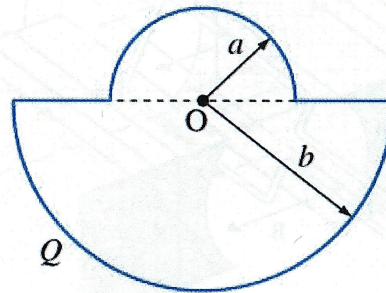


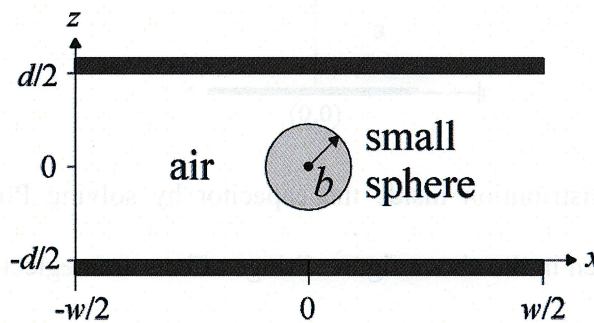
國立清華大學命題紙

101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 3 頁第 1 頁 *請在試卷(答案卷)內作答

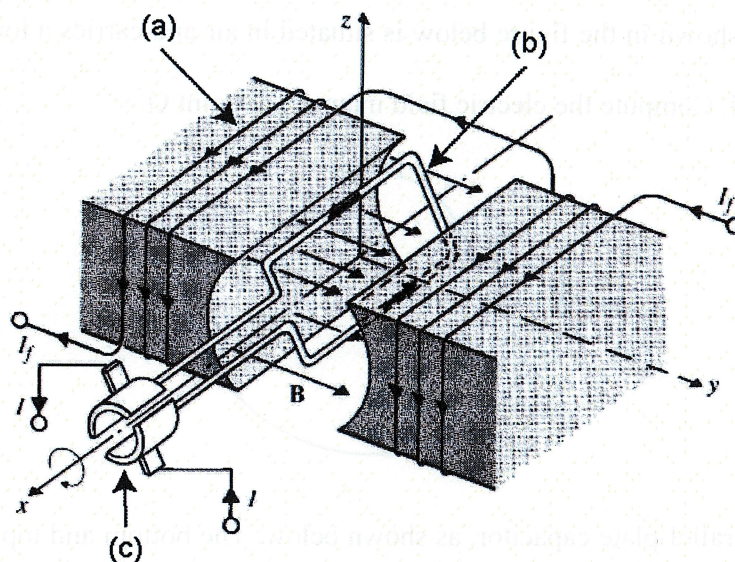
1. (10%) A contour as shown in the figure below is situated in air and carries a total charge of Q that is uniformly distributed. Compute the electric field intensity at point O.



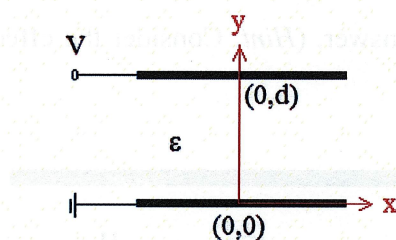
2. (10%) Consider a parallel-plate capacitor, as shown below. The bottom and top conducting plates are deposited with free charges $\pm Q$, and a small conducting sphere (with radius $b \ll d$) around $(x, z) = (0, 0)$ is inserted in between. Roughly sketch the distributions of the free charges $\pm Q$ on the conducting plates. Justify your answer. (Hint: Consider the effect of the induced charges on the surface of the sphere.)



3. (15 %) Below shows the perspective view of a dc motor.
- Please clearly describe the principle of how this motor works by stating the functions and mechanisms of each of the parts (a), (b), and (c) as shown. (4%)
 - What determine the maximum speed of the motor? (4%)
 - How to convert a DC motor to a DC generator? (4%)
 - Can you design a motor without the brush? Please explain its principles. (3%)



4. (10%) Consider a simple capacitor shown below:



- (a) Calculate the voltage distribution inside the capacitor by solving Poisson's equation with the boundary conditions given in the above figure. Fringe effects are neglected. (6%)
 - (b) Calculate the electric field distribution inside the capacitor. (2%)
 - (c) Calculate the charge distribution on the two parallel plates. (2%)
5. (10%)
- (a) Write down Maxwell's equations. (4%)
 - (b) Which term wasn't there when Maxwell first wrote the equations? Could you have an electromagnetic wave without that term? (2%)
 - (c) Derive the wave equation from Maxwell equations. (4%)

6. (8%) The nonlinear Schrödinger equation (NLSE) is a simple model to describe the propagation of a light pulse in an optical fiber,

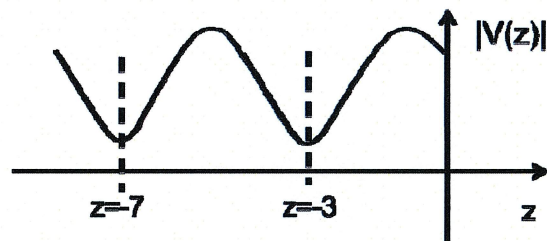
$$i \frac{\partial}{\partial z} E = -\frac{1}{2} \frac{\partial^2}{\partial x^2} E - \gamma |E|^2 E,$$

where E is the envelope function of the light pulse. Find the corresponding Plane Wave solutions for NLSE.

7. (7%) A time-harmonic electromagnetic plane wave has a frequency of 1 GHz, propagating in vacuum along the direction $\frac{1}{\sqrt{2}}(\hat{a}_x + \hat{a}_z)$, where \hat{a}_x, \hat{a}_z are unit vectors in x and z , respectively. (a) If any, what is the polarization direction of this plane wave in the x - z plane? (3%) (b) Assume this wave is polarized along y with a real amplitude of E_0 and an initial phase of ϕ , write down the phasor expression of the electric field of this plane wave. Specify the units for the numerical values in the phase. (4%)

8. (15%) An air-filled lossless 100Ω TEM transmission line is terminated with a complex load Z_L .

- (a) What is the numerical value of the inductance L for this line? (5%)
 (b) The magnitude of the voltage $|V(z)|$ is measured on this line as illustrated. The $\text{SWR}=3$. What fraction of the power incident upon the load is being reflected? (5%)



- (c) What is the impedance Z at the location $z = -3$ m? (5%)
9. (15%) A metallic planar waveguide is shown as follow. What is the frequency range so that only one TE guided mode exists? Suppose the metal is a perfect conductor.

