UCLA Department of Electrical Engineering
EE101 – Engineering Electromagnetics
Winter 2012
Quiz 1, January 31 2012, (20 minutes)

Name ______________________________ Student number ______________________________

This is a closed book quiz – no notes or equations.

Please be neat – we cannot grade what we cannot decipher.

	Topic	Max Points	Your points
Problem 1	Electric field	50	
Problem 2	Capacitor	50	
Total		100	

Maxwell's Equations:

$$\nabla \cdot \mathbf{D} = \rho_f$$

$$\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t}$$

$$\nabla \cdot \mathbf{B} = 0$$

$$\nabla \times \mathbf{H} = \mathbf{J}_f + \frac{\partial \mathbf{D}}{\partial t}$$

Auxillary Fields:

$$\mathbf{D} = \varepsilon_0 \mathbf{E} + \mathbf{P}$$

$$\mathbf{H} = \frac{\mathbf{B}}{\mu_0} - \mathbf{M}$$

In linear media:

$$\mathbf{P} = \varepsilon_0 \chi_e \mathbf{E} \qquad \mathbf{D} = \varepsilon \mathbf{E}$$

$$\mathbf{M} = \chi_m \mathbf{H} \qquad \mathbf{B} = \mu \mathbf{H}$$

Electrostatic Potential: $\mathbf{E} = -\nabla V$ Vector potential: $\mathbf{B} = \nabla \times \mathbf{A}$

Gradient Theorem: $\int_a^b (\nabla f) \cdot d\mathbf{l} = f(b) - f(a)$

Divergence Theorem: $\int_V (\nabla \cdot \mathbf{A})\, dV = \oint_S \mathbf{A} \cdot d\mathbf{S}$

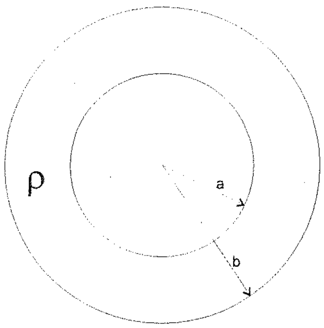
Stokes's Theorem: $\int_S (\nabla \times \mathbf{A}) \cdot d\mathbf{S} = \oint_C \mathbf{A} \cdot d\mathbf{l}$

Electric energy density: $W_e = \frac{1}{2}\mathbf{E} \cdot \mathbf{D}$ or $W_e = \frac{1}{2}\varepsilon E^2$ (in linear media)

Magnetic energy density: $W_m = \frac{1}{2}\mathbf{B} \cdot \mathbf{H}$ or $W_m = \frac{1}{2}\mu H^2$ (in linear media)

Capacitance: $C = \frac{Q}{V}$ Inductance: $L = \frac{\Lambda}{I} = N\frac{\Phi}{I}$

1.



Consider a spherical shell of charge (volume density ρ). $\varepsilon=\varepsilon_0$ everywhere. When giving answers, don't forget the vector direction.

(a) What is the E-field for $R<a$?

Use Gauss's Law

$R<a$ $\quad \oint_S \vec{E}\cdot d\vec{S} = \frac{Q_{enclosed}}{\varepsilon_0} = 0$

$$\boxed{E = 0 \quad R<a}$$

(b) What is the E-field field for $R>b$?

E must be in radial direction due to symmetry

$$\oint_S \vec{E}\cdot d\vec{S} = \frac{Q_{enclosed}}{\varepsilon_0} \qquad Q_{enclosed} = \frac{4}{3}\pi(b^3-a^3)\rho$$

$$4\pi R^2 E_R = \frac{Q_{enc}}{\varepsilon_0} = \frac{4\pi}{3\varepsilon_0}(b^3-a^3)\rho$$

$$\boxed{\vec{E} = \hat{R}\,\frac{(b^3-a^3)\rho}{3\varepsilon_0 R^2}} \quad R>b$$

2. Consider a parallel plate capacitor with a potential difference V_0 applied across the plates. On the left figure, sketch the electric field lines **E** inside the dielectric, and the location and sign of the free charge. On the right side, sketch the polarization field **P**, and sketch the location and sign of the bound charge. **Please be precise and neat**!

$$\vec{P} = \varepsilon_0 \chi_e \vec{E}$$