Name $\qquad$
Physics 111 Quiz \#2, January 18, 2019
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.

1. Suppose that you have the distribution of charges shown below. At what position (or positions) expressed in terms of the variable $d$, would the electric field be zero? Take the origin of the coordinate system to be located at the $+Q$ charge.

$$
\begin{aligned}
& E_{n e t}=E_{+}-E_{-}=\frac{k Q}{x^{2}}-\frac{k Q / 2}{(x-d)^{2}}=0 \rightarrow \frac{k Q}{x^{2}}=\frac{k Q}{2(x-d)^{2}} \rightarrow x^{2}=2(x-d)^{2} \\
& \pm \sqrt{2}(x-d)=x \rightarrow\left\{\begin{array}{l}
\sqrt{2}(x-d)=x \rightarrow x=\frac{\sqrt{2}}{\sqrt{2}-1} d=3.4 d \\
-\sqrt{2}(x-d)=x \rightarrow x=\frac{\sqrt{2}}{\sqrt{2}+1} d=0.6 d
\end{array}\right.
\end{aligned}
$$

So, $x=3.4 d$ and $x=0.6 d$, but the only physical solution is $x=3.4 d$.

Suppose that you have an insulated rope suspended from the ceiling. The insulated rope has a length $L=27 \mathrm{~cm}$. At the end of the insulated rope a 250 g ball is suspended and a charge $-78 \mu \mathrm{C}$ has been placed on the ball. At some point in time an external electric field is turned on and the ball moves into the position shown below. When equilibrium is achieved the insulated rope makes $\theta=24^{\circ}$ an angle of with respect to the vertical.

2. What is the direction of the external electric field?
a. The electric field points horizontally across the page and points left to right.
b. The electric field points horizontally across the page and points right to left.
c. The electric field points vertically and points from the top to bottom of the page.
d. The electric field points vertically and points from the bottom to top of the page.
e. The electric filed has both horizontal and vertical components but the exact direction cannot be determined.
3. What magnitude of the assumed constant external electric field would produce this situation?

$$
\begin{aligned}
& \sum F_{x}: F_{e}-F_{T} \sin \theta=0 \rightarrow q E=F_{T} \sin \theta \rightarrow q E=\left(\frac{m g}{\cos \theta}\right) \sin \theta \rightarrow E=\frac{m g}{q} \tan \theta \\
& \sum F_{y}: F_{T} \cos \theta-F_{T}=0 \rightarrow F_{T}=\frac{m g}{\cos \theta} \\
& \therefore E=\frac{m g}{q} \tan \theta=\frac{0.250 \mathrm{~kg} \times 9.8 \frac{m}{s^{2}}}{78 \times 10^{-6} \mathrm{C}} \tan 24=1.7 \times 10^{4} \frac{\mathrm{~N}}{\mathrm{C}}
\end{aligned}
$$

## Physics 111 Equation Sheet

Electric Forces, Fields and Potentials

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

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

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

Electric Circuits

$$
I=\frac{\Delta Q}{\Delta t}
$$

$$
V=I R=I\left(\frac{\rho L}{A}\right)
$$

$$
R_{\text {series }}=\sum_{i=1}^{N} R_{i}
$$

$$
\frac{1}{R_{\text {parallel }}}=\sum_{i=1}^{N} \frac{1}{R_{i}}
$$

$$
P=I V=I^{2} R=\frac{V^{2}}{R}
$$

$$
Q=C V=\left(\frac{\kappa \varepsilon_{0} A}{d}\right) Y=\left(\kappa C_{0}\right) V
$$

$$
P E=\frac{1}{2} Q V=\frac{1}{2} C V^{2}=\frac{Q^{2}}{2 C}
$$

$$
Q_{\text {charge }}(t)=Q_{\max }\left(1-e^{-\frac{t}{R C}}\right)
$$

$$
Q_{\text {discharge }}(t)=Q_{\max } e^{-\frac{t}{R C}}
$$

$$
C_{\text {parallel }}=\sum_{i=1}^{N} C_{i}
$$

$$
\frac{1}{C_{\text {series }}}=\sum_{i=1}^{N} \frac{1}{C_{i}}
$$

Light as a Particle \& Relativity

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

Light as a Wave

$$
\begin{aligned}
& c=f \lambda=\frac{1}{\sqrt{\varepsilon_{o} \mu_{o}}} \\
& S(t)=\frac{\text { energy }}{\text { time } \times \text { area }}=c \varepsilon_{o} E^{2}(t)=c \frac{B^{2}(t)}{\mu_{0}} \\
& I=S_{\text {avg }}=\frac{1}{2} c \varepsilon_{o} E_{\max }^{2}=c \frac{B_{\max }^{2}}{2 \mu_{0}} \\
& P=\frac{S}{c}=\frac{\text { Force }}{\text { Area }} \\
& S=S_{o} \cos ^{2} \theta \\
& v=\frac{1}{\sqrt{\varepsilon \mu}}=\frac{c}{n} \\
& \theta_{\text {incc }}=\theta_{\text {ref }} \\
& n_{1} \sin \theta_{1}=n_{2} \sin \theta_{2} \\
& \frac{1}{f}=\frac{1}{d_{o}}+\frac{1}{d_{i}} \\
& M=\frac{h_{i}}{h_{o}}=-\frac{d_{i}}{d_{o}} \\
& M_{\text {tootal }}=\prod_{i=1}^{N} M_{i} \\
& S_{\text {out }}=S_{\text {in }} e \sum_{i}-\sum_{i x_{i}} \\
& H U=\frac{\mu_{w}-\mu_{m}}{\mu_{w}}
\end{aligned}
$$

Nuclear Physics
$E_{\text {binding }}=\left(Z m_{p}+N m_{n}-m_{r ब t}\right) c^{2}$
$\frac{\Delta N}{\Delta t}=-\lambda N_{o} \rightarrow N(t)=N_{o} e^{-\lambda t}$
$A(t)=A_{o} e^{-\lambda t}$
$m(t)=m_{o} e^{-\lambda t}$
$t_{\frac{1}{2}}=\frac{\ln 2}{\lambda}$

Misc. Physics 110 Formulae
$\vec{F}=\frac{\Delta \vec{p}}{\Delta t}=\frac{\Delta(m v)}{\Delta t}=m \vec{a}$
$\vec{F}=-k \vec{y}$
$\vec{F}_{C}=m \frac{v^{2}}{R} \hat{r}$
$W=\Delta K E=\frac{1}{2} m\left(v_{f}^{2}-v_{i}^{2}\right)=-\Delta P E$
$P E_{\text {gravity }}=m g y$
$P E_{\text {spring }}=\frac{1}{2} k y^{2}$
$|\vec{A}|=\sqrt{A_{x}^{2}+A_{y}^{2}}$

## Geometry

$$
\begin{aligned}
& \text { Circles: } \quad C=2 \pi r=\pi D \quad A=\pi r^{2} \\
& \text { Triangles: } \quad A=\frac{1}{2} b h \\
& \text { Spheres: } \quad A=4 \pi r^{2} \quad V=\frac{4}{3} \pi r^{3}
\end{aligned}
$$

