; criteria for the existence of limits; two important limits; comparison of infinitesimals; continuity of functions; types of discontinuities; operations on continuous functions and continuity of elementary functions; properties of continuous functions on closed intervals.	L1	L3	Understand the concepts of functions and limits. Apply common limit laws and properties to compute limits. Demonstrate understanding of continuity and its properties.

Derivatives and differentials of single-variable functions	Concept of derivative; differentiation rules; higher-order derivatives; derivatives of implicit functions; derivatives for parametric equations; differentials.	L1	L3	Demonstrate understanding of the concepts of derivative and differential. Apply common rules of differentiation and differential operations. Perform differentiation of implicit functions and parametric equations.
Introduction to the mean value theorems and applications of derivatives	Introduction to the Lagrange mean value theorem (to be expanded in Semester 3); L'Hôpital's rule; monotonicity of functions; extrema and maximum–minimum problems for single-variable functions.	L1	L3	Understand the Lagrange mean value theorem and its corollaries. Apply L'Hôpital's rule proficiently to compute limits. Master methods for finding extrema and maximum/minimum values of single-variable functions.
Indefinite integrals of single-variable functions	Concept and properties of indefinite integrals; substitution method; integration by parts; integration of rational functions.	L1	L3	Understand the concept and properties of indefinite integrals. Use common techniques of integration to compute indefinite integrals.
Definite integrals of single-variable functions and their applications	Concept and properties of definite integrals; fundamental theorem of calculus; substitution method and integration by parts for definite integrals.	L1	L3	Understand the concept and properties of definite integrals. Apply Newton–Leibniz formula proficiently to compute definite integrals. Apply common techniques and formulas of definite integrals proficiently.

3. Pre-requisit

None

4. Textbooks and Other Learning Resources

Course Textbook:

Lin Xiaoping and Li Jian, *New Edition of Calculus* (Science and Engineering), Volume I, Peking University Press, 2020. (Department-compiled textbook of the Mathematics Department, Shantou University.)

Recommended References:

[1] Department of Mathematics, Tongji University, *Advanced Mathematics* (7th Edition, Vol. I & II), Higher Education Press, 2015.

[2] Wang Miansen & Ma Zhisi (Eds.), *Foundations of Mathematical Analysis for Engineering*, Vol. I & II, Higher Education Press.

[3] Department of Mathematics, East China Normal University, *Mathematical Analysis*, Vol. I & II, Higher Education Press.

[4] Fikhtengolts, *Course of Differential and Integral Calculus*, People's Education Press, First Edition (April 1957; reprinted January 1980).

[5] George B. Thomas, Maurice D. Weir, Joel Hass, *Thomas' Calculus* (13th Edition), Pearson, 2014.

[6] James Stewart, Calculus (7th Edition), Brooks/Cole, 2012.

Course Website

http://my.stu.edu.cn

5. Teaching and Learning Activities

Teaching Segment	Lectures (Theory)	Exercise Classes	Laboratory Work	Seminars	Social Practice	Project Work	Online Learning Others	Mid-Term Test	Total
Hours (In-class)	54	10							64
Hours (Out-of-class)	100	92		8					200

6. Assessment Scheme

Assessment item	Description / Assessment criteria	Weight
Continuous Assessment	Classroom participation, seminar engagement, in-class quizzes	20%
Homework	Performance on after-class assignments	10%
Midterm Examination	Closed-book exam	20%
Final Examination	Closed-book exam	50%

7. Course Schedule (The following teaching plan is based on the 2023 cohort for reference only.)

Week	Hour	Teaching format	Teaching content
4	4	Lectures + Seminar	Preface and course orientation; introduction to major contributions of modern Chinese mathematicians in analysis and differential equations. (Classes suspended on Thursday due to the university sports day.) 1.1 Single-variable functions; 1.2 Definition of limits (sequences).
5	4	Lectures + Seminar	National Day Holiday (No Classes) 1.2 Definition of limits (functions).
6	4	Lectures + Seminar	1.3 Infinitesimals and infinities; 1.4 Limit operations and properties. Tutorial session and in-class quiz. 1.5 Two important limits;
7	4	Lectures + Seminar	1.6 Comparison of infinitesimals; 1.7 Continuity.
8	4	Lectures + Seminar	1.8 Properties of continuous functions on closed intervals. Tutorial session and in-class quiz.
9	4	Lectures + Seminar	2.1 Concept of derivatives; 2.2 Differentiation rules.

10	4	Lectures + Seminar	2.3 Higher-order derivatives; 2.4 Derivatives of implicit and parametric functions; 2.5 Differentials.
11	4	Lectures + Seminar	Tutorial session and in-class quiz. Midterm Exam
12	4	Lectures + Seminar	3.1.2 Lagrange mean value theorem; 3.2 L'Hospital's Rule (Part 1); According to the academic calendar, classes are suspended for the whole day on Thursday due to the university sports day.
13	4	Lectures + Seminar	3.2 L'Hospital's Rule (Part 2); 3.3.2 Convexity and concavity. 3.3.3 Local extrema; 3.4 Absolute extrema.
14	4	Lectures + Seminar	Tutorial session and in-class quiz; 4.1 Concept and properties of indefinite integrals;
15	4	Lectures + Seminar	4.2.1 Substitution method (Part 1); 4.2.1 Substitution method (Part 2); 4.2.2 Integration by parts;
16	4	Lectures + Seminar	4.3 Integration of rational functions. Tutorial session and in-class quiz;
17	4	Lectures + Seminar	5.1 Concept and properties of definite integrals; 5.2 Fundamental theorem of calculus.
18	4	Lectures + Seminar	5.3.1 Substitution method for definite integrals. Tutorial session and in-class quiz.

Note:

All discussion sessions are arranged according to the instructor's schedule and students' actual needs. Homework assignments are issued at the instructor's discretion and may vary based on teaching progress.

汕头大学本科教学
课程教学大纲

课　程　名（COURSE TITLE）：	微积分 B-I
课程代码（COURSE CODE）：	MAT1801A
学　　　分（CREDIT VALUE）：	4
课内课时（CONTACT OURS）：	64
先修课要求（PRE-REQUISIT）	无
开课单位（DEPARTMENT/UNIT）：	数学与计算机学院
版　　　本（VERSION）：	2025.9.5
课程负责人（COURSE COORDINATOR）：	谭超强　　(签章)
审　核　人（APPROVER）：	方睿　　(签章)
审核日期（APPROVE DATE）：	

汕头大学数学与计算机学院

2025 年 9 月

1、课程简介（Course Description）

微积分 B-I 是大学数学的主要公共基础课程之一。通过本课程学习，使学生系统地获得微积分与常微分方程的基本知识，必要的基础理论和常用的运算方法，并注意培养学生比较熟练的运算能力、抽象思维能力、逻辑推理能力、几何直观和空间想象能力。从而使学生受到数学分析方法和运用这些方法解决几何、力学、物理等实际问题的初步训练，为学习后继课程和进一步扩大数学知识奠定必要的数学基础。

学完本课程后学生应能够：

技术知识目标：

1. 理解函数极限和连续性，熟练掌握极限的计算方法，理解函数的连续性的性质；
2. 理解导数和微分的概念和意义，熟练计算函数的导数；
3. 了解微分中值定理、熟练应用洛必达法则求函数的极限；
4. 熟练计算不定积分；
5. 熟练一元函数定积分运算及其应用；
6. 熟练应用微积分的技巧解决实际生产中遇到的问题。

能力目标：

1. 理解抽象的数学概念和理论，具备较高的分析能力；
2. 初步具备应用数学方法解决实际问题的能力；
3. 具备沟通及合作的能力。

课程思政：

通过介绍我国近现代数学家在分析、方程等领域所做出的突出贡献，引导学生努力学好数学并应用于本专业的实践、服务国家发展战略需求。

2、预期学习结果 （Intended Learning Outcomes）

本课程的预期学习结果为

知识单元	知识点	初始程度	要求程度	预期学习结果
1. 一元函数与极限	一元函数, 数列的极限, 函数的极限, 极限运算法则, 极限存在准则, 两个重要极限, 无穷小的比较, 函数的连续性, 函数的间断点, 连续函数运算与初等函数的连续性, 闭区间上连续函数性质	L1	L3	理解函数概念和极限概念. 应用极限的常用运算法则及其性质求极限. 展现对函数连续性概念及其性质的理解.
2. 一元函数的导数与微分	导数概念, 函数的求导法则, 高阶导数, 隐函数的导数, 参数方程的导数、函数的微分	L1	L3	展现对导数概念和微分概念的理解. 应用导数和微分的常用运算法则进行求导和微分运算. 实施隐函数、参数方程的求导.

3. 微分中值定理初步与导数的应用	拉格朗日中值定理简介（第 3 学期再提升）， 洛必达法则、函数单调性， 一元函数的极值、最值及其求法	L1	L3	理解拉格朗日微分中值定理及其推论的内容． 熟练应用洛必达法则求函数的极限． 熟练掌握一元函数的极值和最值的求法方法.
4. 一元函数的不定积分	不定积分概念与性质， 换元积分法， 分部积分法， 有理函数的积分	L1	L3	理解不定积分的概念及其性质. 使用不定积分的常用积分方法进行积分.
5. 一元函数的定积分及其应用	定积分的概念与性质， 微积分基本公式， 定积分的换元法和分部积分法	L1	L3	理解定积分的概念和性质. 熟练应用牛−莱公式求定积分. 熟练应用定积分常用的积分方法和公式求定积分.

3、先修要求 （Pre-requisit）

无

4、教材及其他教学资源 （Textbooks and Other Learning Resources）

课程教材：

新编微积分(理工类) 上册，林小苹、李健编著，北京大学出版社，2020 年，汕大数学系自编教材。

推荐参考资料：

[1] 同济大学数学教研室，《高等数学》(第 7 版 上、下册)，高等教育出版社，2015

[2] 王绵森、马知思主编，《工科数学分析基础》上、下册， 高等教育出版社。

[3] 华东师范大学数学系编，《数学分析》上、下册，高等教育出版社。

[4] 菲赫金哥尔茨著，《微积分学教程》，人民教育出版社，1957 年 4 月第 1 版（1980 年 1 月）

[5] George B. Thomas, Maurice D. Weir, Joel Hass. Thomas Calculus (13th Edition), Pearson, 2014.

[6] James. Stewart., Calculus (7th.Edition), Brooks/ Cole, 2012.

课程网站：

http://my.stu.edu.cn

5、主要教学环节 （Teaching and Learning Activities）

理论课	习题课	实验	研讨	社会实践	项目	在线学习	其他

（小时）		（小时）		（小时）		（小时）		（小时）		（小时）		（小时）		（小时）	
课内	课外	课内	课外	课内	课外	课内	课外	课内	课外	课内	课外	课内	课外	课内	课外
54	100	10	92	无	无	0	8	无	无	无	无	无	无	无	无

6、课程考核 （Assessment Scheme）

考核项目	考核内容和考试方法简介	权重
平时表现	课堂参与情况、研讨、课堂测试等	20%
课后作业	课后作业的完成情况	10%
期中考试	闭卷考试	20%
期末考试	闭卷考试	50%

7、学习进度 （Course Schedule，下面是23级的教学进度表，仅供参考）

周次	教学时数	教学形式	教　学　内　容
4	4	研讨+讲授	序言（导学）、介绍我国近现代数学家在分析、方程等领域所做出的突出贡献 1.1 一元函数； 1.2 极限的概念（数列）；
5	4	同上	国庆节放假 1.2 极限的概念（函数）；
6	4	同上	1.3 无穷小、无穷大，1.4 极限的运算与性质； 1.5 两个重要极限；
7	4	同上	1.6 无穷小的比较； 1.7 函数的连续性；
8	4	同上	1.8 闭区间上连续函数性质； 习题课、课堂测验；

周次	教学时数	教学形式	教　学　内　容
12	4	同上	3.1.2 拉格朗日中值定理，3.2 洛必达法则（1）； 根据校历，周四校运会全天停课
13	4	同上	3.2 洛必达法则（2），3.3.2 函数凹凸性； 3.3.3 极值，3.4 最值；
14	4	同上	习题课、课堂测验； 4.1 不定积分概念与性质；
15	4	同上	4.2.1 换元积分法（1）； 4.2.1 换元积分法（2），4.2.2 分部积分法；
16	4	同上	4.3 有理函数的积分； 习题课、课堂测验；

9	4	同上	2.1 导数概念； 2.2 求导法则；	17	4	同上	5.1 定积分的概念与性质； 5.2 微积分基本公式；
10	4	同上	2.3 高阶导数、2.4 隐函数与参数式函数的导数； 2.5 函数的微分；	18	4	同上	5.3.1 定积分的换元法； 习题课、课堂测验；
11	4	同上	习题课、课堂测验； 期中考试				

注明：所有课程的讨论视授课教师时间与学生的实际情况斟酌实施；每个课程的作业布置以授课教师视实际时间情况斟酌实施

Shantou University
Module Description for Undergraduate Courses

COURSE TITLE:	Calculus B-II
COURSE CODE:	MAT1803A
CREDIT VALUE:	4
CONTACT HOURS:	64
PRE-REQUISITE	Calculus B-I
DEPARTMENT/UNIT:	Department of Mathematics and Computer Science
VERSION:	2025.2.24- MAT1803A
COURSE COORDINATOR:	Tan Chaoqiang (Signature and Seal)
APPROVER:	Fang Rei (Signature and Seal)
APPROVE DATE:	2025/02/24

Shantou University
Faculty of Mathematics and Computer Science
February 2025

1. Course Description

Calculus B-II is one of the major foundational courses for students in science and engineering. Building upon *Calculus B-I*, this course further develops the fundamental theories, methods, and applications of multivariable calculus. It provides essential mathematical foundations for subsequent courses such as real analysis, complex analysis, functional analysis, differential equations, numerical methods for differential equations, differential geometry, probability theory, theoretical mechanics, as well as relevant elective courses. The course aims to cultivate students' ability to apply mathematical tools to solve practical problems.

Upon completion of this course, students should be able to:

Technical Knowledge Objectives:

1. Proficiently solve several common types of differential equations.
2. Understand the fundamental ideas and methods of multivariable calculus.
3. Perform multiple-integral operations accurately and efficiently.
4. Apply techniques of calculus to solve practical problems arising in real-world contexts.

Ability Objectives:

1. Demonstrate the ability to simplify, analyze, and solve engineering problems using mathematical tools.
2. Possess solid skills in performing basic differentiation and integration operations.
3. Exhibit an adequate level of abstract reasoning.

2. Intended Learning Outcomes

The intended learning outcomes of this course are summarized in the table below.

Knowledge Unit	Key Knowledge Points	Initial Level	Required Level	Expected Learning Outcomes
1. Definite Integrals of Single-Variable Functions and Their Applications	Improper integrals; Geometric applications of definite integrals; Physical applications of definite integrals.	L1	L3	1. Understand the concept and properties of improper integrals. 2. Apply common techniques and formulas to compute improper integrals proficiently. 3. Use the element-based method of definite integrals to solve selected problems in geometry and physics.
2. Differential Equations and Their Applications	Basic concepts of differential equations; Separable differential equations; Homogeneous equations; First-order linear differential equations; Reducible higher-order differential equations; Higher-order linear differential equations; Second-order linear homogeneous differential	L1	L3	Understand key concepts such as order, general solution, initial conditions, and particular solution of differential equations. Solve first-order differential equations and selected higher-order differential equations to obtain both particular and general solutions. Apply differential-equation methods to solve certain simple geometric problems.

	equations with constant coefficients; Second-order linear non-homogeneous differential equations with constant coefficients.			
3. Spatial Analytic Geometry and Vector Algebra	Vectors and linear operations; Dot product; Cross product; Planes and their equations; Lines in space and their equations; Surfaces and their equations; Space curves and their equations.	L1	L3	1. Understand the concepts and properties of vectors, dot products, and cross products. 2. Understand the relationships among planes, lines in space, surfaces, space curves, and their corresponding equations.
4. Differential Techniques for Multivariable Functions and Applications	Basic concepts of multivariable functions; Partial derivatives and total differentials; Differentiation rules for multivariable composite functions; Implicit differentiation; Geometric applications of multivariable differential calculus; Directional derivatives and gradients; Extrema and maxima/minima of multivariable functions and their computation.	L1	L3	1. Understand the concepts and properties of multivariable functions, partial derivatives, and total differentials. 2. Apply standard rules to compute partial derivatives and total differentials of multivariable functions (including implicit functions). 3. Understand geometric applications of multivariable differential calculus. 4. Understand directional derivatives, gradients, and methods for determining extrema and maxima/minima of multivariable functions.
5. Multiple Integrals	Concepts and properties of double integrals; Computation of double integrals.	L1	L3	1. Understand the concepts and properties of double integrals. 2. Apply commonly used techniques to compute double integrals proficiently.

3. Pre-requisit

Calculus B-I

4. Textbooks and Other Learning Resources

Course Textbook:

Lin Xiaoping, Tan Chaoqiang, and Li Jian. *New Calculus* (Science and Engineering), Volume II, Peking University Press, 2021.

Department-compiled teaching materials from the Department of Mathematics, Shantou University.

Recommended References:

[1] Department of Mathematics, Tongji University, *Advanced Mathematics* (7th Edition, Vol. I & II), Higher Education Press, 2015.

[2] Wang Miansen & Ma Zhisi (Eds.), *Foundations of Mathematical Analysis for Engineering*, Vol. I &

II, Higher Education Press.

[3] Department of Mathematics, East China Normal University, *Mathematical Analysis*, Vol. I & II, Higher Education Press.

[4] Fikhtengolts, *Course of Differential and Integral Calculus*, People's Education Press, First Edition (April 1957; reprinted January 1980).

[5] George B. Thomas, Maurice D. Weir, Joel Hass, *Thomas' Calculus* (13th Edition), Pearson, 2014.

[6] James Stewart, *Calculus* (7th Edition), Brooks/Cole, 2012.

Course Website

http://my.stu.edu.cn

5. Teaching and Learning Activities

Teaching Segment	Lectures (Theory)	Exercise Classes	Laboratory Work	Seminars	Social Practice	Project Work	Online Learning Others	Mid-Term Test	Total
Hours (In-class)	54	10							64
Hours (Out-of-class)	100	92		8					200

6. Assessment Scheme

Assessment item	Description / Assessment criteria	Weight
Homework	Performance on after-class assignments	10%
Continuous Assessment	Classroom participation, seminar engagement, in-class quizzes	20%
Midterm Examination	Closed-book exam	20%
Final Examination	Closed-book exam	50%

7. Course Schedule (The following teaching plan is based on the 2023 cohort for reference only.)

Week	Hour	Teaching format	Teaching content
1	4	Lectures + Seminar	Review of integrals; §5.3.2 Integration by Parts for Definite Integrals; §5.4.1 Method of Elements; §5.4.2 Area of Plane Figures.
2	4	Lectures + Seminar	Applications of definite integrals in geometry: (3) Volume of solids; (4) Arc length of plane curves; §5.5 Applications of Definite Integrals in Physics (self-study).
3	4	Lectures + Seminar	Chapter 5, Section 5.6: Improper Integrals. Exercise session and in class quiz.

4	4	Lectures + Seminar	Chapter 6: Basic concepts of differential equations; separable differential equations; First-order linear differential equations.
5	4	Lectures + Seminar	Homogeneous equations (self-study); reducible higher-order differential equations; Structure of solutions for linear differential equations.
6	4	Lectures + Seminar	Solutions to second-order linear homogeneous differential equations with constant coefficients. Solutions to second-order non-homogeneous linear differential equations with constant coefficients;
7	4	Lectures + Seminar	Exercise session and quiz; Chapter 7: Rectangular coordinate system in space, vectors and their linear operations.
8	4	Lectures + Seminar	Vector products; Equations of planes and lines in space.
9	4	Lectures + Seminar	Pencil of planes; surfaces and their equations; Space curves and their equations.
10	4	Lectures + Seminar	Quadric surfaces; Labor Day Holiday (no class).
11	4	Lectures + Seminar	Exercise session and quiz; Thursday midterm examination.
12	4	Lectures + Seminar	Chapter 8: Basic concepts of multivariable functions; Partial derivatives.
13	4	Lectures + Seminar	Total differential; Chain rule for multivariable composite functions.
14	4	Lectures + Seminar	Implicit differentiation; Geometric applications of multivariable differential calculus.
15	4	Lectures + Seminar	Directional derivatives and gradient; Extrema of multivariable functions and methods of determination.
16	4	Lectures + Seminar	Chapter 9: Concept and properties of double Exercise session and in class quiz.

Note:

All discussion sessions are arranged according to the instructor’s schedule and students’ actual needs. Homework assignments are issued at the instructor’s discretion and may vary based on teaching progress.

汕头大学本科教学
课程教学大纲

课　程　名（**COURSE TITLE**）：	微积分 B-II
课程代码（**COURSE CODE**）：	MAT1803A
学　　　分（**CREDIT VALUE**）：	4
课内课时（**CONTACT OURS**）：	64
先修课要求（**PRE-REQUISIT**）	微积分 B-I
开课单位（**DEPARTMENT/UNIT**）：	数学与计算机学院
版　　　本（**VERSION**）：	2025.2.24- MAT1803A
课程负责人（**COURSE COORDINATOR**）：	谭超强　　(签章)
审　核　人（**APPROVER**）：	方睿　　(签章)
审核日期（**APPROVE DATE**）：	2025/02/24

汕头大学数学与计算机学院

2025 年 2 月

1、课程简介 （Course Description）

微积分 B-II 是理工科各专业的主要基础课程之一。本课程的教学目的是在微积分 B-I 的基础上进一步讲授多元微积分的基本理论、方法和应用。为学习后续课程，如：实变函数、复变函数、泛函分析，微分方程、微分方程的数值解、微分几何、概率论、理论力学等课程及有关的选修课等提供必要的基础知识，培养学生运用数学工具解决实际问题的能力。

学完本课程后学生应能够：

技术知识目标：

1. 熟练计算一些类型的微分方程；
2. 理解多元微积分的基本思想、方法；
3. 熟练进行函数多元积分的运算；
4. 熟练应用微积分的技巧解决实际生产中遇到的问题。

能力目标：

1 具备利用数学工具简化、分析和解决实际工程问题的能力；

2 具备运用基本的积分微分运算的能力；

3 具备一定的抽象思维能力。

课程思政：

通过介绍我国近现代数学家在分析、方程等领域所做出的突出贡献，引导学生努力学好数学并应用于本专业的实践、服务国家发展战略需求。

2、预期学习结果 （Intended Learning Outcomes）

本课程的预期学习结果如下表：

知识单元	知识点	初始程度	要求程度	预期学习结果
1.一元函数的定积分及其应用	反常积分； 定积分在几何学上的应用； 定积分在物理学上的应用。	L1	L3	1. 理解反常积分的概念和性质； 2. 熟练应用反常积分常用的积分方法和公式求反常积分； 3. 应用定积分的元素法解决定积分在几何学和物理学上的某些应用。
2.微分方程及其应用	微分方程基本概念， 可分离变量的微分方程， 齐次方程， 一阶线性微分方程， 可降阶的高阶微分方程， 高阶线性微分方程，	L1	L3	理解微分方程及其解、阶、通解、初始条件和特解等概念。 解决一阶微分方程和特定高阶微分方程的特解和通解。 使用微分方程的方法解决某些简单的几何问题。

	二阶常系数齐次线性微分方程，二阶常系数非齐次线性微分方程			
3. 空间解析几何与向量代数	向量及其线性运算； 数量积、向量积； 平面及其方程； 空间直线及其方程； 曲面及其方程； 空间曲线及其方程。	L1	L3	1. 了解向量、数量积、向量积的概念和性质； 2. 理解平面、空间直线、曲面、空间曲线及其方程的关系。
4. 多元函数微分法及其应用	多元函数基本概念； 偏导数、全微分； 多元复合函数的求导法则； 隐函数求导公式； 多元函数微分学的几何应用； 方向导数与梯度； 多元函数的极值、最值及其求法。	L1	L3	1. 理解多元函数、偏导数、全微分的概念和性质； 2. 熟练应用偏导数、全微分的常用运算法则求多元函数（包括隐函数）的偏导数和全微分； 3. 理解多元函数微分学的几何应用问题； 4. 理解方向导数与梯度、多元函数的极值、最值及其求法。
4. 重积分	二重积分概念与性质； 二重积分的计算。	L1	L3	1. 理解二重积分的概念与性质； 2. 熟练应用二重积分常用的积分方法求二重积分。

3、先修要求 （Pre-requisit）

微积分 B-I

4、教材及其他教学资源 （Textbooks and Other Learning Resources）

课程教材：

新编微积分(理工类) 下册，林小苹、谭超强、李健编著，北京大学出版社，2021，汕大数学系自编教材。

推荐参考资料：

[1] 同济大学数学教研室，《高等数学》（第 7 版 上、下册），高等教育出版社，2015

[2] 王绵森、马知思主编，《工科数学分析基础》上、下册， 高等教育出版社。

[3] 华东师范大学数学系编，《数学分析》上、下册，高等教育出版社。

[4] 菲赫金哥尔茨著，《微积分学教程》，人民教育出版社，1957 年 4 月第 1 版（1980 年 1 月）

[5] George B. Thomas, Maurice D. Weir, Joel Hass. Thomas Calculus (13th Edition), Pearson, 2014.

