Fundamentals of Electromagnetic Fields – Prof. C. Riva
February 28, 2014

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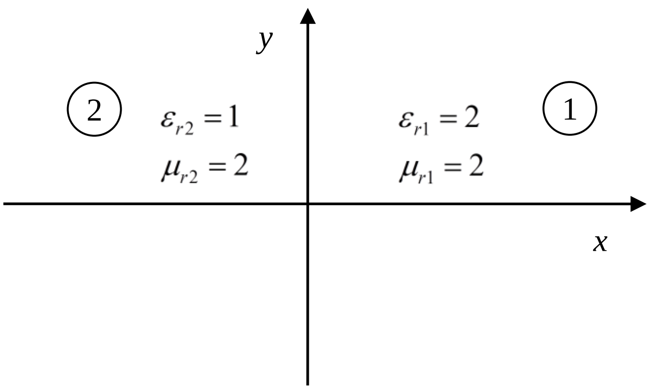
Exercise 1



The static (independent) electric and magnetic fields in medium 1 ($x > 0$) and medium 2 ($x < 0$), respectively (see figure), are given by:

$\vec{E}_1 = \vec{a}_x - 0.5 \cdot \vec{a}_y$ (V/m)

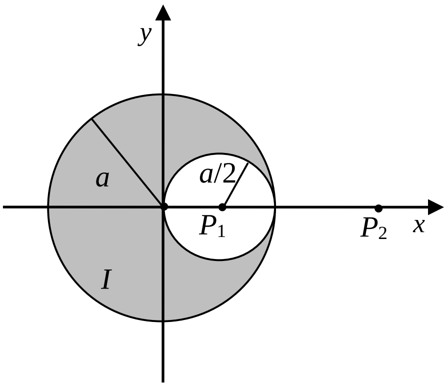
$\vec{H}_2 = 2\vec{a}_x + \vec{a}_y$ (A/m),

Calculate $\vec{E}_2$ and $\vec{H}_1$ (electric field in medium 2 and magnetic field in medium 1), taking into account that between the two media (for $x = 0$) there is a charge surface density $\rho_s = 2.2 \cdot 10^{-12}$ (C/m^2) and a current surface density $\vec{J}_s = 2\vec{a}_z$ (A/m).

Solution:

Exercise 2

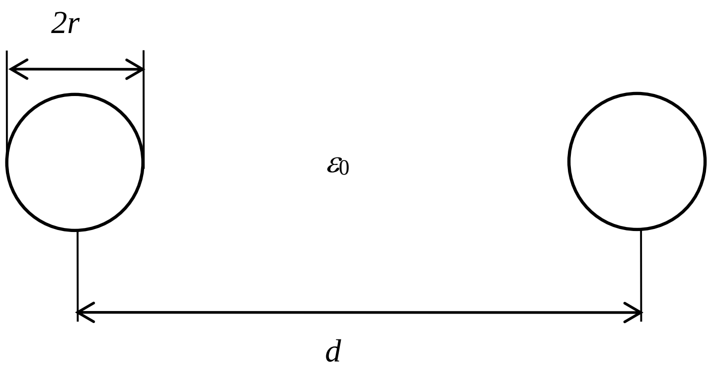
Consider a cylindrical wire (axis coincident with *z* axis) with radius $a = 1$ cm. In the cylindrical solid wire an inner cylindrical hole has been realized with a centre in $P_1(x = a/2, y = 0)$ and radius $a/2$ (see figure). In the grey region in the figure a uniform current $I = 1$ (A) flows in $+z$ direction.
Calculate the force (vector) acting on a particle $q = -1$ C moving at a speed $v_z = 3$ m/s when the particle is in P_1 and in $P_2(x = 2a, y = 0)$.
Note: the structure has not a cylindrical symmetry, but using the superposition principle...



