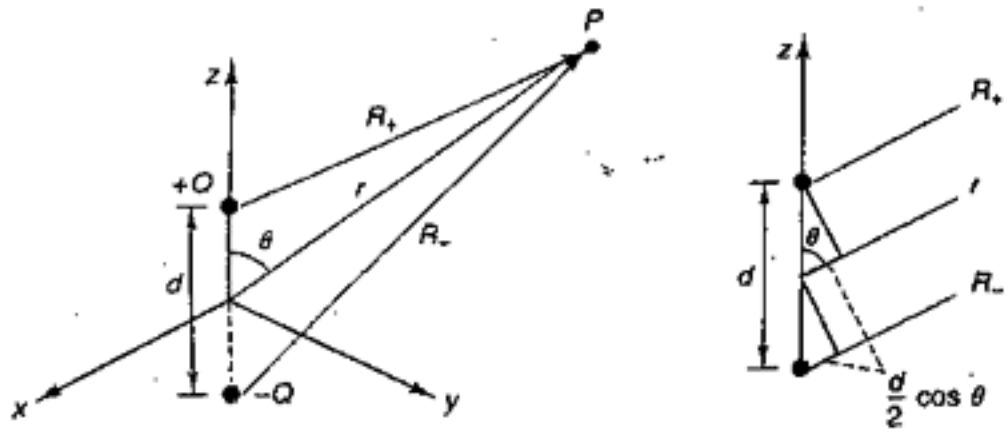
* $\varepsilon_0 = 10^{-9}/(36\pi)$ (F/m); $\mu_0 = 4\pi \times 10^{-7}$ (H/m);

1. **Maxwell's Equations** (30%)
   (a) Write down the Maxwell's equations in differential form.
   (b) Which term in Maxwell's equations is the ***displacement current density*** ? What is the difference between the displacement current and the free current?
   (c) Write down the equation of continuity.
   (d) Write down the scalar Poisson's equation for the scalar electric potential Φ and the expression of E-field in tern of Φ.
   (e) Write down the vector Poisson's equation for the vector magnetic potential $\bar{A}$ and the expression of B-field in tern of $\bar{A}$.

2. The far-zone potential of the electric dipole is (10%)

$$V(\bar{r}) = \frac{Qd\cos\theta}{4\pi\varepsilon_0 r^2} \qquad r >> d \text{ (far zone)}$$

   (a) Determine the far-zone E-field.
   (b) Prove the above far-zone potential satisfies Laplace's equation.



del operator $\nabla = \left(\hat{a}_r \frac{\partial}{\partial r} + \hat{a}_\theta \frac{1}{r}\frac{\partial}{\partial\theta} + \hat{a}_\phi \frac{1}{r\sin\theta}\frac{\partial}{\partial\phi}\right)$
Laplacian operator $\nabla^2 V = \frac{1}{r^2}\frac{\partial}{\partial r}\left(r^2\frac{\partial V}{\partial r}\right) + \frac{1}{r^2\sin\theta}\frac{\partial}{\partial\theta}\left(\sin\theta\frac{\partial V}{\partial\theta}\right) + \frac{1}{r^2\sin\theta}\left(\frac{\partial^2 V}{\partial\phi^2}\right)$
(spherical coordinate)

3. A **parallel-plate capacitor** with a **uniform lossy dielectric** has a resistance of 1 [KΩ]. The plate surface area is $S = 1$ cm^2 and spaced by $d = 0.1$ cm. If the dielectric constant is $\varepsilon_r = 10$, find the **conductivity** σ of the dielectric. (Note: $RC = \varepsilon/\sigma$) (5%)

4. If $\mu_r = 500$ and the density of atoms is 9.02×10^{22} [cm^{-3}] for cobalt, calculate the average magnetization dipole moment per atom when a sample of cobalt is placed in a uniform B-field $B_m = 0.1$ [T]. (5%)

Magnetization $\vec{M} = \chi_m \vec{H}$ ..... **for linear, isotropic magnetic materials**

χ_m = magnetic susceptibility

$\vec{B} = \mu_0(\vec{H} + \vec{M}) = \mu_0(1+\chi_m)\vec{H} = \mu_0\mu_r\vec{H} = \mu\vec{H}$ ... **equation relating *B* and *H***

(背面仍有題目,請繼續作答)

7>1>A

(25%) 5. 簡答題

(1) phonon scattering
(2) punch through
(3) two-dimensional electron gas
(4) molecular beam epitaxy
(5) metal organic chemical vapor deposition

(15%) 6. 就 一 n-p-n bipolar transistor 而言, 試列舉三種可有效提高其電流增益(current gain)的方法,並說明之.

(10%) 7. 如下圖所示之一度空間無限深量子井(quantum well)

(1) 試推導並畫出在井內的能階分佈及波函數(wave function).

(2) 井寬(Lz)縮小與放大時,能階分佈有何變化?其物理意義爲何?