Name $\qquad$
Physics 111 Quiz \#4, February 4, 2011
Please show all work, thoughts and/or reasoning in order to receive partial credit. The quiz is worth 10 points total.

1. Suppose that you connect a light bulb (of resistance $R$ ) to a battery (of potential $V$ ) that produces a current $I$. If you were to wire a string of 100 identical light bulbs in parallel and wire this combination to the same battery, compared to the brightness of the single light bulb, the brightness of these 100 bulbs will be
a. dimmer than the single bulb.
b. the same brightness as the single bulb.
c. brighter than the single bulb.
d. impossible to predict since we don't know the exact current or battery voltage.

2a. A proton with a speed of $3.5 \times 10^{6}-\mathrm{m} / \mathrm{s}$ is shot into a region between two plates that are separated by a distance of $0.23-\mathrm{m}$. There is a magnetic field between the plates, as shown, and this field is perpendicular to the proton's velocity. What is the magnitude of the magnetic field needed so that the proton just misses colliding with the opposite plate? Which way will the proton move in the magnetic field?

The magnetic force will cause the proton to bend in an upward
circle and the magnetic field is given by

$$
F_{b}=q v B=m \frac{v^{2}}{r} \rightarrow B=\frac{m v}{q r}=\frac{1.67 \times 10^{-27} \mathrm{~kg} \times 3.5 \times 10^{6} \frac{\mathrm{~m}}{s}}{1.6 \times 10^{-19} \mathrm{C} \times 0.23 \mathrm{~m}}=0.16 \mathrm{~T}
$$



2 b . A single-turn square coil of wire has sides of length $0.32-\mathrm{m}$ and a current of $12-A$ flows in clockwise in the coil. If the coil is placed in a $0.25-T$ magnetic field where the magnetic field is parallel to the plane of the coil, what are the magnetic forces on each of the four sides? Be sure to specify your sides and forces carefully.
$F_{\text {left }}=F_{\text {right }}=0$
$F_{\text {top }}=F_{\text {botoom }}=I L B=12 \mathrm{~A} \times 0.32 \mathrm{~m} \times 0.25 \mathrm{~T}=0.96 \mathrm{~N}$
and $F_{\text {top }}$ is directed out of the page and $F_{\text {bottom }}$ is directed into the page.


## Physics 111 Equation Sheet

Electric Forces, Fields and Potentials

$$
\begin{aligned}
& \vec{F}=k \frac{Q_{1} Q_{2}}{r^{2}} \hat{r} \\
& \vec{E}=\frac{\vec{F}}{q} \\
& \vec{E}_{Q}=k \frac{Q}{r^{2}} \hat{r} \\
& P E=k \frac{Q_{1} Q_{2}}{r} \\
& V(r)=k \frac{Q}{r} \\
& E_{x}=-\frac{\Delta V}{\Delta x} \\
& W_{A, B}=q \Delta V_{A, B}
\end{aligned}
$$

Magnetic Forces and Fields

$$
\begin{aligned}
& F=q v B \sin \theta \\
& F=I l B \sin \theta \\
& \tau=N I A B \sin \theta=\mu B \sin \theta \\
& P E=-\mu B \cos \theta \\
& B=\frac{\mu_{0} I}{2 \pi r} \\
& \varepsilon_{\text {induced }}=-N \frac{\Delta \phi_{B}}{\Delta t}=-N \frac{\Delta(B A \cos \theta)}{\Delta t}
\end{aligned}
$$

Constants
$g=9.8 \frac{\mathrm{~m}}{\mathrm{~s}^{2}}$
$1 e=1.6 \times 10^{-19} \mathrm{C}$
$k=\frac{1}{4 \pi \varepsilon_{o}}=9 \times 10^{9} \frac{\mathrm{C}^{2}}{\mathrm{Nm}}{ }^{2}$
$\varepsilon_{o}=8.85 \times 10^{-12} \frac{\mathrm{~N} m^{2}}{\mathrm{C}^{2}}$
$1 \mathrm{eV}=1.6 \times 10^{-19} \mathrm{~J}$
$\mu_{o}=4 \pi \times 10^{-7} \frac{\mathrm{Tm}^{4}}{A}$
$c=3 \times 10^{8} \frac{\mathrm{~m}}{\mathrm{~s}}$
$h=6.63 \times 10^{-34} \mathrm{JS}$
$m_{e}=9.11 \times 10^{-31} \mathrm{~kg}=\frac{0.511 \mathrm{MeV}}{c^{2}}$
$m_{p}=1.67 \times 10^{-27} \mathrm{~kg}=\frac{937.1 \mathrm{MeV}}{c^{2}}$
$m_{n}=1.69 \times 10^{-27} \mathrm{~kg}=\frac{948.3 \mathrm{MeV}}{c^{2}}$
$1 \mathrm{amu}=1.66 \times 10^{-27} \mathrm{~kg}=\frac{931.5 \mathrm{MeV}}{c^{2}}$
$N_{A}=6.02 \times 10^{23}$
$A x^{2}+B x+C=0 \rightarrow x=\frac{-B \pm \sqrt{B^{2}-4 A C}}{2 A}$