Solution:

Exercise 3

A two-wire line in air ($\varepsilon = \varepsilon_0$, conductors radius r = 2 mm, distance between conductors axis d = 2 cm) is composed by lossy conductors with $\sigma_c = 5 \cdot 10^7$ S/m (see figure). Calculate the attenuation in Np and in dB for a length of 50 m at 200 MHz frequency.
Note: consider that r<<d (thin wire approximation)

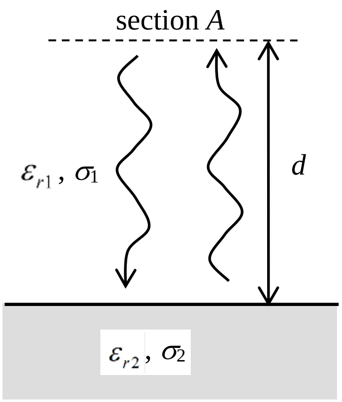


Solution:

Exercise 4

A uniform plane wave propagates (frequency 100 MHz, power density at section *A*, S_i=10 W/m^2) in a dielectric with small losses (μ_{r1} = 1, ε_{r1}, σ_1) and is reflected by a perfect conductor (μ_{r2} = 1, ε_{r2}=1, σ_2=∞), as shown in the figure. Assuming that the power density of the reflected wave only equals S_r=9 W/m^2, and that the incident wave takes τ = 5 ns (*d*=1 m) to arrive at the bottom conductor, calculate ε_{r1} and σ_1.

Note: use the good dielectrics approximations

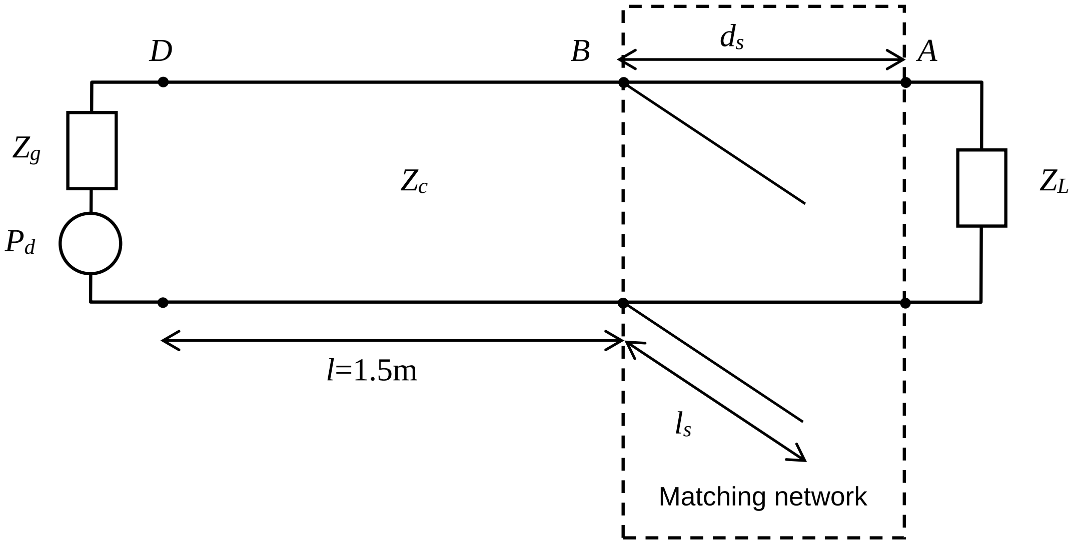


Solution:

Exercise 5

A generator (impedance Z_g = 75 Ω, maximum available power P_d = 20W, frequency 150 MHz) is connected to the load Z_L = 150-j50 Ω by means of a transmission line without losses (ε_r=4), with characteristic impedance Z_c = 75 Ω, and length l = 1.5 m (see figure without matching network).

1. Design the shunt open circuit stub network between sections A and B to match the load to the line (using transmission lines with characteristics impedance Z_c = 75 Ω and ε_r=4).
2. Calculate the power dissipated in the load without the matching network.
3. Calculate the power dissipated in the load with the matching network.



Solution: