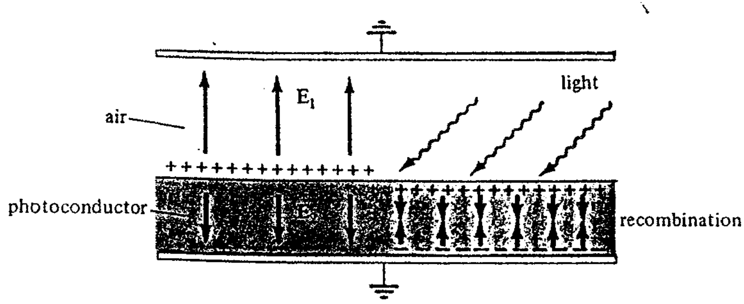
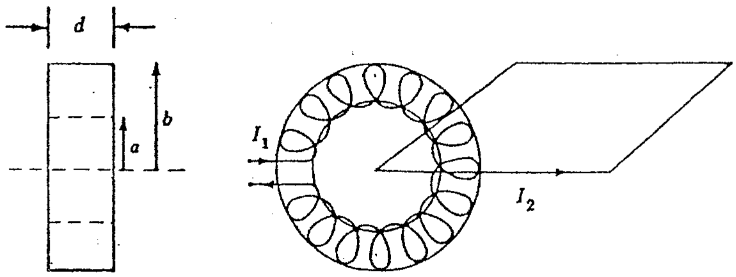
1. What does (a) linear (b) isotropic (c) homogeneous dielectric mean? (9%)

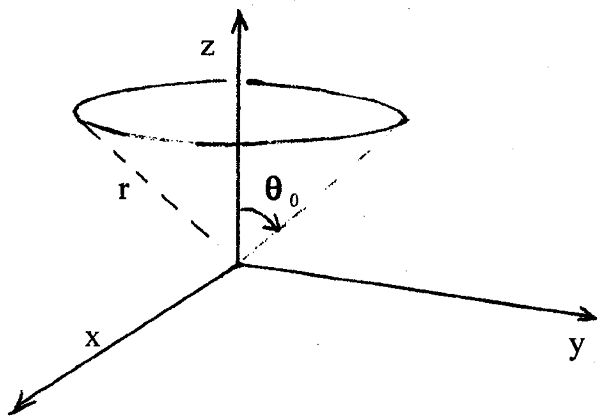
2. The basic operation principle of a xerographic copy machine is as follow: The surface of the photoconductor is initially charged uniformly as in figure shown below. When light from the document to be copied is focused on the photoconductor, the charges on the lower surface combine with those on the upper surface to neutralize each other. The image is developed by pouring a charged black powder, which is later transferred to paper and melted to form a permanent image. Determine the electric field below and above the surface of the initially charged photoconductor with surface charge density ρ_s and dielectric constant ε. (13%)



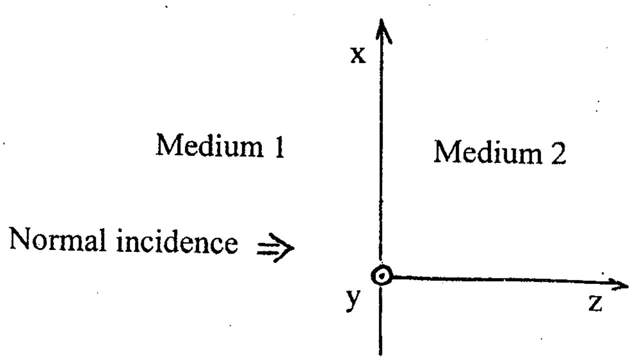
3. The figure (as shown below) on the right shows a tightly wound toroidal coil with N turns and current I1 and a square coil with current I2. The figure on the left is the side view of the toroidal coil. Calculate the mutual inductance of the coils. (13%)



4. A current flows from a point charge $q_0\cos(\omega t)$ coulomb at the origin to infinity along a straight wire occupying the positive half of the z-axis. Consider a circular path in the plane normal to the wire and centered at a point on the z-axis(see below). Find the line integral of $\vec{H}$ (magnetic field) around the circular path in the sense of increasing ϕ. (13%)



5. Consider the problem of a plane wave incidence upon some medium, as shown below. Suppose the electric field $\vec{E}$ and magnetic field $\vec{H}$ in medium 1 can be expressed in the phasor notation as $\hat{x}E_1\exp(-j\beta_1 z)[1+\Gamma\exp(j2\beta_1 z)]$ and $\hat{y}H_1\exp(-j\beta_1 z)[1-\Gamma\exp(j2\beta_1 z)]$, respectively. And the electric and magnetic fields in medium 2 can be expressed as $\hat{x}E_2\exp(-j\beta_2 z)$ and $\hat{y}H_2\exp(-j\beta_2 z)$, respectively. Where, β_1 and β_2 are propagation constants, and Γ is the reflection coefficient.



(a) Write the instantaneous expressions for the electric field and the magnetic field in both media. (10%)

(b) If Γ can be written as $\exp(-j\theta)$, plot the standing wave pattern for the electric field and the magnetic field in medium 1. (10%)

6. Hollow rectangular metallic waveguides find wide spread application in microwave frequency. Let us consider a hollow rectangular metallic waveguide with a dimension of $a \times b$ ($a > b$). Answer the following questions concisely.

(a) Sketch the attenuation coefficient versus frequency for both hollow rectangular metallic waveguide and coaxial transmission line. (4%)

(b) Why the hollow rectangular metallic waveguide is preferred over the coaxial transmission line? (4%)

(c) For single mode operation, discuss the effects of dimension a and b on the cutoff frequency, the bandwidth, the attenuation and the power handle ability of this hollow rectangular metallic waveguide. (12%)

(d) Can a wave exist in this hollow rectangular metallic waveguide at a wavelength greater than the cutoff wavelength? If so, what is it called? Explain. (4%)

7. Microwave transponder on a geostationary satellite orbiting at Clark orbit (which is 36000 km above the surface equator) is used extensively by the cable TV program supplier. The received uplink and downlink of the TV signal power are governed by the Friis transmission formula

$$\frac{P_r}{P_t} = \frac{A_{er} A_{et}}{r^2 \lambda^2}$$

where P_r is the received power, P_t the transmitted power, A_{er} the effective aperture of receiving antenna, A_{et} the effective aperture of transmitting antenna, and λ is the wavelength. In addition, the noise of the receiving antenna can be expressed in terms of antenna temperature T_{sys} as $Bk_B T_{sys}$ where B is the bandwidth, k_B the Boltzmann constant ($k_B = 1.38 \times 10^{-23}$ J/°K). Assuming a 4 GHz C-band transponder with power = 5W and antenna gain = 30 dB on this satellite to downlink the FM TV signal to an Earth receiving station. For a 30 MHz bandwidth FM TV signal, find the signal to noise (S/N) ratio for the Earth receiver with an antenna gain of 40 dB and antenna temperature of 100 °K. For a FM TV reception, a minimum S/N = 10 dB is required. Is this Earth receiving state adequate for FM TV signal reception? (8%)