

## Calendar

SES #	TOPICS	READINGS	HOMEWORK
Lecture 1.	Introduction. Vectors, index notation for scalar and cross products. The symbols $\delta_{ij}$ and $\epsilon_{ijk}$ . Differential vector calculus. Gradient	Griffiths: Chapter 1 – skip section 1.1.5	Homework 1 is handed out.
Lecture 2.	Divergence and curl. Divergence of curl, and curl of gradient. Gauss and Stokes theorem. From $E^{\rightarrow}$ to $\Phi$ . Delta functions as singular distributions of charge.	Griffiths: Finish reading Chapter 1.	
Recitation 1.	Questions on homework # 1.		
Lecture 3.	Properties of delta functions. Delta function in spherical coordinates. The laplacian of $1/r$ . Coulomb's law and calculation of the electric field.		Homework 2 is available.
Lecture 4.	Deriving the electrostatic equations from Coulomb's law. Scalar Potential, and $E = -\nabla V$ . Examples of use of Gauss's law. Boundary conditions for electric field. Conductors.	Griffiths: from p.58 -82.	
Recitation 2.	Orthogonal curvilinear coordinates. Questions on homework 2.		
Lecture 5.	Electrostatic energy for discrete and continuous charge distributions. Energy as $\int  E ^2$ . Comments on self energy. Force computed by the method of virtual displacement. Generalized capacitance, capacitors.	Griffiths: from p.82 to end of Chapter 2.	Homework 2 due. Homework 3 is handed out.

Lecture 6.	Uniqueness of solutions. Green's theorem. Green's functions for the Dirichlet, Neumann and mixed BV problems.	Partial material in Griffiths: p.110-120 (you may consult Jackson sections 1.9 and 1.10, but it should not be really necessary)	
Recitation 3.	Mean value theorem. Go over homework 3.		
Lecture 7.	Example of Dirichlet Green's function. Mean value theorem. Images and conducting spheres. Separation of variables for Laplace's equation in cartesian coordinates.		Homework 3 due. Homework 4 is handed out.
Lecture 8.		Griffiths: p.121-137.	
Recitation 4.	Homework 4, energy and images.		
Lecture 9.	The case of axial symmetry, finding the basic solutions $r^l P_l$ and $r^{-(l+1)} P_l$ . Generating function for Legendre polynomials.	Griffiths: p.136-145.	Homework 4, due. Homework 5 is handed out.
Recitation 5.	Homework 5 discussed.		
Lecture 10.	Tensors under rotations. Multipole expansion.	Griffiths: p.146-155.	Homework 5 due. Hand out homework 6.
Lecture 11.	Dipoles, quadrupoles. Azimuthal symmetry. Magnetostatics, charge conservation and magnetic force.	Griffiths: p.202-232.	
Recitation 6.	Homework 6.		
Lecture 12.	Biot-Savart law. Magnetic potential for loops. Deriving the basic equations from the "inverse square law". The vector potential $A$ and the Coulomb gauge $\nabla \cdot A = 0$ .		Homework 6 is due. Hand out Homework 7.

Lecture 13.	Ampere's law. Boundary conditions for magnetic fields. Multipole expansion of the magnetic field, magnetic dipoles.	Griffiths: p.285-310	
Recitation 7.	Homework 7 discussed.		
Lecture 14.	Electromotive force and Faraday's law. Inductance, energy in magnetic fields, Maxwell equations.	Griffiths: p.310-328.	Homework 7 due.
Test 1.	One hour and a half test on the material including up to Homework 7.		
Lecture 15.	Energy in an external electric field. And Basics of magnetostatics.	J: p.142-143. And J: p.168-177.	Homework 6 is handed out.
Lecture 16.	Integral forms for magnetostatics. Magnetic multipoles. Relation between magnetic moment and angular momentum.	J: p.180-183.	
Lecture 17.	Dielectrics. The polarization vector $P$ and the effective charge density and surface charge. The modified Gauss' law in terms of $D$ and the free charge density. Slits in dielectrics. The field of a polarized sphere. Clausius-Mossoti equation.	J: p.143-155.	
Lecture 18.	Magnetic materials. Qualitative discussion of diamagnetism paramagnetism and ferro magnetism. The magnetization vector $M$ and its effective currents. The magnetic field strength $H$ .	Jackson: p.187-191.	Homework 7 is handed out.

