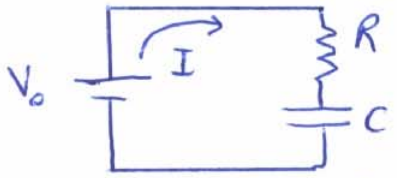
Physics 2020 Assignment 10

1. Consider a capacitor connected to a battery and resistor as shown below.



   a) Show that $V_o = IR + \frac{Q}{C}$ where Q is the capacitor charge.

   b) Solve for Q(t).

   c) RC is a time constant characterizing the speed of capacitor charging. If R = 500 ohm and C = 2 μF, what is RC in sec?

   d) What is the current I(t)?

2. What is the maximum electromotive force induced in a coil of 4000 turns, average radius 12 cm, rotating at 30 revolutions per sec in the earth's magnetic field of 0.5 gauss?

3. Derive an approximate formula for the mutual inductance of two circular rings of the same radius a, arranged like wheels on the same axle with their centers b cm apart. Use an approximation good for b>>a.

4. A coil with resistance of 0.01 ohm and self inductance 0.50 millihenry is connected across a large 12 volt battery of negligible internal resistance.
   a) How long after the switch is closed will the current reach 90% of its final value?

   b) At that time, how much energy in joules is stored in the magnetic field?

   c) How much energy has been withdrawn from the battery up to that time?

5. A magnetic field exists in most of the interstellar space in our galaxy. There is evidence that its strength in most regions is between 10^{-6} and 10^{-5} gauss.
   a) Adopting 3×10^{-6} gauss as a typical value, find in order of magnitude, the total energy stored in the magnetic field of the galaxy. Assume the galaxy is a disk roughly 10^{23} cm in diameter and 10^{21} cm thick.

   b) To see whether the magnetic energy amounts to much, you might consider the fact that all the stars in the galaxy are radiating about 10^{44} ergs/sec. How many years of starlight is the magnetic energy worth?

6. It has been estimated that the magnetic field strength at the surface of a neutron star or pulsar may be as high as 10^{12} gauss.
   a) What is the energy density in such a field?

   b) Express the energy density using the mass energy equivalence in grams per cm^3.