Benha University
Faculty of Engineering at Shoubra
Electrical Engineering Department
Third Year Communications

Final Term Exam
Date: Monday 23/1/2017
Subject: Electromagnetic Waves
Duration: 3 hours

- **Answer all the following questions**
- **Illustrate your answers with sketches when necessary**
- **No. of questions: 4**
- **Total Mark: 90 Marks**

Question 1 | 25 marks

a- A 50 V voltage generator at 20 MHz is connected to the plates of an air dielectric parallel-plate capacitor with plate area 2.8 cm^2 and separation distance 0.2 mm. Find the maximum value of (i) displacement current density and (ii) displacement current.

b- Let the fields, $E(z, t) = 1800 \cos(10^7\pi t - \beta z)a_x$ V/m and $H(z, t) = 3.8 \cos(10^7\pi t - \beta z)a_y$ A/m, represent a uniform plane wave propagating at a velocity of 1.4×10^8 m/s in a perfect dielectric. Find: (i) β. (ii) λ. (iii) η. (iv) μ_r. (v) ε_r.

Question 2 | 20 marks

a- A linearly polarized uniform plane wave is propagating in a homogenous medium. The following information is provided:

- The operating frequency is 10 GHz.
- The attenuation constant in the medium is $4\pi\times10^2$ Nepers/mm.
- $|E|/|H| = 0.0889\ \Omega$.
- The magnetic field phasor lags the electric field one by 45°.

(i) What is the wavelength in the medium?

(ii) What distance must the wave propagate for its time-average power density to be reduced by 50%?

(iii) Calculate the magnetic permeability and the conductivity of the medium?

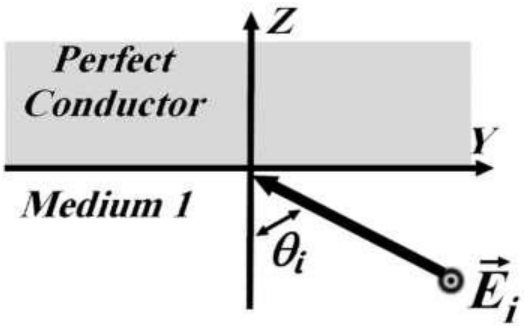
b- It is required a minimum field of 0.25 mV/m for AM station covering the area of a city. What is the power density (W/m^2) associated with this minimum field?

Some Constants:

Free-space permittivity $\varepsilon_0 = 8.85\times10^{-12}$ F/m.

Free-space permeability $\mu_0 = 4\pi\times10^{-7}$ H/m.

Question (3)



A **TE** plane wave with its electric field polarized in the ***X*** direction, is incident from air (medium 1) onto a perfect conductor at an angle $\theta_i = 60°$ as shown in the figure to the right. Accordingly, the total field in the air is a pure standing wave. The amplitude of the phasor E_i of the electric field is equal to ***37.7 V/m***. The angular frequency $\omega = 3\times10^9$ rad/s.

Calculate:

a) The phase propagation constant β (wave number) of the incident wave.

b) Calculate the components of the wave vector $\vec{\beta}$ of the incident and reflected waves.

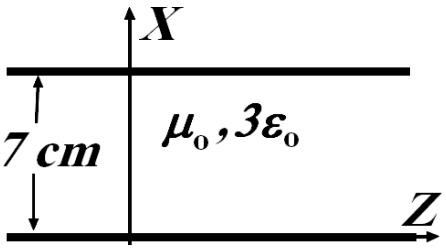
c) Calculate the phasor form of all the components (incident and reflected) of the electric and magnetic fields in air.

d) Calculate all the components (electric and magnetic fields) of the ***standing wave*** in the ***time*** domain as functions of (y,z,t).

e) Calculate the ***magnitude*** and ***direction*** of the ***phase*** and ***group*** velocity of the standing wave.

(25 marks)

Question (4)



The TM_2 mode propagates in the parallel-plate waveguide shown in the figure to the right at a frequency ***10*** GHz. Calculate the positions in the *X* direction where the ***magnitude*** of the electric field component E_z is maximum.

(20 marks)

Some Constants:

Free-space permittivity = 8.85×10^{-12} F/m.

Free-space permeability = $4\pi\times10^{-7}$ H/m.

Good Luck

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