國立中山大學107學年度碩士暨碩士專班招生考試試題

科目名稱：電磁學【電機系碩士班戊組、通訊所碩士班乙組、電波領域聯合】　題號：482004
※本科目依簡章規定「可以」使用計算機（廠牌、功能不拘）（問答申論題）　共3頁第1頁

1. (10%) (a) Explain Gradient, Divergence, and Curl. (b) Curl of a Gradient field, $\nabla\times\nabla V = 0$, Divergence of a Curl, $\nabla\cdot\nabla\times A = 0$. V is a scalar field, A is a vector field. 說明其物理意義(why?)，或舉例。

2. (10%) For a coaxial transmission line, Fig. 1, the capacitance per unit length is $c' = \frac{2\pi\cdot\varepsilon_0}{\ln\frac{b}{a}}\left[\frac{\text{F}}{\text{m}}\right]$, and the inductance per unit length is $\ell' = \frac{\mu_0}{8\pi}+\frac{\mu_0}{2\pi}\ln\frac{b}{a}\left[\frac{\text{H}}{\text{m}}\right]$. At high frequencies, the internal inductance drops off. <u>Find</u> the characteristic impedance of the coaxial line, $Z_c=\sqrt{\frac{\ell'}{c'}}$, <u>at high frequencies</u>. Please also write down the unit of Z_c, *i.e.*, what is the square root of (H/F)? What is the speed the wave travels in the coaxial cable? You can find it by calculating velocity$=\frac{1}{\sqrt{\ell'\cdot c'}}$.

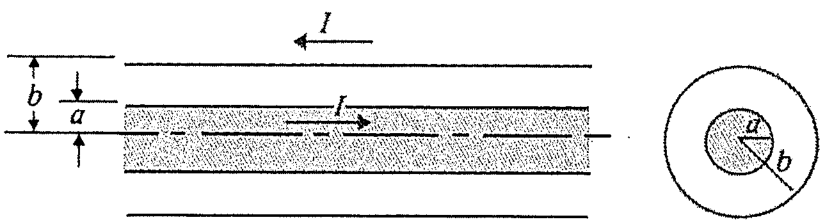

Fig. 1. Coaxial cable

3. (10%) In the following configurations, Fig. 2, assuming both grounds are perfect conductors, current directions are as indicated (the solid arrows); the image current for both cases are shown. Using $a_n\times H = J$, H is the magnetic field intensity on the ground, a_n is the normal vector of the top surface of the grounds, <u>determine</u> the direction of the currents on the top surface of the grounds.

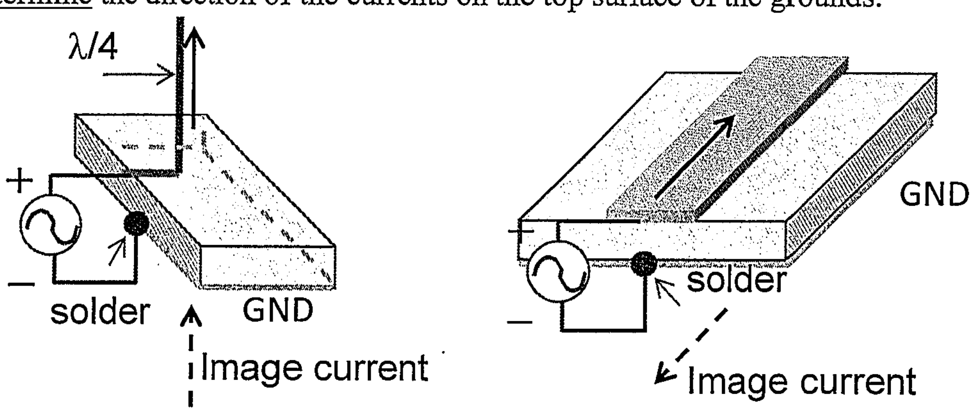

Fig. 2. Current relative to the ground.

Considering both the original current and its induced current on the ground, <u>which</u> one, left or right, is likely to be an effective antenna structure, why?

4. (5%) Using the Method of Image, <u>write down</u> the potential distribution, $V(x, y, z)$, for an observing point $P(x, y, z)$ in the space, Fig. 3. The dielectric constant of the space is ε_0. Q is a positive point

