Name $\qquad$
Physics 111 Quiz \#3, January 31, 2014
Please show all work, thoughts and/or reasoning in order to receive partial credit. The quiz is worth 10 points total.

I affirm that I have carried out my academic endeavors with full academic honesty.

A circuit is shown below where all the resistors are $R=75 \Omega$ and they are connected to a $V=12 \mathrm{~V}$ battery.
a. What is the equivalent resistance of the circuit?

Resistors $R_{1}, R_{2}$, and $R_{3}$ are in series and their equivalent resistance is

$$
R_{123}=R_{1}+R_{2}+R_{3}=3 R_{1}=3 \times 75 \Omega=225 \Omega .
$$

Resistors $R_{4}$ and $R_{5}$ are in series and their equivalent resistance is $R_{45}=R_{4}+R_{5}=2 R_{4}=2 \times 75 \Omega=150 \Omega$.

Resistors $R_{123}$ and $R_{45}$ are in parallel and their equivalent resistance is


$$
\frac{1}{R_{12345}}=\frac{1}{R_{123}}+\frac{1}{R_{45}} \rightarrow R_{12345}=\left(\frac{1}{R_{123}}+\frac{1}{R_{45}}\right)^{-1}=\left(\frac{1}{225 \Omega}+\frac{1}{150 \Omega}\right)^{-1}=90 \Omega .
$$

Resistors $R_{12345}$ and $R_{6}$ are in series and this is the equivalent resistance of the circuit. Thus we have $R_{e q}=R_{123456}=R_{12345}+R_{6}=90 \Omega+75 \Omega=165 \Omega$.
b. What is the total current produced by the battery?

$$
I_{\text {total }}=\frac{V}{R_{e q}}=\frac{12 \mathrm{~V}}{165 \Omega}=0.073 \mathrm{~A}=73 \mathrm{~mA}
$$

c. What is the potential drop across $R_{6}$ ?

$$
V_{6}=I_{\text {total }} R_{6}=0.073 \mathrm{~A} \times 75 \Omega=5.45 \mathrm{~V}
$$

d. What is the current between resistors $R_{2}$ and $R_{3}$ ?

The potential difference across the combination of resistors $R_{1}, R_{2}$, and $R_{3}$ is given by $V_{123}=V_{B}-V_{6}=12 \mathrm{~V}-5.45 \mathrm{~V}=6.55 \mathrm{~V}$. The current between resistors $R_{2}$ and $R_{3}$ is given by $I_{123}=\frac{V_{123}}{R_{123}}=\frac{6.55 \mathrm{~V}}{225 \Omega}=0.029 \mathrm{~A}=29 \mathrm{~mA}$.
e. What is the power dissipated as heat across $R_{5}$ ?

The power dissipated across resistor $R_{5}$ is given by
$P_{5}=I_{45}^{2} R_{5}=(0.044 \mathrm{~A})^{2} \times 75 \Omega=0.145 \mathrm{~W}=145 \mathrm{~mW}$, where
$I_{45}=I_{\text {total }}-I_{123}=73 \mathrm{~mA}-29 \mathrm{~mA}=44 \mathrm{~mA}=0.044 \mathrm{~A}$.

