



Introductory Physics

U.C. Berkeley

Physics 8B, Fall 2011

Section I

Exam 2

December 9, 2011

Notes: Correct answers without supporting derivations will not receive credit. You **must** show your work, and partial credit will be given. Answer the questions in your blue book. Please be clear and neat, and **indicate your final answer**. Ask for assistance if any problem is unclear.

No electronics aids of any type are permitted on this exam. Electronic aids include calculators, computers, cell phones, etc.

Make sure you list your Name, SID, Section Number and Section Time in your Blue Book.

Possibly Useful Formulas

Force on a charged particle $\mathbf{F} = q\mathbf{E} + q\mathbf{v} \times \mathbf{B}$	Electric field from a plane $E = \frac{\sigma}{2\epsilon_0}$	Electric Field from a point $E = \frac{q}{4\pi\epsilon_0 r^2}$
Gauss's Law $\epsilon_0 \int \mathbf{E} \cdot d\mathbf{A} = q_{\text{enc}}$	Potential difference $\Delta V = -\int \mathbf{E} \cdot d\mathbf{x}$	Electric field from a line charge $E = \frac{\lambda}{2\pi\epsilon_0 r}$
Electric field between two oppositely charged planes $E = \frac{\sigma}{\epsilon_0}$	Power $P = IV$	Ohm's Law $V = IR$
Electric energy density $U = \frac{1}{2}\epsilon_0 E^2$	Resistance $R = \frac{\rho L}{A}$	Microscopic Resistance $\rho = \frac{2mv}{e^2 n \lambda}$
Capacitor formula $Q = CV$	Energy in a capacitor $U = \frac{1}{2} CV^2$	Parallel plate capacitance $C = \epsilon_0 \frac{A}{d}$
Resistors in series $R = R_1 + R_2$	Resistors in parallel $R = \frac{R_1 R_2}{R_1 + R_2}$	RC time constant $\tau = RC$
Discharge of a capacitor $Q(t) = Q_0 e^{-t/\tau}$	Capacitor charging $Q(t) = Q_0 (1 - e^{-t/\tau})$	Biot-Savart law $\mathbf{B} = \frac{\mu_0 I}{4\pi} \int \frac{d\mathbf{l} \times \mathbf{r}}{r^3}$
Ampere's law $\oint \mathbf{B} \cdot d\mathbf{l} = \mu_0 I + \mu_0 \epsilon_0 \frac{d\Phi_E}{dt}$	Field from a straight wire $\mathbf{B} = \frac{\mu_0 I}{2\pi r} \hat{\phi}$	Radius of orbit in uniform magnetic field $r = \frac{mv}{qB}$
Force on a wire $\mathbf{F} = I\mathbf{L} \times \mathbf{B}$	Magnetic Moment $\mu = NI A$	Torque on a magnetic moment $\tau = \mu \times \mathbf{B}$
Field in a solenoid $B = \mu_0 n I$	Field at the center of a loop of radius R $B = \frac{\mu_0 I}{2R}$	Magnetic energy density $U = \frac{1}{2\mu_0} B^2$
Lenz's law $\mathcal{E} = -\frac{d\Phi_B}{dt}$	Faraday's law $\oint \mathbf{E} \cdot d\mathbf{l} = -\frac{d\Phi_B}{dt}$	Inductive EMF $V = -L \frac{dI}{dt}$
Inductance of a solenoid $L = \mu_0 n^2 A l$	RL time constant $\tau = \frac{L}{R}$	Flux in an inductor $\Phi = LI$

Discharge of an inductor $I(t) = I_0 e^{-t/\tau}$	Inductor charging $I(t) = I_0 (1 - e^{-t/\tau})$	Transformer ratio $I_2 = \frac{N_1}{N_2} I_1$ $V_2 = \frac{N_2}{N_1} V_1$
Energy stored in an inductor $U = \frac{1}{2} LI^2$	LC time constant $\omega = \frac{1}{\sqrt{LC}}$	"Magnetic" Gauss's Law $\int \mathbf{B} \cdot d\mathbf{A} = 0$
Speed of Light $c = \frac{1}{\sqrt{\epsilon_0 \mu_0}}$	Snell's Law $n_1 \sin \theta_1 = n_2 \sin \theta_2$	Total internal reflection $\theta_c = \sin^{-1} \frac{n_2}{n_1}$
Lens/Mirror formula $\frac{1}{f} = \frac{1}{s_o} + \frac{1}{s_i}$	Magnification $\frac{h_i}{h_o} = \frac{s_i}{s_o}$	Wavelength transformation $\lambda_n = \frac{\lambda}{n}$
Two slit maxima $d \sin \theta = m\lambda, \quad m = 0, 1, 2, \dots$	Two slit minima $d \sin \theta = (m + \frac{1}{2})\lambda,$ $m = 0, 1, 2, \dots$	Soap film interference maxima $\frac{2dn}{\lambda \sin \theta} = (m + \frac{1}{2}),$ $m = 0, 1, 2, \dots$
Soap film interference minima $\frac{2dn}{\lambda \sin \theta} = m, \quad m = 0, 1, 2, \dots$	Single slit diffraction minima $d \sin \theta = m\lambda, \quad m = 0, 1, 2, \dots$	Circular aperture diffraction $\sin \theta = 1.22 \frac{\lambda}{d}$

