國 立 清 華 大 學 命 題 紙

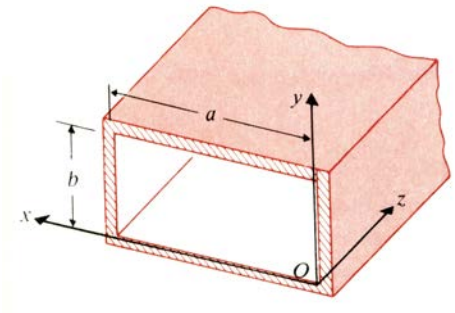
一百學年度第二學期 光電工程研究所 博士班研究生資格考試

科目 電磁理論 共 頁第 頁 ＊請在試卷(答案卷)內作答

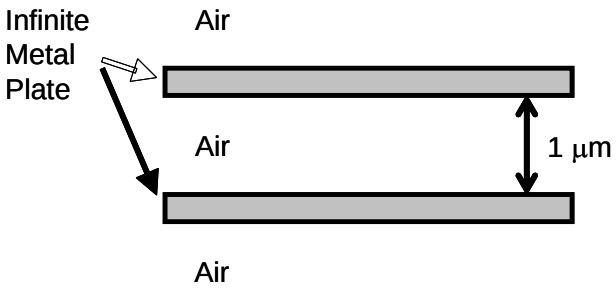
1. Consider a rectangular waveguide made by perfect metal as shown in the following figure. Suppose $a > b$.

1A) (5%) What is the smallest mode number (m,n) of TE_{mn}?

1B) (10%) What is the cut-off frequency?



2. (10%) A metallic planar waveguide is shown as follows. What is the frequency range so that only one TE guided mode exists? Suppose the metal is a perfect conductor.



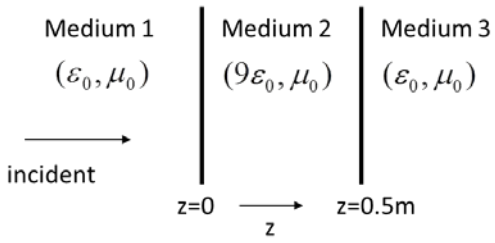
3. Consider transmission lines:

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

3B) (8%) From your sketch, derive the generalized transmission-line equations.

3C) (4%) From your results in Problem 3B, derive the expressions for the wave propagation constant for a lossless transmission-line.

4. For a sinusoidal time-varying uniform plane wave incident normally from medium 1 to a boundary at z=0 as shown below.



4A) (10%) Please show that there is a minimum value of the frequency for which a wave at that frequency or any integer multiple of that frequency undergoes no reflection at the interface (between medium 1 and 2). (Do not just plug in the equation but derive your answer from matching the fields.)

4B) (5%) Please find the maximum value of the period of a non-sinusoidal periodic wave for which no reflection occurs at the interface. Explain your reasoning.

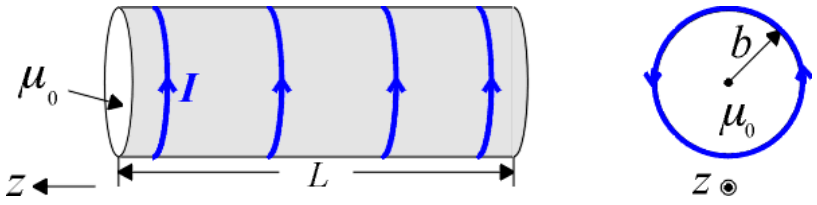
5) The electric field of a uniform plan wave propagating in free space is described below:

$$\vec{E} = 10(\hat{a}_x + j0.4\hat{a}_y + j0.3\hat{a}_z)e^{j(0.6y-0.8z)}$$

5A) (5%) Please discuss the polarization of the wave. (Answer without explanation won't count.)

5B) (5%) Please find the associated magnetic field.

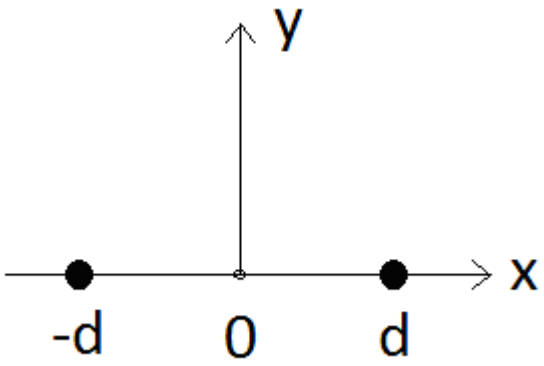
6) Consider a hollow cylindrical solenoid with *n* turns per unit length and flowing with a constant current *I*. The radius and length of the solenoid are *b* and *L*, respectively (see the following figure). Neglect the fringing effect at the edges.



6A) (5%) What is the magnetic field intensity $\vec{H}(\vec{r})$ inside the solenoid? Justify your answer.

6B) (10%) If the current becomes time-varying $I(t) = \mathrm{Re}\{I_0 e^{j\omega t}\}$, what is the time-averaged Poynting vector $\vec{P}_{av}(\vec{r})$ at every point inside the solenoid? (*Hint*: $\vec{P}_{av}$ can be derived by taking real part of the cross product of field vector phasors.)

7) Consider two positive charges placed on *x*-axis with distance 2*d* to each other.



7A) (6%) If there is a 3rd positive charge sits near the origin, show that (a) under what condition, and (b) in which direction, it behaves like a harmonic oscillator.

7B) (6%) If the 3rd charge is negative, show that (a) under what condition, and (b) in which direction, it behaves like a harmonic oscillator.

7C) (4%) How to extend the idea in Problem 7A to form a 2D harmonic oscillator?

7D) (4%) Is it possible to extend the idea in Problem 7B to form a 2D harmonic oscillator?