Electric Circuits

$$
\begin{aligned}
& I=\frac{\Delta Q}{\Delta t} \\
& V=I R=I\left(\frac{\rho L}{A}\right) \\
& R_{\text {series }}=\sum_{i=1}^{N} R_{i} \\
& \frac{1}{R_{\text {parallel }}}=\sum_{i=1}^{N} \frac{1}{R_{i}} \\
& P=I V=I^{2} R=\frac{V^{2}}{R} \\
& Q=C V=\left(\frac{\kappa \varepsilon_{0} A}{d}\right) V=\left(\kappa C_{0}\right) V \\
& P E=\frac{1}{2} Q V=\frac{1}{2} C V^{2}=\frac{Q^{2}}{2 C} \\
& Q_{\text {charge }}(t)=Q_{\max }\left(1-e^{-\frac{t}{R C}}\right) \\
& Q_{\text {discharge }}(t)=Q_{\max } e^{-\frac{t}{R C}} \\
& C_{\text {paralel }}=\sum_{i=1}^{N} C_{i} \\
& \frac{1}{C_{\text {series }}}=\sum_{i=1}^{N} \frac{1}{C_{i}}
\end{aligned}
$$

Light as a Particle \& Relativity

$$
\begin{aligned}
& E=h f=\frac{h c}{\lambda}=p c \\
& K E_{\max }=h f-\phi=e V_{\text {stop }} \\
& \Delta \lambda=\frac{h}{m_{e} c}(1-\cos \phi) \\
& \gamma=\frac{1}{\sqrt{1-\frac{v^{2}}{c^{2}}}} \\
& p=\gamma m v \\
& E_{\text {total }}=K E+E_{r e s t}=\gamma m c^{2} \\
& E_{\text {total }}^{2}=p^{2} c^{2}+m^{2} c^{4} \\
& E_{\text {rest }}=m c^{2}
\end{aligned}
$$

Geometry
Misc. Physics 110 Formulae
$\vec{F}=\frac{\Delta \vec{p}}{\Delta t}=\frac{\Delta(m v)}{\Delta t}=m \vec{a}$
$\vec{F}=-k \vec{y}$
$\vec{F}_{C}=m \frac{v^{2}}{R} \hat{r}$
$W=\Delta K E=\frac{1}{2} m\left(v_{f}^{2}-v_{i}^{2}\right)=-\Delta P E$
$P E_{g r a v i t y}=m g y$
$A=\pi r^{2} P E_{\text {spring }}=\frac{1}{2} k y^{2}$
Circles: $C=2 \pi r=\pi D$
Light as a Wave
$c=f \lambda=\frac{1}{\sqrt{\varepsilon_{o} \mu_{o}}}$
$S(t)=\frac{\text { energy }}{\text { time } \times \text { area }}=c \varepsilon_{o} E^{2}(t)=c \frac{B^{2}(t)}{\mu_{0}}$
$I=S_{\text {avg }}=\frac{1}{2} c \varepsilon_{o} E_{\text {max }}^{2}=c \frac{B_{\text {max }}^{2}}{2 \mu_{0}}$
$P=\frac{S}{c}=\frac{\text { Force }}{\text { Area }}$
$S=S_{o} \cos ^{2} \theta$
$v=\frac{1}{\sqrt{\varepsilon \mu}}=\frac{c}{n}$
$\theta_{\text {inc }}=\theta_{\text {ref } l}$
$n_{1} \sin \theta_{1}=n_{2} \sin \theta_{2}$
$\frac{1}{f}=\frac{1}{d_{o}}+\frac{1}{d_{i}}$
$M=\frac{h_{i}}{h_{o}}=-\frac{d_{i}}{d_{o}}$
$M_{\text {total }}=\prod_{i=1}^{N} M_{i}$
$d \sin \theta=m \lambda$ or $\left(m+\frac{1}{2}\right) \lambda$
$a \sin \phi=m^{\prime} \lambda$
Nuclear Physics

$$
\begin{aligned}
& \left.E_{\text {binding }}=\left(Z m_{p}+N m_{n}-m_{\text {rest }}\right)\right)^{2} \\
& \frac{\Delta N}{\Delta t}=-\lambda N_{o} \rightarrow N(t)=N_{o} e^{-\lambda t} \\
& A(t)=A_{o} e^{-\lambda t} \\
& m(t)=m_{o} e^{-\lambda t} \\
& t_{\frac{1}{2}}=\frac{\ln 2}{\lambda}
\end{aligned}
$$

$$
K E=(\gamma-1) m c^{2}
$$

Triangles: $\quad A=\frac{1}{2} b h$
Spheres: $A=4 \pi r^{2} \quad V=\frac{4}{3} \pi r^{3}$