[6] James. Stewart., Calculus (7th.Edition), Brooks/ Cole, 2012.

课程网站：

http://my.stu.edu.cn

5、主要教学环节 （Teaching and Learning Activities）

理论课（小时）		习题课（小时）		实验（小时）		研讨（小时）		社会实践（小时）		项目（小时）		在线学习（小时）		其他（小时）	
课内	课外	课内	课外	课内	课外	课内	课外	课内	课外	课内	课外	课内	课外	课内	课外
54	100	10	92	无	无	0	8	无	无	无	无	无	无	无	无

6、课程考核 （Assessment Scheme）

考核项目	考核内容和考试方法简介	权重
作业	课后作业完成情况	10%
平时成绩	考勤、课堂表现、课堂测试，研讨，小论文，应用拓展项目等	20%
期中考试	根据每学期实际教学进度表，前 8 周的内容，闭卷考试	20%
期末考试	全部知识点，闭卷考试	50%

7、学习进度 （Course Schedule，下面是24级教学进度表，仅供参考）

周次	教学时数	教学形式	教学内容
1	4	研讨+讲授	介绍我国近现代数学家在分析、方程等领域所做出的突出贡献，复习积分，5.3.2 定积分的分部积分法，5.4.1 元素法；5.4.2 平面图形的面积；

周次	教学时数	教学形式	教学内容
12	4	研讨+讲授	**第八章：** 多元函数基本概念；偏导数；

2	4	同上	定积分在几何的应用(3)—立体的体积；定积分在几何的应用(4)—平面图形的弧长；5.5 定积分在物理的应用(自学)
3	4	同上	第五章 5.6 反常积分；习题课、课堂测验；
4	4	同上	第六章 微分方程基本概念，变量可分离的微分方程；一阶线性微分方程；
5	4	同上	齐次方程(自学)；可降阶的高阶微分方程；线性微分方程及其解的结构；
6	4	同上	二阶常系数齐次线性微分方程的解法；二阶常系数非齐次线性微分方程的解法；
7	4	同上	习题课、课堂测验；**第七章：**空间直角坐标系、向量及其线性运算；
8	4	同上	向量的乘积；空间平面、直线及其方程；
9	4	同上	平面束：，曲面及其方程；空间曲线及其方程；
10	4	同上	二次曲面；五一节放假
11	4	同上	习题课、课堂测验；5.8 周四期中考试

13	4	同上	全微分；多元复合函数的求导法则；
14	4	同上	隐函数求导公式；多元函数微分学的几何应用；
15	4	同上	方向导数与梯度；多元函数的极值与最值；
16	4	同上	**第九章：** 二重积分概念与性质；习题课、课堂测验；

注明：所有课程的讨论视授课教师时间与学生的实际情况斟酌实施；每个课程的作业布置以授课教师视实际时间情况斟酌实施

Shantou University
Module Description for Undergraduate Courses

COURSE TITLE:	Advance Calculus
COURSE CODE:	MAT2801A
CREDIT VALUE:	4
CONTACT HOURS:	64
PRE-REQUISITE	Calculus B1, Calculus B2
DEPARTMENT/UNIT:	Department of Mathematics and Computer Science
VERSION:	MAT2801A-20240903
COURSE COORDINATOR:	Shi Yongjie (Signature and Seal)
APPROVER:	Fang Rei (Signature and Seal)
APPROVE DATE:	20240903

Shantou University
Faculty of Mathematics and Computer Science
September 2025

1. Course Description

Advanced Calculus is one of the compulsory foundational courses for students in science and engineering disciplines. It is designed for majors including Electronic Information Engineering, Communication Engineering, Electronic and Computer Engineering, Computer Science and Technology, Data Science and Big Data Technology, Mechanical Design and Manufacturing and Automation, Intelligent Manufacturing Engineering, Civil Engineering, Biomedical Engineering, Materials Science and Engineering, Environmental Engineering, Physics, and Optoelectronic Information Science and Engineering.

The course builds upon Calculus B-I and Calculus B-II, extending the study to the fundamental theories, methods, and applications of multivariable calculus. It provides essential mathematical foundations for subsequent courses such as Complex Analysis, Probability and Mathematical Statistics, Theoretical Mechanics, Physics, and other relevant electives. The course also aims to strengthen students' ability to apply mathematical tools to practical problems. Upon completing this course, students are expected to achieve the following learning outcomes:

Technical Knowledge Objectives

1. Understand the fundamental concepts and methods of multivariable calculus.
2. Perform calculations involving line integrals and surface integrals proficiently.
3. Apply calculus techniques effectively to solve practical problems in real-world production and engineering contexts.

Skills Objectives

1. Develop the ability to simplify, analyze, and solve practical engineering problems using mathematical tools.
2. Demonstrate proficiency in basic differential and integral operations.
3. Strengthen abilities in abstract and logical reasoning.

Ideological and Educational Objectives

This course emphasizes cultivating rigorous mathematical competence, critical thinking, and innovative thinking. It aims to foster scientific spirit and attitudes characterized by curiosity, truth-seeking, and practical inquiry. By introducing elements of mathematical history and showcasing the achievements of mathematicians—especially Chinese mathematicians—the course guides students to develop a scientific worldview, healthy values, cultural literacy, and moral integrity.

The ideological design of *Advanced Calculus* may focus on themes such as the connection between mathematics and the real world, and the innovative spirit and scientific attitudes of mathematicians.

1. Introduce the stories and achievements of mathematicians (e.g., Cauchy) to inspire students with their innovation and scientific rigor.
2. Connect course content to practical applications. Topics such as multiple integrals, line integrals, surface integrals, and infinite series are widely applied in physics and engineering. These examples demonstrate the close relationship between mathematics and real-world problems, highlight the importance of mathematics in understanding natural laws, and illustrate its contribution to societal development.

2. Intended Learning Outcomes

The intended learning outcomes of this course are summarized in the table below.

Knowledge Unit	Key Knowledge Points	Initial Level	Required Level	Expected Learning Outcomes
1. Multiple Integrals	1.1 Concept of triple integrals	L1	L2	Understand the concept and properties of triple integrals.

	1.2 Evaluation of triple integrals	L1	L3	Apply common integration techniques to compute triple integrals.
	1.3 Applications of multiple integrals	L1	L3	Use multiple integrals to compute surface area, centroid, and moment of inertia.
2. Line Integrals and Surface Integrals	2.1 Line integrals with respect to arc length	L1	L3	Understand the concept and properties of line integrals with respect to arc length, and compute such integrals.
	2.2 Line integrals with respect to coordinates	L1	L3	Understand the concept and properties of line integrals with respect to coordinates, and compute such integrals.
	2.3 Surface integrals with respect to area	L1	L3	Understand the concept and properties of surface integrals with respect to area, and compute such integrals.
	2.4 Surface integrals with respect to coordinates	L1	L3	Understand the concept and properties of surface integrals with respect to coordinates, and compute such integrals.
	2.5 Green’s Theorem	L1	L3	Apply Green’s Theorem to evaluate integrals.
	2.6 Gauss’s Theorem	L1	L3	Apply Gauss’s Theorem to evaluate integrals.
	2.7 Stokes’ Theorem	L1	L3	Apply Stokes’ Theorem to evaluate integrals.
	2.8 Flux and divergence	L1	L3	Understand the concepts and properties of flux and divergence, and compute them.
	2.9 Circulation and curl	L1	L3	Understand the concepts and properties of circulation and curl, and compute them.
3. Cauchy Mean-Value Theorem and Taylor Formula	3.1 Cauchy Mean-Value Theorem	L1	L3	Understand the mean-value theorem and apply its mathematical reasoning to prove related properties of functions.
	3.2 Proof of L’Hôpital’s Rule	L1	L2	Understand the proof techniques of L’Hôpital’s Rule.
	3.3 Taylor Formula	L1	L3	Understand the Taylor formula and use standard methods to perform Taylor expansions of functions.
4. Infinite Series	4.1 Concepts and properties of series of constants	L1	L2	Understand the concept and properties of series with constant terms.
	4.2 Convergence tests	L1	L3	Use standard convergence tests to determine the convergence or divergence of constant-term series.

	4.3 Power series	L1	L2	Understand the concept and properties of power series.
	4.4 Power series expansion of functions	L1	L3	Apply standard methods to expand functions into power series.
	4.5 Fourier series	L1	L3	Understand the concept and properties of Fourier series and apply standard methods to expand 2π-periodic functions into Fourier series.
	4.6 Fourier series of general periodic functions	L1	L3	Apply standard methods to expand general periodic functions into Fourier series.
	4.7 Sine and cosine series	L1	L3	Apply standard methods to expand functions into sine series and cosine series.

3. Pre-requisit

Calculus B1, Calculus B2

4. Textbooks and Other Learning Resources

Required Textbooks

Lin Xiaoping & Li Jian (Eds.), *New Calculus for Science and Engineering* (2nd Edition, Volume I), Peking University Press, 2025.

Lin Xiaoping, Tan Chaoqiang & Li Jian (Eds.), *New Calculus for Science and Engineering* (Volume II), Peking University Press, 2021.

Recommended Textbooks

Department of Mathematics, Tongji University, *Advanced Mathematics* (8th Edition, Vol. I & II), Higher Education Press, 2023.

Department of Mathematics, East China Normal University, *Mathematical Analysis* (6th Edition, Vol. I & II), Higher Education Press, 2025.

Course Website

http://my.stu.edu.cn

5. Teaching and Learning Activities

Teaching Segment	Lectures (Theory)	Exercise Classes	Laboratory Work	Seminars	Social Practice	Project Work	Online Learning	Mid-Term Test	Total
Hours (In-class)	54	8	0	0	0	0	0	2	64
Hours (Out-of-class)	108	24	0	0	0	0	0	0	132

6. Assessment Scheme

Assessment item	Description / Assessment criteria	Weight

Homework	Performance in weekly assignments	10%
Continuous Assessment	Attendance, class participation, quizzes, seminars, and application-oriented extension tasks	20%
Mid-Term Examination	Closed-book exam covering the first two knowledge units (multiple integrals, line and surface integrals; specific content adjusted according to teaching progress)	20%
Final Examination	Closed-book exam covering all knowledge units	50%

7. Course Schedule (For reference; the actual schedule may vary depending on the semester arrangement.)

Week	Hour	Teaching format	Teaching content
1	4	Lectures + Seminar	Review of definite integrals and double integrals; introduction to the major contributions of modern Chinese mathematicians in analysis and differential equations. Concept of triple integrals; computation of triple integrals.
2	4	Lectures + Seminar	Variable substitution for triple integrals; applications of multiple integrals (surface area, centroid, moment of inertia—only the triple-integral part); note: double-integral parts were covered last semester.
3	4	Lectures + Seminar	Exercise session; Line integrals with respect to arc length.
4	4	Lectures + Seminar	Line integrals with respect to coordinates; Surface integrals with respect to area.
5	4	Lectures + Seminar	Surface integrals with respect to coordinates.
6	4	Lectures + Seminar	Green's Theorem; Gauss's Theorem.
7	4	Lectures + Seminar	Stokes' Theorem; Path independence of line integrals and the existence of potential functions.
8	4	Lectures + Seminar	Flux and divergence; Circulation and curl.
9	4	Lectures + Seminar	Exercise session; Mid-term examination (scheduled according to teaching progress).
10	4	Lectures + Seminar	Cauchy's differential mean value theorem; Proof of L'Hôpital's Rule; Taylor's formula.
11	4	Lectures + Seminar	Series with constant terms; Series of positive terms.

12	4	Lectures + Seminar	General term (arbitrary term) series; Concept of functional series.
13	4	Lectures + Seminar	Power series; Taylor expansion of functions.
14	4	Lectures + Seminar	Exercise session; Fourier series.
15	4	Lectures + Seminar	Fourier series of functions with period 2ℓ; Sine series and cosine series.
16	4	Lectures + Seminar	Exercise session.

汕头大学本科教学

课程教学大纲

课程名（COURSE TITLE）：	高等微积分
课程代码（COURSE CODE）：	MAT2801A
学分（CREDIT VALUE）：	4
课内课时（CONTACT HOURS）：	64
先修课要求（PRE-REQUISITE）	微积分 B-I，微积分 B-II
开课单位（DEPARTMENT/UNIT）：	数学与计算机学院
版本（VERSION）：	MAT2801A-20240903
课程负责人（COURSE COORDINATOR）：	史永杰（签章）
审核人（APPROVER）：	方睿（签章）
审核日期（APPROVE DATE）：	20240903

汕头大学数学与计算机学院

2025年9月

1、课程简介（Course Description）

高等微积分（Advanced Calculus）是各理工科专业的必修的公共基础课程之一，适用于电子信息工程，通信工程，电子与计算机工程，计算机科学与技术，数据科学与大数据技术，机械设计制造及其自动化，　智能制造工程，土木工程，生物医学工程，材料科学与工程，环境工程，物理学，光电信息科学与工程等专业。本课程的教学目的是在微积分 B-I 和微积分 B-II 的基础上进一步讲授多元微积分的基本理论、方法和应用，为学习后续课程，如：复变函数，概率论与数理统计、理论力学、物理等课程及有关的选修课等提供必要的基础知识，培养学生运用数学工具解决实际问题的能力。学完本课程后学生应能够：

技术知识目标：

1. 理解多元微积分的基本思想、方法；
2. 熟练进行曲线和曲面积分的运算；
3. 熟练应用微积分的技巧解决实际生产中遇到的问题。

能力目标：

1. 具备利用数学工具简化、分析和解决实际工程问题的能力；
2. 具备运用基本的积分微分运算的能力；
3. 具备一定的抽象思维能力。

课程思政目标与设计：

本课程注重培养学生严谨的数学素养，批判思维和创新思维能力，培养学生勇于探索，实事求是，求真务实的科学精神和态度。通过介绍数学史和数学家特别是中国数学家所取得成就，引领学生树立科学的世界观，正确的人生观和价值观，培养家国情怀，提升文化素养和道德修养等，达到立德树人的思政目标。

《高等微积分》课程的思政设计可以围绕数学与现实世界的联系、数学家的创新精神和科学态度等方面展开。

1. 介绍数学家的故事，如柯西的学术成就和对数学发展的贡献，引导学生学习数学家的创新精神和严谨的科学态度。

2. 课程内容联系实际应用。重积分、曲线积分、曲面积分、无穷级数等内容在物理、工程等领域应用广泛，展示数学与实际问题的紧密联系，强调数学对理解自然规律的重要性，也说明数学理论对社会发展的贡献。

2、预期学习结果（Intended Learning Outcomes）

本课程的预期学习结果如下表：

知识单元	知识点	初始程度	要求程度	预期学习结果
1.重积分	1.1 三重积分的概念	L1	L2	理解三重积分的概念与性质
	1.2 三重积分的计算	L1	L3	应用三重积分常用的积分方法计算三重积分
	1.3 重积分的应用	L1	L3	应用重积分计算曲面的面积、质心、转动惯量
2.曲线积分与曲面积分	2.1 对弧长的曲线积分	L1	L3	理解对弧长的曲线积分的概念及性质，并计算对弧长的曲线积分
	2.2 对坐标的曲线积分	L1	L3	理解对坐标的曲线积分的概念及性质，并计算对坐标的曲线积分
	2.3 对面积的曲面积分	L1	L3	理解对面积的曲面积分的概念及性质，并计算对面积的曲面积分
	2.4 对坐标的曲面积分	L1	L3	理解对坐标的曲面积分的概念及性质，并计算对坐标的曲面积分
	2.5 格林公式及其应用	L1	L3	应用格林公式计算积分
	2.6 高斯公式	L1	L3	应用高斯公式计算积分
	2.7 斯托克斯公式	L1	L3	应用斯托克斯公式计算积分
	2.8 通量与散度	L1	L3	理解通量与散度的概念及性质，并计算通量与散度
	2.9 环流量与旋度	L1	L3	理解环流量与旋度的概念及性质，并计算环流量与旋度
3.柯西中值定理与泰勒公式	3.1 柯西微分中值定理	L1	L3	理解微分中值定理，并应用其数学思想和方法证明某些函数问题
	3.2 洛必达法则的证明	L1	L2	理解洛必达法则的证明方法
	3.3 泰勒公式	L1	L3	理解泰勒公式，并应用常用方法对函数进行泰勒展开
4.无穷级数	4.1 常数项级数的概念与性质	L1	L2	理解常数项级数的概念及其性质
	4.2 常数项级数的审敛法	L1	L3	利用审敛法对常数项级数进行敛散性判断
	4.3 幂级数	L1	L2	理解幂级数的概念及性质
	4.4 函数的幂级数展开及应用	L1	L3	应用常用方法对函数进行幂级数展开
	4.5 傅里叶级数	L1	L3	理解傅里叶级数的概念及性质，并应用常用方法对周期为 2π 的函数进行傅里叶级数展开
	4.6 一般周期函数的傅里叶级数	L1	L3	应用常用方法对一般周期函数进行傅里叶级数展开
	4.7 正弦级数和余弦级数	L1	L3	应用常用方法将函数展开为正弦级数与余弦级数

3、先修要求（Pre-requisite）

微积分 B-I，微积分 B-II

4、教材及其他教学资源（Textbooks and Other Learning Resources）

指定教材：
林小苹、李健编著，新编微积分(理工类)（第二版，上册），北京大学出版社，2025 年；
林小苹、谭超强、李健编著，新编微积分(理工类) 下册，北京大学出版社，2021 年。

推荐教材：
同济大学数学教研室，《高等数学》（第 8 版 上、下册），高等教育出版社，2023 年；
华东师范大学数学系编，《数学分析》（第 6 版 上、下册），高等教育出版社，2025 年。

课程网站：http://my.stu.edu.cn

5、主要教学环节（Teaching and Learning Activities）

教学环节	理论课（小时）	习题课（小时）	实验（小时）	研讨（小时）	社会实践（小时）	项目（小时）	在线学习（小时）	期中测试（小时）	合计
课内	54	8	0	0	0	0	0	2	64
课外	108	24	0	0	0	0	0	0	132

6、课程考核（Assessment Scheme）

考核项目	考核内容和考试方法简介	权重
作业	课后作业完成情况	10%
平时成绩	考勤、课堂表现、课堂测试，研讨，应用拓展项目等	20%
期中考试	前两个知识单元（重积分、曲线积分和曲面积分，具体内容根据实际教学进度安排），闭卷考试	20%
期末考试	全部知识单元，闭卷考试	50%

7、学习进度（Course Schedule）(供参考，实际进度根据学期具体情况安排)

周次	教学时数	教学形式	教学内容
1	4	讲授+研讨	复习定积分、二重积分，介绍我国近现代数学家在分析、方程等领域所做出的突出贡献 三重积分概念； 三重积分的计算；

2	4	讲授+研讨	三重积分的换元法； 重积分的应用(曲面面积，质心、转动惯量只讲三重积分方面)； 注:质心、转动惯量二重积分方面上学期已讲
3	4	讲授+研讨	习题课； 对弧长的曲线积分；
4	4	讲授+研讨	对坐标的曲线积分； 对面积的曲面积分；
5	4	讲授+研讨	对坐标的曲面积分；
6	4	讲授+研讨	格林公式； 高斯公式；
7	4	讲授+研讨	斯托克斯公式； 曲线积分与路径的无关性、原函数问题；
8	4	讲授+研讨	通量与散度； 环流量与旋度；
9	4	讲授+研讨	习题课； 期中考试（按具体教学进度安排）；
10	4	讲授+研讨	柯西中值定理； 洛必达法则的证明； 泰勒公式；
11	4	讲授+研讨	常数项级数； 正项级数；
12	4	讲授+研讨	任意项级数； 函数项级数的概念；

13	4	讲授+研讨	幂级数； 函数的幂级数展开式；
14	4	讲授+研讨	习题课； 傅里叶级数；
15	4	讲授+研讨	以 21 为周期的函数的傅里叶级数； 正弦级数和余弦级数；
16	4	讲授+研讨	习题课

Shantou University

Module Description for Undergraduate Courses

COURSE TITLE:	Probability and Statistics
COURSE CODE:	MAT2802A
CREDIT VALUE:	3
CONTACT HOURS:	48
PRE-REQUISITE	Calculus B2, Calculus C2
DEPARTMENT/UNIT:	Department of Mathematics
VERSION:	202408- MAT2802A
COURSE COORDINATOR:	Shi Yongjie (Signature and Seal)
APPROVER:	Tan Chaoqiang (Signature and Seal)
APPROVE DATE:	202408

Shantou University

Faculty of Mathematics and Computer Science

August 2025

1. Course Description

Probability and Statistics (Although the literal translation and the original module catalogue both use the title "Probability and Mathematical Statistics," the transcript records the course as "Probability and Statistics." Therefore, this document follows the title as it appears on the transcript.) is a mathematical discipline that studies the laws governing random phenomena. With the widespread use of computers and the development of powerful mathematical and statistical software, this discipline has been increasingly applied in various fields of natural sciences and social sciences. In accordance with the university's educational orientation and the training objectives of emerging engineering disciplines, this course has become one of the compulsory general foundational courses for students majoring in Computer Science and Technology, Mechanical Design Manufacturing and Automation, Civil Engineering, Biomedical Engineering, Materials Science and Engineering, Environmental Engineering, and Optoelectronic Information Science and Engineering.

This course consists of two major parts: Probability Theory and Mathematical Statistics.

