國 立 清 華 大 學 命 題 紙

八十九學年度第二學期 電機工程 電子工程 研究所 博士班研究生資格考試

科目 電磁理論 科號_____ 共 2 頁第 1 頁 ＊請在試卷(答案卷)內作答

1. Describe **how** does the "method of image" work in determining the electrostatic potential of a certain charge distribution. Explain **why** does it work. (10%)

2. Explain in detail the operation principle of a simple direct-current motor. The direct-current motor is composed of a current loop placed in a magnetic field (10%)

3. We can heat up a metal by placing it in a time-varying magnetic field to create a so called "eddy current" in the metal. Explain in detail **why** does it work. (10%)

4. (a) Explain the physics of group velocity? (3%)
   (b) Explain the physics of phase velocity? (3%)
   (c) It is found that in a very lossy waveguide group velocity could be larger than the velocity of light in a vacuum. Give a satisfactory explanation. (4%)

5. (a) Explain the physical original of the Brewster Angle. In other words, why is (not what) the Brewster angle? (Please do not just write down the definition of the Brewster angle.) (5%)
   (b) When the incident angle is slightly larger or smaller than the Brewster angle, the reflected electromagnetic waves from a dielectric are out of phase by a 180-degree phase angle. Explain the physics of this phase shift by using the concept of a dipole antenna. (5%)

6. (a) Explain **why** a hollow waveguide cannot support a TEM wave? (5%)
   (b) With the above in mind, explain **why** a parallel-plate waveguide can support a TEM wave? A parallel-plate waveguide consists of two infinitely large conducting plates with a suitable vacuum gap between them. (5%)

7. A radio wave is incident on an infinitely large conducting plate with a hollow aperture on it. If the aperture diameter is several times smaller than the incidence wavelength, the electromagnetic wave behind the aperture is evanescence. Explain the physics of this phenomenon. (5%)

8. The rectangular cavity resonator, a microwave counterpoint of the resonant circuit, consists of a box comprising the region $0 < x < a$, $0 < y < b$, and $0 < z < d$, and bounded by perfectly conducting walls on all of its sides. The electric and magnetic fields inside the resonator for a particular mode are given by

$$\vec{E} = \hat{a}_y E_0 \sin\frac{\pi x}{a}\sin\frac{\pi z}{d}\cos\omega t$$

$$\vec{H} = \hat{a}_x H_{01}\sin\frac{\pi x}{a}\cos\frac{\pi z}{d}\sin\omega t - \hat{a}_z H_{02}\cos\frac{\pi x}{a}\sin\frac{\pi z}{d}\sin\omega t$$

where E_0, H_{01}, and H_{02} are constants, and ω is the radian frequency of oscillation. The energy stored in the resonator is continuously interchanged between the electric and magnetic fields, with the total remaining constant. Assume the medium to be free space. **(a)** Find the value of ω. **(b)** Show that the energy stored in the electric field, when the magnetic field is zero ($\sin\omega t = 0$), is the same as the energy stored in the magnetic field, when the electric field is zero ($\cos\omega t = 0$). (15%)

國 立 清 華 大 學 命 題 紙

八十九學年度第二學期 電機工程 電子工程 研究所 博士班研究生資格考試

科目 電磁理論 科號 共 2 頁第 2 頁 *請在試卷(答案卷)內作答

9. **Why** is the dimension b of a rectangular waveguide generally chosen to be less than or equal to one-half the dimension a? (5%)

10. **Why** is the expression for radiation resistance of a Hertzian dipole not valid for a linear antenna of any length? (5%)

11. Explain **why** the pulse broadening as it passes through a dispersive medium. (5%)

12. Is the cutoff **wavelength** dependent on the dielectric material filled in the waveguide? Is the cutoff **frequency** dependent on the dielectric material filled in the waveguide? (5%)