本試題是否可以使用計算機：☑可使用，□不可使用（請命題老師勾選）

1. (a) Show that the electric field $\boldsymbol{E}$ can be expressed in terms of potentials: $\boldsymbol{E} = -\nabla V - \frac{\partial \boldsymbol{A}}{\partial t}$. (5%)

   (b) Use the result of part (a) to discuss the concept of qA (q is charge). (5%)

2. As shown in Fig. 1, a cylindrical capacitor of length L consists of a central conductor of radius r_i and surrounded by a cylindrical shell of radius r_o. The empty space between the surfaces is half-filled with a dielectric of permittivity ε_1, while the other half contains a dielectric of permittivity ε_2. Find the capacitance. (10%)

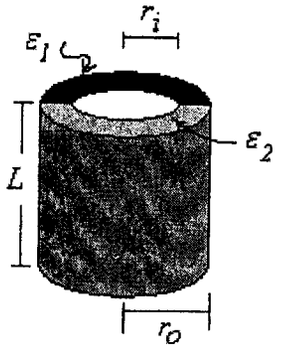

Fig.1

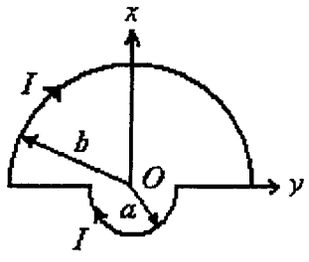

Fig.2

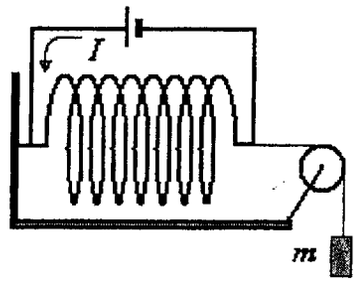

Fig.3

3. Two semicircle loops of radius a and b have a common center and their ends are joined by straight wires, as shown in Fig. 2. If the two loops are perpendicular to each other (xy plane and yz plane), what is the $\boldsymbol{B}$ field at the center? (10%)

4. A circular coil of length L and radius a has N turns of wire and carries a current I. A block with mass m is connected to the coil by a light thread that passes over a frictionless pulley, as shown in Fig. 3. What is the current if the coil is not stretched. (10%)

5. Assuming the electron is a sphere of radius r_0 with uniform volume-charge distribution. The sphere rotates about one of its diameters with constant angular velocity ω.
   (a) Determine the magnetic moment.
   (b) The value of electron spin magnetic moment is 9.27×10^{-24} J/T. Evaluate the tangential velocity on the equator. ($r_0 = 2.8\times10^{-15}$ m, $e = 1.6\times10^{-19}$ C).

(背面仍有題目,請繼續作答)

(c) Discuss your result obtained in (b). (15%)

6. Consider two infinite conducting parallel planes carrying equal and opposite currents, as shown in Fig.4(a), produce a uniform field inside and zero field outside. Image a cubical section, as shown in the three-dimensional view of Fig. 4(b), is cut from the two parallel sheets. A structure such as this is called field cell if its dimensions are small. (a) Find the inductance of the cell. (b) Use the result in part (a), discuss the meaning of permeability μ_0. (15%)

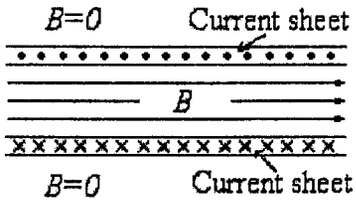

Fig.4(a)

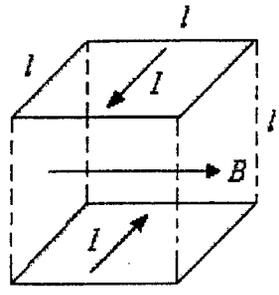

Fig.4(b)

7. Two conducting planes intersect at an angle α is shown in Fig.5. The potential at the plane $\phi = 0$ is zero and the potential of the plane at $\phi = \alpha$ is held at V_0. Find the electric field $\boldsymbol{E}$ in the space between the two planes. (10%)

In cylindrical coordinates

$$\nabla^2 V = \frac{1}{\rho}\frac{\partial}{\partial \rho}\left(\rho \frac{\partial V}{\partial \rho}\right) + \frac{1}{\rho^2}\frac{\partial^2 V}{\partial \phi^2} + \frac{\partial^2 V}{\partial z^2}$$

8. A wire with radius a and conductivity σ is connected to a battery, as shown in the Fig. 6. (a) Find the Poynting vector. (b) Use the Poynting vector to show that the rate at which energy enters the wire is equal to the power loss due to the heating. (10%)

9. Consider the propagation of TE waves in a rectangular waveguide with inner dimensions a, b. Show that if $a > b$, the lowest cutoff frequency, $\omega_{1,0}$, that of the dominant TE mode is $\omega_{1,0} = \frac{\pi}{\sqrt{\mu\varepsilon}\,a}$. (10%)

本試題是否可以使用計算機：☑可使用 ，☐不可使用 （請命題老師勾選）

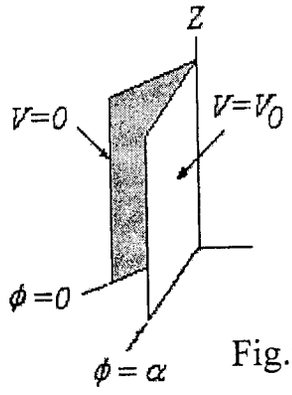

Fig.5

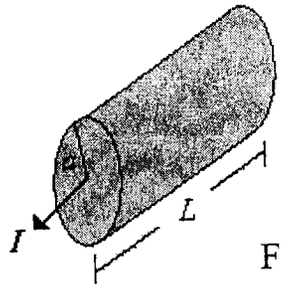

Fig.6