The probability-theory part studies the regularities of random phenomena—uncertain phenomena that commonly exist in nature and social life—from the perspective of quantitative relationships, and it provides the theoretical foundation for the statistical part. The mathematical-statistics part examines the statistical regularities of random phenomena by integrating theory with practical applications. Based on data obtained from experiments or observations, the course investigates randomness and makes reasonable estimations and judgments about the objective laws governing the research object. Through this course, students will systematically master the basic ideas and methods for handling random phenomena, develop the ability to analyze and solve practical problems using probability and statistical approaches, and obtain the necessary mathematical foundation for subsequent professional courses and future career development.

Technical Objectives

1. Enable students to understand the historical development of probability theory and mathematical statistics and their applications across various disciplines, thereby enhancing students' interest and enthusiasm for learning. Students will gain clarity about what they are learning and why they are learning it, and be encouraged from the perspective of social mission to study diligently. Students will develop an appreciation of the "scientific spirit" and strengthen their sense of social responsibility.
2. While learning theories and methods, students will gain an understanding of the descriptive power and depth of mathematical language applied to natural or social phenomena, and will attempt to comprehend the truth-seeking nature of mathematics.
3. Cultivate perseverance in learning and a rigorous scholarly attitude, laying a solid foundation for future study, work, and life. Students will be encouraged to establish correct values and to uphold the spirit of truth-seeking, pragmatism, and integrity in both learning and daily life.
4. Help students understand the philosophical foundations of statistics: mathematical statistics, based on probability theory, studies the statistical regularities of random phenomena. Through organizing, grouping, computing, and summarizing sample data, students will make inferences and predictions about the population. It is a process of moving from experience toward rational understanding—a science that uses randomness to uncover underlying laws, revealing necessity within chance.

Skills Objectives

1. Understand the basic concepts of random events, as well as relationships and operations among events; master the fundamental concepts and properties of probability; and be able to apply the basic theorems of probability theory to compute event probabilities.
2. Master the fundamental concepts of random variables and major probability distributions; compute probability-related problems and numerical characteristics of important distributions proficiently.
3. Understand the Law of Large Numbers and the Central Limit Theorem, and master their applications in practical probability problems; develop proficiency in computing sampling distributions.
4. Master the computational methods for parameter estimation and hypothesis testing.

Ability Objectives

1. Possess the ability to simplify, analyze, and solve practical probability problems.
2. Acquire the ability to compute fundamental probability problems and numerical characteristics of discrete and continuous random variables, and to analyze and interpret the results.
3. Be able to apply the Law of Large Numbers and the Central Limit Theorem to analyze and solve real-world problems.

4. Develop the ability to identify, analyze, describe, reason about, and solve problems in real applications using the basic principles and methods of interval estimation and hypothesis testing.

2. Intended Learning Outcomes

The intended learning outcomes of this course are summarized in the table below.

Knowledge Unit	Key Knowledge Points	Initial Level	Required Level	Expected Learning Outcomes
Basic Concepts of Probability Theory	Basic concepts of probability theory: random experiment, sample space, random event, event probability	L1	L3	1. Understand the basic concepts of random experiment, sample space, random event, and event probability. 2. Use properties of probability to compute the probabilities of complex events. 3. Apply fundamental counting methods to solve probability problems in classical and geometric probability models.
Fundamental Theorems of Probability	Addition rule, multiplication rule, law of total probability, Bayes' formula	L1	L3	1. Use the addition rule and multiplication rule to compute probabilities of union and intersection events. 2. Compute conditional probabilities. 3. Use independence to compute event probabilities. 4. Apply the law of total probability and Bayes' formula to solve practical problems.
Discrete Random Variables	Random variables and distributions, discrete random variables and probability mass functions, important discrete random variables, expectation and variance of discrete random variables	L1	L3	1. Understand the concept of random variables and their distributions. 2. Demonstrate understanding of discrete random variables and their distributions. 3. Use definitions and properties to determine the distribution of discrete random variables and their functions. 4. Explain major discrete random-variable distributions and compute associated probabilities proficiently. 5. Compute the expectation and variance of discrete random variables and their functions. 6. Use properties of expectation and variance to compute these quantities for specific discrete random variables.
Continuous Random Variables	Continuous random variables and probability density functions, distribution functions, important continuous random variables, expectation and variance, Chebyshev inequality, Law of Large Numbers,	L1	L3	1. Demonstrate understanding of continuous random variables and their distributions. 2. Use definitions and properties to determine the distribution of continuous random variables and their functions.

	De Moivre–Laplace Central Limit Theorem			3. Explain major continuous random-variable distributions and compute related probabilities proficiently. 4. Compute the expectation and variance of continuous random variables and their functions. 5. Use properties of expectation and variance to compute these quantities for specific continuous random variables. 6. Use the Chebyshev inequality to estimate probabilities. 7. Understand the Law of Large Numbers and illustrate its applications. 8. Apply the De Moivre–Laplace Central Limit Theorem to solve practical problems.
Multivariate Random Variables	Basics of multivariate random variables: joint distributions, marginal distributions, conditional distributions, independence, expectation and variance, covariance and correlation coefficient, moments and covariance matrix, Lindeberg–Lévy Central Limit Theorem	L1	L3	1. Understand the concepts and distributions of two-dimensional random variables; compute probabilities using definitions and properties. 2. Describe common types of bivariate distributions. 3. Understand marginal and conditional distributions and demonstrate ability to compute them. 4. Discuss independence of random variables. 5. Solve distribution problems for functions of two random variables. 6. Compute expectation, variance, covariance, and correlation coefficients of two random variables; describe moments and covariance matrices. 7. Use properties of expectation, variance, and covariance to solve related problems. 8. Apply the Lindeberg–Lévy Central Limit Theorem to solve practical problems.
Fundamental Concepts of Mathematical Statistics	Population and sample, statistics, important statistical distributions and upper α-quantiles, sampling distributions of normal populations	L1	L3	1. Demonstrate understanding of population, sample, and simple random sample. 2. Understand the concept of statistics and explain common statistics. 3. Use definitions to solve inference problems involving important statistical distributions. 4. Compute upper α-quantiles and related probabilities proficiently. 5. Solve practical probability problems using sampling

				distribution theorems of normal populations.
Parameter Estimation	Point estimation, method of moments, maximum likelihood estimation, criteria for evaluating estimators, interval estimation	L1	L3	1. Understand the basic concepts of parameter estimation. 2. Use the method of moments and maximum likelihood estimation to obtain point estimators. 3. Evaluate point estimators using estimator selection criteria. 4. Solve interval-estimation problems for normal populations.
Hypothesis Testing	Basic concepts of hypothesis testing, hypothesis tests for the mean and variance of a normal population	L1	L3	1. Understand the basic concepts of hypothesis testing. 2. Solve hypothesis-testing problems for the mean and variance of a single normal population.

3. Pre-requisit

Calculus B2, Calculus C2

4. Textbooks and Other Learning Resources

Course Textbooks

Hao Zhifeng (Ed.). *Probability Theory and Mathematical Statistics*. Peking University Press, 2021.

Recommended References

Sheng Zhuo et al. (Eds.). *Probability Theory and Mathematical Statistics*. Higher Education Press, 5th Edition, 2020.

Yao Mengchen. *Probability Theory and Mathematical Statistics*. Renmin University of China Press, 2nd Edition, 2021.

Devore, J. L. *Probability and Mathematical Statistics*. Higher Education Press, 5th Edition, 2004.

National Quality Course (University of Science and Technology Beijing): https://www.icourse163.org/course/USTB-1003768006

5. Teaching and Learning Activities

Teaching Segment	Lectures (Theory)	Exercise Classes	Laboratory Work	Seminars	Social Practice	Project Work	Online Learning	Other	Total
Hours (In-class)	48	0	0	0	0	0	0	0	48
Hours (Out-of-class)	48	20	0	10	0	0	20	0	98

6. Assessment Scheme

Assessment item	Description / Assessment criteria	Weight

Class Performance	Class participation, seminar performance, in-class quizzes	10%
Homework	After-class exercises and reflective tasks	10%
Midterm Examination	Chapters 1–3 and selected topics from Chapters 4–5; closed-book exam	30%
Final Examination	Selected topics from Chapters 4–5 and Chapters 6–8; closed-book exam	50%

7. Course Schedule

(Assuming 4 contact hours per week during Weeks 1–8 and 2 contact hours per week during Weeks 9–16; for reference only)

Week	Hour	Teaching format	Teaching content
1	4	Lectures + Seminar	Chapter 1 Basic Concepts of Probability Theory § 1.1 Introduction; Random Experiments § 1.2 Random Events § 1.3 Probability of Events (Frequency and Probability, Properties of Probability, Classical Probability Model, Basic Counting Methods, Geometric Probability) Chapter 2 Fundamental Theorems of Probability Theory § 2.1 Addition Theorem
2	4	Lectures + Seminar	§ 2.2 Multiplication Theorem (Conditional Probability, Multiplication Theorem, Independence of Events) § 2.3 Total Probability Formula and Bayes' Formula Exercise Session
3	4	Lectures + Seminar	Chapter 3 Discrete Random Variables § 3.1 Basic Concepts (Random Variables, Discrete Random Variables and Their Probability Mass Functions, n-fold Bernoulli Trials) § 3.2 Important Discrete Random Variables § 3.3 Other Discrete Random Variables Chapter 4 Continuous Random Variables § 4.1 Basic Concepts (Distribution Function, Continuous Random Variables) (1)
4	4	Lectures + Seminar	§ 4.1 Basic Concepts (Distribution Function, Continuous Random Variables) (2) § 4.4 Important Continuous Random Variables Supplement: Distribution of Functions of One-Dimensional Random Variables
5	4	Lectures + Seminar	Chapter 5 Multivariate Random Variables § 5.1 Basic Concepts (Two-Dimensional Random Variables and Joint Distribution Functions, Bivariate Discrete Random Variables and Joint Probability Mass Functions, Bivariate Continuous Random Variables and Joint Density Functions) § 5.2 Marginal and Conditional Distributions

6	4	Lectures + Seminar	§ 5.3 Independence of Random Variables § 5.4 Probability Distributions of Functions of Two-Dimensional Random Variables Exercise Session
7	4	Lectures + Seminar	§ 3.4 + §4.2 + §5.5 (1) Mathematical Expectation of Random Variables § 3.4 + §4.2 + §5.5 (2) Variance of Random Variables § 4.3 Chebyshev's Inequality and the Law of Large Numbers (1)
8	4	Lectures + Seminar	Midterm Examination (scheduled according to actual teaching progress) § 5.5 (3) Numerical Characteristics of Bivariate Random Variables (Covariance and Correlation Coefficient)
9	2	Lectures + Seminar	§ 4.3 Chebyshev's Inequality and the Law of Large Numbers (2)
10	2	Lectures + Seminar	§ 4.5 De Moivre–Laplace Theorem § 5.6 Lindeberg–Lévy Theorem Exercise Session
11	2	Lectures + Seminar	Chapter 6 Fundamentals of Mathematical Statistics § 6.1 Population and Sample § 6.2 Statistics
12	2	Lectures + Seminar	§ 6.3 Common Important Statistical Distributions and Upper-α Quantiles § 6.4 Sampling Distributions of Normal Populations
13	2	Lectures + Seminar	Chapter 7 Parameter Estimation § 7.1 Point Estimation
14	2	Lectures + Seminar	§ 7.2 Criteria for Evaluating Estimators § 7.3 Interval Estimation (Basic Concepts; Interval Estimation for the Mean and Variance of a Normal Population)
15	2	Lectures + Seminar	Chapter 8 Hypothesis Testing § 8.1 Basic Concepts of Hypothesis Testing (Concept, Types of Errors, Basic Steps)
16	2	Lectures + Seminar	§ 8.2 Hypothesis Tests for the Mean and Variance of a Single Normal Population Exercise Session

汕头大学本科教学
课程教学大纲

课　程　名（COURSE TITLE）：	概率论与数理统计(工科)
课程代码（COURSE CODE）：	MAT2802A
学　　　分（CREDIT VALUE）：	3
课内课时（CONTACT OURS）：	48
先修课要求（PRE-REQUISIT）	微积分 B-II，微积分 C-II
开课单位（DEPARTMENT/UNIT）：	数学系
版　　　本（VERSION）：	202408- MAT2802A
课程负责人（COURSE COORDINATOR）：	史永杰　　（签章）
审　核　人（APPROVER）：	谭超强　　（签章）
审核日期（APPROVE DATE）：	202408

汕头大学数学与计算机学院

2024 年 8 月

一、课程简介 （Course Description）

概率论与数理统计（Probability and Mathematical Statistic）是一门研究随机现象规律的数学学科，随着计算机的普及和功能强大的数学、统计软件的开发，概率论与数理统计学科在自然科学和社会科学的各个领域的应用越来越广泛。结合学校的办学定位、新工科人才培养目标，概率论与数理统计课程成为面向我校计算机科学与技术，机械设计制造及其自动化，土木工程，生物医学工程，材料科学与工程，环境工程，光电信息科学与工程等专业学生必修的公共基础课程之一。

本课程包括概率论与数理统计两部分，概率论部分是从数量关系角度研究自然界和社会生活中普遍存在的不确定现象，即随机现象的规律性，并为后续统计部分内容提供理论基础。数理统计部分是从理论与实际相结合的角度研究随机现象的统计规律性，它以概率论为理论基础，根据试验或观察得到的数据来研究随机现象，对研究对象的客观规律性做出合理的估计与判断。通过对本课程的学习，使学生系统掌握处理随机现象的基本思想和方法，培养他们运用概率与数理统计的方法去分析和解决有关实际问题的能力，并为后继的专业课程的学习和职业发展提供必要的数学理论基础。另外，通过介绍我国近现代数学家在概率论与数理统计领域所做出的突出贡献，引导学生努力学好本门课程并应用于本专业的实践、服务国家发展战略需求。

通过本课程的学习，达到以下教学目标：

思政育人目标：

1. 让学生认识到概率论与数理统计学科的发展史以及其在各学科领域里的应用情况，从而激发学生的学习兴趣和热情，知道自己在学什么，学完干什么，从社会使命感的角度鼓励学生努力学习。让学生领悟到“科学精神”，同时增强学生的社会责任感。

2. 在学习理论和方法的同时，让学生了解数学语言描述自然现象或社会现象的能力和深刻性，尝试理解数学的真理性。

3. 使学生认识到整体与局部、对立与统一、理论与实践、偶然与必然等的辩证关系，形成良好的辩证唯物主义世界观。

4. 培养学生具有坚持不懈的学习精神和严谨治学的科学态度，为未来的学习、工作和生活奠定良好的基础。让学生意识到无论学习还是生活都要树立正确的价值观，一定要有求真、务实、诚信的精神。

5. 让学生认识到统计学的哲学思想：数理统计以概率论为基础，研究随机现象的统计规律性。通过对样本数据整理、分组、计算、归纳，对总体做出推断和预测。它是一种由经验到理性的认识，是一种运用偶然性，发现规律性的科学，偶然中蕴含着必然。

知识目标：

1. 理解随机事件的基本概念及事件之间的关系与运算，熟练掌握随机事件概率的基本概念及其相关性质，能熟练应用概率论基本定理计算随机事件的概率；

2. 熟练掌握随机变量的基本概念以及重要的随机变量的分布，熟练计算概率分布相关的概率问题和几种重要的概率分布的数字特征；

3. 理解大数定律与中心极限定理并熟练掌握它们在实际概率问题中的应用，熟练进行抽样分布的计算；

4. 熟练掌握参数估计和假设检验的计算。

能力目标：

1. 具备简化、分析和解决实际概率事件的能力。

2. 具备计算离散型及连续型随机变量相关基本概率问题以及数字特性的能力，并对计算结果进行事件分析和判断的能力。

3. 能利用大数定律和中心极限定理分析和解决实际问题的能力；

4. 具有根据区间估计和假设检验的基本思想和方法，发现问题、分析问题、描述问题、推理和分析相关实际解决问题的能力。

二、预期学习结果 （Intended Learning Outcomes）

本课程的预期学习结果为：

知识单元	知识点	初始程度	要求程度	预期学习结果
概率论的基本概念	概率论的基本概念，随机试验， 样本空间，随机事件，事件的概率	L1	L3	1. 理解随机试验、 样本空间、随机事件及事件的概率等基本概念； 2. 利用概率的性质计算复杂事件的概率； 3. 应用基本计数方法求解古典概型和几何概型的概率问题。
概率论的基本定理	加法定理，乘法定理，全概率公式和贝叶斯公式	L1	L3	1. 利用加法定理和乘法定理计算和事件与积事件的概率； 2. 计算条件概率； 3. 利用独立性计算事件的概率； 4. 应用全概率公式和贝叶斯公式解决实际

				问题。
离散型随机变量	随机变量及其分布，离散型随机变量及其分布律， 重要的离散型随机变量，离散型随机变量的数学期望与方差	L1	L3	1. 理解随机变量及其分布的概念； 2. 展现对离散型随机变量及其分布的理解； 3. 利用定义和性质求离散型随机变量及其函数的分布； 3. 阐释几种重要的离散型随机变量的分布，并熟练计算相关事件的概率； 4. 计算离散型随机变量及其函数的数学期望和方差； 5. 利用离散型随机变量的数学期望与方差的性质计算某些离散型随机变量的数学期望和方差。
连续型随机变量	连续型随机变量及其概率密度， 随机变量的分布函数,重要的离散型随机变量，连续型随机变量的数学期望与方差，切比雪夫不等式，大数定律，棣莫弗-拉普拉斯中心极限定理	L1	L3	1. 展现对连续型随机变量及其分布的理解； 2. 利用定义和性质求连续型随机变量及其函数的分布； 3. 阐释几种重要的连续型随机变量的分布，并熟练计算相关事件的概率； 4. 计算连续型随机变量及其函数的数学期望和方差； 5. 利用连续型随机变量的数学期望与方差的性质计算某些连续型随机变量的数学期望和方差； 6. 利用切比雪夫不等式估算概率； 7. 理解大数定律并举例说明其应用； 8. 利用棣莫弗-拉普拉斯中心极限定理来解决实际问题。
多维随机变量	多维随机变量的基本概念， 边缘分布， 条件分布， 相互独立性，数学期望和方差，协方差及相关系数， 矩和协方差矩阵，林德贝格-列维中心极限定理	L1	L3	1. 理解二维随机变量及其分布，并利用定义和性质求二维随机变量的分布以及相关的概率问题； 2. 描述几种常见的二维随机变量的分布； 3. 理解二维随机变量的边缘分布和条件分布的概念，展示对边缘分布和条件分布的求解； 4. 讨论随机变量的独立性； 5. 解决二维随机变量函数的分布问题； 6. 计算二维随机变量的数学期望与方差，协方差及相关系数；描述矩和协方差矩阵； 7. 利用多维随机变量的数学期望、方差、和协方差的性质求解相关问题； 8. 利用林德贝格-列维中心极限定理来解

				决实际问题。
数理统计的基本概念	总体和样本，统计量 常见的统计学重要分布和上α分位点 正态总体的抽样分布	L1	L3	1.展示总体，样本和简单随机样本的理解； 2.理解统计量的概念，阐释常见的统计量； 3.利用定义求解常见的统计学重要分布的推断问题； 4.熟练计算上α分位点以及相关的概率； 5.利用正态总体的抽样分布定理解决实际的概率问题；
参数估计	点估计，矩估计，极大似然估计，估计量的评选标准，区间估计	L1	L3	1.理解参数估计的基本概念； 2.使用矩估计法和最大似然估计法求点估计； 3.利用估计量的评选标准来评价点估计； 4.解决正态总体的区间估计问题。
假设检验	假设检验的基本概念 正态总体均值和方差的假设检验	L1	L3	1.理解假设检验的基本概念； 2.解决单个正态总体均值与方差的假设检验问题。

三、先修要求 （Pre-requisit）

微积分B-II，微积分C-II

四、教材及其他教学资源 （Textbooks and Other Learning Resources）

课程教材

郝志峰主编 《概率论与数理统计》，北京大学出版社，2021

推荐参考资料

1.盛骤等主编 《概率论与数理统计》，高等教育出版社， 第五版，2020

2.姚孟臣编 《概率论与数理统计》，中国人民大学出版社，第二版，2021

3.德沃尔 (Devore.J.L.)《概率论与数理统计》，高等教育出版社，第五版， 2004

4.国家精品课程（北京科技大学）：https://www.icourse163.org/course/USTB-1003768006

五、主要教学环节 （Teaching and Learning Activities）

理论课（小时）		习题课（小时）		实验（小时）		研讨（小时）		社会实践（小时）		项目（小时）		在线学习（小时）		其他（小时）	
课内	课外	课内	课外	课内	课外	课内	课外	课内	课外	课内	课外	课内	课外	课内	课外
48	48	无	20	无	无	无	10	无	无	无	无	无	20	无	无

六、课程考核 （Assessment Scheme）

考核项目	考核内容和考试方法简介	权重
平时成绩	课堂参与情况，研讨、课堂测试等	10%
作业	课后作业与思考	10%
期中考试	第 1-3 章、第 4-5 章的部分内容，闭卷考试	30%
期末考试	第 4-5 章的部分内容、第 6-8 章，闭卷考试	50%

七、教学进度表 （Course Schedule）（以1-8周4学时/周，9-16周2学时/周为例，仅供参考）

周次	教学时数	教学形式	教 学 内 容
1	4	讲授+研讨	第一章 概率论的基本概念 §1.1 绪论、随机试验 §1.2 随机事件 §1.3 事件的概率（频率与概率，概率的性质，古典概型，基本计数方法，几何概率） 第二章 概率论的基本定理 §2.1 加法定理
2	4	讲授+研讨	§2.2 乘法定理（条件概率，乘法定理，事件的独立性） §2.3 全概率公式和贝叶斯公式 习题课
3	4	讲授+研讨	第三章 离散型随机变量 §3.1 基本概念（随机变量、离散型随机变量及其分布律，n 重伯努利试验） §3.2 重要的离散型随机变量 §3.3 其他的离散型随机变量 第四章 连续型随机变量 §4.1 基本概念（随机变量的分布函数，连续型随机变量）（1）
4	4	讲授+研讨	§4.1 基本概念（随机变量的分布函数，连续型随机变量）（2） §4.4 重要的连续型随机变量 补充： 一维随机变量函数的分布

5	4	讲授+研讨	第五章 多维随机变量 §5.1 基本概念（二维随机变量及其联合分布函数，二维离散型随机变量及其联合分布律，二维连续型随机变量及其联合密度函数） §5.2 边缘分布与条件分布
6	4	讲授+研讨	§5.3 随机变量的独立性 §5.4 二维随机变量的函数的概率分布 习题课
7	4	讲授+研讨	§3.4+§4.2+§5.5（1）随机变量的数学期望 §3.4+§4.2+§5.5（2）随机变量的方差 §4.3 切比雪夫不等式和伯努利大数定律（1）
8	4	讲授+研讨	期中考试（根据实际进度安排） §5.5（3）二维随机变量的数字特征（协方差及相关系数）
9	2	讲授+研讨	§4.3 切比雪夫不等式和伯努利大数定律（2）
10	2	讲授+研讨	§4.5 棣莫弗-拉普拉斯定理 §5.6 林德贝格-列维定理 习题课
11	2	讲授+研讨	第六章 数理统计的基本概念 §6.1 总体和样本 §6.2 统计量
12	2	讲授+研讨	§6.3 常见的统计学重要分布和上α分位点 §6.4 正态总体的抽样分布
13	2	讲授+研讨	第七章 参数估计 §7.1 点估计
14	2	讲授+研讨	§7.2 估计量的评选标准 §7.3 区间估计（基本概念，正态总体均值与方差的区间估计）
15	2	讲授+研讨	第八章 假设检验 §8.1 假设检验的基本概念（思想方法、两类错误，基本步骤）
16	2	讲授+研讨	§8.2 单个正态总体均值和方差的假设检验 习题课

Shantou University

Module Description for Undergraduate Courses

COURSE TITLE:	Functions of Complex Variable
COURSE CODE:	MAT2803A
CREDIT VALUE:	2
CONTACT HOURS:	32
PRE-REQUISITE	Advance Calculus
DEPARTMENT/UNIT:	Department of Mathematics and Computer Science
VERSION:	20240726- MAT2803A
COURSE COORDINATOR:	Tan Chaoqiang (Signature and Seal)
APPROVER:	Fang Rui (Signature and Seal)
APPROVE DATE:	20240726

Shantou University
Faculty of Mathematics and Computer Science
January 2024

1. Course Description

Complex Analysis is one of the principal foundational courses in engineering mathematics. It has extensive applications in engineering fields such as computer graphics, signal processing, and communications. The aim of this course is to help students understand and master the mathematical concepts and methods of complex analysis, and to gradually develop the ability to apply these tools to practical problems in electromagnetics, computer graphics, fluid mechanics, and related areas. After completing this course, students should be able to achieve the following learning outcomes:

Technical Knowledge Objectives:

1. Understand the mathematical concepts and methods in complex analysis.
2. Perform computations involving powers and roots of complex numbers proficiently.
3. Apply Cauchy's integral formula effectively in calculations.
4. Expand and compute Taylor series for complex functions competently.