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charge of Q *Coul.*

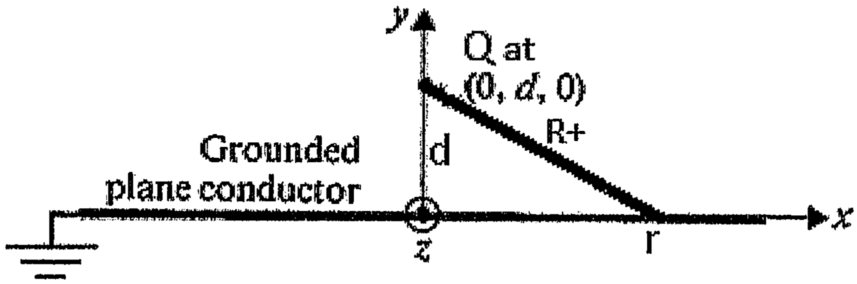
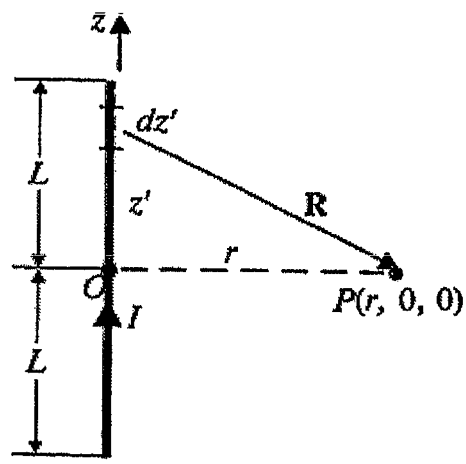


Fig. 3. A charge source Q above a ground.

5. (10%) 下圖 Fig. 4 之 magnetic flux density B can be found as,



$$\mathrm{B} = \mathbf{a}_\phi \frac{\mu_0 I L}{2\pi r\sqrt{L^2+r^2}}$$

Fig. 4. An observing point P near a current source I.

簡化上列之 B as a function of r, μ_0, and a_ϕ when $L>>r$. In cylindrical coordinate system,

$\nabla\cdot\mathrm{B} = \frac{1}{r}\frac{\partial}{\partial r}(rB_r)+\frac{1}{r}\frac{\partial B_\phi}{\partial\phi}+\frac{\partial B_z}{\partial z}$. Show that $\nabla\cdot\mathrm{B}=0$.

6. (5%) What are the permittivity ε and permeability μ of Copper, a very good conductor? Provide your reasoning.

7. (10%) Analyze the performance of a right-hand circularly polarized wave received respectively by linearly or circularly polarized antennae.

8. (15%) As shown in Fig. 5, a waveguide filled with a material whose $\varepsilon_r = 2.25$ has dimensions $a = 2$ cm and $b = 1.4$ cm. If the guide is to transmit 13.5 GHz signals, what possible modes can be used for the transmission? Please respectively calculate the cutoff frequencies of the possible modes.

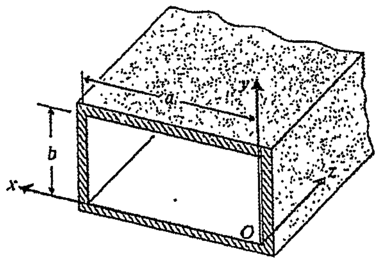


Fig. 5

9. (15%) According to Fig. 6, write the input impedance of the transmission line in differential special cases.
   (a) (6%) Open-circuit termination, and also plot the reactance-line length diagram
   (b) (6%) Short-circuit termination, and also plot the reactance-line length diagram
   (c) (3%) Quarter-wave section

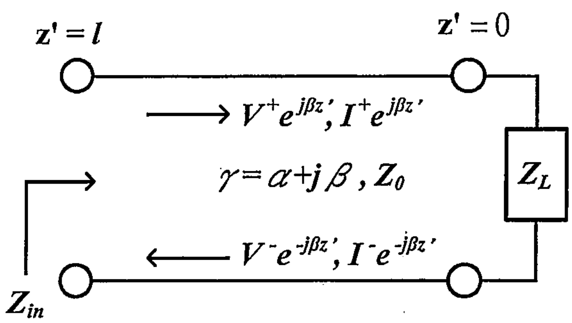


Fig. 6

10. (10%) As shown in Fig. 7, calculate the average power transmitted into the infinite 150 Ω line. The λ/2 line is lossless and the infinitely long line is slightly lossy. (Hint: The input impedance of an infinitely long line is equal to its characteristic impedance so long as the line is not lossless)

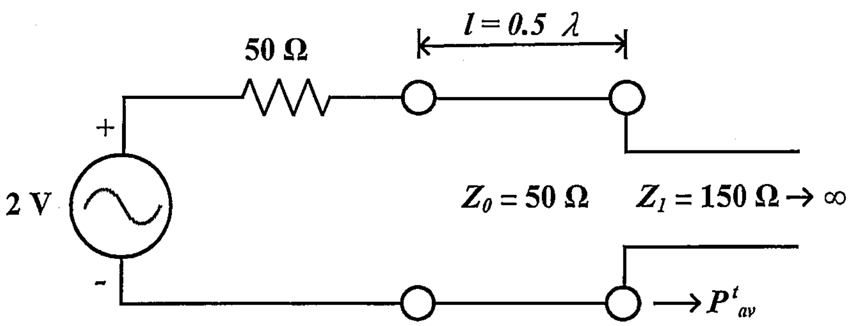


Fig. 7