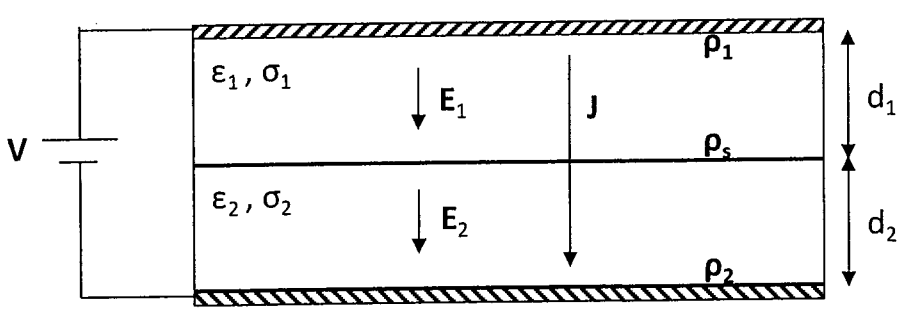
國立清華大學 103 學年度碩士班考試入學試題

系所班組別：聯合招生(工科丙組、先進光源工科組)(0598)

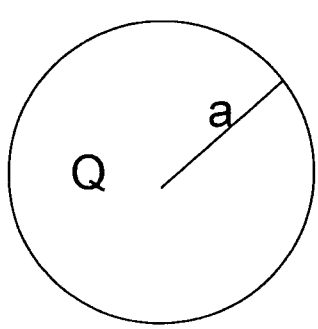
考試科目（代碼）：電磁學（9803）

1. (10%) Derive the "**equation of continuity**" in differential form.

2. (20%)
A voltage V is applied across a parallel-plate capacitor of area **S** as shown in following figure. The space between the conducting plates is filled with two different lossy dielectrics of thickness $\mathbf{d_1}$ and $\mathbf{d_2}$, permittivties ε_1 and ε_2, and conductivities σ_1 and σ_2, respectively.
(a). Determine the current density **J** ($J_1 = J_2 = J$) between the plates. (4%)
(b). Determine the electrical field intensities ($\mathbf{E_1}$ & $\mathbf{E_2}$) in both dielectrics. (8%)
(c). Determine the surface charge densities (C/m^2) ρ_1 & ρ_2 on the two plates, and at the interface ρ_s. (8%)



3. (10%) Find the energy required to assemble a uniform sphere of total charge Q and radius a as shown in following figure.



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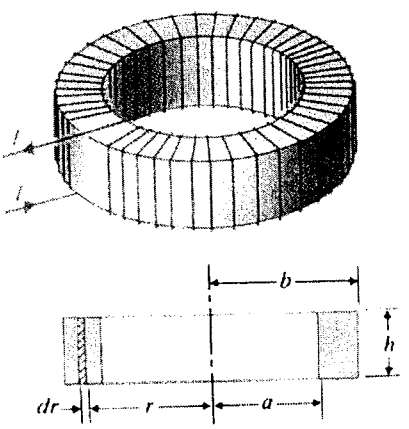
4. (10%) Assume that N turns of wire are tightly wound on a toroidal frame of a rectangular cross section with dimensions as shown in following figure. Then, assuming the permeability of the medium to be μ_0, find the **self-inductance L** of the toroidal coil.



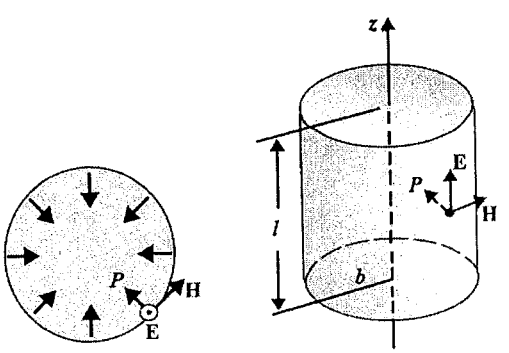
5. (20%)

(a). Electromagnetic waves carry with them electromagnetic power.

Derive the Poynting's theorem. $-\oint_S \vec{P}\cdot d\vec{S} = \frac{\partial}{\partial t}\int_V (w_e + w_m)dv + \int_V p_\sigma dv$ (10%)

(b). **Find the Poyting vector** on the surface of a long straight conducting wire (of radius b and conductivity σ) that carries a direct current ***I,*** as shown in following figures. (5%)

(c). From (b), verify Poynting's theorem. (5%)



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6. (10%) Derive the **source free homogeneous vector wave equations of** $\vec{E}$ **and** $\vec{H}$, respectively.

7. (20%) Consider the situation in following figure, where the incident wave travels in the +z direction and the boundary surface is the plane z=0. The incident electric and magnetic field intensity phasors are

$$\vec{E}_i(z) = \hat{a}_x E_{i0} e^{-j\beta_1 z}$$

$$\vec{H}_i(z) = \hat{a}_y \frac{E_{i0}}{\eta_1} e^{-j\beta_1 z}$$

(a). Determine the reflected wave $\vec{E}_r$ and $\vec{H}_r$. (5%)

(b). Determine the transmitted wave $\vec{E}_t$ and $\vec{H}_t$. (5%)

(c). Determine the reflection coefficient Γ. (5%)

(d). Determine the transmission coefficient τ. (5%)