Skills Objectives:

1. Transform general integral problems into the computation of residues.
2. Determine whether a complex integral depends on the path of integration.
3. Demonstrate a solid understanding of the theoretical foundations of complex analysis.

2. Intended Learning Outcomes

Knowledge Unit	Key Knowledge Points	Initial Level	Target Level	Expected Learning Outcomes
1.Complex Variables and Analytic Functions	Geometric representation of complex numbers; algebraic operations; powers and roots of complex numbers; notion of domains; complex functions, limits, and continuity; derivatives and differentials; definition of analytic functions; Cauchy–Riemann equations; elementary analytic functions.	L1	L3	1. Understand the concepts of complex numbers, complex functions, and analytic functions. 2. Determine whether a complex function is analytic. 3. Apply definitions to compute the values of elementary analytic functions.

2. Complex Integration and Fundamental Theorems	Definition and properties of complex integrals; Cauchy's integral theorem and its extensions; Cauchy's integral formula; principles relating analytic and harmonic functions.	L1	L3	1. Understand the concepts of complex integration, Cauchy's integral theorem, and Cauchy's integral formula. 2. Apply standard techniques for evaluating complex integrals. 3. Apply Cauchy's integral formula proficiently.
3. Series Theory in Complex Analysis	Complex series; power series; radius of convergence; Taylor series; Laurent series.	L1	L3	1. Understand the concepts and properties of complex series, power series, and Laurent series. 2. Apply standard methods to compute Taylor and Laurent expansions of complex functions.
4. Residue Theory	Isolated singularities; residue theory; application of residues to definite integrals.	L1	L3	1. Understand the concepts and properties of isolated singularities and residues. 2. Apply residue theory to evaluate certain definite integrals.

3. Pre-requisit

Advance Calculus

4. Textbooks and Other Learning Resources

References

Engineering Mathematics — Complex Analysis (4th Edition), compiled by the Higher Mathematics Teaching and Research Office of Xi'an Jiaotong University, Higher Education Press.

Recommended References

Complex Analysis, edited by Zhong Yuquan, Higher Education Press.

5. Teaching and Learning Activities

Teaching Segment	Lectures (Theory)	Exercise Classes	Laboratory Work	Seminars	Social Practice	Project Work	Online Learning	Other	Total
Hours (In-class)	30	2							32
Hours (Out-of-class)	64	32		10			20		126

7. Assessment Scheme

Assessment item	Description / Assessment criteria	Weight
Continuous Assessment	Class participation, discussions, in-class tests	20%

Homework	Completion of after-class assignments	30%
Final Examination	Closed-Book Examination:	50%

7. Course Schedule

Week	Teaching format	Hour	Teaching content
1	Seminar + Lecture	2	Geometric representation of complex numbers; algebraic operations
2	Same as above	2	Powers and roots of complex numbers
3	Same as above	2	Concept of domains
4	Same as above	2	Limits and continuity of complex functions
5	Same as above	2	Derivatives and differentials; analytic functions; Cauchy–Riemann equations
6	Same as above	2	Elementary analytic functions; definition and properties of complex integrals
7	Same as above	2	Cauchy’s integral theorem and its extensions
8	Same as above	2	Cauchy’s integral formula; analytic functions and harmonic functions
9	Same as above	2	Complex series; power series
10	Same as above	2	Radius of convergence
11	Same as above	2	Taylor series
12	Same as above	2	Laurent series
13	Same as above	2	Isolated singularities; residues; residue theorem
14	Same as above	2	Applications of residues to definite integrals (I)
15	Same as above	2	Applications of residues to definite integrals (II)
16	Same as above	2	Final review

汕头大学本科教学
课程教学大纲

课　程　名（COURSE TITLE）：	复变函数(工科)
课程代码（COURSE CODE）：	MAT2803A
学　　　分（CREDIT VALUE）：	2
课内课时（CONTACT OURS）：	32
先修课要求（PRE-REQUISIT）	高等微积分
开课单位（DEPARTMENT/UNIT）：	数学与计算机学院
版　　　本（VERSION）：	20240726- MAT2803A
课程负责人（COURSE COORDINATOR）：	谭超强　　（签章）
审　核　人（APPROVER）：	方睿　　（签章）
审核日期（APPROVE DATE）：	20240726

汕头大学数学与计算机学院

2024 年 7 月

一、课程简介 （Course Description）

复变函数是工科的主要工学基础课程之一。复变函数具有广泛的工程应用，例如计算机图形学、信号处理、通信等。本课程的教学目的是使得学生理解和掌握复变函数中的数学概念和方法，并逐步培养利用这些概念和方法解决诸如电磁学、计算机图形学、流体力学等实际问题的能力。学完本课程后学生应能够掌握：

技术知识目标：

1.理解复变函数中的数学概念和方法

2 熟练进行求复数乘幂与方根

3 熟练应用柯西积分公式进行计算

4 熟练展开泰勒展开式和计算

能力目标：

1 具备把一般数学积分问题转化为求留数的能力

2 具备判断复积分是否与路径相关的能力

3 具备理解复变函数理论的能力

课程思政：

通过介绍我国近现代数学家在复分析领域所做出的突出贡献，引导学生努力学好数学并应用于本专业的实践、服务国家发展战略需求。

二、预期学习结果 （Intended Learning Outcomes）

本课程的预期学习结果为：

知识单元	知识点	初始程度	要求程度	预期学习结果
1. 复变函数与解析函数概念	复数几何表示及其代数运算，复数的乘幂与方根，区域的概念，复变函数、极限与连续性，导数、微分、解析函数的概念柯西--黎曼方程，初等解析函数.	L1	L3	1. 理解复数、复变函数和解析函数概念。 2. 熟练判断复变函数的解析性。 3. 熟练应用定义求初等解析函数值。
2. 复变函数积分	复积分定义与性质，柯西积分定理及其推	L1	L3	1. 理解复积分、柯西积分定理与公式概念与

与基本定理	广，柯西积分公式解析函数与调和函数			原理。 2. 熟练应用复积分常用方法求积分。 3. 熟练应用柯西积分公式。
3. 复变函数的级数理论	复级数，幂级数，收敛半径，泰勒级数，洛朗级数	L1	L3	1. 理解复级数、幂级数和洛朗级数的概念及其性质。 2. 熟练应用常用方法对复变函数进行泰勒展开与洛朗展开。
4. 留数理论	孤立奇点，留数理论，留数在定积分计算的应用	L1	L3	1. 理解孤立奇点和留数的概念及其性质。 2. 熟练应用留数理论对某些特殊定积分进行计算。

三、先修要求 （Pre-requisit）

高等微积分

四、教材及其他教学资源 （Textbooks and Other Learning Resources）

课程教材

《工程数学—复变函数》（第四版），西安交通大学高等数学教研室编，高等教育出版社

推荐参考资料

《复变函数》，钟玉泉编，高等教育出版社。

五、主要教学环节 （Teaching and Learning Activities）

理论课（小时）		习题课（小时）		实验（小时）		研讨（小时）		社会实践（小时）		项目（小时）		在线学习（小时）		其他（小时）	
课内	课外	课内	课外	课内	课外	课内	课外	课内	课外	课内	课外	课内	课外	课内	课外
30	64	2	32	无	无	无	10	无	无	无	无	无	20	无	无

六、课程考核 （Assessment Scheme）

考核项目	考核内容和考试方法简介	权重

平时表现	课堂参与情况、研讨、课堂测试等	20%
课后作业	课后作业的完成情况	30%
期末考试	闭卷考试	50%

七、教学进度表 （Course Schedule）（以一周2学时为例，仅供参考）

周次	教学形式	教学时数	教　学　内　容	思政元素
1	研讨+讲授	2	复数几何表示及其代数运算	**提升民族自豪感,立志奉献：**引入我国数学家关于值分布中的贡献“张-杨”定理。弘扬爱国主义情怀，以及数学家治之以恒的科研情怀。引起学生的共鸣，振奋学生精神，立志努力学习，并为祖国的发展奉献个人的一份力。
2	同上	2	复数的乘幂与方根	
3	同上	2	区域的概念	
4	同上	2	复变函数极限与连续性	
5	同上	2	导数与微分 解析函数的概念柯西--黎曼方程	**加强理解对立统一：**“微分与积分的相辅相成”，“离散与连续的对立统一”，“函数、映射和变换的统一”，“复球面与复平面的统一”，“直线对称和圆周对称的统一”，“正则与奇异的对立统一”等。
6	同上	2	初等解析函数，复积分定义与性质	
7	同上	2	柯西积分定理 及其推广	**增强辩证思维能力：**从同一不定积分选取不同求解方法将可能产生不同积分结果，到通过适当选取积分常数来实现异型积分结果之间的互相转换，加深学生对“条条大路通罗马”“殊途同归”“个性和共性”的哲学辩证思考。
8	同上	2	柯西积分公式 解析函数与调和函数	
9	同上	2	复级数，幂级数	**欣赏数学智慧之美：**在级数学习中可引入“芝诺悖论”解决

10	同上	2	收敛半径	的典故；用复级数的敛散性和零点理论，可引入千禧年七大数学猜想之一的“黎曼猜想问题”。理解理性数学文化的文化价值,体会数学真理的严谨性、精确性，能够欣赏数学智慧之美,引导学生喜欢数学,热爱数学。
11	同上	2	泰勒级数	
12	同上	2	洛朗级数	
13	同上	2	孤立奇点 留数、留数定理	**化繁为简：**通过定积分的几何意义的讲解，体会解决问题的思路：即将一个复杂的问题分解为若干简单函数的线性组合，进而得到问题的答案。启发学生面对困难，可以将问题从不同层面、角度进行分解为简单问题，然后再并对其进行线性组合，从而化繁为简，逐步解决原来较困难的问题。
14	同上	2	定积分计算（一）	
15	同上	2	定积分计算（二）	
16	同上	2	总复习	

注明:

1.所有课程的讨论视授课教师时间与学生的实际情况斟酌实施

2.每个课程的作业布置以授课教师视实际时间情况斟酌实施

Shantou University

Module Description for Undergraduate Courses

COURSE TITLE：	Scientific research training A
COURSE CODE：	PHY5022A
CREDIT VALUE：	1
CONTACT HOURS：	16
PRE-REQUISITE	none
DEPARTMENT/UNIT：	Department of Physics
VERSION：	20240731-PHY5022A
COURSE COORDINATOR：	Xie Xiangsheng (Signature and Seal)
APPROVER：	Chi Lingfei (Signature and Seal)
APPROVE DATE：	20240731

Shantou University Faculty of Science

July 2024

1. Course Description

(1) Nature of the Course

Scientific Research Training A is a compulsory course for students majoring in Physics.

This course provides an accessible introduction to frontier scientific research based on high-school-level physics, covering both theoretical and experimental developments in modern physics and optoelectronic information science (optoelectronics).

Students will gain a clear understanding of the major frontier areas in the two physics-related undergraduate programs, as well as the principal research directions (research directions) of faculty members.

The course aims to inspire academic interest and help students identify directions they may wish to pursue.

(2) Course Content

The course consists of eight research-oriented lectures representing three major research directions in the Department of Physics:

1. Computational Photonics (computational photonics)
2. Optoelectronic Materials and Devices (optoelectronic materials and devices)
3. Imaging and Display Photonics (imaging and display photonics)

Topics include:

- Laser–matter interaction (laser–matter interaction)
- High-speed / high-precision liquid crystal optical modulation (liquid crystal optical modulation)
- Microstructured optical fibers and functional microstructured fibers (microstructured optical fibers)
- Wide-bandgap semiconductor Ga_2O_3 and its optoelectronic applications (wide-bandgap semiconductor)
- Advanced optical imaging from smartphones to the metaverse
- Experimental techniques in ultrafast optics (ultrafast optics)
- Applications of two-dimensional materials (2D materials)
- Future technological revolution: quantum information technology (quantum information technology)

(3) Course Objectives

This course helps students understand the major research activities, laboratory backgrounds, and scientific challenges in each research direction.

It prepares students to join research groups or initiate undergraduate innovation projects.

By connecting frontier scientific developments with practical applications, the course broadens students' scientific vision, develops methodological thinking, and deepens their understanding of cutting-edge science.

After completing this course, students should be able to:

1. Understand the methodological foundations of scientific research and engineering practice.
2. Comprehend the major research directions at the frontier of optoelectronic science.
3. Build meaningful connections between theoretical knowledge and scientific applications.
4. Acquire an initial understanding of academic writing, including research articles and review reports.

This course supports the cultivation of academic-oriented undergraduate physics students by strengthening both disciplinary foundations and frontier research capabilities.

It directly contributes to the following program learning outcomes:

4.2 Ability to design and optimize basic optoelectronic systems, optical information processing systems, and optoelectronic devices

8.1 Ability to communicate scientific and engineering topics effectively with peers and the public

8.2 Possession of international perspective, understanding global industry trends, and communicating in cross-cultural contexts

2. Intended Learning Outcomes

The expected learning outcomes of this course are summarized as follows:

Knowledge Unit	Key Knowledge Points	Initial Level	Required Level	Expected Learning Outcomes
1. Laser–Matter Interaction Studies	1.1 Principles and Experimental Concepts	L0	L2	Understand the fundamental concepts of ultrafast laser physics and attosecond science.
	1.2 Latest research progress in ultrafast laser physics and attosecond science	L0	L2	Understand current research hotspots in ultrafast laser physics and attosecond science.
	1.3 Selected achievements in computational photonics	L0	L2	Understand the basic concepts and main methods of computational photonics.
	1.4 Extended applications of computational photonics	L0	L2	Understand the extended applications of computational photonics.
2. Introduction to High-Speed/High-Precision Liquid Crystal Optical Modulation Technologies and Their Applications	2.1 Introduce optical modulation technology and its applications	L0	L2	Understand high-speed/high-precision liquid crystal optical modulation techniques.
	2.2 Introduce applications of liquid crystal optics in astronomical observation (astronomical observation)	L0	L2	Understand how liquid crystal optics is used in astronomy.
	2.3 Introduce applications of liquid crystal optics in biological imaging (biological imaging)	L0	L2	Understand liquid crystal optics applied to biological imaging.
	2.4 Introduce liquid crystal optics in laser processing and magnetic detection (laser processing; magnetic detection)	L0	L2	Understand the applications of liquid crystal optics in laser processing and magnetic detection.
3. Microstructured Light-Guiding Fibers and Functional Microstructured Fibers	3.1 Introduce types and fabrication processes of specialty microstructured fibers	L0	L2	Understand the categories and fabrication processes of specialty microstructured optical fibers.
	3.2 Introduce light-guiding properties and applications of microstructured fibers	L0	L2	Understand guiding properties and applications of microstructured fibers.
	3.3 Introduce applications in sensors and wearable intelligent textiles	L0	L2	Understand examples of microstructured fibers in sensing and wearable smart textiles.

4. Wide-Bandgap Semiconductor Gallium Oxide (Ga_2O_3) and Its Optoelectronic Device Applications	4.1 Introduce preparation of Ga_2O_3 wide-bandgap semiconductor materials	L0	L2	Understand preparation methods of Ga_2O_3 wide-bandgap semiconductor materials.
	4.2 Introduce high-power devices based on Ga_2O_3 (high-power devices)	L0	L2	Understand categories of Ga_2O_3-based high-power devices
	4.3 Introduce solar-blind detectors and transparent conductive applications	L0	L2	Understand Ga_2O_3 solar-blind detectors and transparent conductive applications.
	4.4 Introduce transparent conductive applications (transparent conductive materials)	L0	L2	Understand Ga_2O_3 transparent conductive applications.
5. Advanced Optical Imaging: From Smartphones to the Metaverse	5.1 Development history of mobile phones	L0	L2	Understand the optoelectronic background behind mobile phone evolution.
	5.2 Face ID and structured light technology	L0	L2	Understand the principles behind Face ID and structured light.
	5.3 Concepts and approaches in near-eye optics	L0	L2	Understand key concepts and frontier methods in near-eye optics.
6. Introduction to Experimental Techniques in Ultrafast Optics	6.1 Ultrafast laser and electron momentum spectrometer	L0	L2	Understand the basics of ultrafast lasers and electron momentum spectrometers.
	6.2 Introduction to chirped pulse amplification	L0	L2	Understand the principles and methods of chirped pulse amplification.
	6.3 Pump–probe technique, ARPES, and COLTRIMS	L0	L2	Understand pump–probe methods, angle-resolved photoemission spectroscopy (ARPES), and cold-target recoil-ion momentum spectroscopy (COLTRIMS).
7. Applications of Two-Dimensional Materials	7.1 Basic introduction to two-dimensional materials	L0	L2	Understand basic concepts of 2D materials.
	7.2 Applications of two-dimensional materials	L0	L2	Understand the applications of 2D materials.
	7.3 Research progress of two-dimensional materials	L0	L2	Understand the research progress in 2D materials.
8. The Coming Technological Revolution — Quantum Information Technology	8.1 Evolution of quantum entanglement and quantum information technology	L0	L2	Understand the historical development of quantum entanglement and quantum information technology.
	8.2 Basic principles of quantum communication and quantum imaging	L0	L2	Understand the concepts of quantum communication and quantum imaging.
	8.3 Revolutionary characteristics of quantum information technology	L0	L2	Understand the revolutionary nature of quantum information technologies.
	8.4 Future prospects of the quantum information revolution	L0	L2	Understand the future prospects of the quantum information revolution.

3. Pre-requisit

This course is designed as a general-science lecture series and has no pre-requisite requirements.

4. Textbooks and Other Learning Resources

Required Textbooks

None.

Recommended Textbooks

None.

Course Website:

http://my.stu.edu.cn/

5. Teaching and Learning Activities

Teaching Segment	Lectures (Theory)	Experiments	Lab Reports	Seminars	Online Learning	Total
Hours (In-class)	16	0	0	0	0	16
Hours (Out-of-class)	0	0	0	8	8	16

Basis for Out-of-Class Workload calculation:

As this course is an introductory lecture series on frontier scientific topics for lower-year students, the content is broad and conceptually demanding, with an emphasis on inspiration and exploration. Each week includes 2 hours of in-class instruction (for a total of 8 weeks). Students are expected to spend 1 hour per week engaging in online self-study of relevant materials, and 1 hour per week conducting necessary discussions to complete the course paper.

6. Assessment Scheme

Assessment Component	Description of Assessment Content and Methods	Weight
Final Assignment	Students may select one lecture topic of personal interest and write an article based on it. The submission may take the form of a review or a reflective essay. The work is graded by the respective lecturer.	100%

7. Course Schedule

Week	Hour	Topic	Abstract	Lecturer
9	2	Laser–Matter Interaction	This lecture introduces the fundamental background of ultrafast laser physics and attosecond science, as well as recent research progress both domestically and internationally. It also covers selected advances in computational photonics and their extended applications.	Prof. Pengcheng Li
10	2	High-Speed / High-Precision Liquid-Crystal Optical	This lecture presents high-speed and high-precision liquid-crystal optical modulation technologies and their applications. It outlines how liquid-crystal optics have expanded from astronomical observation to biological imaging,	Assoc. Prof. Lishuang Yao

		Modulation Technologies	laser processing, magnetic detection, and related areas.	
11	2	Microstructured Light-Guiding Fibers and Functional Microstructured Fibers	This lecture provides a systematic introduction to various types of special microstructured optical fibers, their fabrication processes, guiding characteristics, and applications. Using one-dimensional photonic-crystal Bragg fibers as examples, the lecture demonstrates devices such as biochemical sensors, displacement/curvature sensors, fiber spectrometers, and wearable intelligent textiles. It further introduces microstructured piezoelectric fibers, capacitive fibers, and battery fibers, explaining the material properties, mechanical performance, and electrical characteristics of each.	Assoc. Prof. Hang Qu
12	2	Wide-Bandgap Semiconductor Ga_2O_3 and Its Optoelectronic Applications	Ga_2O_3, as a new wide-bandgap semiconductor, has attracted significant attention in recent years. Compared with third-generation semiconductors such as SiC and GaN, it possesses a larger bandgap (~4.8 eV), higher breakdown field, and greater Baliga's figure of merit. It is a promising candidate for high-voltage, high-power, high-frequency, and low-loss power devices, as well as deep-UV optoelectronic devices. This lecture covers Ga_2O_3 growth, doping, and applications in high-power devices, solar-blind detectors, and transparent conductive materials.	Assoc. Prof. Chaoping Liu
13	2	Advanced Optical Imaging from Smartphones to the Metaverse	Smartphones have become indispensable electronic devices, while the metaverse represents the next integrated information-technology frontier. This lecture explores the core optoelectronic technologies behind these industries and examines current research hotspots.	Assoc. Prof. Xiangsheng Xie
14	2	Experimental Techniques in Ultrafast Optics	This lecture introduces how ultrafast lasers combined with electron momentum spectrometers enable comprehensive observation of electronic dynamics in matter. It covers chirped-pulse amplification, pump–probe techniques, angle-resolved photoemission spectroscopy, and cold-target recoil-ion momentum spectroscopy.	Dr. Fei Li
15	2	Applications of Two-Dimensional Materials	Two-dimensional materials exhibit properties distinct from traditional three-dimensional systems due to their reduced dimensionality. Since the first isolation of monolayer graphene in 2004, extensive research has uncovered wide-ranging applications. This lecture provides an overview of research progress in various application domains.	Dr. Dian Li
16	2	Future Technological Revolutions: Quantum Information Technology	Quantum information technology has achieved breakthroughs in quantum computing and quantum communication and plays a pivotal role in future national science and technology strategies. This lecture reviews the development of quantum entanglement and quantum information, introduces basic principles of quantum communication and quantum imaging, and analyzes the revolutionary features of quantum information across scientific, technological, and philosophical dimensions.	Dr. Haoxu Guo

