Introductory Physics
U.C. Berkeley
Physics 8B, Fall 2011
Section I
Exam 1
October 5, 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 $F = q E + q v \times B$	Electric field from a plane $E = \dfrac{\sigma}{2\varepsilon_0}$	Electric Field from a point $E = \dfrac{q}{4\pi\varepsilon_0 r^2}$
Gauss's Law $\varepsilon_0 \int E \cdot dA = q_{enc}$	Potential difference $\Delta V = -\int E \cdot dx$	Electric field from a line charge $E = \dfrac{\lambda}{2\pi\varepsilon_0 r}$
Electric field between two oppositely charged planes $E = \dfrac{\sigma}{\varepsilon_0}$	Power $P = IV$	Ohm's Law $V = IR$
Electric energy density $U = \dfrac{1}{2}\varepsilon_0 E^2$	Resistance $R = \dfrac{\rho L}{A}$	Microscopic Resistance $\rho = \dfrac{2mv}{e^2 n\lambda}$
Capacitor formula $Q = CV$	Energy in a capacitor $U = \dfrac{1}{2} CV^2$	Parallel place capacitance $C = \varepsilon_0 \dfrac{A}{d}$
Resistors in series $R = R_1 + R_2$	Resistors in parallel $R = \dfrac{R_1 R_2}{R_1 + R_2}$	RC time constant $\tau = RC$
Discharge of a capacitor $Q(t) = Q_0 e^{-t/\tau}$	Capacitor charging $Q(t) = Q_0 \left(1 - e^{-t/\tau}\right)$	Biot-Savart law $B = \dfrac{\mu_0 I}{4\pi}\int \dfrac{dl \times r}{r^3}$
Ampere's law $\oint B \cdot dl = \mu_0 I + \mu_0 \varepsilon_0 \dfrac{d\Phi_E}{dt}$	Field from a straight wire $B = \dfrac{\mu_0 I}{2\pi r}\hat\theta$	Radius of orbit in uniform magnetic field $r = \dfrac{mv}{qB}$
Force on a wire $F = IL \times B$	Magnetic Moment $\mu = NIA$	Torque on a magnetic moment $\tau = \mu \times B$
Field in a solenoid $B = \mu_0 nI$	Field at the center of a loop of radius R $B = \dfrac{\mu_0 I}{2R}$	Magnetic energy density $U = \dfrac{1}{2\mu_0} B^2$
Lenz's law $\mathcal{E} = -\dfrac{d\Phi_B}{dt}$	Faraday's law $\oint E \cdot dl = -\dfrac{d\Phi_B}{dt}$	Inductive EMF $V = -L\dfrac{dI}{dt}$
Inductance of a solenoid $L = \mu_0 n^2 Al$	RL time constant $\tau = \dfrac{L}{R}$	Flux in an inductor $\Phi = LI$

Discharge of an inductor	Inductor charging	Transformer ratio
$I(t) = I_0 e^{-t/\tau}$	$I(t) = I_0\left(1 - e^{-t/\tau}\right)$	$I_2 = \dfrac{N_1}{N_2} I_1 \quad V_2 = \dfrac{N_2}{N_1} V_1$

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$c = 3 \times 10^8 \,\text{m/s}$	$\varepsilon_0 = 8.85 \times 10^{-12} \,\text{F/m}$	$\mu_0 = 4\pi \times 10^{-7} \,\text{H/m}$
$e = 1.6 \times 10^{-19} \,\text{C}$	$m_{\text{electron}} = 9.11 \times 10^{-31} \,\text{kg}$	$m_{\text{proton}} = 1.67 \times 10^{271} \,\text{kg}$
$k = 1.38 \times 10^{-23} \,\text{J/K}$	$h = 6.63 \times 10^{-34} \,\text{J} \cdot \text{s}$	$1 \,\text{eV} = 16 \times 10^{-19} \,\text{J}$

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]

Stationary charges $+Q$ and $-Q$ are separated by a distance of 4m as shown below in the diagram. A test charge $+q$, which starts 3m to the right of the $+Q$ charge, is moved along the path shown to a final position 3m above the $+Q$. What is the work done on the test charge?
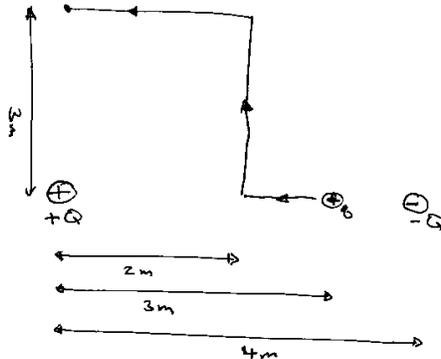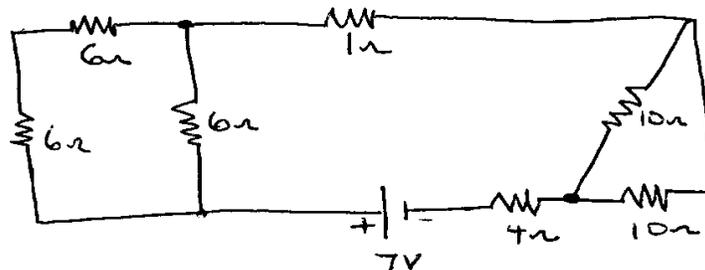

Problem 2: [25 points]

An infinite slab of thickness d has a uniform charge density ρ. Give formulas for the electric field everywhere.

Problem 3: [25 points]

On the circuit diagram below (redraw the diagram in your blue book), indicate the voltage drop across every resistor. Also indicate which end of each resistor is positive (at higher potential) relative to the other end.

Problem 4: [25 points]

A metal bar slides on metal rails with velocity v as shown in the diagram below. The rails are separated by distance d. The system in immersed in a uniform magnetic field oriented as shown. How much charge is on the capacitor C? What sign of charge is on the top plate of the capacitor? (Ignore the self-inductance of the loop. If you don't understand this comment, don't worry about it.)