系所組別： 光電科學與工程研究所甲、乙組

考試科目： 電磁學

考試日期：0219，節次：2

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1. Two conducting spheres of radii $\mathbf{b_1}$ and $\mathbf{b_2}$ that have a very high conductivity. If these two spheres are immersed in a poorly conducting medium (for example, they are buried very deep in the ground) of conductivity $\boldsymbol{\sigma}$ and permittivity $\boldsymbol{\varepsilon}$, what is the resistance between the conducting spheres? (Note: the distance, **d**, between the spheres is very large in comparison with the radii) (5pts)

(A) $R = \frac{1}{4\pi\sigma}\left(\frac{1}{b_1} + \frac{1}{b_2} - \frac{1}{d-b_1} - \frac{1}{d-b_2}\right)$ (B) $R = \frac{1}{4\pi\sigma}\left(\frac{1}{b_1} + \frac{1}{b_2} - \frac{2}{d}\right)$ (C) $R = \frac{1}{4\pi\sigma}\left(\frac{1}{b_1} + \frac{1}{b_2} - \frac{1}{d}\right)$

(D) $R = \frac{1}{4\pi\sigma}\left(\frac{1}{b_1} + \frac{1}{b_2}\right)$

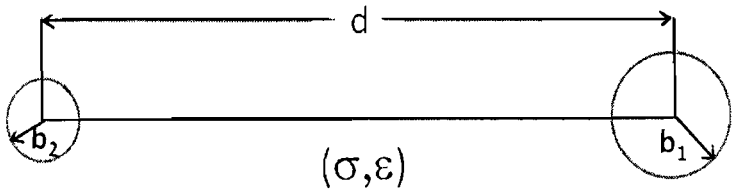

Figure 1

2.Determine the mutual inductance between a very long straight wire and a conducting circular loop, as shown in Figure 2. (5pts)

(A) $L = \mu_0(d - \sqrt{b^2 - d^2})$ (B) $L = \mu_0(d - \sqrt{d^2 - b^2})$ (C) $L = \mu_0(d + \sqrt{b^2 - d^2})$

(D) $L = \mu_0(b - \sqrt{b^2 - d^2})$

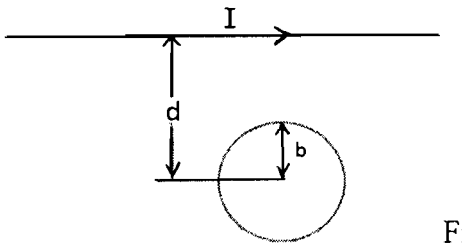

Figure 2

(背面仍有題目,請繼續作答)

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3. As shown in Figure 3, a TM wave is incident onto a medium with a dielectric permittivity, ε_2, from a medium with dielectric permittivity, ε_1, at the Brewster's angle of no reflection, θ_B.

   Both media have the same magnetic permeability $\mu_1=\mu_2=\mu$. The reflection coefficient for a TM wave is

$$\frac{\hat{E}_r}{\hat{E}_i} = R = \frac{\eta_1 \cos\theta_i - \eta_2 \cos\theta_t}{\eta_1 \cos\theta_i + \eta_2 \cos\theta_t}$$

(a) What is the transmitted angle θ_t =_____when $\theta_i = \theta_B$? (5pts)

(b) What is the Brewster angle, $\tan\theta_B$=_____, of no reflection? (5pts)