汕头大学本科教学

课程教学大纲

课程名（COURSE TITLE）：	科研综合训练 A
课程代码（COURSE CODE）：	PHY5022A
学分（CREDIT VALUE）：	1
课内课时（CONTACT HOURS）：	16
先修课要求（PRE-REQUISITE）	无
开课单位（DEPARTMENT/UNIT）：	理学院
版本（VERSION）：	20240731-PHY5022A
课程负责人（COURSE COORDINATOR）：	谢向生 (签章)
审核人（APPROVER）：	池凌飞(签章)
审核日期（APPROVE DATE）：	20240731

汕头大学理学院

2024 年 7 月

1、课程简介（Course Description）

（1）课程性质：科研综合训练 A（Scientific research training A）是物理学专业的专业必修课。本课程主要以前沿科学的科普性介绍为主，在高中物理知识的基础上，介绍物理学和光电信息前沿领域的理论和实验研究及最新的应用，让学生清楚物理学系两个专业的主要前沿领域以及本系老师的主要科研方向，激发学生学习兴趣，促成学生树立自己感兴趣的方向。

（2）课程内容：本课程包括物理学系计算光子学、光电材料与器件和成像与显示光子学三个研究方向的八个报告。具体内容包括：激光与物质相互作用研究、高速/高精液晶光调控技术及应用简介、微结构导光纤维与微结构功能性纤维、宽禁带半导体氧化镓及其光电器件应用、手机到元宇宙中的先进光学成像、超快光学中的实验技术简介、二维材料的应用、未来科技革命——量子信息技术等。

（3）课程目标：让学生了解物理学系各个研究方向和实验室的主要研究工作及其背景，为同学们进入科研团队或开展大学生创新创业项目做准备。结合前沿科学进展，开拓学生科学视野，了解理论用于实践的方法和创新思路，提高学生对前沿科学的了解。为从事光电信息科学相关领域的科学研究和应用研究进行启蒙。学完本课程后学生应能够：

1）正确认识我国科技实力，树立“四个自信”，自觉地将个人追求与国　　家需要相结合；

2）掌握科学研究和工程技术中的科学方法论

3）理解光电学科科研前沿的主要研究方向

4）建立理论课程与科学应用的联系

5）初步掌握学术论文或综述报告的写作方法

本课程为物理学专业学术型本科人才培养提供专业理论与前沿应用研究能力培养，高度支撑该专业本科人才培养方案中的毕业要求指标点“1.坚定的理想信念、2.正确价值观和社会责任感、4.2 具备对基础光电系统、光信息处理系统、光电子器件的设计与优化能力、8.1 具备就专业的科学与工程问题与业界同行、社会公众进行有效沟通和交流的能力、8.2 具备一定的国际视野，了解国际业界发展动态，能在跨文化背景下进行沟通和交流”。

2、 预期学习内容（Intended Learning Outcomes）

本课程的预期学习内容如下表：

知识单元	知识点	初始程度	要求程度	预期学习结果
1. 激光与物质相互作用研究	1.1 超快激光物理和阿秒科学的基本背景知识	L0	L2	理解超快激光物理和阿秒科学基本概念
	1.2 超快激光物理和阿秒科学的最新研究进展	L0	L2	理解全超快激光物理和阿秒科学研究热点
	1.3 计算光子学方面的一些研究成果	L0	L2	理解计算光子学方面的基本概念和主要方法
	1.4 计算光子学方面相关拓展应用	L0	L2	理解计算光子学方面拓展应用
2. 高速/高精液	2.1 介绍高速/高精液晶光调控技术及应用研究	L0	L2	理解高速/高精液晶光调控技术

晶光调控技术及应用简介	2.2 介绍液晶光学在天文观测领域的应用	L0	L2	理解液晶光学在天文观测领域的应用
	2.3 介绍液晶光学拓展到生物成像的应用	L0	L2	理解液晶光学拓展到生物成像的应用
	2.4 介绍液晶光学在激光加工、磁探测等应用情况。	L0	L2	理解液晶光学在激光加工、磁探测等应用情况
3. 微结构导光纤维与微结构功能性纤维	3.1 介绍特种微结构光纤的种类、制作工艺流程	L0	L2	理解特种微结构光纤的种类、制作工艺流程
	3.2 介绍特种微结构光纤导光特性及微结构光纤的应用	L0	L2	理解特种微结构光纤导光特性及微结构光纤的应用
	3.3 介绍微结构光纤在各种传感和可穿戴型智能织物等多种器件的实例	L0	L2	理解微结构光纤在各种传感和可穿戴型智能织物等多种器件的实例
4. 宽禁带半导体氧化镓及其光电器件应用	4.1 介绍 Ga2O3 新型宽禁带半导体材料制备	L0	L2	理解 Ga_2O_3 新型宽禁带半导体材料制备方法
	4.2 介绍 Ga2O3 材料的高功率器件	L0	L2	理解 Ga_2O_3 材料的高功率器件分类
	4.3 介绍 Ga2O3 材料日盲探测器及透明导电方面的应用	L0	L2	理解 Ga_2O_3 材料日盲探测器及透明导电方面的应用
	4.4 介绍 Ga2O3 材料透明导电方面的应用	L0	L2	理解 Ga_2O_3 材料透明导电方面的应用
5. 手机到元宇宙中的先进光学成像	5.1 手机的发展历史	L0	L2	理解手机发展的光电技术背景
	5.2 Face ID 及其背后的结构光技术	L0	L2	理解 Face ID 及其背后的结构光技术
	5.3 近眼光学主要概念和潜在方法	L0	L2	理解近眼光学主要概念和前沿方法
6. 超快光学中的实验技术简介	6.1 超快激光与电子动量谱仪的基本技术	L0	L2	理解超快激光与电子动量谱仪的基本技术
	6.2 啁啾脉冲放大技术简介	L0	L2	理解啁啾脉冲放大技术的原理和方法
	6.3 泵浦-探测技术以及角分辨光电子能谱和冷靶反冲离子动量谱仪的基本原理	L0	L2	理解泵浦-探测技术以及角分辨光电子能谱和冷靶反冲离子动量谱仪的基本原理
7. 二维材料的应用	7.1 二维材料的简单介绍	L0	L2	理解二维材料的基本概念
	7.2 二维材料的应用介绍	L0	L2	理解二维材料的应用介绍
	7.3 二维材料的研究进展	L0	L2	理解二维材料的研究进展
8. 未来科技革命——量子信息技术	8.1 梳理了量子纠缠与量子信息技术的演变历程	L0	L2	理解量子纠缠与量子信息技术的演变历程
	8.2 简单介绍量子通信原理与量子成像	L0	L2	理解量子通信原理与量子成像的概念
	8.3 分析量子信息技术革命性特征	L0	L2	理解量子信息技术革命性特征
	8.4 总结了量子信息革命的前景	L0	L2	理解量子信息革命的前景

3、先修要求（Pre-requisite）

本课程为科普性讲座，无先修要求。

4、教材及其他教学资源（Textbooks and Other Learning Resources）

指定教材：

无。

推荐教材：

无。

课程网站：

http://my.stu.edu.cn/

5、主要教学环节（Teaching and Learning Activities）

教学环节	理论课（小时）	习题课（小时）	实验（小时）	研讨（小时）	社会实践（小时）	项目（小时）	在线学习（小时）	期中测试（小时）	合计
课内	16	0	0	0	0	0	0	0	16
课外	0	0	0	8	0	0	8	0	16

课外课时计算依据:

本课程为低年级前沿科学讲座，内容较多难度大，主要是启发性，预计每周课内学时 2 小时（共 8 周），需要学生课外线上学习相关知识 1 小时，为完成课程论文进行必要的研讨 1 小时。

6、课程考核（Assessment Scheme）

考核项目	考核内容和考试方法简介	权重
期末考察	学生可以选择感兴趣的讲座内容写一篇文章，内容可以是综述也可以是感想，由讲座老师评分。	100%

7、学习进度 （Course Schedule）

周次	教学时数	题目	摘要	讲座人
9	2	激光与物质相互作用研究	介绍超快激光物理和阿秒科学的基本背景知识和当前国内外的最新研究进展，介绍计算光子学方面的一些研究成果，及其相关拓展应用。 思政：我国在超短超强激光领域的发展，主张我国社会主义制度，科技报国使命担当。	李鹏程教授
10	2	高速/高精液晶光调控技术及应用简介	介绍高速/高精液晶光调控技术及应用研究，介绍液晶光学应用领域从天文观测领域逐步拓展到生物成像、激光加工、磁探测等应用情况。 思政：光场调控和天文观测需要精益求精，要有工匠精神	姚丽双 副教授

11	2	微结构导光纤维与微结构功能性纤维	系统性地介绍特种微结构光纤的种类、制作工艺流程、导光特性及微结构光纤的应用，并以一维光子晶体布拉格光纤为例展示利用微结构光纤开发生物化学传感器、位移曲率传感器、光纤光谱仪、可穿戴型智能织物等多种器件的实例。此外，主讲人还将介绍另一种多芯微结构光纤的制备以及基于此多芯光纤的马赫-曾德型纳米级位移/曲率传感器的开发。 进一步介绍几种具有微结构的压电纤维、电容纤维和电池纤维的研发制备过程，并对每种功能性纤维的材料特性、机械性能、电学性能分别进行阐述说明。 思政：光纤的发明和运用——从最基础模型，到广泛的应用，科学方法论	曲航副教授
12	2	宽禁带半导体氧化镓及其光电器件应用	Ga_2O_3作为新型宽禁带半导体材料，近年来受到了人们的广泛关注。相比于第三代半导体 SiC 和 GaN，具有更大的禁带宽度（~4.8 eV）、更高的击穿电场、更大的 Baliga 品质因子等优点，有望成为高压、大功率、高频、低损耗功率器件和深紫外光电子器件的优选材料。本讲座主要介绍 Ga_2O_3 材料的制备、掺杂及其在高功率器件、日盲探测器及透明导电方面的应用。 思政：对我国半导体材料领域发展的介绍，让学生感受我国科技的发展和优势，增强“四个自信”和民族自豪感，激发学生为我国科技发展贡献青春的动力。	刘超平副教授
13	2	手机到元宇宙中的先进光学成像	手机逐渐成为人们生活必不可少的电子产品，元宇宙则是下一代的信息技术的集成，Facebook 更是为此改名为 meta(元宇宙)。这两种重要产业依赖的光电核心技术是什么?当前科研热点在哪? 思政：慎思笃行，从身边的需求寻找科技灵感，教导学生要知行合一，实事求是	谢向生副教授
14	2	超快光学中的实验技术简介	超快激光与电子动量谱仪的有机结合使得能够更全面地观测物质中的电子，从而加深对光与物质相互作用的认知。本报告主要介绍上述实验设备中涉及的啁啾脉冲放大技术、泵浦-探测技术以及角分辨光电子能谱和冷靶反冲离子动量谱仪的基本原理。 思政：介绍我国大型激光器的成就——家国情怀、爱国主义、大国工匠，科技报国	李飞博士
15	2	二维材料的应用	二维材料由于其空间中维度被限制在一个平面上而产生了许多与传统三维材料不同的物理化学性质，自从 2004 年单原子层厚度的石墨烯被制备出来开始，科学家们对二维材料进行了深入的研究，并在多个领域得到了广泛的应用。本讲内容将对二维材料在多个领域的研究做一个简单的介绍，使学生对二维材料的研究进展有所了解。 思政元素：培养具有爱国主义情怀、民族自豪感、强烈责任感和使命感、精益求精精神的卓越工程师	李典博士
16	2	未来科技革命一量子信息技术、	作为全球瞩目的新兴战略技术焦点，量子信息技术已经在量子计算与量子通信等领域取得了突破性进展，对我国未来的科技发展战略也有着直接影响。本讲座梳理了量子纠缠与量子信息技术的演变历程对量子通信原理与量子成像进行简单介绍，分析量子信息技术在科学技术、哲学等多个层面的革命性特征，总结了量子信息革命对未来科技战略及科学发展模式的意义与启示。 思政：引用陈创天院士的话 “我这一生始终能保持乐观向上的态度，养成遇困难不低头，遇权威不屈服的良好性格，即使是在最困难时期，我也坚信在共产党的领导下，中华民族必有立于世界民族之林的能力”	郭昊旭博士

Shantou University

Module Description for Undergraduate Courses

COURSE TITLE：	Scientific research training B
COURSE CODE：	PHY5023A
CREDIT VALUE：	1
CONTACT HOURS：	32
PRE-REQUISITE	Scientific research training A
DEPARTMENT/UNIT：	Department of Physics
VERSION：	20240731-PHY5023A
COURSE COORDINATOR：	李飞 (Signature and Seal)
APPROVER：	Chi Lingfei (Signature and Seal)
APPROVE DATE：	20240731

Shantou University Faculty of Science

July 2024

1. Course Description

(1) Nature of the Course

Scientific Research Training B is a compulsory course for Physics majors. This course series is a guidance-based module designed to lead students through the full process of project selection, project execution, and outcome summarization. It aims to provide students with initial training in scientific research capabilities. Meanwhile, through participation in the Mathematical Contest in Modeling (MCM), the course encourages students to develop creativity and the ability to face challenges.

(2) Course Content

Scientific Research Training B is the second course in this series. Under the supervision of the instructor, students form groups independently and select an interesting topic from the year's Mathematical Contest in Modeling as their competition question. Under the teacher's guidance, students undergo pre-competition training, become familiar with commonly used mathematical analysis software, and practice literature review, data analysis, and academic report writing using problems from previous competitions.

During the contest period, students are required to work in groups according to the regulations of the Mathematical Contest in Modeling, select an appropriate problem, conduct analysis, and independently complete model construction and report writing. Throughout the training and competition, students gain first-hand experience in analyzing, solving, and formulating problems. This process effectively strengthens their integrative thinking, mastery and application of scientific methodology, perseverance, and execution ability.

According to the teaching plan, this course is guidance-based. The training lasts for one semester, and the course is completed through participation in the competition.

(3) Course Objectives

With the ongoing wave of scientific and technological revolutions and industrial transformations, global competition in science and technology is increasingly shifting toward fundamental frontiers. Solving key technological problems from the origin and foundational level has become an urgent requirement. In this context, the Physics program offers the Scientific Research Training series to spark students' interest in frontier research and cultivate their scientific research capabilities. *Scientific Research Training B* is the second-stage course in this series.

This guidance-based course aims to help students develop an initial understanding of how to select research questions and choose appropriate mathematical tools to solve them through participation in mathematical modeling competitions.

Through this course, students are expected to acquire the following abilities:

1. A preliminary understanding of general scientific research methods and frameworks;
2. Familiarity with literature review techniques and common approaches to topic investigation;
3. Initial mastery of problem analysis, problem solving, and integrative summarization;
4. Mastery of common methods for data processing and analysis;
5. Enhanced teamwork ability and strengthened team awareness.

This course supports the development of theoretical knowledge and research abilities for students in the Physics major. It strongly aligns with and supports the following program learning outcome indicators:

3.1 Mastery of fundamental theories and professional knowledge in physics,

4.1 Mastery of physical technologies, resources, information tools, and modern engineering tools,

5.1 Ability to conduct research based on scientific principles and methods,

6.1 Ability to identify, express, and analyze scientific problems in physics-related fields through literature research and to draw effective conclusions."

2. Intended Learning Outcomes

The expected learning outcomes of this course are summarized as follows:

Knowledge Unit	Key Knowledge Points	Initial Level	Required Level	Expected Learning Outcomes
Mathematical Modeling Training	Notes on mathematical modeling and academic writing	L0	L3	Explain the standards of academic writing in mathematics. Use software such as Word or LaTeX for writing academic papers.
	Innovative thinking in mathematical modeling	L0	L3	Connect real-world problems with theoretical knowledge
	Common Mathematical Software	L0	L3	Apply MATLAB for programming
	Numerical Fitting Methods	L0	L3	Use MATLAB to solve interpolation and fitting problems
	Optimization Algorithms	L0	L3	Apply optimization algorithms such as genetic algorithms and particle swarm optimization to obtain optimal solutions
	Data Processing and Analysis	L0	L3	Use software such as SPSS and Origin for data processing and analysis
	Mathematical Modeling Practical Training	L0	L5	Analyze problems, construct models, and design solutions

3. Pre-requisit

None.

4. Textbooks and Other Learning Resources

Required Textbooks

None.

Recommended Textbooks

None.

Course Website:

http://my.stu.edu.cn/

5. Teaching and Learning Activities

Teaching Segment	Lectures (Theory)	Experiments	Lab Reports	Seminars	Online Learning	Total
Hours (In-class)	10	10	10	10		40
Hours (Out-of-class)	16	48	32			96

Basis for Out-of-Class Workload calculation:

In addition to the instructor's in-class training, students are required to complete 16 hours of self-study. Beyond the 10 hours of in-class experimental training, students must complete 48 hours of out-of-class experimental validation for the MCM/ICM competition, as well as 32 hours for writing the experimental report, forming the final English competition paper.

6. Assessment Scheme

Assessment Component	"Scientific Research Training B" is a compulsory course assessed on a percentage scale. Considering that the course is conducted in competition format, the grading scheme is as follows: Course Grade = Training Performance × 50% + MCM/ICM Performance × 50% 1. Assessment Criteria for Training Projects: Each project consists of no more than three students. During the training period, under faculty supervision, students must complete topic selection, literature review, modeling, computation, analysis, and summary, and prepare a written report. The training report will be graded collectively by the modeling competition instructors. The instructors will award differentiated grades based on the student's performance during training and the submitted summary report. 2. Assessment Criteria for the MCM/ICM Competition: Differentiated scores are awarded based on the nature of the competition outcome. If the competition result is an Outstanding (O), Finalist (F), Meritorious (M), or Honorable Mention (H), the score is weighted at 100%. If the result is a Successful Participant (S) or Unsuccessful (U), a reasonable score will be given, but the weight must not exceed 90%.

7. Course Schedule

The learning process of this course includes the following components:

(1) After the end of each academic year's autumn semester, a one-week training session (2 hours per session) will be conducted by the instructor. The schedule is as follows：

1. Notes on mathematical modeling and academic writing standards
2. Innovative thinking in mathematical modeling
3. Common mathematical software
4. Numerical fitting methods
5. Optimization algorithms
6. Data processing and analysis
7. Data processing and analysis (continued)
8. Mathematical modeling practical training. After the training, students independently select past competition problems for simulation practice and write a paper, which will be reviewed by the instructor.

(2) Participation in the Competition

The MCM/ICM competition is normally held in February each year. After the problems are released, students independently choose a problem, complete the work, write the final paper, and submit it.

(3) After the competition, students must submit a course summary report to the instructor during the spring semester.

汕头大学本科教学

课程教学大纲

课程名（COURSE TITLE）：	科研综合训练 B
课程代码（COURSE CODE）：	PHY5023A
学分（CREDIT VALUE）：	1
课内课时（CONTACT OURS）：	32
先修课要求（PRE-REQUISIT）	科研综合训练 A
开课单位（DEPARTMENT/UNIT）：	物理系
版本（VERSION）：	20240731-PHY5023A
课程负责人（COURSE COORDINATOR）：	李飞 (签章)
审核人（APPROVER）：	池凌飞(签章)
审核日期（APPROVE DATE）：	20240731

汕头大学理学院

2024 年 7 月

1. 课程简介（Course Description）

（1）课程性质

科研综合训练 B（Scientific research training B）是物理学专业的必修课，该系列课程属于指导型课程，旨在让学生完成从项目选题、开展工作、总结成果的完整过程，让学生初步受到科研能力的训练，同时通过参加美国数学建模比赛，培养学生的创新意识和迎难而上的品质。

（2）课程内容

科研综合训练 B 为本系列的第二门课程，学生在指导教师的指导下，学生自由组建小组，在当年的美国大学生数学建模竞赛中选择感兴趣的内容作为参赛题目。学生需在教师的指导下，进行竞赛前的培训工作，熟悉各类常用数学分析软件，并以以往竞赛题目为对象，学习文献调研、数据分析和撰写报告的能力。在比赛期间，需按美国大学生数学建模竞赛的要求，以小组为单位，选择合适的参赛题目，在对选定的题目进行分析的基础上，独立完成建模、报告撰写等工作。学生在训练和参赛过程中，能初步体验如何分析问题、解决问题和提出问题，对学生的整合思维能力、科学方法论的掌握和运用、意志力、行动力都是很好的锻炼。根据教学计划，本课程为指导型课程，培训时间持续一学期，以参加比赛形式完成课程。

（3）课程目标

随着新一轮科技革命和产业变革的深入，国际科技竞争逐步向基础前沿移动。从源头和底层解决关键技术问题，是应对国际科技竞争的迫切需要。在此情况下，物理学专业为激发学生对前沿研究的兴趣，培养学生的科研能力，设立了“科研综合训练”系列课程，“科研综合训练 B”是此系列的第二阶段课程。“科研综合训练 B”属于指导型课程，旨在让学生通过参加数学建模竞赛，初步了解如何选定问题以及如何选择合适的数学工具解决问题。

通过课程训练，学生应该具备以下能力，

1） 初步掌握科学研究的一般方法和模式；
2） 熟悉文献资料的查阅方法，了解课题调研的常用方法；
3） 初步掌握分析问题、解决问题和整合总结能力；
4） 掌握数据处理和分析的常用方法；
5） 提高团队协作能力，增强团队意识。

本课程为支持物理学专业的同学提供专业理论与研究能力培养，高度支撑上述专业毕业要求指标点毕业要求指标中的“1. 坚定的理想信念，2. 正确价值观和社会责任感，、3.1 掌握物理学的基础理论和专业知识、4.1 掌握物理学及相关的技术、资源、信息技术工具和现代工程工具、5.1 具备基于科学原理和方法进行研究的能力、6.1 具备识别、表达、通过文献研究分析物理相关领域的科学问题，并获得有效结论”。

2. 预期学习结果（Intended Learning Outcomes）

本课程的预期学习结果如下表：

知识单元	知识点	初始程度	要求程度	预期学习结果
数学建模	数学建模注意事项与论文写作	L0	L3	说明数学专业论文写作规范

培训	规范			使用 Word 或 LaTeX 等软件进行论文写作
	数学建模的创新思维	L0	L3	关联实际问题和理论知识
	常用数学软件	L0	L3	应用 MATLAB 进行程序设计
	数值拟合方法	L0	L3	应用 MATLAB 实现插值拟合问题的求解
	优化算法	L0	L3	应用遗传算法、粒子群算法等优化算法进行最优解问题求解
	数据处理与分析	L0	L3	使用 SPSS、Origin 等软件进行数据处理和分析
	数学建模实训	L0	L5	分析题目、建模和设计

3. 先修要求（Pre-requisite）

无

4. 教材及其他教学资源（Textbooks and Other Learning Resources）

指定教材：

无

推荐参考资料

无

课程网站：

http://my.stu.edu.cn

5. 主要教学环节（Teaching and Learning Activities）

教学环节	理论课（小时）	实验（小时）	实验报告（小时）	研讨（小时）	在线学习（小时）	合计
课内	10	10	10	10	0	40
课外	16	48	32	0	0	96

课外课时计算依据：

除了老师课内培训外，还需要课外学习16个小时，课内10个小时的实验外，为了参加美赛需要课外48小时的实验验证，并且需要32小时实验报告撰写，形成英文比赛论文。

6. 课程考核（Assessment Scheme）

考核要求 Assessment Scheme

考核要求	“科研综合训练 B”课程为必修课，百分制评分。考虑到课程为竞赛形式，评分标准为： 课程成绩 = 培训成绩×50% + 美国数学建模竞赛成绩×50% 1. 科研训练项目评分标准： 每个项目不超过三人，在培训期间，由指导教师指导，完成选题、调研、建模、计算、分析、总结等环节，撰写报告。 培训报告由建模竞赛指导老师集体打分确定成绩。竞赛指导教师需根据学生培训期间表现、培训总结报告，给予差异化评分。 6. 美国数学建模竞赛评分标准： 根据成果性质，给予差异化评分。 如果比赛成绩为 O 奖、F 奖、M 奖、H 奖等，按 100%的权重给分。 如果比赛成绩为 S 奖、U 奖等，按情况给予适当的评分，但权重不得超过 90%。

7. 学习进度 （Course Schedule）

本课程修读过程包含以下部分：

（1）每学年秋季学期结束后，由指导教师对修读本课程的学生进行为期一周的培训，每次培训时间为2小时，具体安排如下：

①数学建模注意事项与论文写作规范；

②数学建模的创新思维；

③常用数学软件；

④数值拟合方法；

⑤优化算法；

⑥数据处理与分析；

⑦数据处理与分析；

⑧数学建模实训。培训结束后由学生自行选择往年竞赛题目进行模拟，并撰写论文，由指导教师进行评阅。

（2）参赛。美国大学生数学建模竞赛时间一般为每年2月，在赛题公布之后，由学生自行选择题目完成，撰写竞赛论文并提交。

（3）在竞赛结束后，学生需要在春季学期向指导教师提供一份课程总结报告。

Shantou University

Module Description for Undergraduate Courses

COURSE TITLE：	Comprehensive scientific research training level C
COURSE CODE：	PHY5024A
CREDIT VALUE：	1
CONTACT HOURS：	40
PRE-REQUISITE	Scientific research training B
DEPARTMENT/UNIT：	Department of Physics
VERSION：	20240731-PHY5024A
COURSE COORDINATOR：	Xie Xiangsheng (Signature and Seal)
APPROVER：	Chi Lingfei (Signature and Seal)
APPROVE DATE：	20240731

Shantou University Faculty of Science

July 2024

1. Course Description

(1) Nature of the Course

Comprehensive scientific research training level C is a general elective course for Physics majors. "Scientific Research Training C" and "Scientific Research Training D" are open exclusively to students selected into the Elite Program. These courses adopt a personalized training model that permits withdrawal during the process but does not allow mid-course entry. As a guidance-based course series, it aims to engage students in active participation in a research group and to experience the full process of scientific research.

