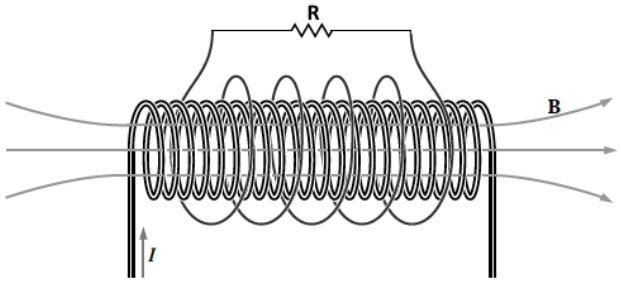
Fall Quarter 2024 – UCSB Physics 110b
Practice Final

- **Problem 1**

  A positron (e^+) is the antimatter partner of the electron, i.e., a particle identical to the electron (e^-) but with positive charge.
  A positron of energy E collides with an electron which is at rest. The electron and the positron annhilate into two photons, $e^+e^- \rightarrow \gamma\gamma$. The two photons are measured to emerge from the collision with equal energies E_γ.
  (a) What is E_γ?
  (b) What is the angle made by the momentum vector of one of the two photons and the momentum vector of the incoming positron.
  (Take the mass of one electron or one positron to be m).

- **Problem 2**



  A solenoid of length L and diameter d consists of N turns of wire. A 5-turn coil with negligible resistence is wrapped around the solenoid and connected to a resistor R as shown in the figure.
  The direction of the current in the solenoid is such that the solenoid magnetic field points to the right. At time $t = 0$ the solenoid current begins to decay exponentially as $I_S(t) = I_0 e^{-\frac{t}{\tau}}$.
  (a) What is the direction of the current in the resistor (I_C) as the solenoid current decays. (specify "from left to right" or "or from right to left").
  (b) Find $I_C(t)$.
  Approximate the solenoid as an ideal infinitely long solenoid...even if

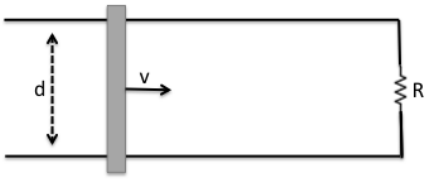
it does not look like that in the picture. Neglect the self-inductance of the coil.

- **Problem 3**

  An infinitely long circular wire of radius R and conductivity σ carries a current $I = \alpha t$, where α is a constant and t is time. The current is distributed uniformly inside the wire. Reminder: conductivity is defined a $\vec{J} = \sigma \vec{E}$, where $\vec{J}$ is the current density and $\vec{E}$ is the electric field.
  (a) Find the magnitude of the displacement current as a function of time at a distance r from the center of the wire, with $r < R$.
  (b) Find the magnitude of the magnetic field as a function of time at a distance r from the center of the wire, with $r > R$.

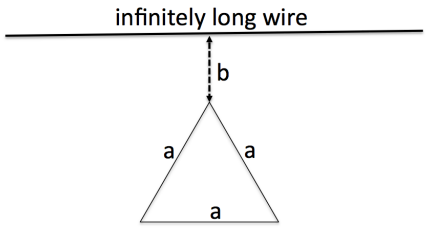
- **Problem 4**

  A conducting bar is sliding at constant velocity v on conducting rails connected to a resistor as shown in the figure. There is a uniform magnetic field B pointing into the paper.
  (a) Find the magnitude of the current in the circuit.
  (b) Find the force that has to be applied externally to maintain the constant velocity v.
  (c) Find the power supplied by this force.



- **Problem 5**

  Consider a infinitely long straight wire and a triangular loop of wire as shown in the figure. Find the mutual inductance of the wire and the loop.



- **Problem 6**

  Suppose that you send an electromagnetic wave at normal incidence on a thin dielectric film between two semi-infinite transparent media (dielectric layer of thickness l). This layer is made of a medium of permeability $\mu = \mu_0$ and with permittivity which decreases from ϵ_1 on superior side to ϵ_2 on inferior side, following a function $\epsilon = f(x)$, where x is the distance to the superior side. What is the time τ to pass the layer?
  The function is: $f(x) = Ae^{-bx}$, with A and b constants with appropriate units.

- **Problem 7**

  An electron of mass m starts from rest and moves through a potential difference of $-V_0$ with acceleration a. If the electron travels a distance d, how much energy is required?