Name

Physics 111 Quiz #2, January 25, 2013

*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 capacitor is constructed from two copper plates each  $10cm \times 20cm$ , separated by 1cm, with rubber  $(\kappa = 7)$  used as an insulating material to keep the plates separate. This capacitor is connected to a 120V battery and charged fully. The battery is removed and the capacitor is connected to a  $500\Omega$  resistor.

a. What is the capacitance of this capacitor?

$$C = \frac{\kappa \varepsilon_0 A}{d} = \frac{7 \times 8.85 \times 10^{-12} \frac{C^2}{Nm^2} \times (0.1m \times 0.2m)}{0.01m} = 1.24 \times 10^{-10} F$$

b. How much charge is initially stored on the capacitor?

$$Q = CV = 1.24 \times 10^{-10} F \times 120V = 1.5 \times 10^{-8} C$$

c. What is the maximum current that will flow when the capacitor is connected to the resistor? (Hint: Use Ohm's law, V = IR.)

$$I = \frac{V}{R} = \frac{Q}{CR} = \frac{1.5 \times 10^{-8} C}{1.24 \times 10^{-10} F \times 500\Omega} = 0.24 A$$

d. How much energy was initially stored in the capacitor?

$$E = \frac{1}{2}CV^{2} = \frac{1}{2} \times 1.24 \times 10^{-10} F \times (120V)^{2} = 8.9 \times 10^{-7} J$$

- e. As the capacitor discharges through the resistor R, energy is dissipated as heat across the resistor. As a function of time, the energy dissipated by the resistor is given by
  - 1.  $E = Q_{\max} V_{\max} e^{-\frac{t}{RC}}$ . 2.  $E = 2Q_{\max}^2 e^{-\frac{t}{RC}}$ . 3.  $E = \frac{Q_{\max}^2}{2C} e^{-\frac{t}{RC}}$ . 4.  $E = \frac{1}{2} C V_{\max}^2 e^{-\frac{2t}{RC}}$ .

## **Physics 111 Equation Sheet**

**Electric Circuits** 

**Electric Forces, Fields and Potentials** 

$$\vec{F} = k \frac{Q_1 Q_2}{r^2} \hat{r}$$
$$\vec{E} = \frac{\vec{F}}{q}$$
$$\vec{E}_Q = k \frac{Q}{r^2} \hat{r}$$
$$PE = k \frac{Q_1 Q_2}{r}$$
$$V(r) = k \frac{Q}{r}$$
$$E_x = -\frac{\Delta V}{\Delta x}$$
$$W_{f,i} = -q \Delta V_{f,i}$$

**Magnetic Forces and Fields** 

 $F = qvB\sin\theta$   $F = IlB\sin\theta$   $\tau = NIAB\sin\theta = \mu B\sin\theta$   $PE = -\mu B\cos\theta$  $B = \frac{\mu_0 I}{2\pi r}$ 

$$\varepsilon_{induced} = -N \frac{\Delta \phi_B}{\Delta t} = -N \frac{\Delta (BA \cos \theta)}{\Delta t}$$
Constants  
 $g = 9.8 \frac{m}{s^2}$   
 $le = 1.6 \times 10^{-19} C$   
 $k = \frac{1}{4\pi\varepsilon_o} = 9 \times 10^9 \frac{C^2}{Nm^2}$   
 $\varepsilon_o = 8.85 \times 10^{-12} \frac{Nm^2}{C^2}$   
 $leV = 1.6 \times 10^{-19} J$   
 $\mu_o = 4\pi \times 10^{-7} \frac{Tm}{A}$   
 $c = 3 \times 10^8 \frac{m}{s}$   
 $h = 6.63 \times 10^{-34} Js$   
 $m_e = 9.11 \times 10^{-31} kg = \frac{0.511MeV}{c^2}$   
 $m_p = 1.67 \times 10^{-27} kg = \frac{937.1MeV}{c^2}$   
 $m_n = 1.69 \times 10^{-27} kg = \frac{948.3MeV}{c^2}$   
 $lamu = 1.66 \times 10^{-27} kg = \frac{931.5MeV}{c^2}$   
 $N_A = 6.02 \times 10^{23}$   
 $Ax^2 + Bx + C = 0 \Rightarrow x = \frac{-B \pm \sqrt{B^2 - 4AC}}{2A}$ 

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

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

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

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

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

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

$$PE = \frac{1}{2}QV = \frac{1}{2}CV^{2} = \frac{Q^{2}}{2C}$$

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

$$Q_{discharge}(t) = Q_{max}e^{-\frac{t}{RC}}$$

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

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

Light as a Particle & Relativity

$$E = hf = \frac{hc}{\lambda} = pc$$

$$KE_{max} = hf - \phi = eV_{stop}$$

$$\Delta \lambda = \frac{h}{m_e c} (1 - \cos \phi)$$

$$\gamma = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}}$$

$$p = \gamma mv$$

$$E_{total} = KE + E_{rest} = \gamma mc^2$$

$$E_{total}^2 = p^2 c^2 + m^2 c^4$$

$$E_{rest} = mc^2$$

$$KE = (\gamma - 1)mc^2$$

Geometry

Circles:  $C = 2\pi r = \pi D$   $A = \pi r^2$ Triangles:  $A = \frac{1}{2}bh$ Spheres:  $A = 4\pi r^2$   $V = \frac{4}{3}\pi r^3$  Light as a Wave

$$c = f\lambda = \frac{1}{\sqrt{\varepsilon_o \mu_o}}$$

$$S(t) = \frac{energy}{time \times area} = c\varepsilon_o E^2(t) = c\frac{B^2(t)}{\mu_0}$$

$$I = S_{avg} = \frac{1}{2}c\varepsilon_o E_{max}^2 = c\frac{B_{max}^2}{2\mu_0}$$

$$P = \frac{S}{c} = \frac{Force}{Area}$$

$$S = S_o \cos^2 \theta$$

$$v = \frac{1}{\sqrt{\varepsilon\mu}} = \frac{c}{n}$$

$$\theta_{inc} = \theta_{refl}$$

$$n_1 \sin \theta_1 = n_2 \sin \theta_2$$

$$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}$$

$$M = \frac{h_i}{h_o} = -\frac{d_i}{d_o}$$

$$M_{total} = \prod_{i=1}^N M_i$$

$$d \sin \theta = m\lambda \text{ or } (m + \frac{1}{2})\lambda$$

$$a \sin \phi = m'\lambda$$

Nuclear Physics  $E_{binding} = (Zm_p + Nm_n - m_{rest})^2$   $\frac{\Delta N}{\Delta t} = -\lambda N_o \rightarrow N(t) = N_o e^{-\lambda t}$   $A(t) = A_o e^{-\lambda t}$   $m(t) = m_o e^{-\lambda t}$   $t_{\frac{1}{2}} = \frac{\ln 2}{\lambda}$ 

**Misc. Physics 110 Formulae** 

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

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

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

$$W = \Delta KE = \frac{1}{2}m(v_{f}^{2} - v_{i}^{2}) = -\Delta PE$$
  

$$PE_{gravity} = mgy$$
  

$$PE_{spring} = \frac{1}{2}ky^{2}$$