(2) Course Content

Comprehensive scientific research training level C is the third course in the series, offered only to students enrolled in the Elite Program. Upon joining a research team, students are required to participate in all relevant research activities, including group seminars and theory- or experiment-related assignments designated by the supervisor. Students will complete a series of tasks such as familiarization with the group's research direction, topic selection, initiation of preliminary work, and preparation of a literature-based review of the chosen research topic.

(3) Course Objectives

The Department of Physics currently hosts three major research directions: Computational Photonics and Fiber Sensing, Optoelectronic Materials and Devices, and Imaging and Display Photonics. Students select a research direction, discuss with the corresponding direction leader, and subsequently join the associated research group. Through this course, students will develop an initial understanding of the basic methodology of scientific research and gain familiarity with the group's major research topics and ongoing projects.

Students participating in research-team activities will experience authentic research workflows similar to those encountered by graduate-level researchers. The course enhances students' abilities in problem analysis, problem solving, and question formulation. It also strengthens integrative thinking, scientific methodology, perseverance, and execution skills—key qualities for future research training. According to the teaching plan, this is a guidance-based course conducted over one semester. By the end of the course, students are expected to demonstrate a solid understanding of the background and forefront developments of their selected research topic, complete a review paper, and prepare for subsequent scientific research work.

Students are expected to acquire the following competencies through the course:

1. Ability to conduct preliminary literature retrieval and organization through background research on the chosen topic;
2. Familiarity with the fundamental principles, methods, and experimental skills related to the research project, thereby cultivating autonomous learning ability;
3. Development of professional literacy for conducting scientific research;
4. Strengthened ability to analyze, solve, and formulate scientific problems;
5. Enhanced teamwork skills and increased team awareness.

This course provides theoretical and research-focused training for students in the Physics major selected into the Elite Program. It strongly supports the corresponding graduation requirement indicators, including:

3.3 Ability to engage in work in related professional fields through continuous learning;

5.3 Demonstration of innovation in research/design/development processes;

7.2 Ability to exercise leadership within a team and facilitate effective collaboration.

2. Intended Learning Outcomes

The expected learning outcomes of this course are summarized as follows:

Knowledge Unit	Key Knowledge Points	Initial Level	Required Level	Expected Learning Outcomes
Participation in Research Group Activities	Group seminars	L1	L3	Understand most of the content presented by postgraduate researchers.
	Mathematical Methods or Techniques	L0	L4	Identify and analyze the skills necessary for different research topics.
	Project Investigation	L0	L3	Understand the background knowledge required for the project and read relevant English literature.
	Literature review writing	L0	L4	Be able to read a large amount of English literature, summarize the major contributions of the reviewed works, categorize and analyze the literature, and produce a comprehensive review paper.

3. Pre-requisit

None.

4. Textbooks and Other Learning Resources

Required Textbooks

None.

Recommended Textbooks

None.

Course Website:

To be designated by the research group.

5. Teaching and Learning Activities

Students will join a research group, attend weekly group meetings and project discussions, with an attendance requirement of over 80%. Students shall conduct preliminary topic-based study and research activities in accordance with the supervisor's arrangements. Participation in group activities must not be fewer than 40 hours in total. A literature review report on the research direction must be completed.

6. Assessment Scheme

Assessment Component	This course, Scientific Research Comprehensive Training C, is a compulsory module and is graded on a percentage scale. Considering the competition-based nature of the course, the grading scheme is as follows: Course Grade = 50% Research Group Activity Performance + 50% Literature Review Report 1. Research Group Activity Performance Students' participation in each group meeting and project discussion will be assessed by the supervisor based on attendance, engagement in topic-based study, and involvement in research activities. The supervisor shall provide differentiated scoring according to students' performance during group activities, the presentations they deliver, and their understanding of the project. 2. Literature Review Report The score will be given by the academic lead of each research direction, based on the completeness and academic relevance (frontier quality) of the review. Differentiated scoring will be implemented.

7. Course Schedule

The schedule is determined by the respective research teams.

汕头大学本科教学

课程教学大纲

课程名（COURSE TITLE）：	科研综合训练 C
课程代码（COURSE CODE）：	PHY5024A
学分（CREDIT VALUE）：	1
课内课时（CONTACT OURS）：	40
先修课要求（PRE-REQUISIT）	科研综合训练 B
开课单位（DEPARTMENT/UNIT）：	物理学系
版本（VERSION）：	20240731-PHY5024A
课程负责人（COURSE COORDINATOR）：	谢向生 (签章)
审核人（APPROVER）：	池凌飞(签章)
审核日期（APPROVE DATE）：	20240731

汕头大学理学院

2024 年 7 月

1. 课程简介（Course Description）

（1）课程性质

科研综合训练 C（Scientific research training C）是物理学专业的公共选修课，“科研综合训练 C”和“科研综合训练 D”仅限入选“拔尖计划”学生选修，采用个性化培养方式，允许中途退出，不允许中途加入。该系列课程属于指导型课程，旨在让学生开始参与到具体的课题组，参与研究的全过程。

（2）课程内容

“科研综合训练 C”为本系列的第三门课程，但仅限于“拔尖计划”的同学。学生加入到科研团队后，需要参加课题组的科研活动，包括课题组小组会、导师安排的理论和实验工作。完成课题组科研方向的学习了解、科研选题、初步开展工作和撰写研究课题综述等过程。

（3）课程目标

物理系目前由“计算光子学与光纤传感”、“光电材料与器件”和“成像与显示光子学”三个研究方向，学生选择研究方向，与方向负责人讨论并进入相应科研团队中。通过学习，初步掌握科学研究的基本方法，了解所在科研小组的研究方向和主要研究内容。本课程学生在科研团队的科研活动中，能体验如何研究生科研开展过程，提高分析问题、解决问题和提出问题的能力，对学生的整合思维能力、科学方法论的掌握和运用、意志力、行动力都是很好的锻炼。根据教学计划，本课程为指导型课程，培训时间持续一学期，课程结束时，学生需要对所选科研项目背景和前沿有较深刻的理解，撰写本方向综述论文一篇，并为下一步科学研究工作深入开展做准备。

通过课程训练，学生应该具备以下能力，

1）通过对研究课题的调研，使学生初步掌握文献检索和整理的能力；
2）熟悉课题研究所涉的基本原理、方法和实验技能，培养学生自主学习的能力；
3）培养和提高学生从事科学研究的素养；
4）培养学生分析问题、解决问题、提出问题的能力；
5）提高团队协作能力，增强团队意识。

本课程为支持物理学专业入选“拔尖计划”的同学提供专业理论与研究能力培养，高度支撑上述专业毕业要求指标点毕业要求指标中的“1. 坚定的理想信念，2. 正确价值观和社会责任感，、3.3 具备通过学习获得相近专业领域工作的能力、5.3 在研究/设计/开发过程中体现创新意识、7.2 能在团队中发挥领导力，促进团队合作”。

2. 预期学习结果（Intended Learning Outcomes）

本课程的预期学习结果如下表：

知识单元	知识点	初始程度	要求程度	预期学习结果
参与课题组科研活动	组会	L1	L3	听懂大部分研究生工作的内容
	数学方法或手段	L0	L4	分析各种研究课题所需要掌握的技能

	项目开展调研	L0	L3	理解项目所需知识的背景和英文文献的阅读
	综述论文撰写	L0	L4	能阅读大量英文文献，总结概括所读文献主要研究贡献，分析归类并撰写综述论文

3. 先修要求（Pre-requisite）

无

4. 教材及其他教学资源（Textbooks and Other Learning Resources）

指定教材：

无

推荐参考资料

无

课程网站：

由课题组指定

5. 主要教学环节（Teaching and Learning Activities）

进入课题组，参加每次的小组会，和项目讨论，出勤率需要超过80%，开展初步的课题学习和科研活动，具体根据指导教师安排。要求参与课题组集体活动时间不得低于40学时。撰写研究方向综述报告。

6. 课程考核（Assessment Scheme）

考核要求 Assessment Scheme

考核要求	“科研综合训练 C”课程为必修课，百分制评分。考虑到课程为竞赛形式，评分标准为： 课程成绩 = 导师组科研活动成绩×50% + 综述报告成绩×50% 1. 导师组科研活动成绩标准： 每个同学参加导师组的每次小组会和项目的讨论会，由指导老师根据学生的出勤率、课题学习情况和科研项目参与情况进行打分。 指导教师需根据学生参加小组科研活动期间表现、报告和对项目的理解，给予差异化评分。 2. 综述报告评分标准： 由每个研究方向负责人打分，根据综述内容的完整性和前沿性给予差异化评分。

7. 学习进度 （Course Schedule）

由各个科研团队安排

Shantou University
Module Description for Undergraduate Courses

COURSE TITLE:	Comprehensive Scientific Research Training Level D
COURSE CODE:	PHY5025A
CREDIT VALUE:	1
CONTACT HOURS:	40
PRE-REQUISITE	Comprehensive Scientific Research Training Level C
DEPARTMENT/UNIT:	Department of Physics
VERSION:	20240731-PHY5025A
COURSE COORDINATOR:	Li Fei (Signature and Seal)
APPROVER:	(Signature and Seal)
APPROVE DATE:	20240731

Shantou University Faculty of Science
July 2024

1. Course Description

(1) Nature of the Course

Comprehensive Scientific Research Training Level D (The original document lists the course as "Scientific Research Training D," while the transcript shows it as "Comprehensive Scientific Research Training Level D." This document will adopt the same title as the transcript for consistency.) is an elective course for physics majors, exclusively available to students enrolled in the "Top-Talent Program" The course adopts a personalized training model, allowing students to withdraw midway but not to join after the course has started. This series of courses is supervisory in nature, aiming to immerse students in actual research teams and involve them in the entire scientific research process. *Scientific Research Training D* is the final course of the series, requiring students to have achieved preliminary research results, writting an academic paper (non-review), and deliver a presentation.

(2) Course Content

This course is limited to Top-Talent Program students who have already completed at least one year of scientific research within a research team. Students are expected to have a deep understanding of the background and frontiers of their research projects and have participated in practical research activities exceeding one semester, including both theoretical and experimental studies. The main focus of this course is the execution and preliminary summarization of ongoing research projects, forming initial research results, drafting an academic paper (non-review), and presenting the work.

(3) Course Objectives

The Physics Department currently has three research directions:Computational Photonics and Fiber Sensing、Optoelectronic Materials and Devices、Imaging and Display Photonics

Students who have joined a research team for more than one year and have conducted project research for over one semester will further enhance their abilities through this course. The course aims to improve students' academic problem-analysis, problem-solving, and problem-posing skills, as well as their integrative thinking, mastery and application of scientific methodology, perseverance, and initiative.

Upon completion of the course, students are expected to:

1. Become familiar with the research work of their group and efficiently conduct literature search and organization;
2. Master specific methods for conducting research and develop strong participation capabilities in scientific research;
3. Enhance academic literacy and paper-writing skills through research activities;
4. Cultivate the ability to analyze, solve, and pose scientific problems;
5. Improve teamwork skills and strengthen team awareness.

This course provides targeted theoretical and research training for physics majors enrolled in the Top-Talent Program, strongly supporting the corresponding graduate-level learning outcomes, including:

3.3 Ability to acquire skills relevant to similar professional fields through study;

4.2 Mastery of physics-related technologies, resources, information tools, and modern engineering tools;

5.3 Demonstration of innovation awareness in research/design/development processes;

6.2 Ability to investigate and optimize applied problems in physics and related fields based on fundamental physics;

7.2 Leadership skills to facilitate teamwork and cooperation.

2. Intended Learning Outcomes

Knowledge Unit	Key Knowledge Points	Initial Level	Target Level	Expected Learning Outcomes
Participation in Research Team Activities	Weekly group meetings	L2	L3	Understand most of the work undertaken by graduate-level researchers.
	Analytical and computational techniques required for research	L4	L5	Compare, categorize, and apply mathematical skills needed for research projects.
	Literature review, background study, and research project survey	L3	L4	Conduct background research, read and interpret English-language literature, and understand the context necessary for the project.
	Drafting and writing research articles	L0	L4	Read extensive English literature, summarize research work, produce an academic paper, and analyze the main innovations of the project.

3. Pre-requisit

None.

4. Textbooks and Other Learning Resources

Textbook:

None.

Recommended References

None.

Course website`

Designated by the research team

5. Teaching and Learning Activities

Students are required to join their assigned research group and participate in all regular group meetings and project discussions. A minimum attendance rate of 80% is required. Under the supervision of the academic advisor, students engage in preliminary topic study and research activities. The total time devoted to group-based research participation must not be less than 40 hours.

In addition, students are expected to prepare a review report on the research direction of their project, summarizing the scientific background, relevant progress, and key literature in the field.

6. Assessment Scheme

Assessment item	The course “Scientific Research Training D” is compulsory and adopts a percentage-based grading scheme. Given the competitive nature of the course, the final grade is determined as follows: Final Grade =(Performance in Research Group Activities × 50%) + (Final Report and Oral Defense × 40%) + (Bonus for Research Outcomes × 10%) 1. Performance in Research Group Activities (50%) Students are evaluated by their academic advisor based on attendance at group meetings, engagement in project discussions, progress in topic study, and participation in day-to-day research activities. The advisor assigns differentiated scores according to each student’s performance, quality of reports, and progress made during the research period. 2. Final Report and Oral Defense (40%) The score is assigned by the coordinator responsible for the corresponding research direction. Differentiated scoring is applied based on the completeness, depth, and frontier relevance of the research content.

7. Course Schedule

Arranged by each research team

汕头大学本科教学

课程教学大纲

课程名（COURSE TITLE）：	科研综合训练 D
课程代码（COURSE CODE）：	PHY5025A
学分（CREDIT VALUE）：	1
课内课时（CONTACT OURS）：	40
先修课要求（PRE-REQUISIT）	科研综合训练 C
开课单位（DEPARTMENT/UNIT）：	物理学系
版本（VERSION）：	20240731-PHY5025A
课程负责人（COURSE COORDINATOR）：	李飞 (签章)
审核人（APPROVER）：	(签章)
审核日期（APPROVE DATE）：	20240731

汕头大学理学院

2024 年 7 月

1. 课程简介（Course Description）

（1）课程性质

“科研综合训练 D（Scientific research training D）” 是物理学专业的公共选修课，“科研综合训练 D”仅限入选“拔尖计划”学生选修，采用个性化培养方式，允许中途退出，不允许中途加入。该系列课程属于指导型课程，旨在让学生参与到具体的科研团队中，参与科学研究的全过程。本课程为系列课程的最后一个课程，要求学生在科研上有初步的研究成果，撰写学术论文（非综述类），并进行汇报。

（2）课程内容

“科研综合训练 D”仅限于“拔尖计划”的同学选修，学生已经在科研团队中完成一年的科学研究活动，对所开展的研究项目背景和前沿有较深刻的理解，开展具体科学研究活动也超过一学期，包括理论研究和实验研究。本课程主要内容集中在所开展科研项目的执行和初步总结上，包括形成初步的科研成果，撰写学术论文初稿（非综述类），进行学术汇报。

（3）课程目标

物理学系目前由“计算光子学与光纤传感”、“光电材料与器件”和“成像与显示光子学”三个研究方向，学生已经进入研究团队一年以上时间，已经开展具体的科研项目研究超过一学期。在此基础上，本课程进一步提高学术分析问题、解决问题和提出问题的能力，对学生的整合思维能力、科学方法论的掌握和运用、意志力、行动力都是很好的锻炼。

通过课程训练，学生应该具备以下能力，

1） 熟悉课题组的研究工作，能快速开展文献检索和整理；
2） 掌握了课题研究的具体方法，具有较强的参与科研能力；
3） 在研究工作中提升学术修养和论文撰写能力。；
4） 培养学生分析问题、解决问题、提出问题的能力；
5） 提高团队协作能力，增强团队意识。

本课程为支持物理学专业入选“拔尖计划”的同学提供专业理论与研究能力培养，高度支撑上述专业毕业要求指标点毕业要求指标中的“1. 坚定的理想信念，2. 正确价值观和社会责任感，、3.3 具备通过学习获得相近专业领域工作的能力、4.2 掌握物理学相关领域的技术、资源、信息技术工具和现代工程工具、5.3 在研究/设计/开发过程中体现创新意识、6.2 具备从物理基础出发，对物理学及相关领域中的应用问题研究与优化能力、7.2 能在团队中发挥领导力，促进团队合作”。

2. 预期结果（Intended Learning Outcomes）

本课程的预期学习结果如下表：

知识单元	知识点	初始程度	要求程度	预期学习结果
参与课题组科研活动	组会	L2	L3	理解大部分研究生工作的内容
	数学方法或手段	L4	L5	比对和归类研究课题所需要掌握的技能
	项目开展调研	L3	L4	调研和逆袭项目所需知识的背景和英文文献的阅读
	学术论文撰写	L0	L4	能阅读大量英文文献，总结课题研究工作并形成学术论文，分析主要的创新。

3. 先修要求（Pre-requisite）

无

4. 教材及其他教学资源（Textbooks and Other Learning Resources）

指定教材：

无

推荐参考资料

无

课程网站：

由课题组指定

5. 主要教学环节（Teaching and Learning Activities）

进入课题组，参加每次的小组会，和项目讨论，出勤率需要超过80%，开展初步的课题学习和科研活动，具体根据指导教师安排。要求参与课题组集体活动时间不得低于40学时。撰写研究方向综述报告。

6. 课程考核（Assessment Scheme）

考核要求 Assessment Scheme

考核要求	"科研综合训练 D"课程为必修课，百分制评分。考虑到课程为竞赛形式，评分标准为： 课程成绩 = 导师组科研活动成绩×50% + 结题报告（含答辩）×40% + 成果加分×10% 1. 导师组科研活动成绩标准： 每个同学参加导师组的每次小组会和项目的讨论会，由指导老师根据学生的出勤率、课题学习情况和科研项目参与情况进行打分。 指导教师需根据学生参加小组科研活动期间表现、报告和项目开展进度，给予差异化评分。 2. 结题报告评分标准： 由每个研究方向负责人打分，根据研究内容完整性和前沿性给予差异化评分。

7. 学习进度 （Course Schedule）

由各个研究团队安排

Shantou University

Module Description for Undergraduate Courses

COURSE TITLE：	Innovative Theoretical Basis of Physics
COURSE CODE：	PHY4014A
CREDIT VALUE：	2
CONTACT HOURS：	32
PRE-REQUISITE	Mathematical methods of physics, Theoretical Mechanics, Quantum Mechanics Ⅰ
DEPARTMENT/UNIT：	Department of Physics
VERSION：	PHY4014A-20250911
COURSE COORDINATOR：	Li Pengcheng (Signature and Seal)
APPROVER：	Chi Lingfei (Signature and Seal)
APPROVE DATE：	20250911

Shantou University Faculty of Science

September 2025

1. Course Description

(1) Course Nature

Innovative Theoretical Basis of Physics is a compulsory course for physics majors. Since the 2020s, Artificial Intelligence (AI) has become a dynamic and promising field, gradually permeating all aspects of daily life and profoundly reshaping the world. In 2024, the Nobel Prize in Physics set a historic precedent by being awarded, for the first time, to two scientists who made exceptional contributions to the field of artificial intelligence: J. J. Hopfield from Princeton University (USA) and G. Hinton from the University of Toronto (Canada), in recognition of their pioneering work applying physical principles and methods to machine learning and neural networks.

Today, the integration of artificial intelligence and physics has become increasingly prominent. Physics not only provides the theoretical foundation for constructing neural networks but also serves as a core driving force that continually pushes the boundaries of AI innovation.

Through introducing the fundamental theories of several frontier research areas in physics and their connections with AI, this course aims to foster a strong interactive relationship between physics and artificial intelligence. Students will gradually develop a comprehensive and systematic theoretical framework, along with a distinctive methodological system, opening new pathways to address complex challenges in fundamental physical sciences.

Moreover, the course guides students in forming a scientific worldview, values, and outlook on life, playing an important role in cultivating scientific thinking, enhancing personal qualities, and strengthening overall competence.

(2) Course Content

This course covers: interpretations of the Nobel Prizes in Physics awarded over the past decade; case studies of innovative research in physics; current hot topics in physics; and the roles that artificial intelligence plays in these areas.

(3) Course Objectives

1. To master the theoretical foundations for integrating AI technologies with physics education, providing theoretical support for practical applications.
2. To explore concrete application scenarios of AI in physics and propose targeted application strategies.
3. To deepen the understanding of physical concepts (such as entropy, waves, and relativity) through AI-related cases, such as neural-network simulations of quantum systems or AI-based predictions of celestial motion.
4. To develop computational thinking by learning to use AI algorithms (such as regression analysis and clustering) to solve physics problems (such as trajectory prediction or thermodynamic statistics), fostering data-driven scientific reasoning.
5. To strengthen problem-solving abilities by applying AI techniques to complex physical problems (such as circuit optimization or chaotic-system simulation), thereby enhancing interdisciplinary competence.
6. To build foundational skills in programming and modeling. Using Python or modular programming (e.g., Scratch for AI), students will implement simple simulations of physical phenomena (e.g., simple harmonic motion or electromagnetic field visualization).
7. To acquire data analysis and visualization skills through AI tools (such as Tableau and Matplotlib) for presenting and analyzing experimental data.

