Physics UN2802 Professor Christ
Midterm Examination (practice) 02/22/2021

Answer **three (3)** of the following **four (4)** questions. Please give a complete description of your method of solution since *partial credit* will be given.

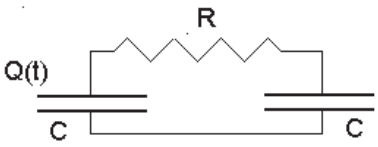
1. A long straight wire of radius R carries a total current I. Assume that the current I is distributed uniformly over the crossection of the wire.

   (a) What is the current density $\vec{j}$ within the wire? [5 points]

   (b) Find the magnetic field $\vec{B}$ outside the wire, $r \geq R$. [14 points]

   (c) Find the magnetic field $\vec{B}$ inside the wire, $r \leq R$. [14 points]

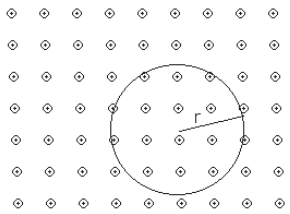
2. Two identical capacitors and a resistor are connected together as shown at the right. Assume that at $t = 0$ the left capacitor has a charge Q_0 and the right capacitor is uncharged. Find the charge $Q(t)$ on the left capacitor as a function of time. [33 points]



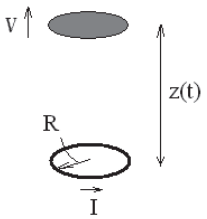
3. Consider a proton with rest energy $mc^2 = 939MeV$ and charge $e = 4.8\ 10^{-10}esu$.

   (a) A proton with energy $20\,TeV$ $(20 \times 10^{12}eV)$ moves in a region of uniform magnetic field $\vec{B}$ of magnitude $50KGauss$. If the proton's velocity is perpendicular to $\vec{B}$, show that it moves in a circle and find that circle's radius. [18 points]

   (b) A proton with initial velocity $\vec{v}_0$ enters a region with a uniform electric and magnetic field $\vec{E}$ and $\vec{B}$. If the vectors $\vec{E}$ and $\vec{B}$ are orthogonal, what condition must $\vec{v}$ satisfy if the proton is to move through the region without being deflected? [15 points]



4. A fixed, horizontal, conducting loop of radius R carries a constant current I. A uniformly charged, non-conducting disk, also horizontal and of radius R, is a distance $z(t)$ directly above the first. You may assume that $z(t) \gg R$. The disk carries a uniform charge density σ.



   (a) Find the magnetic field due to the current in the fixed loop at the height $z(t)$. [15 points]

   (b) Find the torque $\vec{\tau}$ (both its magnitude and direction) exerted on the charged disk if it is is moving upward with velocity $v = \dot{z}(t)$. [18 points]