## 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
$F=q \nu B \sin \theta$
$F=I l B \sin \theta$
$\tau=N I A B \sin \theta=\mu B \sin \theta$
$P E=-\mu B \cos \theta$
$B=\frac{\mu_{0} I}{2 \pi r}$
$\varepsilon_{\text {induced }}=-N \frac{\Delta \phi_{B}}{\Delta t}=-N \frac{\Delta(B A \cos \theta)}{\Delta t}$
Constants
$g=9.8 \frac{\mathrm{~m}}{\mathrm{~s}^{2}}$
$1 e=1.6 \times 10^{-19} \mathrm{C}$
$k=\frac{1}{4 \pi \varepsilon_{o}}=9 \times 10^{9} \frac{\mathrm{C}^{2}}{\mathrm{Nm}}{ }^{2}$
$\varepsilon_{o}=8.85 \times 10^{-12} \frac{\mathrm{Nn}{ }^{2}}{\mathrm{C}^{2}}$
$1 \mathrm{eV}=1.6 \times 10^{-19} \mathrm{~J}$
$\mu_{o}=4 \pi \times 10^{-7} \frac{\mathrm{~T}_{m}}{\mathrm{~A}}$
$c=3 \times 10^{8} \frac{\mathrm{~m}}{\mathrm{~s}}$
$h=6.63 \times 10^{-34} \mathrm{Js}$
$m_{e}=9.11 \times 10^{-31} \mathrm{~kg}=\frac{0.511 \mathrm{MeV}}{c^{2}}$
$m_{p}=1.67 \times 10^{-27} \mathrm{~kg}=\frac{937.1 \mathrm{MeV}}{c^{2}}$
$m_{n}=1.69 \times 10^{-27} \mathrm{~kg}=\frac{948.3 \mathrm{MeV}}{c^{2}}$
$1 \mathrm{amu}=1.66 \times 10^{-27} \mathrm{~kg}=\frac{931.5 \mathrm{MeV}}{c^{2}}$
$N_{A}=6.02 \times 10^{23}$
$A x^{2}+B x+C=0 \rightarrow x=\frac{-B \pm \sqrt{B^{2}-4 A C}}{2 A}$

Electric Circuits

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

Light as a Particle \& Relativity

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

Geometry
Circles: $C=2 \pi r=\pi D$

$$
A=\pi r^{2}
$$

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

Light as a Wave

$$
\begin{aligned}
& c=f \lambda=\frac{1}{\sqrt{\varepsilon_{o} \mu_{o}}} \\
& S(t)=\frac{\text { energy }}{\text { time } \times \text { area }}=c \varepsilon_{o} E^{2}(t)=c \frac{B^{2}(t)}{\mu_{0}} \\
& I=S_{\text {avg }}=\frac{1}{2} c \varepsilon_{o} E_{\text {max }}^{2}=c \frac{B_{\text {max }}^{2}}{2 \mu_{0}} \\
& P=\frac{S}{c}=\frac{F o r c e}{\text { Area }} \\
& S=S_{o} \cos ^{2} \theta \\
& v=\frac{1}{\sqrt{\varepsilon \mu}}=\frac{c}{n} \\
& \theta_{\text {inc }}=\theta_{\text {ref } l} \\
& n_{1} \sin \theta_{1}=n_{2} \sin \theta_{2} \\
& \frac{1}{f}=\frac{1}{d_{o}}+\frac{1}{d_{i}} \\
& M=\frac{h_{i}}{h_{o}}=-\frac{d_{i}}{d_{o}} \\
& M_{\text {total }}=\prod_{i=1}^{N} M_{i} \\
& d \sin \theta=m \lambda \text { or }\left(m+\frac{1}{2}\right) \lambda \\
& a \sin \phi=m^{\prime} \lambda \\
& N u c l e a r ~ P h y s i c s \\
& \left.E_{\text {binding }}=\left(Z m_{p}+N m_{n}-m_{\text {rest }}\right)\right)^{2} \\
& \frac{\Delta N}{\Delta t}=-\lambda N_{o} \rightarrow N(t)=N_{o} e^{-\lambda t} \\
& A(t)=A_{o} e^{-\lambda t} \\
& m(t)=m_{o} e^{-\lambda t} \\
& t_{\frac{1}{2}}=\frac{\ln 2}{\lambda}
\end{aligned}
$$

Misc. Physics 110 Formulae

$$
\vec{F}=\frac{\Delta \vec{p}}{\Delta t}=\frac{\Delta(m v)}{\Delta t}=m \vec{a}
$$

$$
\vec{F}=-k \vec{y}
$$

$$
\vec{F}_{C}=m \frac{v^{2}}{R} \hat{r}
$$

$$
W=\Delta K E=\frac{1}{2} m\left(v_{f}^{2}-v_{i}^{2}\right)=-\Delta P E
$$

$$
P E_{g r a v i t y}=m g y
$$

$$
P E_{\text {spring }}=\frac{1}{2} k y^{2}
$$

$x_{f}=x_{i}+v_{i x} t+\frac{1}{2} a_{x} t^{2}$
$v_{f x}=v_{i x}+a_{x} t$
$v_{f x}^{2}=v_{i x}^{2}+2 a_{x} \Delta x$

