國立臺北科技大學 103 學年度碩士班招生考試

系所組別：2402 光電工程系碩士班

第三節　電磁學　試題（選考）

注意事項：

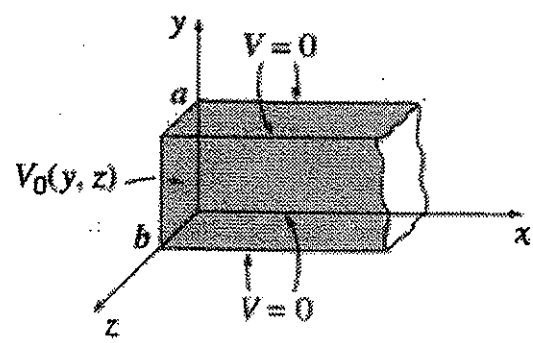
1. 本試題共 6 題，配分共 100 分。
2. 請標明大題、子題編號作答，不必抄題。
3. 全部答案均須在答案卷之答案欄內作答，否則不予計分。

For your reference: $\varepsilon_0 = 8.85\times10^{-12}\ F/m$　　$\mu_0 = 4\pi\times10^{-7}\ H/m$

$$\int \sin^2 x dx = \frac{x}{2} - \frac{\sin 2x}{4}$$

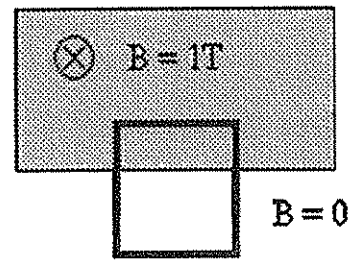
1. Answer the following questions with brief calculation or reasoning:
   (a) A point charge q is held a distance d above an infinite grounded conducting plane. How much work is required to move the charge to infinity? (5%)
   (b) There are two concentric spherical metal shells of radii R_1 and R_2 ($R_1 < R_2$). What is the charge on the inner shell if it is grounded and the outer shell carries a charge q? (5%)
   (c) A parallel-plate capacitor has plates of area 1 m^2 separated by 1 cm. It is connected to a 1000-V battery. What is the force between the plates in newtons? (5%)
   (d) An airplane with a wingspan of 40 m flies at 350 m/s in which the vertical component of the earth's field is 0.5 G. A passenger on the plane tries to measure the induced emf by connecting the leads of a voltmeter to the wingtips. What would the voltmeter read? (5%)

2. An infinitely long rectangular metal pipe (side a and b) is grounded, but one end, at x = 0, is maintained at a potential $V_0(y,z) = \sin(\frac{3\pi}{a}y)\sin(\frac{5\pi}{b}z)$, as shown in the figure. Find the potential inside the pipe. (15%)



3. A long circular cylinder of radius R carries a magnetization $\vec{M} = kr^2\hat{\phi}$, where k is a constant, r is the distance from the axis, and $\hat{\phi}$ is the usual azimuthal unit vector. Find the magnetic field $\vec{B}$ due to $\vec{M}$, for points inside and outside the cylinder. (15%)

4. A vertical square loop of copper wire is falling from a region where the magnetic field is horizontal, uniform and of magnitude B = 1T into a region where the field is zero, as shown in the figure. (In the figure, shading indicates the field region; $\vec{B}$ points into the page.) If the velocity of fall reaches a steady value while its upper segment remains in the magnetic field region, calculate this terminal velocity (in m/s). The resistivity of copper is $1.7\times10^{-6}\Omega\cdot cm$; the density is 8.9 g/cm^3. (15%)



5. The electric field of a plane wave propagating in a dielectric medium is given by a complex form of:

$$\vec{E}(\vec{r},t) = (5\hat{y} - 12\hat{z})e^{j(3\times10^6 y + \frac{5}{4}\times10^6 z + \frac{13}{2}\times10^{14} t)} \quad (V/m)$$

Please find (a) the wavelength λ, (5%)

(b) dielectric constant ε_r of the medium if $\mu = \mu_0$, (5%)

(c) the angle between the propagation direction and +Z-axis, (5%)

(d) complex form of $\vec{H}(\vec{r},t)$-field. (5%)

6. Consider an air-filled rectangular waveguide with dimensions 2.29 cm x 1.02 cm.

(a) What TE modes will propagate in this wave guide, if it operates at 18 GHz? (10%)

(b) If you want to excite only one TE mode, what range of frequencies could you use? (5%)