1. (50 points)
A spherical capacitor system is shown, where the surface \( r = a \) has charge \( Q \) with uniform charge density, relative permittivity \( \varepsilon_{r1} = 2, \varepsilon_{r2} = 1 \), and a conducting surface located at \( r = 3a \) with a ground attached.

\[
\begin{array}{c}
\varepsilon_{r2} \\
\varepsilon_{r1} \\
a \\
2a \\
3a
\end{array}
\]

(a) (5 points) What is the electric field at the origin, i.e., \( E(0) \)?
(b) (15 points) Find \( E(r) \) for \( a < r < 3a \).
(c) (15 points) Find an expression for the capacitance.
(d) (15 points) How much work was done in charging this capacitor?

2. (50 points)
Two infinite current sheets are located at \( y = a/2 \) (\( J_s = \hat{y} J_0 \)) and \( y = -a/2 \) (\( J_s = -\hat{y} J_0 \)).

(a) (20 points) Find \( \mathbf{H} \) everywhere assuming the currents are in free space.
(b) (20 points) Find an expression for the inductance of a unit width and unit length section (1 meter) of this current sheet system.
(c) (10 points) What is the inductance if the region between the two current sheets has relative permeability \( \mu_r \)?
$$\varepsilon_0 \approx \frac{1}{36\pi \times 10^9} \text{ F/m}$$
$$c \approx 3 \times 10^8 \text{ m/s}$$
$$e \approx 1.6 \times 10^{-19} \text{ C}$$

$$\nabla \cdot \bar{D} = \rho$$
$$\int_S \bar{D} \cdot d\vec{S} = Q_{\text{enc}}$$

$$\nabla \cdot \bar{B} = 0$$
$$\int_S \bar{B} \cdot d\vec{S} = 0$$

$$\nabla \times \bar{E} = -\frac{\partial \bar{B}}{\partial t}$$
$$\int_C \bar{E} \cdot d\vec{l} = -\frac{d}{dt} \int_S \bar{B} \cdot d\vec{S}$$

$$\nabla \times \bar{H} = \bar{J} + \frac{\partial \bar{D}}{\partial t}$$
$$\int_C \bar{H} \cdot d\vec{l} = I + \frac{d}{dt} \int_S \bar{D} \cdot d\vec{S}$$

$$\bar{D} = \varepsilon_0 \bar{E} + \bar{P} \quad \text{and if} \quad \bar{P} = \varepsilon_0 \chi \bar{E} \quad \text{then} \quad \bar{D} = \varepsilon_0 \varepsilon_r \bar{E} = \varepsilon \bar{E}$$

$$\bar{B} = \mu_0 (\bar{H} + \bar{M}) \quad \text{and if} \quad \bar{M} = \chi \bar{H} \quad \text{then} \quad \bar{B} = \mu_0 \mu_r \bar{H} = \mu \bar{H}$$

$$W_E = \frac{1}{2} \int_V \bar{D} \cdot \bar{E} \ d\nu$$

$$\int \nabla \cdot \bar{A} \ d\nu = \int \bar{A} \cdot d\vec{S}$$

$$\int \nabla \times \bar{A} \cdot d\vec{S} = \int \bar{A} \cdot d\vec{l}$$