國　立　清　華　大　學　命　題　紙

95 學年度 工程與系統科學 系（所） 戊 組碩士班入學考試

科目 電磁學 科目代碼 3602 共 2 頁第 1 頁 *請在試卷【答案卷】內作答

1. Two charges q and $-q$ are placed at the opposite sides of a grounded conducting sphere of radius a with a distance $2a$ from the center of the conductor, as shown in Fig. 1. Find the force on the charge q. (20%)

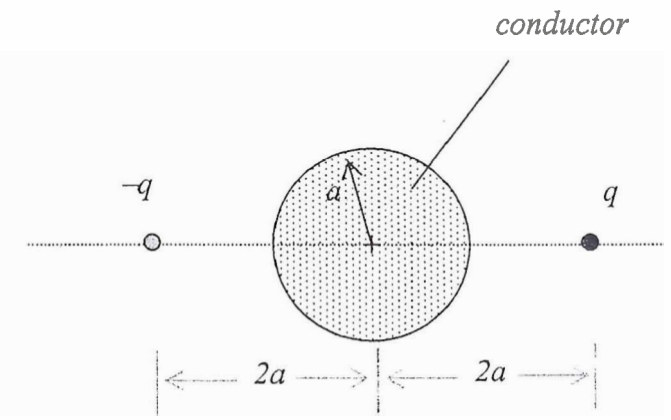

Fig. 1

2. (a) For static electric fields, write down the two differential equations governing the distribution of electric fields, i.e., the *divergence* and *curl* of $\mathbf{E}$ = ??

(b) From (a), find the *boundary conditions* for electric fields just above and below a surface with a surface charge density σ, in terms of electric field components *normal* and *parallel* to the surface.

(c) From (b), find the boundary conditions for electric potential, both potential itself and its normal derivative. (20 %)

3. Describe the trajectory of an *electron* initially at rest ($\mathbf{v} = 0$) in a region having an electric field $\mathbf{E}$ and a magnetic field $\mathbf{B}$, assuming $\mathbf{E} \perp \mathbf{B}$ and both are uniform. Briefly explain why the electron follows such a trajectory (from the electric and magnetic forces on the electron). (20 %)

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4. For a waveguide formed by two parallel plates (free space in between) of width a and spacing b as shown in Fig. 2, solve the wave equation of **TM** modes. (assume $b << a$, and the fields are uniform in x-direction):

(a) show that the cutoff frequency (angular frequency) is given by (20 %)

$$\omega_m = c m\pi/b\,,\ m = 0,1,2\ \ldots.$$

(b) find the electric and magnetic fields distributions (in components form). Show that TM_0 mode exists, i.e., the transverse fields are non-vanishing for $m = 0$ (it is just the TEM mode).

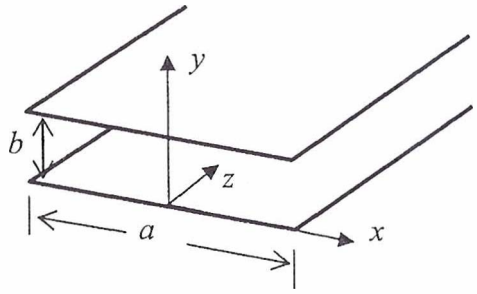

Fig. 2

5. An infinite long rectangle with a height and a width of $a = 1$ cm and $b = 2$ cm, respectively, is filled with a dielectric of relative permittivity $\varepsilon_r = 2$ and enclosed by perfect electric conductors which are held at different electrostatic potentials, as shown in Fig. 3 (cross sectional view). (20 %)

(a) Find the potential distribution everywhere inside the rectangle.

(b) Find the charge density distribution everywhere, including both free and bound charges.

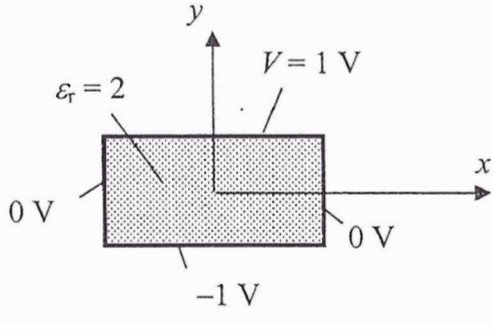

Fig. 3