This course provides disciplinary theoretical foundations and research training for academic physics students, strongly supporting the program's graduation requirement indicators "1. Firm ideals and convictions; 2. Correct values and social responsibility; and 5.1 Ability to conduct research based on scientific principles and methods."

2. Intended Learning Outcomes

Training Objectives	Knowledge Units / Competencies Standards	Initial Level	Target Level	Expected Learning Outcomes
Summary of the Nobel Prize in Physics over the past decade (2015–2024), including award-winning work, scientific significance, laureates, research areas, and key contributions.	2015: Neutrino oscillations 2016: Topological phase transitions and topological materials 2017: Gravitational-wave detection 2018: Laser physics and precision tools 2019: Exoplanets and cosmic evolution 2020: Black hole theory and observation 2021: Complex systems and climate physics 2022: Quantum entanglement and information science 2023: Attosecond light pulses and electron dynamics 2024: Interdisciplinary advances between AI and physics	L2	L4	1. Become familiar with foundational frontiers such as quantum mechanics, cosmology, and particle physics. 2. Understand technological applications including lasers, LEDs, climate models, metamaterials, and artificial intelligence. 3. Comprehend the dual value of physics in exploring natural laws and addressing real-world problems.
Development of artificial intelligence: major milestones, branches, and applications.	**1. Development:** Dartmouth Conference defining AI; rise of machine learning; IBM Deep Blue defeating the world chess champion; AlphaGo, ChatGPT, DeepSeek. **2. Branches:** Machine Learning (ML), Deep Learning (DL), Computer Vision (CV), Natural Language Processing (NLP), robotics, Reinforcement Learning (RL). **3. Applications:** healthcare, finance, manufacturing, education, entertainment.	L2	L4	1. Understand that AI is reshaping all sectors of society by modeling and extending human intelligence through data-driven methods. 2. Recognize that the integration of AI and physics is transforming scientific research—from theoretical inquiry to experimental analysis—accelerating breakthroughs in physics. 3. Gain knowledge of major AI applications in physics: computational physics and numerical simulation, quantum physics and quantum computing, high-energy physics and particle accelerators, condensed matter physics and materials science, astrophysics and cosmology.

3. Pre-requisit

Mathematical methods of physics， Theoretical Mechanics，Quantum Mechanics I

4. Textbooks and Other Learning Resources

Recommended References

1. *A Century Review of the Nobel Prize in Physics*, Guo Yiling & Shen Huijun, Shanghai Scientific Popularization Press, 2002.
2. *Quantum Mechanics*, Volume II, Zeng Jinyan, Science Press, 5th Edition, 2014.
3. *Principles and Technology of Lasers*, edited by Xia Min, Science Press, 2016.
4. *Reviews of Modern Physics*, Nobel Prize Special Issue, American Physical Society (APS).

Course website`

my.stu.edu.cn

rainclassroom

5. Teaching and Learning Activities

Teaching Segment	Lectures (Theory)	Home work	Experiment	Seminars	Extracurricular Reading	Project Work	Online Learning	Total
Hours (In-class)	32	0	0	0	0	0	0	32
Hours (Out-of-class)	24	16	0	8	24	0	0	64

Basis for Calculating Out-of-Class Study Hours

Given the difficulty of the course content and the required amount of independent reading, it is estimated that the weekly in-class workload is 2 class hours. Students are expected to spend 1.5 hours on pre-class preparation and 1.5–2 hours on post-class review each week. In addition, each homework assignment is expected to require approximately 3 hours to complete (about 4 assignments in total).

7. Assessment Scheme

Assessment item	Description / Assessment criteria	Weight
Class Attendance	Assessment of class attendance. (Each unexcused absence results in a 1% deduction, until the score is exhausted.)	5%
Regular Performance	**Homework:** Whether assignments are submitted on time; whether the basic concepts and reasoning used in solving problems are clear; whether formulas are applied correctly; whether the logic is complete. (Each missing assignment results in a 5% deduction; additional deductions will be made as appropriate, until the score is exhausted.)	30%
	Class Participation: Whether the student listens attentively; actively participates in discussions or raises questions; and completes required preparation or background searches.	5%
Final Examination	Closed-book final exam.	60%

7. Course Schedule

Week	Hour	Teaching format	Teaching content
1	2	Lecture	From Condensed Matter Physics to Artificial Neural Networks
2	2	Lecture	Entropy
3	2	Lecture	Computational Electromagnetics, Differential Geometry, and Transformation Optics
4	2	Lecture	Complex Systems and Climate Physics (I)
5	2	Lecture	Complex Systems and Climate Physics (II)
6	2	Lecture	Quantum Entanglement and Information Science (I)
7	2	Lecture	Quantum Entanglement and Information Science (II)
8	2	Lecture	Neutrino Oscillations (I)
9	2	Lecture	Neutrino Oscillations (II)
10	2	Lecture	Topological Phase Transitions and Topological Materials (I)
11	2	Lecture	Topological Phase Transitions and Topological Materials (II)
12	2	Lecture	Interdisciplinary Research between Artificial Intelligence and Physics (I)
13	2	Lecture	Interdisciplinary Research between Artificial Intelligence and Physics (II)
14	2	Lecture	Interdisciplinary Research between Artificial Intelligence and Physics (III)
15	2	Lecture	Frontier Topics in Innovative Theory: Attosecond Pulses and Electron Dynamics
16	2	Lecture	Cosmic Evolution and Gravitational-Wave Detection

汕头大学本科教学
课程教学大纲

课程名（COURSE TITLE）：	物理学创新理论基础
课程代码（COURSE CODE）：	PHY4014A
学分（CREDIT VALUE）：	2
课内课时（CONTACT OURS）：	32
先修课要求（PRE-REQUISIT）	数学物理方法，理论力学，量子力学
开课单位（DEPARTMENT/UNIT）：	物理学系
版本（VERSION）：	PHY4014A-20250911
课程负责人（COURSE COORDINATOR）：	李鹏程 (签章)
审核人（APPROVER）：	池凌飞 (签章)
审核日期（APPROVE DATE）：	2025.9.11

汕头大学理学院

2025 年 9 月

1.课程简介（Course Description）

（1）课程性质

《物理学创新理论基础》（Innovative Theoretical Basis of Physics）是物理学专业的必修课。本世纪 20 年代以来，人工智能（Artificial Intelligence，简称 AI）是一个充满活力和潜力的领域，它正逐渐渗透到我们生活的方方面面，并深刻改变着我们的世界。2024 年，诺贝尔物理学奖的颁发开创了一个历史性先例，首次授予了在人工智能领域作出卓越贡献的两位科学家：美国普林斯顿大学的霍普菲尔德(J.J.Hopfield)与加拿大多伦多大学的辛顿(G.Hinton)，以表彰他们利用物理学的方法和思想在机器学习和神经网络领域的开创性贡献。如今，人工智能与物理学的融合趋势日益显著，物理学不仅为神经网络的构筑奠定了坚实的理论基础，更成为推动人工智能技术不断突破边界，实现创新的核心驱动力。本课程通过介绍物理学的若干前沿研究领域的基础理论以及这些领域与人工智能的关联，旨在推动物理学与人工智能之间形成强互动关系，使学生逐渐构建起了一套完备且系统的理论体系，并形成独具特色的方法论体系，为物理学基础科学领域面临的复杂挑战开辟全新的解决路径。同时，引导学生形成科学的世界观、价值观与人生观，对于培养他们的科学思维方式、提升个人素质与综合能力具有重要的价值。

（2）课程内容

本课程内容包括：近 10 年诺贝尔物理学奖解读，若干物理创新研究的案例，当前物理学研究的热点问题及其人工智能在这些研究中所起的作用等。

（3）课程目标

1)掌握人工智能技术与物理教学融合的理论基础,为实践应用提供理论支持。

2)探索人工智能在物理学中的具体应用场景,提出具有针对性的应用策略。

3) 结合人工智能案例（如神经网络模拟量子系统、AI 预测天体运动），深化对物理概念（如熵、波动、相对论）的理解。

4）发展计算思维。学习利用 AI 算法（如回归分析、聚类）处理物理问题（如运动轨迹预测、热力学统计），培养数据驱动的科学思维。

5）强化问题解决能力。运用 AI 技术解决复杂物理问题（如优化电路设计、模拟混沌系统），提高跨学科应用能力。

6）编程与建模基础。通过 Python 或模块化编程（如 Scratch for AI），实现简单的物理现象模拟（如简谐运动、电磁场可视化）。

7）数据分析与可视化。利用 AI 工具（如 Tableau、Matplotlib）对实验数据进行可视化呈现与分析。

本课程为物理学专业学术型人才培养提供专业理论与研究能力培养，高度支撑该专业毕业要求指标点“1. 坚定的理想信念；2. 正确价值观和社会责任感；5.1 具备基于科学原理和方法进行研究的能力”。

2.　预期学习结果（Intended Learning Outcomes）

知识单元	知识点	初始程度	要求程度	预期学习结果
近 10 年（2015-2024 年）诺贝尔物理学奖的获奖内容及科学意义总结，涵盖获奖者、研究领域和关键贡献。	2015 年：中微子振荡 2016 年：拓扑相变与拓扑材料 2017 年：引力波探测 2018 年：激光物理与精密工具 2019 年：系外行星与宇宙演化 2020 年：黑洞理论研究与观测 2021 年：复杂系统与气候物理 2022 年：量子纠缠与信息科学 2023 年：阿秒光脉冲与电子动力学 2024 年：人工智能与物理交叉研究	L2	L4	1.熟悉基础前沿（量子力学、宇宙、粒子物理） 2.熟悉技术应用（激光、LED、气候模型、超构材料、人工智能） 3.理解物理学在探索自然规律与解决实际问题中的双重价值。
	课程思政：强调唯物主义认识论，树立科技强国理念。			
人工智能的发展历程、主要分支和应用	1.发展：达特茅斯会议确立 AI 概念；机器学习兴起，IBM 深蓝击败国际象棋冠军；AlphaGo、ChatGPT、DeepSeeK）。 2.分支：机器学习（ML）、深度学习（DL）、计算机视觉（CV）、自然语言处理（NLP），机器人技术、强化学习（RL）。 3.应用：医疗、金融制造业、教育、娱乐。	L2	L4	1.理解人工智能正在重塑各行各业，其核心是通过数据驱动的方式模拟和扩展人类智能。 2.熟悉人工智能（AI）与物理学的结合正在深刻改变科学研究的方式，从理论探索到实验分析，AI 正在加速物理学的突破。 3.了解 AI 在物理学中的主要应用：计算物理与数值模拟、量子物理与量子计算、高能物理与粒子加速器、凝聚态物理与材料科学、天体物理与宇宙学。
	课程思政：建立正确的世界观，树立勇于探索精神。			

3.先修要求（Pre-requisit）

《数学物理方法》、《理论力学》、《量子力学》。

4. 教材及其他教学资源（Textbooks and Other Learning Resources）

课程教材

推荐参考资料

(1) 《诺贝尔物理学奖百年回顾》，郭奕玲 / 沈慧君，上海科学普及出版社，2002。

(2)《量子力学 卷 II》，曾谨言，科学出版社，第五版，2014.1。

(3)《激光原理与技术》夏珉主编，科学出版社，2016.1。

(4)《Reviews of Modern Physics》诺奖特辑，美国物理学会（APS）。

网络资源

my.stu.edu.cn

雨课堂

5. 主要教学环节（Teaching and Learning Activities）

教学环节	理论学习（小时）	作业（小时）	实验（小时）	研讨（小时）	课外阅读（小时）	项目（小时）	在线学习（小时）	期中测试（小时）	合计
课内	32	0	0	0	0	0	0	0	32
课外	24	16	0	8	24	0	0	0	64

课外课时计算依据：

本课程内容较难且需要一定的课外阅读量，预计每周课内学时2学时，需要学生课外预习1.5小时，课外复习1.5~2小时；另外，课外完成每次作业需3小时（约4次作业）。

6. 课程考核（Assessment Scheme）

考核项目	**考核内容和方法**	**权重**
上课出勤	考核上课出勤情况 （无故缺勤一次扣 1%，扣完为止）	5%
平时表现	**课后作业：**是否及时提交作业？解题过程中基本概念和思路是否清晰？公式使用是否正确？逻辑方面是否完整？ （缺一次作业扣 5%，其余根据情况适当扣分，扣完为止）	30%
	课堂参与：是否认真听课？是否积极参与讨论或提出问题？是否会根据要求查询准备资料？	5%

期末考试	期末闭卷考试	60%

7. 教学进度表（Course Schedule）

周次	教学时数	教学形式	教学内容
1	2	课堂教学	从凝聚态物理到人工神经网络
2	2	课堂教学	熵
3	2	课堂教学	计算电磁学、微分几何与变换光学
4	2	课堂教学	复杂系统与气候物理（一）
5	2	课堂教学	复杂系统与气候物理（二）
6	2	课堂教学	量子纠缠与信息科学（一）
7	2	课堂教学	量子纠缠与信息科学（二）
8	2	课堂教学	中微子振荡（一）
9	2	课堂教学	中微子振荡（二）
10	2	课堂教学	拓扑相变与拓扑材料（一）
11	2	课堂教学	拓扑相变与拓扑材料（二）
12	2	课堂教学	人工智能与物理交叉研究（一）
13	2	课堂教学	人工智能与物理交叉研究（二）
14	2	课堂教学	人工智能与物理交叉研究（三）
15	2	课堂教学	创新理论前沿：阿秒光脉冲与电子动力学
16	2	课堂教学	宇宙演化与引力波探测

Shantou University
Module Description for Undergraduate Courses

Note

For the *Undergraduate Innovation and Entrepreneurship Training Program*, the university does not provide an official syllabus. The following section first presents a general description of the course content based on my own experience, followed by a translated version of the *Shantou University Undergraduate Innovation and Entrepreneurship Training Program Management Guidelines*.

Course Description

This program requires students to work under the supervision of one or two faculty advisors on a year-long research or innovation project. Throughout the process, students and supervisors jointly select a research topic. Students then engage in discipline-specific background study, literature review, methodology development, problem-solving and design, coding implementation, data processing, and project presentation. The program emphasizes independent inquiry, critical thinking, scientific communication, and hands-on research experience.

Overview of the Innovation and Entrepreneurship Training Program Workflow

(1) Project Proposal Application

At the beginning of the program, each team must undergo a **project initiation review**. Team members prepare a **Project Proposal Application** and participate in an **initiation defense**. Based on both the written proposal and the defense performance, the review committee first determines whether the project is approved. Under a limited quota, approved projects are then assigned to **national**, **provincial**, or **university** levels, with corresponding funding amounts of **¥8,000**, **¥6,000**, and **¥2,000**.

The *Project Proposal Application* includes:

- Basic project information (title, principal investigator, team members, supervisor, contact information)
- Project description
- Rationale (team knowledge base, resources, skills, interests, and preliminary preparation)
- Project plan (timeline, technical route, division of responsibilities)
- Project features and innovation
- Project schedule
- Budget plan
- Expected outcomes

(2) Mid-Term Review

Approximately six months later, teams must submit **mid-term review materials**, which will be assessed by the committee. Projects that pass may access the **second phase of funding**, and their mid-term performance will serve as an important reference for the final evaluation.

Projects that fail the mid-term review must revise their work within a specified period. Only after passing re-evaluation may they continue, **but they will not receive the second phase of funding**. Projects that still fail to meet the requirements will be terminated and handled according to the program's termination regulations.

After the mid-term review, changes to project information or team members are generally **not permitted**. Supervisors, the college, and the university will all provide review comments during this stage.

Mid-Term Review Materials include:

Mid-Term Review Form:

- Research progress
- Team participation, with attached *Meeting Minutes of Group Discussions*
- Major challenges and corresponding strategies
- Next-stage research plan and timeline
- Funding usage
- Attached *Project Progress Log*

Progress Report:

- Research/experimental content
- Research/experimental objectives
- Methods
- Procedures
- Data and conclusions
- Identified problems and solutions
- Reflections and insights

Each section contains comments from supervisors and college-level reviewers.

(3) Final Review and Project Completion

For project completion, teams must submit **final evaluation materials** and **participate** in a final defense. The committee then determines whether the project is successfully completed.

Projects that do not pass may have their funding withdrawn, or may be given six months for improvement before resubmitting materials for another evaluation. A second failure results in funding withdrawal and a failing grade (0–59).

Projects that pass will receive a final score in the 60–100 range based on their overall progress throughout the year.

Final Review Materials include:

Final Acceptance Report:

1. **Project Implementation:**
   - Completion status of project tasks
   - Completed content, product/service description, key technologies and effectiveness
   - Innovation, originality, practical value, social and economic impact
   - Overall schedule and execution (with *Progress Report* attached)
   - Use of supporting platforms and resources
   - Major issues encountered and corresponding solutions
   - Self-evaluation (including achievements, failures, and personal development in innovation and practical ability)
2. **Project Outcomes:**
   - Key innovations and value of the 成果
   - Detailed outcomes: publications, patents, final reports, prototypes, hardware development, apps, drawings, award certificates, and others (submitted as attachments)
3. **Funding Usage Summary**
4. **Project Progress Log:**

- Research log sheets
- Experimental summaries
- Preliminary analysis
- Problems to be addressed
- Technical 方案 and evaluation
- Conclusions
- Practical applications or significance
- Publication records

- Minutes of group discussion meetings

5. **Student Reflections:**
Personal reflections on academic, technical, and experiential development.

All sections receive comments from supervisors, university experts, and the college's review committee.

My Work in the Program

A detailed record of my work is documented in my CV

Assessment Scheme

A detailed record of my work is documented in my CV

Intended Learning Outcomes

Knowledge Unit	Key Knowledge Points	Initial Level	Required Level	Expected Learning Outcomes
Participation in Research Group Activities	Group seminars	L0	L5	Understand most of the content presented by postgraduate researchers.
	Mathematical Methods or Techniques	L0	L5	Identify and analyze the skills necessary for different research topics.
	Project Investigation	L0	L5	Understand the background knowledge required for the project and read relevant English literature.
	Weekly group meetings	L0	L5	Understand most of the work undertaken by graduate-level researchers.
	Analytical and computational techniques required for research	L0	L5	Compare, categorize, and apply mathematical skills needed for research projects.
	Literature review, background study, and research project survey	L0	L5	Conduct background research, read and interpret English-language literature, and understand the context necessary for the project.

Course Schedule

The schedule is determined by the respective research teams.

Next is the translation of the *Shantou University Regulations on the Administration of the Undergraduate Innovation and Entrepreneurship Training Program (Revised)*.

Shantou University Regulations on the Administration of the Undergraduate Innovation and Entrepreneurship Training Program (Revised)

(Approved at the 2nd University Leadership Meeting on March 19, 2015 and promulgated thereafter; First revision approved at the 15th President's Executive Meeting on July 6, 2023)

I. General Provisions

Article 1

To ensure the effective implementation of the Guangdong Undergraduate Innovation and Entrepreneurship Training Program, to promote the reform of educational philosophy in higher education institutions, to improve talent-training models, to strengthen students' capacity for innovation and entrepreneurship, and to cultivate high-level innovative talents needed for the development of an innovation-driven nation, these Regulations are formulated in accordance with the Notice of the Ministry of Education on the Implementation of the National Undergraduate Innovation and Entrepreneurship Training Program under the "Undergraduate Teaching Quality and Reform Project" (Jiaogao Letter [2012] No. 5), and in consideration of the specific circumstances of Shantou University.

Article 2

The Undergraduate Innovation and Entrepreneurship Training Program is a student-centered, project-based practical activity designed to cultivate innovation and entrepreneurship skills. Following the principles of fairness, openness, and impartiality, the Program integrates theoretical learning with practical application, in-class learning with extracurricular activities, and on-campus with off-campus resources.

Undergraduate students may apply for projects individually or as a team. Under the guidance of faculty supervisors, students independently carry out research-oriented learning, including identifying research topics, managing the project, designing and implementing research plans, conducting data analysis, and preparing summary reports. The University encourages faculty–student cooperation in scientific research and supports the formation of interdisciplinary and cross-year project teams.

II: Administrative Mechanism

Article 3

The University shall establish the "Shantou University Undergraduate Innovation and Entrepreneurship Training Program Management Committee" (hereinafter referred to as the "Management Committee"), chaired by the Vice President in charge of teaching. Members are appointed based on institutional representation, with one representative each from the Academic Affairs Office, the Research Office, and each college, typically the respective leaders of these units. Experts may be invited to join the Committee as needed.

An Administrative Office shall be set up under the Management Committee and placed within the Academic Affairs Office. The Management Committee is responsible for overall program administration, including policy formulation, resource coordination, project supervision, funding allocation, and award implementation.

Article 4

Each college shall establish a "College Working Group for the Undergraduate Innovation and

Entrepreneurship Training Program" (hereinafter the "Working Group"), chaired by the Associate Dean responsible for teaching. Members include leaders and staff from teaching, research, laboratory management, and student affairs.

The Working Group is responsible for the implementation and administration of the Program within the college, including organizing project applications, overseeing project execution, providing laboratory and experimental resources, conducting mid-term inspections, evaluating project outcomes, and managing project funds.

III. Project Establishment

Article 5 Contents of the Undergraduate Innovation and Entrepreneurship Training Program

The contents of the Undergraduate Innovation and Entrepreneurship Training Program align with those of the National Undergraduate Innovation and Entrepreneurship Training Program and include three categories: Innovation Training Projects, Entrepreneurship Training Projects, and Entrepreneurship Practice Projects.

1. Innovation Training Projects involve individual undergraduates or teams who, under the supervision of faculty advisors, independently complete tasks such as innovative research project design, preparation of research conditions, project implementation, research report writing, and academic presentation of outcomes.
2. Entrepreneurship Training Projects are carried out by undergraduate teams. Under faculty guidance, each team member assumes one or more specific roles during the project implementation. Tasks include preparing business plans, conducting feasibility studies, simulating enterprise operations, participating in enterprise practice, and writing entrepreneurship reports.
3. Entrepreneurship Practice Projects are conducted by undergraduate teams under the joint supervision of university mentors and enterprise mentors. Based on outcomes from earlier Innovation Training Projects (or innovative experiments), teams propose a product or service with market potential and carry out entrepreneurship practice activities.

Article 6 Requirements for Project Proposals

Project proposals should feature novel ideas, clearly defined goals, and strong innovation and exploratory value. Research plans and technical routes must be feasible, and budget allocation must be reasonable. The project duration is one year or one and a half years. A mid-term report must be submitted halfway through the implementation period.

Applicants should conduct a feasibility analysis of the research plan and technical route and continuously refine and optimize them during implementation to ensure timely completion.

Article 7 Participants

1. Undergraduate Innovation and Entrepreneurship Training Program projects must be proposed by current undergraduate students. As a general rule, the project leader should complete the project before graduation. For Entrepreneurship Practice Projects, the project leader may be replaced after graduation if necessary, or may continue to serve as project leader as a student entrepreneur, provided that the responsibilities can still be fulfilled. Upon project completion, all related matters shall be properly handled in accordance with relevant laws, regulations, and policies.
2. Participating students must be able to complete the academic requirements of their major as stipulated in the curriculum. They should possess strong interest in scientific research, invention, or entrepreneurship; be willing to explore and practice; demonstrate innovative

thinking and spirit; and exhibit good academic integrity and social conduct.

