UOG-UESTC Joint School of

University of Electronic Science and Technology of China

Electromagnetic Field and Microwave Technology — Spring 2020

Final Exam

09:30—11:30 AM, 4th , September, 2020

Notice: **Please make sure that both your UESTC and UoG Student IDs are written on the top of every sheet. This examination is closed-book and the use of a calculator or a cell phone is not permitted. All scratch paper must be adequately labeled. Unless indicated otherwise, answers must be derived or explained clearly. Please write within the space given below on the answer sheets.**

All questions are compulsory. There are 4 questions and a maximum of 100 marks in total.

The following table is for grader only:

Question	1	2	3	4	Total	Grader
Score						

Score

Question 1 [22 points]

(1) **State what is the magnetization vector $\vec{M}$; describe the relationship among vectors $\vec{M}$, $\vec{B}$ and $\vec{H}$; how to find the volume magnetized current density and surface magnetized current density by magnetization vector M? [5 points]**

(2) **Briefly describe the expression and physical significance of Poynting vector. [5 points]**

(3) **Explain the phase and amplitude conditions for linearly, circularly and elliptically polarized waves, respectively (Assume the wave propagates along +Z direction). [6 points]**

(4) **Illustrate the type of the polarization for the following uniform plane wave. [6 points]**

$$\vec{E} = \vec{e}_x E_{\mathrm{m}} \sin(\omega t + kz) + \vec{e}_y 2E_{\mathrm{m}} \cos(\omega t + kz)$$

Score

Question 2 (20 points)

A straight long wire and a rectangular loop are placed inside the space with left side of free space and right side of material, as shown in Figure. 1. The long wire is placed at the interface of air (μ_0) and magnetic material (μ) where loop located.

(1) Determine the magnetic flux density $\vec{B}$ in both left side and right side of the space; [10 points]

(2) Derive the mutual inductance between the wire and the loop. [10 points]

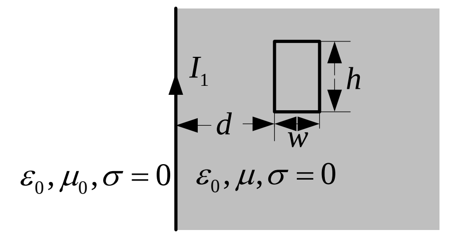

Figure. 1

Score

Question 3 (30 points)

In time-varying field, the electric field and magnetic field can be induced by each other. The complex expression for magnetic field intensity of plane wave in air is $\vec{H} = (-\vec{e}_x A + \vec{e}_y 2 + \vec{e}_z 4)\mathrm{e}^{-\mathrm{j}\pi(4x+3z)}$, **where A is a constant.**

Find: (1) Wave vector $\vec{k}$ **; [5 points]**

(2) Wavelength and frequency; [5 points]

(3) The value of A; [5 points]

(4) The phasor expression for electric field intensity; [7 points]

(5) Average Poynting vector. [8 points]

Score

Question 4 (28 points)

A uniform plane wave with right-hand circular polarization is normally incident from air to an ideal conducting plane at z=0, as shown in Figure 2. The complex electric field is $\vec{E}_i(z) = E_0(\vec{e}_x - j\vec{e}_y)e^{-j\beta z}$ **.**

Find: (1) The electric field and determine the polarization for reflected wave; [10points]

(2) The current density on the conducting plane surface; [10 points]

(3) The total instantaneous expression of electric field intensity for z<0. [8 points]

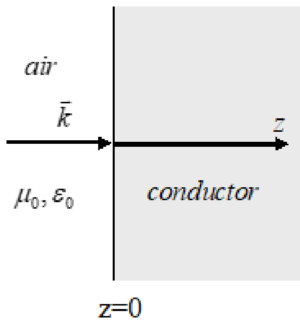

Figure 2

Appendix

Cylindrical coordinate system

$$\nabla\cdot\boldsymbol{A}=\frac{1}{\rho}\frac{\partial}{\partial\rho}(\rho A_\rho)+\frac{1}{\rho}\frac{\partial A_\phi}{\partial\phi}+\frac{\partial A_z}{\partial z}$$

$$\nabla\times\boldsymbol{A}=\frac{1}{\rho}\begin{vmatrix}\boldsymbol{e}_\rho & \rho\boldsymbol{e}_\phi & \boldsymbol{e}_z\\ \frac{\partial}{\partial\rho} & \frac{\partial}{\partial\phi} & \frac{\partial}{\partial z}\\ A_\rho & \rho A_\phi & A_z\end{vmatrix}$$

$$\nabla^2 u=\frac{1}{\rho}\frac{\partial}{\partial\rho}(\rho\frac{\partial u}{\partial\rho})+\frac{1}{\rho^2}\frac{\partial^2 u}{\partial\phi^2}+\frac{\partial^2 u}{\partial z^2}$$

Spherical coordinate system

$$\nabla\cdot\boldsymbol{A}=\frac{1}{r^2}\frac{\partial}{\partial r}(r^2A_r)+\frac{1}{r\sin\theta}\frac{\partial}{\partial\theta}(\sin\theta A_\theta)+\frac{1}{r\sin\theta}\frac{\partial A_\phi}{\partial\phi}$$

$$\nabla\times\boldsymbol{A}=\frac{1}{r^2\sin\theta}\begin{vmatrix}\boldsymbol{e}_r & r\boldsymbol{e}_\theta & r\sin\theta\boldsymbol{e}_\phi\\ \frac{\partial}{\partial r} & \frac{\partial}{\partial\theta} & \frac{\partial}{\partial\phi}\\ A_r & rA_\theta & r\sin\theta A_\phi\end{vmatrix}$$

$$\nabla^2 u=\frac{1}{r^2}\frac{\partial}{\partial r}(r^2\frac{\partial u}{\partial r})+\frac{1}{r^2\sin\theta}\frac{\partial}{\partial\theta}(\sin\theta\frac{\partial u}{\partial\theta})+\frac{1}{r^2\sin^2\theta}\frac{\partial^2 u}{\partial\phi^2}$$