Second Exam: There will be an exam Thursday, April 23, 2015 from 9:20–10:35 am in the usual classroom, LL311. The exam will be closed book and closed notes; both equation sheets posted on the course web site will be included on the exam. Any physical constants and integrals you need will be given on the exam. The transformation equations for the electric and magnetic fields will also be given.

What to Bring: You should bring a calculator. Don’t use a smart phone, a laptop, or a tablet computer during the exam.

Coverage: The exam covers all the reading we’ve had in Purcell through the end of chapter 7.

Subject Areas: The emphasis of the exam will be the material covered in class or homework. Go over carefully the homework solutions distributed in class. A list of topics and questions follows that you should be familiar with. This list is not necessarily complete but is representative.

- Know the common prefixes femto through Giga.
- Know the vector form of Coulomb’s Law. Know how to find the electric field or potential of several point charges.
- What is the principle of superposition?
- What is the relation between the electric field and the electric potential? Know how to evaluate the gradient.
- For a distribution of charges on a line, find \( \lambda \). Find \( \sigma \) or \( \rho \) for two- or three-dimensional distributions.
- Know how to integrate over a linear charge distribution to get the electric field or potential at an arbitrary point.
- Draw the electric field lines and the equipotential lines of a point charge. Do the same for a dipole. What is an equipotential surface?
- What is the electric field of an infinite sheet of charge? Use this result to find the electric field between the parallel plates of a capacitor.
- What is the energy density in an electric or a magnetic field? How much energy is stored in a charged capacitor? in an inductor?
- What are the magnetic and electric flux? Know how to evaluate them. What does it mean to do a surface integral \( \int \mathbf{E} \cdot d\mathbf{a} \) or \( \int \mathbf{B} \cdot d\mathbf{a} \)? What is the convention for the direction of \( d\mathbf{a} \) if the surface is closed?
- What is Gauss’s Law? Be able to use it to find the field of a spherical, planar, cylindrical, or linear charge distribution.
- Know how to find the potential energy of a charge distribution. Know how to find the potential of a charge distribution. What is the difference?
- What is the difference between an insulator and a conductor?
- What is the electric field inside a conductor (when charges don’t move). What is current? What is the relation between the current, the drift velocity, and the rms motion of electrons in a conductor? What is the current density? What is the relation between current density and the electric field?
- In a circuit diagram, what are the symbols for battery, capacitor, inductor, and resistance? Know how to indicate the + and – terminals of a battery.
- What is Ohm’s Law? How much power is dissipated when a current passes through a resistor?
- What is the difference between resistivity and resistance? What is the relation between them?
- How does a current divide when it branches to flow through two resistors in parallel?
- How do the charges arrange themselves on two capacitors in parallel? in series? What is the effective capacitance for two capacitors in series or parallel? What about resistors?
- Know how to find the charges on a network of capacitors.
- What is a line integral like \( \int \mathbf{E} \cdot ds \)? Know how to evaluate it.
- What are Kirchhoff’s Rules? Know how to write the loop and junction (node) equations that we discussed in class for any circuit. Know how to find the potential difference between any two points on an electric circuit.
- Know how to write the loop equation for an \( RC \) or an \( RL \) circuit. What is the time constant for such a circuit? Know what the functions \( \exp(-t/\tau) \) and \( 1 - \exp(-t/\tau) \) look like. With what time dependence does charge build up on a capacitor? With what time dependence does a capacitor discharge? With what dependence does the current through an inductor build up after a battery is connected? Know how to account for where all the power goes from a battery in the circuit.
- Know how to verify that a given solution satisfies the loop equations for a circuit.
- Know how to account for the energy stored in the capacitor or lost in the resistor of an \( RC \) circuit.
- What is the total force on a charged particle in an electric and magnetic field? Why does a charged particle moving parallel to a long, current-carrying wire experience a force perpendicular to the wire? Does the answer depend on which inertial frame the observer is in?
• In a magnetic field: What is the force on a moving charged particle? What is the force on a current? How does a velocity selector work?

• What are the total force and torque on a current loop? What is the magnetic moment?

• Be able to use the right hand rule to get the direction of magnetic fields or of cross products. Know how to evaluate the cross product $\mathbf{A} \times \mathbf{B}$ if you are given the components of $\mathbf{A}$ and $\mathbf{B}$.

• What does the magnetic field of a current loop look like?

• Be able to use the Biot-Savart Law.

• Know why a charged particle can exhibit circular or spiral motion in a magnetic field.

• What is Faraday’s Law? What is Lenz’s Law? Know how to apply them.

• What is mutual inductance? Know how to calculate it. What is self inductance? Why does a solenoid exhibit self inductance?

• What is Ampere’s Law? Know how to use it to find the magnetic field inside and outside of a long straight wire with finite radius.

• What do “transient” and “steady state” mean?

• Why are there oscillations in an $LC$ circuit? What is the resonant frequency? Be able to track where the energy is during the oscillations.

• Know where to find Maxwell’s Equations on the E&M equation sheet.

• Understand how to apply the Lorentz transformation of the electric and magnetic fields.

• If you are given a description of certain electromagnetic phenomena from the viewpoint of an observer in one inertial frame, you should be able to describe the same set of events from the viewpoint of another observer in a different inertial frame.