Final Exam Study Sheet Answers

1) Switch S in the figure is closed at time t = 0, to begin charging an initially uncharged capacitor of capacitance C = 10 μF through a resistor of resistance R = 20 MΩ.
A) What is the time constant of the circuit? **[200s]**
B) At what time is the electric potential across the capacitor equal to twice that across the resistor? **[220s]**
C) A capacitor is added to decrease the time constant by half. What capacitance needs to be added, and is it in series or parallel to the original capacitor?**[10μF; in series]**

2) Consider the circuit below and the following events. $\mathcal{E}$ = 12V; $C_1 = C_2$ = 47 μF and R_1=15 MΩ. Switch S_1 is closed, C_1 and C_2 are allowed to charge up completely and then S_1 is opened. Now switch S_2 is closed.
A) What is the total energy of the circuit after S_1 is opened and before S_2 is closed? **[6.77mJ]**
B) What is the time constant of the circuit after S_2 is closed? **[1,410s]**
C) At what time is the potential the same across the both capacitors and the resistor?**[Always]**
D) What value capacitor if added between S_2 and R_1 decreases the time constant by 30%?**[219μF]**

3) In a homogenous particle beam, singly charged ions of mass 3.0×10^{-23} kg are accelerated from rest through an electric potential of 250 kV and the directed into a perpendicular uniform magnetic field, as in a mass spectrometer. The ions travel in a circular arc of radius 95.0 cm and are collected in a cup. The cup collects 180.0 mg/hour.
A) What is the strength of the magnetic field? **[10.2 T]**
B) What is the current of the particle beam? **[267μA]**
C) What magnetic force do the particles experience? Give the magnitude and direction.**[8.42x10^{-14} N toward the center of curvature]**

4) In a cyclotron a singly ionized Hydrogen atom travels in a circular arc of radius 25.0 cm in a magnetic field of 0.85 T.
A) Find the frequency of the oscillator.**[1.29x10^{7} Hz]**
B) What is the energy of the Hydrogen ion in joules? **[3.45x10^{-13} J]**
C) In eV? **[2.16 MeV]**

5) An electron is moving at a speed of 1.2×10^4 m/s in a circular path of radius r = 1.8 cm inside a solenoid. The magnetic field of the solenoid is perpendicular to the plane of the electron's path.
A) Find the magnitude of the magnetic field inside the solenoid. **[3.80 μT]**
B) Find the current in the solenoid if the solenoid has 30 turns per cm. **[1.00 mA]**

6) A thinly insulated copper wire of length 80.0 m is wound as a single layer (long, narrow) solenoid of effective radius 3.0 cm. the wire has a diameter of 0.25 mm and a resistivity of 3.5×10^{-8} Ωm.
A) Determine the resistance of the solenoid. **[57.0 Ω]**
B) What is the physical length of the solenoid? **[10.6 cm]**
C) If the solenoid is connected to a 100 volt dc power supply, determine the magnetic field in the solenoid. **[8.84 mT]**
D) What current does the solenoid draw? **[1.75A]**

7) A uniform magnetic field is created within a circle of radius R = 10.0 cm. A copper ring of radius r = 2.0 cm is placed concentric and coaxial in the field (that is the plane of the ring is perpendicular to the field). The magnetic field points into the page and has a time dependence of $\mathbf{B(t) = 0.015t + 0.120t^2}$, with B in Teslas and t in seconds.
A) Which way will the induced current flow in the ring, CW or CCW? **[CCW]**
B) Which point is at a higher potential, **A** or **B**? **[Equipotentials]**
C) What is the electric field at point **B**, magnitude and direction at t=3s?
[7.35×10^{-3} V/m to the right]
D) If an electron is placed at point that same point **(B),** what is the instantaneous acceleration of the electron due to this electric field? Give the magnitude and direction.
[1.29×10^{9} m/s^2 to the right]

8) The inductance of a tightly wound coil is such that an emf of 3.00 mV is induced when the current changes at a rate of 5.00 A/s. A steady current of 8.00 A produces a magnetic flux of 40.0 μWb through each turn.
A) Find the inductance of the coil.
B) Find the number of turns the coil has.

9) A rigid semi-circular current segment of radius 15.0 cm subtends an angle of 57° and carries a steady current of 2.0 A in a CCW direction. A uniform magnetic field of strength 50.0 mT is directed downward, into the page**.** By integration, determine the net magnetic force (magnitude and direction) acting on this loop.

10) At a specific location the Earth's magnetic field is 0.06×10^{-4} T pointing at 75° below the horizontal in a North – South plane. A 15 A current is sent through a 10.0 m long straight wire.
A) If the wire is directed horizontally toward the East, what is the magnitude and direction of the magnetic force on the wire?
B) If the wire is now pointed vertically upward, what is the magnitude and direction of the magnetic force on the wire?

11) An inductor with a value of 12 μH is placed in series with a 4.7 kΩ resistor; A 12 V potential is applied to the pair.
A) What is the time constant (τ) of the circuit?
B) At what time does the current through the resistor reach half it s maximum value?
C) What is the current through the resistor at $t = 0.5\ \tau$?

12) A particular coil has a resistance of 1.5 Ω. With a current of 6A in this coil the magnetic flux is 30 mWb.
A) What is the inductance of the coil?
B) If a 6V emf source were attached to it, how long would it take for the current to rise from 0 to 2A?

13) An RLC series circuit is composed of a 25 Ω resistor, a 14.8 mH inductor and a 47 μF capacitor. The circuit is driven by an emf with an angular frequency of 1500 rad/s.
A) What is the resonant frequency of this circuit?
B) What is the phase angle between the emf and the current at 1500 rad/s?
C) Is the circuit inductor or capacitor dominated?
D) In order to make the circuit resonate at 1500 rad/s, should an additional inductor be placed in series or parallel with the existing inductor?
E) What should the value of this additional inductor be?

14) An RLC series circuit driven by an 120VAC source, ω_d = 2000 rad/s, is composed of a 15 Ω resistor, a 4.8 mH inductor and a 10 .0 μF capacitor.
A) Find the capacitive reactance.
B) Find the inductive reactance.
C) Find the impedance.
D) Find I_o.
E) Find I_{Rms}.
F) Find the power factor of the circuit.