Lecture 20.	Boundary value problems in magnetostatics with and without magnetic materials. Magnetic potential $\Phi_M$ . A uniformly magnetized sphere. And Faraday's law for fixed circuits.	Jackson: p.191-197; p.209-213.	
Lecture 21.	Faraday's law for moving circuits. The electromotive force or emf. Maxwell's equations. Energy conservation, energy in the electromagnetic field and energy flow. Poynting's theorem and the Poynting vector $S$ .	Jackson: p.217-219; p.236-237.	
Lecture 22.	Momentum in the electromagnetic field. The electromagnetic stress tensor $T_{ij}$ . Examples: pressure, force on a conductor and force on a solenoid. Derivation of the conservation law.	Jackson: p.238-239.	Homework 8 is handed out.
Lecture 23.	Example: Spinning up a charged cylinder. Conservation of angular momentum and flux of angular momentum.		
Lecture 24.	Solutions of Maxwell eqns. in terms of potentials. Gauge transformations. The Lorentz gauge and the wave equations for the potentials. Green's functions for the wave equation.	Jackson: p.219-226.	Homework 9 is handed out.
Lecture 25.	Retarded potentials. The information gathering sphere. Plane waves. Linear polarization. Complex vectors.	Jackson: p.269-275.	
Lecture 26.	Time average of bilinears. Energy flow in plane waves. Circular and elliptic polarization. Phase and group velocities. Dispersion.	Jackson: p.299-303.	

Test 2.	Covers up to the material in Homework 8.		
Lecture 27.	Wave propagation with metallic boundaries. Example: modes in rectangular waveguides. TE modes, cutoff frequencies, the dispersion relation, phase and group velocities.	Jackson: p.339-346. Begin with Lienard-Wiechert potentials.	
Lecture 28.	Derivation of the Lienard-Wiechert potentials. The fields of an arbitrarily moving charge. The fields of a charge moving with constant velocity.		Homework 10 is handed out.
Lecture 29.	Fields of a charge moving with a constant velocity $v \rightarrow c$ . The radiation term. Radiation from oscillatory charges. The expansion of the vector potential $\vec{A}$ in powers of $d/\lambda$ .	Jackson: p.391-394.	
Lecture 30.	Electric dipole radiation. The radiation field, the near fields. Radiated power. Example: charge in circular motion.	Jackson: p.394-401.	
Lecture 31.	Finish electric dipole radiation. Qualitative aspects of electric quadrupole and magnetic dipole radiation.		
Lecture 32.	Special relativity. Events, intervals: timelike and spacelike. Proper time. Lorentz transformations.	Jackson: p.506-521 or Landau and Lifshitz: p.1-12.	
Lecture 33.	Length contraction Lorentz tensors. The invariant tensors $\delta^{\nu}_{\mu}$ , $\epsilon^{\mu\nu\rho\sigma}$ and $g_{\mu\nu}$ .		

Lecture 34.	The four-vectors velocity, acceleration, and energy-momentum. Particle collisions. Relativistic form of electrodynamics. Particle motion in electromagnetic fields. The $F^{\mu\nu}$ tensor.	Jackson: p.547-552.	
Lecture 35.	Relativistic form of electrodynamics. The 4-vector potential and Maxwell equations. The stress energy tensor $T_{\mu\nu}$ . Covariance.	Jackson: p.604-606.	
Final Exam	Closed books and closed notes. Comprehensive, but with emphasis in the latter part of the course.		

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