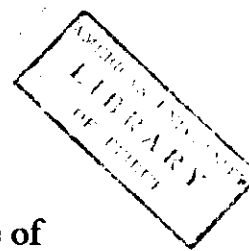**A.U.B.**
Physics Department

Physics 211
FINAL EXAM

Feb. 6, 1996
Time 2 hours

Don't forget to write your name, your I.D.# and your section on your booklet.

Part A 30 min.
20 marks

A1) A small water droplet has a diameter of 4 μm. If it carries a charge of 12 e⁻,

a)-what is the strength and direction of the uniform electric field that will just balance the gravitational force acting on the droplet?

b)-If the magnitude of the electric field is then increased to three times its previous value, how will the droplet behave compared with its behavior in the total absence of the electric field? Given: $e = 1.6 \times 10^{-19}$ C, the density of water is $1 g/cm^3$, Take $g=10$ m/sec².

15 marks

A2) A current of 2.00 A flows in a copper wire of 1.00 mm² cross section. How long does it take an electron to travel 10 cm in this wire under these circumstances ? (Assume that each Cu atom contributes one conduction electron). $\rho_{Cu} = 8.92$ g/cm³, $M^{Cu}_{mole} = 63.5$ g/mol. and $N_A = 6.02 \times 10^{23}$.

15 marks

A3) A toroidal coil is wound with 4000 turns of wire. The average radius of the toroid is 10 cm and the diameter of the coils is 1.5 cm. A second coil of 400 turns is wound over the first.

a)- What emf is induced in the second coil if the current in the 4000-turns coil is changed at a rate of 25 A/sec?

b)- Discuss also the sense of this induced emf.

Part B 30 min.
15 marks

B1)- An electron half-way between two fixed protons on the x-axis, is in stable equilibrium and executes simple harmonic motion after a slight displacement along the y-axis. Find the restoring force on the electron and deduce its natural frequency in terms of its mass m and charge e and proton-proton separation d.
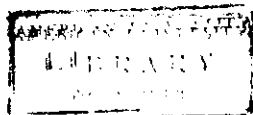
15 marks

B2)- A cylindrical capacitor has radii a<b, length L, and carries a charge q.
a)- Find an expression for its capacitance.
b)-Calculate the electrical energy stored if a = 4.4 mm, b = 5.0 mm,
L = 5.0 cm, q = 6.0 μC and $(4\pi\varepsilon_o)^{-1} = 9 \times 10^9$ $N.m^2/C^2$.

20 marks

B3)- Four long parallel wires forming the corners of a square, side a, run perpendicular to the page and carry equal currents i each into page.
a)- Find the magnetic field $\vec{B}$ at one corner due to the currents at the other corners.
b)-Calculate the magnetic force per meter exerted by $\vec{B}$ on the wire of that corner if i = 2.0 A, a = 50 cm, μ_o = 4π× 10^{-7} T.m/A .
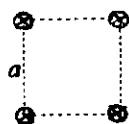
Part C 30 min.

15 marks

C1)- Two identical raindrops, each carrying surplus electrons on its surface to make a net charge -q on each, collide and form a single drop of larger size. Before the collision, the characteristics of each drop are the following : a) surface charge density σ_o , b) electric field $\vec{E}_o$ at the surface, c) electric potential V_o at the surface (where V≡ 0 at r = ∞). For the combined drop , find these three quantities in terms of their original values. (Hint: use the fact that the volume is conserved).

20 marks

C2)- An α particle (q = +2e, m = 4.003 u) travels in a circular path of radius 4.5 cm in a magnetic field with B = 1.2T . Calculate a) its speed, b) its period of revolution, c) its kinetic energy in eV, and d) the potential difference through which it would have to be accelerated to achieve this energy. (u = 1.661× 10^{-24} g , e = 1.60× 10^{-19} C).

15 marks

C3)- At t =0, a source of emf, $\mathcal{E}$ = 500 V, is applied to a coil that has an inductance of 0.80 H and a resistance of 30 Ω.
a)- Find the energy stored in the magnetic field when the current reaches half its maximum value.
b)-How long after the emf is connected does it take for the current to reach this value?

Part D 30 min.
16 marks

D1)- A uniform conducting sphere of radius (a) carries a charge (+q). It is placed at the center of a spherical conducting shell of inner radius (b) and outer radius (c). The outer shell carries a charge of (-q). Find:

a)- $E(r)$ within the sphere ($r<a$). ✓

b)- $E(r)$ between the sphere and the shell. ($a<r<b$).

c)-$E(r)$ outside the shell ($r>c$).

d)- Determine the charges which will appear on the inner and outer surfaces of the shell.
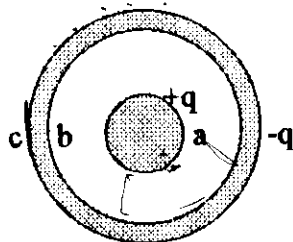
18 marks

D2)- A 2500 Ω resistor is connected in series with a 100 μF capacitor, a 100 V battery and a switch. The capacitor is initially uncharged. The switch is closed at $t = 0$. At what rate is the battery delivering energy to the circuit at $t = 0.5$ sec ?

16 marks

D3)- A solenoid with 1000 turns per meter has an iron core with the magnetization curve shown in the figure below. For a B_o field of 1.2×10^{-3} T ($\mu_o = 4\pi\times10^{-7}$ N/A^2):

a)- Estimate the permeability constant κ_m ?

b)-Determine the current through the windings of the solenoid.