$c = 3 \times 10^8 \text{ m/s}$	$\epsilon_0 = 8.85 \times 10^{-12} \text{ F/m}$	$\mu_0 = 4\pi \times 10^{-7} \text{ H/m}$
$e = 1.6 \times 10^{-19} \text{ C}$	$m_{\text{electron}} = 9.11 \times 10^{-31} \text{ kg}$	$m_{\text{proton}} = 1.67 \times 10^{-27} \text{ kg}$
$k = 1.38 \times 10^{-23} \text{ J/K}$	$h = 6.63 \times 10^{-34} \text{ J} \cdot \text{s}$	$1 \text{ eV} = 1.6 \times 10^{-19} \text{ J}$

Note that all constants are given just for reference; you need not plug in the numeric values of the constants unless you are explicitly directed to give a purely numeric answer.

Kirchhoff's Rules

1. Wires carry currents without changing potentials
2. Traversing a battery increases the potential by the EMF of the battery.
3. Resistors decrease the potential by IR .
4. Current is conserved at a junction
5. The net potential difference along any closed circuit is zero.

Problem 1: [25 points]

A time $t=0$, a current I_0 is passing through the inductor L in the circuit below.

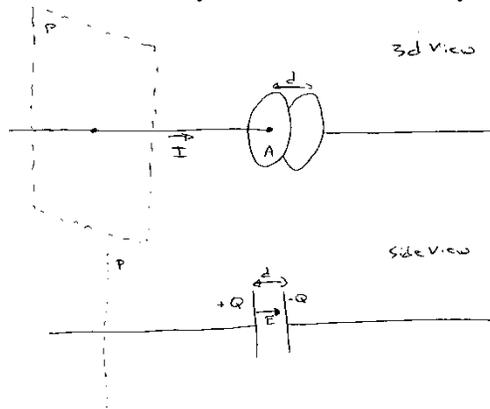
- What is the voltage across the inductor at time $t=0$? Make sure that you indicate the sign (draw it on a circuit diagram.)
- What would be the current in the inductor when the energy in the inductor has dropped by a factor of two?
- What would be the voltage across the inductor when the energy in the inductor has dropped by a factor of two? Make sure that you indicate the sign (draw it on a circuit diagram.) (There are two very different ways to calculate this voltage. Do both for extra credit.)



Problem 2: [25 points]

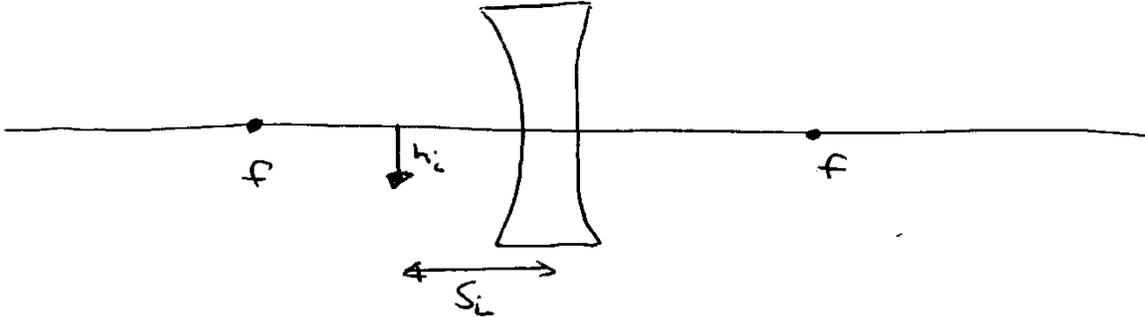
A capacitor consisting of two circular plates of area A and separation d can be modeled as a perfect parallel plate capacitor; the electric field E in between the plates is uniform, and the electric field outside the region between the plates is zero.

- Find the charge Q on the plates as a function of the electric field E between the plates.
- Now assume a current I is flowing onto the plates. How is I related to Q ?
- Find an expression for I which depends on some or all of the parameters A , d , E , and fundamental constants.
- Now write this expression for I in terms of the electric flux Φ_E .
- Will there be a magnetic field created by this electric flux? Fully explain your answer.



Problem 3: [25 points]

For the lens shown below, and the indicated *image*, find the position of the object by ray tracing. Is the image real or virtual? Magnified or demagnified? Then, using your ray diagram, derive the equation relating the position of the object s_o to the position of the image s_i and the focal length f .



Problem 4: [25 points]

A diver is standing on the ocean floor looking at a fish, as shown below. This fish is at the same height as the diver's eyes, and the diver's head is level and remains level throughout this problem. The diver wears a facemask which has a viewport made from completely flat glass. Why does wearing a face mask help the diver see the fish? Fully explain your answer. Next, the diver shifts his gaze to the starfish on the ocean floor. If the diver reaches out to pick up the starfish, will the starfish be in the position that the diver "sees" it to be? Fully explain your answer: drawing a ray diagram may help you answer the question.

