

1. Dielectrics that are somewhat conducting are said to be lossy. For example, most natural substances, such as wood or wheat, show a slight conductivity that is associated with the presence of water. Now, an alternating current is applying to a parallel-plate capacitor containing a lossy dielectric as shown in Fig. 1. It is convenient to express the conductivity in terms of a complex permittivity. What are the real and the imaginary part of the complex permittivity? (10%)

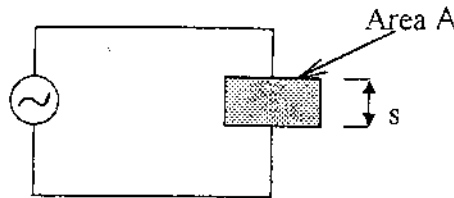


Fig. 1

2. Figure 2 shows the hysteresis loop for a nickel-iron alloy called Deltamax. What is the approximate value of the power dissipation per cubic meter and per cycle when the material is driven to saturation both ways? (10%)

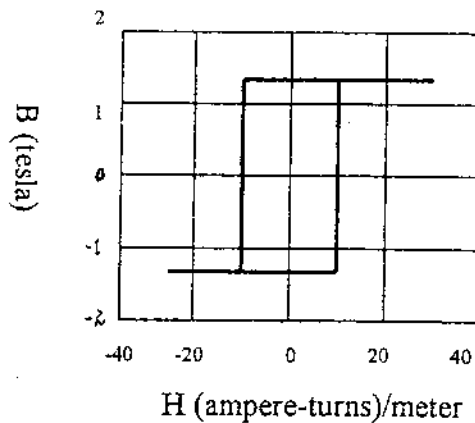


Fig. 2

3. Assume the inner conductor of a coaxial cable to have a radius of a meter and the outer conductor to have an inner radius of b meter and an outer radius of c meter. Assume also the cable's axis is along the z-axis and the cable is infinite long. Show that  $\nabla \times \vec{H} = \vec{J}$  for the field in each conductor of a coaxial cable. The field in the inside conductor ( $r < a$ ) is  $H_\phi = \frac{Ir}{2\pi a^2}$  and in the outside conductor ( $b < r < c$ ) is

$$H_\phi = \frac{I(c^2 - r^2)}{2\pi r(c^2 - b^2)} \quad (15\%)$$

(背面仍有題目,請繼續作答)

4. The dielectric of a parallel-plate capacitor has a permittivity that varies as  $\epsilon_r + ax$ , where  $x$  is the distance from one plate. The area of a plate is  $A$ , and their spacing is  $s$ . (a) Find the capacitance. (b) Show that, if  $\epsilon_r$  varies from  $\epsilon_r$  to  $2\epsilon_r$ , then capacitance  $C$  is 1.44 times as large as if  $a$  were zero. (c) Find polarization  $P$  from the values of displacement field  $D$  and electric field  $E$  for that case. (d) Deduce the value of volume bound charge density  $\rho_b$ . (e) Show that  $\rho_b = -(\epsilon_c / \epsilon_r) \vec{E} \cdot \nabla \epsilon_r$  in a nonhomogeneous dielectric, if volume free charge density  $\rho_f = 0$ . (f) Use the result of (e) to calculate  $\rho_b$ . The result should be the same as that of (d). (25%)
5. Suppose the effect of a magnetic field is to induce a magnetic dipole moment of  $10^{-23}$  A·m<sup>2</sup> per atom. Let there be  $10^{27}$  atoms/m<sup>3</sup>. Find the surface current density at surface making an angle of  $45^\circ$  with  $\vec{M}$ . (10%)
6. Show that the total force on a closed circuit carrying a current  $I$  in a uniform magnetic field is zero. Is there a torque? If there is, what is the torque? (10%)
7. Consider a perfect dielectric medium  $z < 0$  bounded by a perfect conductor  $z > 0$ , as shown in Fig. 3. Let the fields in the dielectric medium be given by the superposition of (+) and (-) uniform plane waves propagating normal to the conductor surface, that is,

$$\vec{E} = E_1 \cos(\omega t - \beta z) \hat{i} + E_2 \cos(\omega t + \beta z) \hat{i}$$

$$\vec{H} = \frac{E_1}{\eta} \cos(\omega t - \beta z) \hat{j} - \frac{E_2}{\eta} \cos(\omega t + \beta z) \hat{j}$$

where  $\beta = \omega \sqrt{\mu \epsilon}$  and  $\eta = \sqrt{\frac{\mu}{\epsilon}}$ . Investigate the relationship between  $E_2$  and  $E_1$ .

Also, find the total electric and magnetic fields in the dielectric and the current density at the surface between the dielectric and the conductor. (20%)

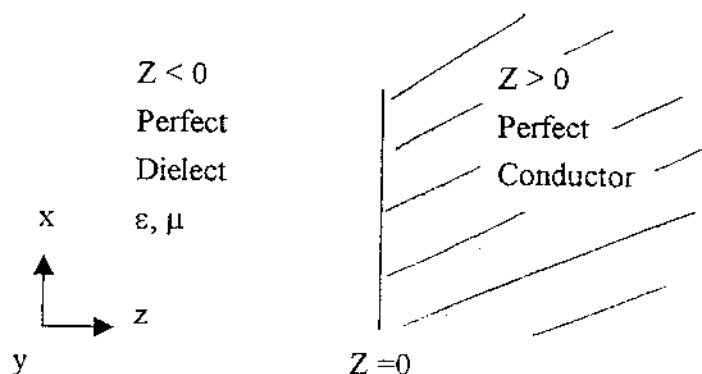


Fig. 3 A perfect dielectric medium bounded by a perfect conductor