國 立 清 華 大 學 命 題 紙

一百零三學年度第一學期 光電工程研究所 博士班研究生資格考試

科目 電磁理論 共 頁第 頁 ＊請在試卷(答案卷)內作答

1. (15%) Show that in a good conductor the magnetic field of a plane wave lags the electric field by 45°, and find the ratio of their amplitude (intrinsic impedance).

2. (10%) Consider a rectangular waveguide, infinitely long in the *z*-direction, with a width (*x*-direction) *2* cm and a height (*y*-direction) *1* cm. With the wave equation which describes the **E** and **B** fields of the lowest modes, and find the phase velocity and group velocity, accordingly, if the lowest mode can propagate.

3. (10%) Describe and explain in detail the basic working principle of the direct current motor.

4. (10%) In waveguide theory, much effort is dedicated to solving the "modes". Can we analyze the electromagnetic wave propagation in a waveguide without knowing the modes? Justify your answer.

5. (10%) Consider transmission lines:

   (a) (3%) Sketch the lumped-element circuit model for a differential length.

   (b) (5%) From your sketch, derive the generalized transmission-line equations.

   (c) (2%) From your results in (b), derive the expressions for the wave propagation constant for a lossless transmission-line.

6. (5%) Maxwell's equations represent one of the most elegant and concise ways to state the fundamentals of electricity and magnetism. Please write down and explain briefly the following four equations and derive the wave equation.

(a) (0.5%) Gauss' law for electricity

(b) (0.5%) Gauss' law for magnetism

(c) (0.5%) Faraday's law of induction

(d) (0.5%) Ampere's law

(e) (3%) Wave equation

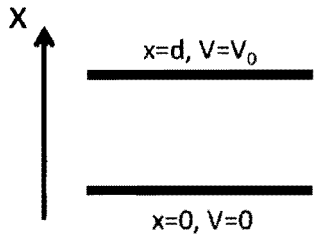
7. (10%) Write down boundary conditions for the Electric field and the Magnetic field (4%) and apply these boundary conditions to examine the behaviour of EM waves at the following three interfaces.

(a) (2%) Dielectric - Dielectric Interface

(b) (2%) Dielectric - Perfect Conductor

(c) (2%) Conductor-Conductor (steady state current)

8. (15%) Consider two infinite, plane, parallel, perfectly conducting plates occupying the planes x=0 and x=d and kept at potentials V=0 and V=V_0, respectively, as shown below.



(a) (2%) Does the potential between the region between the plates satisfy Poisson's or Laplace's equation? Please explain.

(b) (5%) Please find the potential distribution in the region between the plates.

(c) (8%) Assume that the region between the plates is filled with two dielectrics having permittivity ε_1 for $0<x<t$ (region 1) and ε_2 for $t<x<d$ (region 2). Please find the solutions for the potential in the two regions $0<x<t$ and $t<x<d$.

9. (15%) When there is a relative motion between a time-harmonic source and a receiver, the frequency of the wave detected by the receiver tends to be different from that emitted by the source. This phenomenon is known as the Doppler effect. Let us assume that a light transmitter of a time-harmonic wave of a frequency f moves with a velocity u (assume $u << c$) at an angle θ relative to the direct line to a stationary receiver.

(a) (5%) Please derive and show that the frequency of the received wave is $f' = \dfrac{f}{1 - \dfrac{u}{c}\cos\theta}$

(b) (5%) If the transmitted signal has a spectral linewidth of $\Delta\upsilon$, what would be the linewidth of the received signal after the Doppler effect?

(c) (5%) If the stationary receiver (target) has a rough surface comparable to the wavelength of the light, how would the linewidth of the received signal change? Why?