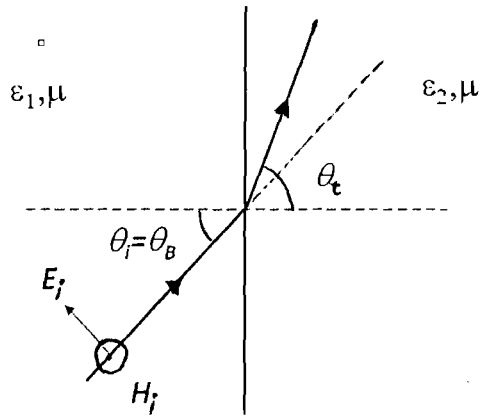

Figure 3

4. A 150MHz uniform plane wave is normally incident from air onto a material whose intrinsic impedance is unknown. Measurements yield a standing wave ratio of 3 and the appearance of an electric field minimum at 0.3 wavelengths in front of the interface. The impedance of the unknown material is _____.(5pts)
5. A T = 5 ps transform-limited pulse propagates in a dispersive channel for which β_2 = 10 ps^2/km. Over what distance will the pulse spread to twice its initial width _____? .(5pts)
6. A propagating TM_1 wave in a parallel-plate waveguide made of two perfectly conducting infinite planes spaced a distance *b* operates in air at a frequency 10GHz. If the conducing planes are made of brass plates (σ=2.56x10^7 S-m^{-1}) separated by a 1.6-cm thick polyethylene slab (ε'_r~2.25, $tan\delta$~4x10^{-4}), for TM_1 mode, (a) the waveguide wavelength $\overline{\lambda}$=_____. (5pts) (b) the attenuation constant α_c = _____ due to conductor losses and α_d = _____ due to dielectric losses. (η~377Ω) (10pts)

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7. A monopole antenna in free space, extending vertically over a perfectly conducting planr, has a linear current distribution. If the length of the antenna is 0.01λ, what value of I_0 is required to: (a) provide a radiation-field amplitude of 100mV/m at a distance of 1 mi, at $\theta=90^\circ$, $I_0=$ _____ (5pts); (b) radiate a total power of 1W, $I_0=$ _____.(5pts)
8. A steal pipe is constructed of a material for which $\mu_R=180$ and $\sigma=4\times10^6$ S/m. The two radii are 5 and 7 mm, and the length is 75m. If the total current I(t) carried by the pipe is $8\cos\omega t$ A, where $w=1200\pi$ rad/s, the skin depth= _____. (5pts)
9. A linearly polarized uniform plane wave, propagating in the forward z direction, is input to a lossless anisotropic material, in which the dielectric constant encountered by waves polarized along y(ε_{Ry}) differs from that seen by waves polarized along x(ε_{Rx}). Suppose $\varepsilon_{Rx}=2.15$, $\varepsilon_{Ry}=2.10$, and the wave electric field at input is polarized at 45° to the positive x and y axes. (a) Determine the shortest length of the material such that the wave as it emerges from the output end is circularly polarized; (5pts) (b) will the output wave be right- or left-circularly polarized? (5pts) (c) Suppose that the length of the medium is made to be twice, describe the polarization of the output wave in this case. (5pts)
10. As shown in Figure 4, concentric cylindrical electrodes with respective radii *a* and *b* and depth *L* enclose an Ohmic material whose constant permittivity is ε and whose conductivity σ varies quadratically with radial position as $\sigma(r)=\sigma_0\frac{r^2}{a^2}$. A DC voltage *V* is applied across the cylindrical electrodes which have been on for a long time so that all time transients have decayed and the system is in the DC steady state. Neglect fringing field effects.

(a)Find the DC steady state electric field $E_r(r)$ between the electrodes. (5pts)

(b)What are the DC steady state free volume charge density, $\rho_f(r)$, and the DC steady state free surface charge densities on the electrodes, $\rho_{sf}(r=a)$? (5pts)

(c)What are the total DC steady state free volume charge in the dielectric and DC steady state total free surface charge on each electrode? What is the total DC steady state free charge in the system? (15pts)

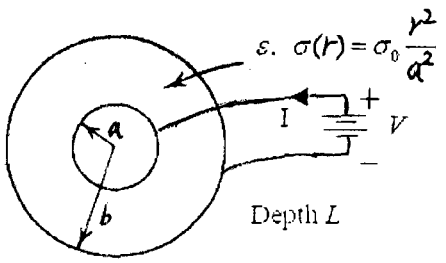

Figure 4