UCLA Department of Electrical Engineering
EE101A – Engineering Electromagnetics
Winter 2014
Quiz 1, January 27 2014, (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	Capacitance	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)

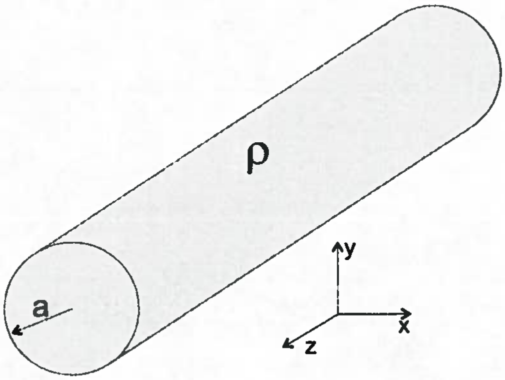
Magnetic energy density: $W_m = \frac{1}{2}\mathbf{B} \cdot \mathbf{H}$ or $W_m = \frac{1}{2}\mu H^2$ (in linear media)

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

1. Consider an infinitely long cylinder of charge (with uniform charge density ρ) with diameter a. The permittivity is ε_0 everywhere. Find an expression for the electric field both for $r<a$ and $r>a$. Make sure to include the vector direction.

Choose cylinder for Gaussian surface, height h

$$\oint_S \vec{E}\cdot d\vec{S} = \int_V \frac{\rho}{\varepsilon_0} dV$$



For $r<a$

$$\oint_S \vec{E}\cdot d\vec{S} = \int_0^{2\pi} r\,d\phi \int_0^h dz\, E_r = \frac{\rho h \pi r^2}{\varepsilon_0}$$

$$2\pi h E_r r = \frac{\rho h}{\varepsilon_0}\pi r^2$$

$$\vec{E} = \hat{r}\,\frac{\rho r}{2\varepsilon_0} \quad r<a$$

For $r>a$

$$2\pi h E_r r = \frac{\rho h \pi a^2}{\varepsilon_0}$$

$$\vec{E} = \hat{r}\,\frac{\rho a^2}{2\varepsilon_0 r} \quad r>a$$

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!**