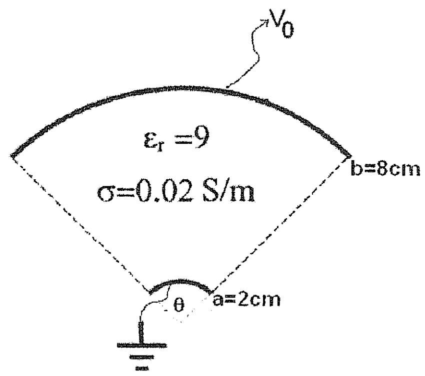
Note : ε_0**=8.854x10**$^{-12}$ **F/m** μ_0**=1.26x10**$^{-6}$ **H/m**

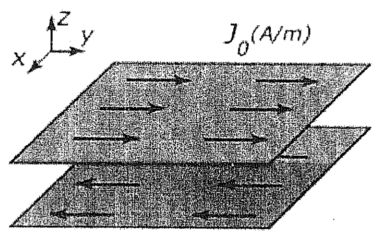
1. (10%) The position-dependent electric potential in the material of relative dielectric constant ε_r=8 is V(x,y)=10xy. Please find the electric field, polarization vector, electric susceptibility and electric flux density ($\vec{E}$, $\vec{P}$, χ_e, and $\vec{D}$), respectively

2. (10%) An infinitely long cylindrical wire of radius ρ_0 aligned along the z-axis is non-uniformly charged. The volume charge density distribution could be represented by $\rho_v(\rho, \varphi, z) = K\rho$ (C/m^3), where ρ is the distance away from the axis of the wire.
   a) Please find the electric field for $\rho > \rho_0$ and $\rho \leq \rho_0$,
   b) Please sketch the electric field strength as a function of ρ.

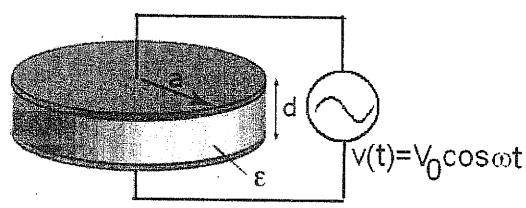
3. (10%) A conical section of material extends over the range 2cm<r<8cm and 0<θ<30° with ε_r= 9 and σ = 0.02 S/m. Two conductive plates are placed at each radial end of this section. Please determine the capacitance of this conical section.



4. (10%) Two infinitely large sheets carry currents with linear current densities $\pm J_0\mathbf{a}_y$ (A/m) respectively.
   a) Please find the magnetic field **B** at different position (between the sheets the sheets and outside them)
   b) Please plot its magnitude as a function of z.



5. (10%) A parallel-plate circular capacitor of radius **a** is filled with a perfect and homogeneous dielectric of permittivity ε. It is connected to a slowly time-varying voltage $v(t)=V_0\cos\omega t$.
   a) As the distance between the plate electrodes d, is much lesser than the dimensions of the plates (so the fringing effects can be neglected). Please find the displacement current density in the dielectric.
   b) As the dielectric between the plates is imperfect, with parameters ε, σ and μ_0. Under these circumstances, please find the magnetic field intensity vector in the dielectric.



6. (24%) A 3.875λ-long lossless transmission line has an open-circuit impedance Zoc=104∠17° and a short-circuit impedance Zsc=24∠-16°. Now this line is connected with a voltage generator that has an impedance of 25 Ω. The input impedance is measured to be (10+j25) Ω. Use the attached Smith Chart if necessary.
   a) What is the characteristic impedance Z_0 of the line ?
   b) What is the voltage standing wave ratio on the line ?
   c) What is the load impedance Z_L ?
   d) What is the reflection coefficient at the load ?
   e) How far is the first voltage minimum from the load ?
   f) If the first voltage maximum from the load is 24 cm, what is the frequency ?
   g) What length of the line (the shortest) can be added between the original line and the generator in order to make the input impedance purely resistive
   (h) Continue with (g), design a quarter-wavelength transformer to match this real impedance to the 25-Ω voltage generator.

7. (16%) A 2-kHz plane wave propagates in sea water (ε_r=80, μ_r=1, σ=4 S/m), which the sea water can be treated as a good conductor. (hint: ln(0.5)= -0.693)
   a) What is the attenuation constant α ?
   b) How far can the wave propagates before its power is reduced by 50% ?
   c) How much has its phase changed in this distance ?
   d) How far can the wave propagates (the penetration depth) in the ice as sea water freezes (ε_r=3.2, μ_r=1, σ=10^{-6} S/m) ?

8. (10%) Please answer the following questions with brief explanation.
   a) A uniform plane wave impinges normally from medium-1(intrinsic impedance =50 Ω) to medium-2 (intrinsic impedance =200 Ω) . It can be found that the transmission coefficient is larger than 1. Is this result against the law of conservation of energy?

   b) Coaxial cable may be viewed as a type of waveguide. Power is transmitted through the radial electric field and the circumferential magnetic field. As we know, the dominant mode of coaxial cable is TEM mode which has zero(DC) cutoff frequency. In practical use, however, a limited operating frequency range is usually recommended for a cable with certain dimensions. Can you explain why ?

The Complete Smith Chart

Black Magic Design