UESTC Student ID_____ UOG Student ID_____ Course Title_____ Lecturer_____

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UOG-UESTC Joint School of

University of Electronic Science and Technology of China

Electromagnetic Field and Microwave Technology — Spring 2019

Final Exam

19:00-21:00pm, 22nd June, 2019

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 6 questions and a maximum of 100 marks in total.

The following table is for grader only:

Question	1	2	3	4	5	6	Total	Grader
Score								

Score

Question1 (20 points)

(1) Please, state Gauss's law. Under what condition is Gauss's law especially useful in determining the electric field intensity of a charge distribution? (5 points)

(2) Please, state the boundary conditions between ideal dielectric interface and air when $\vec{J}_S = 0$ and $\rho_S = 0$. (5 points)

(3) Please, state Joule's first law. Express the power dissipated in a volume in terms of electric field $\vec{E}$ and conductivty σ. (5 points)

(4) Please, briefly describe the expression and physical significance of Poynting vector. (5 points)

Score

Question2 (20 points)

(1) What is the physical meaning of the gradient of a scalar field? Express the space rate of change of a scalar field φ in a given direction $\vec{e}_r$ in terms of its gradient. (5 points)

(2) If the electric field intensity E at a point is zero, does it follow that the electric field potential φ is also zero at that point? Explain. (5 points)

(3) A fixed voltage is connected across a parallel-plate capacitor. Does the electric field intensity in the space between the plates depend on the permittivity of the medium? Explain. (5 points)

(4) Please explain the reason why the B-field of an infinitely-long, straight, current carrying conductor cannot have a component in the direction of the current. (5 points)

Score

Question3 (18 points)

As depicted in Fig.1. A dielectric spherical shell with permittivity ε. The spherical shell centered at the origin. Its inner and outer radius are *a* and *b*, respectively. A point charge *q* is located at the center of the sphere.

Between the two conductors, find:

(1) the polarization intensity vector. （7 points）

(2) the polarized volume charge density inside the shell. （3 points）

(3) the polarized surface charge densities on the inner and outer surfaces of the spherical shell （8 points）

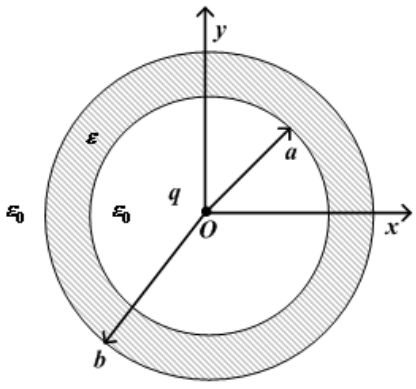

Fig. 1

Score

Question4 (15 points)

As shown in Fig.2, a pair of infinitely-long parallel wires carrying current I in opposite direction are placed close to each other. a = 0.2 m, b = c = d = 0.1 m.

Evaluate:

(1) the magnetic field intensity at point A. (5 points)

(2) the mutual inductance between the parallel wires and the rectangle loop. (8 points)

(3) the induced electromotive force in the rectangle loop if $I = I_0 \cos(\omega t)$. (2 points)

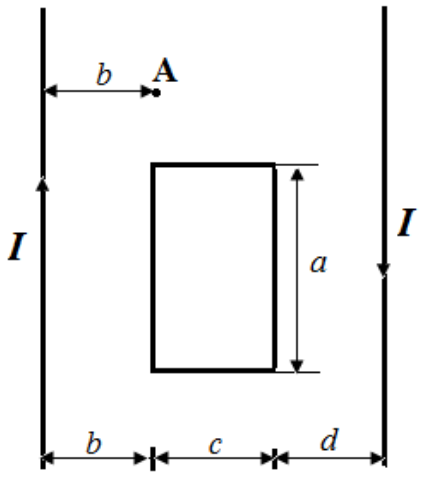

Fig. 2

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Score

Question5 (15 points)

The electric field intensity of a plane wave in air is $\vec{E} = (3\vec{e}_x + 4\vec{e}_y + A\vec{e}_z)e^{-j\pi(4x-3y)}$,

Please, find: (1) the wavelength and frequency. (4 points)

(2) if the plane wave is right-hand polarized, what is the value of A? (6 points)

(3) the expressions of instantaneous electric and magnetic fields. (5 points)

Score

Question6 (12 points)

A plane wave is incident from air onto the surface of an ideal dielectric medium and the standing wave ratio is 3. On the boundary, the electric field of standing wave reaches the minimum and the wavelength in the ideal dielectric is 1/2 the wavelength in air.

Please Evaluate:

(1) the relative permittivity and permeability of the ideal dielectric medium. (8 points)

(2) the ratio between the reflected and the incident waves. (4 points)

Appendix

Cylindrical coordinate system

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

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

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

Spherical coordinate system

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

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

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