國立臺北大學109學年度日間學士班暨進修學士班轉學生招生考試試題

學制系級：通訊工程學系日間學士班2年級

科　　目：物理學

☐可 ☑不可使用計算機

1. (15 points) Three spherical conductors of diameters (直徑) d_1, d_2 ,and d_3 are separated by distances much greater than the radius of each sphere. The spheres are connected by a conducting wire as shown in Figure 1. Assume each of the three spheres is uniformly charged in electrostatic equilibrium. The total charges of the three spheres are Q Coulombs. Find the charge density (6 points), the electric potential (3 points), and the magnitude of electric field (6 points) on the surface of each of the spherical conductors.
2. (15 points) A solid cylindrical conductor of radius a and charge Q is coaxial with a cylindrical shell of negligible thickness, radius $b > a$, and charge $-Q$ (Figure 2).
   a) Find the capacitance of this cylindrical capacitor if its length is ℓ. (5 points)
   b) Calculate the energy stored in the capacitance. (5 points)
   c) Find the resistance between the solid cylindrical conductor and the cylindrical shell. Assume the resistivity between the solid cylindrical conductor and the cylindrical shell is σ. (5 points)
3. (10 points) Suppose two infinite planes of charge are parallel to each other (Figure 3), one positively charged and the other negatively charged. The positively and negatively charged planes have charge densities of σ_L and $-\sigma_R$, respectively. What are the directions and magnitudes of the electric fields at point P1 (to the left of the positively charged plane, 3 points), P3 (to the right of the negatively charged plane, 3 points) and P2 (between the two planes, 4 points).
4. (10 points) As shown in Figure 4, a charged particle with q Coulomb and m kg passes through a region with the first magnetic field B_{in} and the electric field E. It is known that the charged particle can pass through the region without deflection when the charged particle moves in a specific velocity. After entering the second magnetic field $B_{0,in}$, the charged particle moves in a semicircle of radius r before striking a detector at P. Please find r in terms of m, B_{in}, E, $B_{0,in}$, and q.

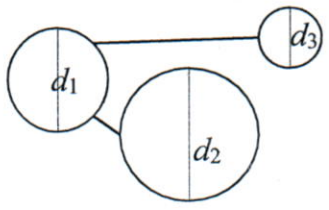

Figure 1

Figure 2

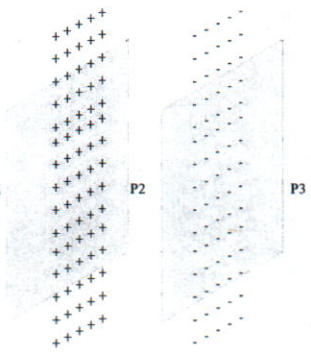

Figure 3

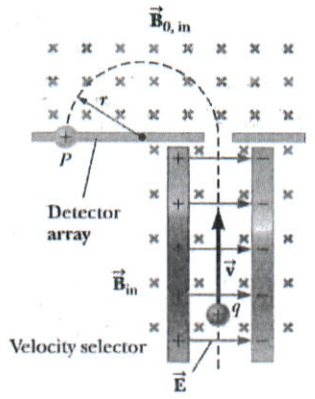

Figure 4

5. (10 points) A long solenoid of radius R has n turns of wire per unit length and carries a time-varying current that varies sinusoidally as $I = I_{max} \cos \omega t$, where I_{max} is the maximum current and ω is the angular frequency of the alternating current source (Figure 5). Please find the magnitudes of the electric field at the points on the dash circle with radius r for the cases $r < R$ (5 points) and $r > R$ (5 points). Assume the magnitude of the magnetic field inside the solenoid is uniform.
6. (10 points) The conducting bar illustrated in Figure 6 moves on two frictionless, parallel rails in the presence of a uniform magnetic field directed into the page. The bar has mass m, and its length

is ℓ. The bar is given an initial velocity $\vec{v}_i$ to the right and is released at $t = 0$. Please find the magnitude of the velocity of the coducting bar as a function of time.

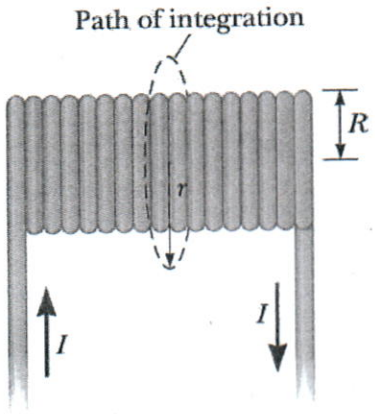

Figure 5

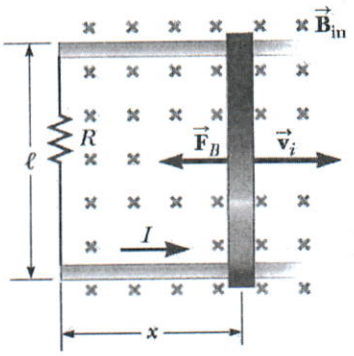

Figure 6

7. (10 points) Figure 7 shows an RL circuit ready to switch from node a to node b. Assume before switching, the current through the inductor has reached the maximum current (i.e. V / R), please prove that the current $I(t)$ after switching to node b is $I(t) = (V / R)e^{-t/(L/R)}$.
8. (10 points) Two infinitely long, parallel wires are lying on the ground a distance a meter apart as shown in Figure 8. A third wire, of length L meter and mass m kg, carries a current of I_1 Ampere and is levitated above the first two wires, at a horizontal position midway between them. The infinitely long wires carry equal currents I_2 in the same direction, but in the direction opposite that in the levitated wire. What current (I_2) must the infinitely long wires carry so that the three wires form an equilateral triangle?

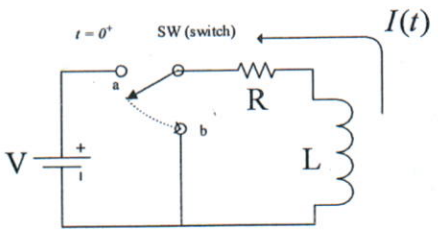

Figure 7

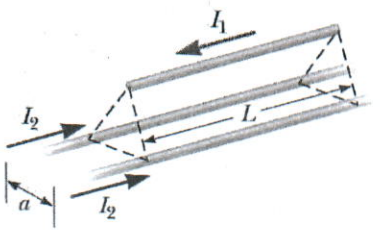

Figure 8

9. (10 points) The electric potential at the position of a point P in three dimensions be given by the vector $r = (x, y, z)$ in Cartesian Coordinates is $(x^2 + y^2 + z^2)^{-0.5}$. Please find the electric field at the point (1, 2, 3).