研究生课程教学大纲（Syllabus）

课程代码 Course Code	PHY6006	*学时 Teaching Hours	64	*学分 Credits	4
*课程名称 Course Name	高等电动力学				
	Advanced Electrodynamics				
*授课语言 Instruction Language	中文（Chinese）				
*开课院系 School	物理与天文学院 （School of Physics and Astronomy）				
先修课程 Prerequisite	四大力学，数学物理方法。				
授课教师 Instructors	姓名 Name	职称 Title	单位 Department	联系方式 E-mail	
	孙弘	教授	物理与天文学院	hsun@sjtu.edu.cn	
*课程简介（中文）Course Description	除了复习和扩展本科阶段已学过的电动力学基础知识外，本课程将重点学习以下内容：具有色散和损耗介质体系内电磁场能量的表达形式；电磁场动量在光镊、冷原子准晶格体系中的应用；等离子体的随机相位近似求解；磁流体波；因果律和 Kramers-Kronig 关系；电磁场的矢量球面波本征解；电磁辐射和散射光的多极矩展开表示；托马斯进动和自旋-轨道角动量耦合；带电粒子在均匀电磁场中的运动；Cherenkov 辐射；渡越辐射；以及一般连续系统（包括电磁场）运动的拉格朗日和哈密顿方程表述。				
*课程简介（English）Course Description	In addition to reviewing and expanding the basic knowledge of electrodynamics learned at the undergraduate level, this course will focus on learning the following subjects: the expression form of electromagnetic field energy in a dispersive and lossy dielectric system; application of electromagnetic field momentum in designing optical tweezers and cold atom quasi-lattice systems; random phase approximate in solution of plasma systems; magnetohydrodynamic waves; causality and Kramers-Kronig relationship; vector spherical wave eigen-solutions of electromagnetic field; multipole moment expansion representation of electromagnetic radiation and scattered light; Thomas precession and spin-orbital angular momentum coupling; the motion of charged particles in a uniform electromagnetic field; Cherenkov radiation; transition radiation; and the Lagrangian and Hamiltonian equations of the motion of general continuous systems (including electromagnetic fields).				
*教学安排 Schedules	周次 Week	教学内容 Content	授课学时 Hours	教学方式 Format	授课教师 Instructor
	1	**Chapter 1: Review of the Maxwell Equations** 1-1 Maxwell's equations 1-2 Vector and scalar potentials, gauge transformations 1-3 Green's functions, and retarded wave solutions 1-4 Poynting's theorem and conservation of energy and momentum for a system of charged particles and electromagnetic fields	4	lecture	孙弘

	2	1-5 Application: optical tweezer and quasi-crystal with cold atoms 1-6 Poynting's theorem in linear dispersive media with losses 1-7 Transformations of electromagnetic fields under rotations, inversion and time-reversal 1-8 Application: magneto-electric effect, quantum mechanical time-reversal and its application in valleytronics	4	lecture	孙弘
	3	**Chapter 2: Wave Propagation** 2-1 Plane electromagnetic waves in non-conducting media 2-2 Linear and circular polarization of plane waves 2-3 Electromagnetic waves in conductors and media with losses 2-4 Frequency dispersions of dielectrics, conductors and plasmas	4	lecture	孙弘
	4	2-5 Random phase approximation 2-6 Magnetohydrodynamic waves 2-7 Superposition of waves in one dimension, group velocity 2-8 Superluminality	4	lecture	孙弘
	5	2-9 Causality in the connection between **D**(**r**, t) and **E**(**r**, t), Kramers-Kronig relation 2-10 Propagation of electromagnetic waves near the surface of and within a conductor	4	lecture	孙弘
	6	**Chapter 3: Radiating Systems** 3-1 Fields and radiation of a localized oscillating source 3-2 Spherical wave expansion of the Green's function for the Helmhotz's equation 3-3 Multipole expansion of electromagnetic fields in the source-free region of vacuum space	4	lecture	孙弘
	7	**Chapter 4: Light Scattering and Diffraction** 4-1 Light scattering at long wavelengths 4-2 Perturbation theory of scattering	4	lecture	孙弘
	8	4-3 Density fluctuation and critical opalescence 4-4 Light scattering at intermediate wavelength by a sphere	4	lecture	孙弘
	9	**Chapter 5: Special Theory of Relativity** 5-1 Lorentz transformations, 4D-velocity, and addition of velocities 5-2 Relativistic momentum and energy of a particle 5-3 Lorentz transformation matrixes	4	lecture	孙弘

	10	5-4 Invariance of electric charge, covariance of electrodynamics 5-5 Transformation of electromagnetic fields 5-6 Application: relativistic Doppler shift, Thomas precession and spin-orbital angular momentum interaction	4	lecture	孙弘
	11	**Chapter 6: Dynamics of Relativistic Particles and Electromagnetic Fields** 6-1 The electromagnetic force on a charged particle 6-2 Motion in a uniform, static magnetic field	4	lecture	孙弘
	12	6-3 Motion in arbitrary combined uniform, static electric and magnetic fields 6-4 Lagrangian and Hamiltonian for a relativistic charged particle in electromagnetic field	4	lecture	孙弘
	13	**Chapter 7: Radiation by Moving Charges** 7-1 Lienard-Wiechert potentials and fields for a point charge 7-2 Angular distribution of radiation emitted by an accelerated charge 7-3 Application: Synchrotron radiation facility and free electron lasers 7-4 Frequency distribution of energy radiated by an accelerated charge	4	lecture	孙弘
	14	7-5 Cherenkov radiation 7-6 Transition radiation 7-7 Appendix: The Maxwell equations in a medium and transformation of ε and μ	4	lecture	孙弘
	15	**Chapter 8: Lagrangian Mechanics for Continuous Systems** 8-1 From a discrete system to a continuous one 8-2 Lagrangian formulation for continuous systems 8-3 Conservation theorems of continuous systems 8-4 Hamiltonian formulation for continuous systems	4	lecture	孙弘
	16	8-5 Lagrangian and Hamiltonian formulation for electromagnetic fields 8-6 Canonical and symmetric stress tensor of electromagnetic fields 8-7 Examples of Hamiltonian formulation for quantum mechanical systems: Klein-Gordon and Schrodinger (or Dirac) equations	4	lecture	孙弘

*考核方式 Grading Policy	第 17-18 周开卷笔试，3 小时。 Open written examination for three hours in weeks 17-18.
*教材或参考资料 Textbooks & References	**参考书：** （1）J.D. Jackson (U.C. Berkeley), Classical Electrodynamics (1999, 3rd edition); （2）郭硕鸿，电动力学（2008，第三版，北京，高等教育出版社）
备注 Notes	

备注说明：

1．带*内容为必填项；

2．课程简介字数为 300-500 字；教学内容、进度安排等以表述清楚教学安排为宜，字数不限。