3. Applications from lower-year students are encouraged, as are team applications. Each project team may have up to five members. Cross-departmental and cross-disciplinary collaborations are encouraged. Each student (including applicants and participants) may only apply for one project at a time and may not apply for a new project while a previous one is still ongoing.
4. Faculty advisors should, in principle, hold at least an intermediate professional title and be familiar with the research field involved in the project. Each project must have one to two advisors. Students or teams complete research training activities under faculty supervision. Advisors are responsible for providing guidance and oversight throughout the entire process. In principle, one advisor may supervise no more than two projects simultaneously.

Article 8 Project Establishment Timeline

The timeline for the establishment of Undergraduate Innovation and Entrepreneurship Training Program projects shall follow regulations issued by the Department of Education of Guangdong Province.

Article 9 Application and Review Procedures

(1) The project leader shall submit an application in response to the university's announcement by completing the Shantou University Undergraduate Innovation and Entrepreneurship Training Program Application Form. The supervising teacher shall review the application, provide written comments, and submit it to the college-level "Working Group."

(2) The College Working Group is responsible for organizing the evaluation of applications within the college. The review focuses on the scientific merit, innovativeness, and feasibility of the project, the soundness of the research plan and budget, the applicant's research capability, and the conditions available for project implementation. The evaluation consists of both a written review and an oral defense, organized at the discretion of the College Working Group. The Group shall decide whether to recommend the project to the university. For projects that pass the college-level review, the Group shall provide review comments and suggestions for improvement. The project team shall revise and resubmit the application accordingly.

(3) The University "Management Group" is responsible for reviewing the projects recommended by each college. Approved projects will be published on the collaborative office system. Projects with no objections during the public announcement period shall be formally approved.

(4) Once approved, Innovation and Entrepreneurship Training Program projects are designated as university-level projects. In principle, provincial-level projects must be applied for on the basis of university-level project development, and national-level projects must be applied for on the basis of provincial-level projects. College-level projects that have already passed acceptance may be given priority when applying for university-level Innovation and Entrepreneurship Training Program projects.

IV. Operation and Management of Projects

Article 10 Requirements for Project Implementation

(1) During project implementation, students must remain the primary actors. Supervising teachers shall provide active support and guidance, regularly follow up on the project's research activities, and offer timely feedback and suggestions in response to issues encountered. They shall foster a harmonious academic atmosphere that promotes mutual learning and help students gain experience in innovative thinking and practice.

(2) All experimental teaching demonstration centers and laboratories across the university shall, without affecting their normal teaching and research activities, actively provide project participants with access to experimental facilities and equipment, ensuring smooth project implementation.

(3) Colleges are encouraged to hold academic lectures, regularly organize discussions and exchanges among students, establish mechanisms for meetings between supervising teachers and students, and provide platforms for project presentation, publicity, academic exchange, and interactive learning.

Article 11 Mid-term Review

A mid-term review shall be conducted when each project reaches the midpoint of its implementation period, organized by the respective college. During the review, the project team shall submit the Mid-term Report for the Undergraduate Innovation and Entrepreneurship Training Program, describing the project execution status, research progress, preliminary 成果, existing issues, and plans for subsequent work.

Colleges shall evaluate the project's progress, completion of tasks, and mid-term 成果, and offer appropriate comments and suggestions for further improvement. If fraud or lack of significant progress is found, the college shall recommend termination of the project. The Mid-term Report shall be archived in the project file and submitted to the University Management Group Office for record-keeping.

Article 12 Project Modification

Once approved, projects shall generally not be modified. Under extremely special circumstances requiring modification, the project leader shall submit a written application to the College Working Group, explaining the specific reasons and detailing any proposed changes regarding project content, team members, or schedule adjustments. The supervising teacher shall provide written comments.

The College Working Group shall conduct an objective review, decide whether to approve the modification, and submit the result to the University Management Group for review. Upon approval by the Management Group Office, the project team will be notified. As a principle, the project leader may not be replaced.

Article 13 Project Acceptance

(1) Upon completion of the research period, acceptance shall be organized by the college. The project leader shall complete the Project Completion Application Form for the Undergraduate Innovation and Entrepreneurship Training Program and submit a final report and supporting materials, including survey reports, developed software or systems, published papers, patents, awards, physical 成果 with design documentation or drawings, etc., and participate in a defense.

(2) Supervising teachers shall provide written comments based on the students' research 成果, attitude, workload, and performance.

(3) Colleges shall organize experts to review the research report and 成果 and conduct an on-site defense. The acceptance results are classified as Excellent, Good, Pass, or Fail. After the defense, colleges shall compile complete project records, photos, and written summaries, and submit them along with the results to the University Management Group Office.

(4) For projects that pass acceptance, the university issues completion certificates and awards each participant 2 innovation credits. The project grade shall be recorded in the academic system.

(5) For papers published by students (as first authors) or patents filed based on funded projects, the acknowledgment "Supported by the Shantou University Undergraduate Innovation and Entrepreneurship Training Program" must be included. Intellectual property rights belong to the university.

(6) Projects shall not pass acceptance if any of the following occur: submitted materials or data are incomplete or false; expected 成果 are 未完成 without valid reasons; project targets or content were modified without authorization. For failed projects, the university will issue a notice within a certain scope. Project members will not receive innovation credits and may not apply for new projects for two years from the date of the acceptance decision. Supervising teachers will not receive workload credit and may not supervise new projects for two years.

(7) Projects shall generally not be terminated. If a project cannot be completed due to objective reasons, the project leader must apply to the College Working Group by submitting a Project Termination Application Form, signed by the supervising teacher. Only upon approval by the University Management Group Office may the project be terminated. Remaining unused funds will not be allocated further, and previously allocated funds may be reclaimed depending on the termination 理由. Other consequences shall follow the same rules as “failed projects.”

Article 14 Financial Discipline

Upon verification, the College Working Group has the authority to order the project leader to cease using project funds and may freeze unused funds or reclaim allocated funds, depending on the severity of the violation. Penalties may also be imposed on responsible individuals, and the case shall be reported to the University Management Group Office. Violations include:

(1) Ineffective project execution, unjustified delays, and failure to implement corrective measures, resulting in inability to meet project expectations;

(2) Misuse or diversion of project funds.

V. Support Conditions

Article 15

Funding for the Undergraduate Innovation and Entrepreneurship Training Program is allocated from the special funds of the Guangdong Provincial Department of Education. The funds are managed as earmarked funds and shall be uniformly allocated by the University.

The use of funds shall comply with the following requirements:

1. The funds for the Undergraduate Innovation and Entrepreneurship Training Program are earmarked and shall not be diverted for other purposes.
2. The allowable expenditure categories include: books and reference materials, internet fees, experimental materials, laboratory fees, simple equipment purchases, design fees, printing and photocopying fees, publication fees, and travel expenses for field investigations. Travel expenses must follow the relevant financial standards and be supported by investigation reports.
3. Fund usage shall be initiated by the project leader according to project progress, verified by project members, approved by the faculty advisor, and paid from the project funds. Total expenditure shall not exceed the allocated funding amount. All project funds must be used exclusively by the students undertaking the project, and no other individuals may appropriate them.
4. Upon project completion, the project team must provide a detailed financial statement and explanatory notes. For projects with extended completion timelines, the University will not allocate additional funding.

Article 16

Each college shall provide the necessary experimental conditions for the implementation of the

Undergraduate Innovation and Entrepreneurship Training Program. If students require cross-college laboratory access or need to use facilities in research or key laboratories, they may submit an application to the relevant college. When necessary, they may request coordination from the University "Management Team" Office. Relevant laboratories shall cooperate to ensure successful project completion.

Article 17 — Reimbursement Management

The Academic Affairs Office allocates funds to each college based on the number of approved projects. Colleges shall release 50% of the allocated funds upon project approval and the remaining 50% after the mid-term review. Projects that fail the mid-term review will be given one month for rectification. If rectification is successful, the project may proceed with 50% of the originally allocated funding. If rectification still fails, the project will be terminated.

For reimbursement, the project leader shall collect all necessary receipts and follow the procedure below:

Project Leader Signature → Faculty Advisor Signature → Review by College Working Group Designee → Signature of College Working Group Leader → Project Team Processes Reimbursement → College Working Group Designee Records the Reimbursement Outcome.

VI. Incentive Mechanisms

Article 18

1. Projects demonstrating strong progress and significant achievements may be selected for recommendation to provincial-level innovation and entrepreneurship competitions.
2. Students who perform excellently in national-level Undergraduate Innovation and Entrepreneurship Training Program projects may, upon recommendation of their faculty advisor and approval of their college's working group, receive priority consideration for admission to master's programs without entrance examinations and for scholarship evaluations.
3. For students whose projects pass the final evaluation and whose research content is related to their major, the results may—with approval from the thesis advisor and the college (or department)—be further developed into their graduation thesis (or design). Thesis topic approval and writing requirements shall follow the University's regulations on graduation thesis management.
4. The University will periodically organize exhibitions showcasing outstanding student innovation and entrepreneurship achievements.

Article 19

1. Guidance of Undergraduate Innovation and Entrepreneurship Training Program projects shall be included in the University's teaching performance evaluation for faculty as part of the "Undergraduate Services" category.
2. For completed projects, the faculty advisor will receive a one-time calculation of teaching workload in accordance with the University's Teaching Workload Calculation Measures.
3. Based on the implementation of the Undergraduate Innovation and Entrepreneurship Training Program, the University will periodically recognize and reward units, teachers, and students with outstanding performance.
4. During project approval, mid-term review, and final evaluation, colleges may provide review fees to expert reviewers (including non-advising faculty from lead units) in accordance with the University's Interim Measures for Payment of Service Fees and Subsidies, under the category of "Project Review Fees". These review fees shall be paid from college funds, not

from project funds.

VII. Supplementary Provisions

Article 20

The right to interpret these measures belongs to Shantou University. The Academic Affairs Office is responsible for specific interpretations.

Article 21

These measures shall take effect from the date of promulgation. The previous Administrative Measures for the Undergraduate Innovation and Entrepreneurship Training Program of Shantou University (Document No. 40 [2015]) shall be repealed simultaneously.

汕头大学大学生创新创业训练计划项目管理办法（修订）

（2015年3月19日第2次校领导会议讨论通过并公布实施；2023年7月6日第15次校长办公会议审议通过第一次修订）

一、总则

第一条 为顺利实施广东省大学生创新创业训练计划项目建设，促进高等学校转变教育思想观念，改革人才培养模式，强化创新创业能力训练，增强高校学生的创新能力和创业能力，培养适应创新型国家建设需要的高水平创新人才，根据《教育部关于做好“本科教学工程”国家级大学生创新创业训练计划实施工作的通知》（教高函〔2012〕5号）文件精神，结合我校具体情况，特制定本办法。

第二条 大学生创新创业训练计划项目是以学生为主体、以项目为载体的创新创业实践活动，在公平、公开、公正的原则下，坚持理论与实践、课内与课外、校内与校外相互结合，由本科生以个人或团队名义自由提出申请，在指导教师指导下，自主完成研究性学习，自主选题、自主管理、自主设计实施方案、进行数据分析处理和撰写总结报告等工作。在训练计划项目申请中，学校倡导教师和学生合作进行科学研究，并鼓励项目组按照学科交叉和年级交叉的方式组建。

二、管理机制

第三条　学校成立“汕头大学大学生创新创业训练计划项目管理小组”（以下简称“管理小组），组长由主管教学工作副校长担任，采用席位制产生管理小组成员，教务处、科研处和各学院各占一个席位，由相关单位领导担任，并视情况需要适当吸收一定数量的专家担任管理小组成员。管理小组下设办公室，办公室设在教务处。管理小组负责宏观管理，包括制定政策、协调资源、指导项目实施、调配经费、实施奖励等工作。

第四条　各学院成立“大学生创新创业训练计划项目工作小组”（以下简称“工作小组”），组长由主管教学工作副院长担任，小组成员由学院教学、科研、实验室、学生工作的领导和工作人员担任。工作小组负责本学院大学生创新创业训练计划项目的具体实施与管理，包括组织项目申报、管理项目实施、提供实验条件、进行中期检查、验收项目成果、管理经费等工作。

三、项目的立项

第五条　大学生创新创业训练计划项目内容

大学生创新创业训练计划内容参照国家级大学生创新创业训练计划项目建设内容，包括创新训练项目、创业训练项目和创业实践项目三类。

（1）创新训练项目是本科生个人或团队，在指导老师指导下，自主完成创新性研究项目设计、研究条件准备和项目实施、

研究报告撰写、成果（学术）交流等工作。

（2）创业训练项目是本科生团队，在指导老师的指导下，团队中每个学生在项目实施过程中扮演一个或多个具体的角色，编制商业计划书、开展可行性研究、模拟企业运行、参加企业实践、撰写创业报告等工作。

（3）创业实践项目是本科学生团队，在学校指导老师和企业指导老师的共同指导下，采用前期创新训练项目（或创新性实验）的成果，提出一项具有市场前景的创新性产品或者服务，以此为基础开展创业实践活动。

第六条 申报项目选题要求思路新颖，目标明确，具有创新性和探索性，研究方案及技术路线可行，经费预算合理。项目的周期为一年或一年半。各项目实施时间过半时需提交中期报告。申报者要对研究方案及技术路线进行可行性分析，并在实施过程中不断调整优化，保证按期完成。

第七条 参与人员

（1）大学生创新创业训练计划项目由在读本科生申报，原则上要求项目负责人在毕业前完成项目。创业实践项目负责人毕业后可根据情况更换负责人，或是在能继续履行项目负责人职责的情况下，以大学生自主创业者的身份继续担任该项目负责人。创业实践项目结束时，要按照有关法律法规和政策妥善处理各项事务。

（2）参与学生应能够按照培养方案的规定完成本专业的学

习任务，对科学研究与发明或创业有浓厚兴趣，敢于探索与实践，具有创新意识与创新精神，具备良好的学术道德和社会公德。

（3）鼓励低年级学生申报，鼓励学生团队申报。项目组人数最多不超过 5 人。鼓励跨院系、跨学科的学生合作申报。每名学生（含申请人与参加人）限同时申报一个项目，在研项目未结题时不能申报新的项目。

（4）指导教师原则上应具有中级及以上职称，熟悉该项目涉及的研究领域。每个项目需邀请指导教师 1 至 2 人。学生或团队在指导教师指导下完成相关研究训练内容。指导教师在全程起辅导、监督作用，负责指导学生的研究与训练。原则上一位指导老师参与指导项目最多不能超过 2 个。

第八条　大学生创新创业训练计划项目的立项时间根据广东省教育厅的相关文件确定。

第九条　申报及评审程序

（1）项目负责人根据学校发布的通知提出申请，填写《汕头大学大学生创新创业训练计划项目申报书》，指导教师审阅并签署意见，提交所在学院的“工作小组”。

（2）学院工作小组负责组织对本学院的申请项目进行评审。主要审查项目的科学性、创新性、可行性，研究计划、经费预算的合理性，申请者的研究能力以及项目实施的条件等。评审分书面评审和答辩评审两部分进行，由学院工作小组决定是否将项目推荐至学校，对通过学院评审的项目提出评审意见和改进建议，

由项目组修正后再次提交项目申请书。

（3）学校“管理小组”负责对各学院推荐的项目进行审核。审核通过的项目在协同办公系统上公示，公示无异议的项目将得到正式立项。

（4）正式立项后的创新创业训练计划项目为校级项目，原则上省级的大学生创新创业训练计划项目须在校级项目建设的基础上申报，国家级大学生创新创业训练计划项目须在省级项目基础上申报。已验收的学院一级建设项目申报校级大学生创新创业训练计划项目，可优先通过立项。

四、项目的运行与管理

第十条 项目实施要求

（1）项目实施过程中，必须坚持以学生为主体。指导教师应发挥积极的辅助引导作用，定期跟踪指导项目研究活动，针对研究中的问题及时提出意见和建议，营造教学相长、和谐融洽的学术氛围，帮助学生在创新思维和创新实践方面有所收获。

（2）全校各类实验教学示范中心和实验室在不影响正常教学、科研工作的前提下，应积极向承担项目的学生提供实验场地和实验仪器设备，确保项目顺利实施。

（3）提倡各学院开设学术讲座，定期组织学生讨论和交流，制定指导教师座谈会和学生科研座谈会制度，提供项目展示、宣传报道、学习交流、互动促进的交流平台。

第十一条 各项目实施时间过半时需开展中期检查一次，由学院负责组织实施。中期检查时项目组应向学院提交《大学生创新创业训练计划项目中期检查报告》，说明项目执行情况、研究进展和取得的阶段性成果、存在的问题、下一步的工作安排等。学院要对项目的工作进度、各项工作完成情况、中期成果等给出恰当的评价，提出项目进一步实施的意见和建议。如发现项目申报或实施过程中有弄虚作假或工作无明显进展的，应提出终止项目运行的建议。《中期检查报告》应存于项目档案，并递交学校“管理小组”办公室备案。

第十二条 项目立项后一般不允许变更。如在研究过程中出现极其特殊情况必须进行项目变更的，由项目负责人向学院“工作小组”提出书面申请，阐明具体原因，对更改项目内容、更换项目成员、提前或推迟项目进度等作出详细陈述，指导教师签署意见。学院“工作小组”对变更申请进行实事求是的审查，给出同意与否的结论，并提交学校“管理小组”审核、管理小组”办公室备案后通知项目组执行。原则上项目负责人不能更换。

第十三条 项目验收

（1）项目达到研究期限后，由学院组织验收。项目负责人填写《大学生创新创业训练计划项目结题申请书》，提交项目总结报告和相关支撑材料，包括调查报告、开发的软件或系统、发表的论文、专利、所获奖项、项目成果实物及相应的设计说明书、图纸等，并参加项目结题答辩。

（2）指导教师根据学生的研究成果和平时的研究态度、研究工作量和研究表现等填写指导教师评语。

（3）各学院组织专家审议项目研究报告和相关研究成果，并组织项目现场答辩验收会。验收结果分为优秀、良好、通过和不合格四个等级。答辩验收结束后，各学院应及时整理完整的项目材料和答辩验收会的图片和文字总结材料，连同验收结果报送至学校“管理小组”办公室。

（4）对通过结题验收的项目负责人及参加者，学校颁发结题证书并每人记 2 个创新学分，项目验收成绩录入教务系统。

（5）受项目资助的学生，作为第一作者发表的论文以及以项目为基础申请的专利，应标注“汕头大学大学生创新创业训练计划项目资助”，专利知识产权归学校所有。

（6）被验收项目存在下列情况之一者，不予通过验收：提供的验收材料、数据不完整、不真实；无故未完成预期成果；擅自更改《大学生创新创业训练计划项目申报书》规定的研究目标和内容。未通过验收的项目，学校在一定范围内予以通报，项目组成员无法获得相应创新学分，自验收之日起两年内不得再次申请大学生创新创业训练计划项目；指导教师无法获得相应工作量，该项目不能计入“本科生服务”工作，两年内不得再指导大学生创新创业训练计划项目。

（7）大学生创新创业训练计划项目原则上不允许终止。如因客观因素确实无法完成项目，项目负责人需向学院工作小组提

出申请，填写《大学生创新创业训练计划项目终止申请表》，经指导老师签名确认，学校“管理小组”办公室同意，方可终止项目。终止项目的剩余经费不再下拨，并且视项目终止理由追缴已拨经费，其他相关处理措施与“未通过验收项目”处理措施相同。

第十四条　经核查，对下列情况，学院“工作小组”有权责令项目负责人停止使用项目研究经费，并可视情节轻重冻结未用经费或追缴已拨经费，对主要责任人予以处罚，并报学校“管理小组”办公室备案：

（1）因项目执行不力，无故延期又无具体改进措施致使项目无法按预期完成的；

（2）将项目经费挪作他用的。

五、条件保障

第十五条　大学生创新创业训练计划项目经费来源于广东省教育厅专项经费。经费实行专项管理，由学校统一下拨。

经费的使用应符合以下要求：

（1）大学生创新创业训练计划项目经费为专项经费，不得变更用途。

（2）经费的列支范围包括：图书资料费、网络费、实验材料费、实验费、简单仪器费、设计费、复印费、论文版面费、调研差旅费等。支付调研差旅费，必须按照财务处的相关标准，并提供调研报告。

（3）经费的使用，首先由大学生创新创业训练计划项目负责人根据项目运行情况提出申请，项目合作者证明，经指导教师同意，从项目经费支付。支出总额度不能超过该项目的资助总额度。项目经费都由承担项目的学生全额使用，其他人不得挪用。

（4）大学生创新创业训练计划项目结束时，项目组要提供项目经费使用清单，并作出说明。对于延期结题的项目，学校不予追加经费。

第十六条　各学院要为大学生创新创业训练计划项目的研究提供相应的实验条件。学生需要跨学院进行实验，或进入科研、重点实验室使用设备、设施的，可向相关学院提出申请，必要时向学校“管理小组”办公室申请协调，相关实验室应予以配合，确保项目的顺利完成。

第十七条　经费报销管理

教务处按照各学院项目数下拨相应经费。各学院在项目立项后下拨经费的 50%，中期检查后下拨剩余的 50%。没有通过中期检查的项目，原则上以一个月为期进行整改，通过后项目按照原经费的百分之50%开展，如整改后仍不能通过检查，则项目终止。报销时，项目负责人收集报销凭证，按以下程序完成报销工作。

项目组负责人签字 → 指导教师签字 → 学院工作小组指定人员审核 →学院工作小组组长签字 → 项目组自行报销 → 学院工作小组指定人员记录报销结果

六、激励机制

第十八条

（1）对于进展良好、成效明显的项目，择优推荐参加省级各类大学生创新创业竞赛项目。

（2）国家级大学生创新创业训练计划项目实施过程中表现优秀的学生，经项目指导教师、项目所在学院工作小组同意，在同等条件下，建议作为免试攻读硕士研究生、奖学金评定的优先条件。

（3）学生参与的项目通过结题验收且项目研究内容与所学专业相关的，可在取得毕业论文指导老师和学院（系）同意的前提下，将研究成果进一步拓展为毕业论文（设计），论文选题审批程序及撰写等要求按照学校毕业论文相关管理规定执行。

（4）学校不定期组织大学生优秀创新创业成果展等交流宣传活动。

第十九条

（1）对大学生创新创业训练计划项目的指导作为汕头大学教师教学综合考核办法“本科生服务”工作内容，与教师教学综合考核办法挂钩。

（2）学校为结题的大学生创新创业训练计划项目指导教师按学校的“教学工作量计算办法”一次性计算其教学工作量。

（3）学校根据 “大学生创新创业训练计划项目”的开展情

况，不定期对组织得力、实施效果显著的单位和教师、学生给予表彰与奖励。

（4）各学院在项目立项、中期检查和验收过程中组织专家评审或答辩，可以参照《汕头大学劳务费和津贴补贴发放管理办法（暂行）》中“项目评审费”的标准，给予评审答辩专家（含牵头单位的非指导教师）发放评审费。评审费的支出由学院其他经费承担，不得在大学生创新创业训练计划项目中支出。

七、其他

第二十条 本办法解释权归汕头大学，具体解释工作由教务处承办。

第二十一条 本办法自公布之日起施行。原《汕头大学大学生创新创业训练计划项目管理办法》（汕大发〔2015〕40 号）同时废止。