General Physics II

Final Exam

Spring Semester 2023

1. Consider a ring with radius R situated in the x-y plane, carrying a charge q distributed uniformly on it. (25 points)

    (a) Calculate the electric potential $V(z)$, where z is a point on the axis of the ring.

    (b) Calculate $\vec{E}(z)$ (Hint: You can use $V(z)$).

    (c) Calculate $V(z)$ and $\vec{E}(z)$ for $z << R$ and $z >> R$, and explain the results on physical grounds.

    (d) Suppose a test charge $-q_0 < 0$ is placed at the point z and released from rest. Qualitatively describe its subsequent motion. compute the frequency of small oscillations about $z = 0$.

2. The current density inside a wire in the shape of a long cylindrical shell, with inner radius r_a and outer radius r_b, is in the direction of the axis and varies linearly with radial distance r from the axis according to $j = j_0 r / a$. Find the magnetic field inside the wire. Express your answer in terms of the total current i carried by the wire. (25 Points)

3. A straight piece of conducting wire with mass M and length L is placed on a frictionless incline tilted at an angle θ from the horizontal. There is a uniform, vertical magnetic field $\vec{B}$ at all points. To keep the wire from sliding down the incline, a voltage source is attached to the ends of the wire. Determine the magnitude and direction of the current in the wire that will cause the wire to remain at rest. In addition, show in a free-body diagram all the forces that act on the wire. (25 points)

4. In an electrical circuit, elements R, L, C, and a switch are all connected in series. Initially the switch is open and the capacitor has charge q_0. At $t = 0$ the switch is closed. Solve the relevant differential equation for $q(t)$, assuming the system to be underdamped. Compute the voltage across all three elements, that is $V_R(t)$, $V_L(t)$ and $V_C(t)$, and qualitatively plot them. (25 points)