Study Guide for Midterm 1 for Calculus-Based Physics: Electricity and Magnetism

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Instructions: Work each problem before looking at the given answer. See if you first understand the problem *conceptually*, then work out the mathematics, then end with plugging in relevant data.

Memory Bank:

1. Coulomb Force: $\vec{F} = k\frac{q_1 q_2}{r^2}\hat{r}$
2. $k = 9 \times 10^9$ N C^{-2} m^2
3. $q_e = 1.6 \times 10^{-19}$ C
4. Mass of a proton: 1.67×10^{-27} kg
5. Electric field and charge: $\vec{F} = q\vec{E}$
6. Field of infinite wire of charge density λ: $\vec{E}(z) = \frac{2k\lambda}{z}\hat{z}$
7. Field of two oppositely charged infinite planes, with charge density σ: $\vec{E}(z) = \frac{\sigma}{\epsilon_0}\hat{z}$
8. $\epsilon_0 \approx 8.85 \times 10^{-12}$ F/m
9. Dipole moment: $\vec{p} = q\vec{d}$
10. Torque on dipole moment: $\vec{\tau} = \vec{p} \times \vec{E}$
11. Electric flux: $\Phi = \vec{E} \cdot \vec{A} = EA\cos\theta$
12. Gauss' law: $\Phi = Q_{enc}/\epsilon_0$
13. Potential energy and voltage: $U = q\Delta V$
14. Voltage of a point charge: $V(r) = k\frac{q}{r}$
15. Voltage and E-field: $\vec{E} = -\nabla V$, single-variable $\vec{E} = -\frac{dV}{dx}$
16. Constant E-field: $E = \frac{\Delta V}{\Delta x}$
17. E-field and voltage: $\Delta V = -\int \vec{E} \cdot d\vec{x}$
18. Capacitance: $Q = CV$
19. Parallel plate capacitor: $C = \frac{\epsilon_0 A}{d}$
20. Adding two capacitors in series: $C_{tot}^{-1} = C_1^{-1} + C_2^{-2}$
21. Adding two capacitors in parallel: $C_{tot} = C_1 + C_2$
22. Definition of current: $I(t) = \frac{dQ}{dt}$
23. Drift velocity: $v_d = \frac{I}{nAq}$
24. Ohm's law: $V = IR$
25. **Adding two resistors in series** $R_{tot} = R_1 + R_2$
26. **Adding two resistors in parallel** $R_{tot}^{-1} = R_1^{-1} + R_2^{-2}$

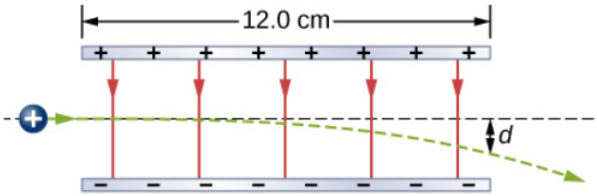

Figure 1: A constant E-field deflecting a positive charge q.

1. **Chapter 5, Electrostatics**

   (a) Protons in an atomic nucleus are typically 10^{-15} m apart. What is the electric force of repulsion between nuclear protons?

   (b) A charge $q_1 = 20\mu$C and a charge $q_2 = 10\mu$C are 1.0 m apart. What is the force on a positive test charge halfway between them, and in which direction is the force?

   (c) Suppose the "deflector" in Fig. 1 is $d = 12$ cm long. If a proton (mass given in Memory Bank) has an initial speed of $v = 1.5 \times 10^7$ m/s, and the field depicted is 4.0×10^5 N/C, by how much has it been deflected? (What is d?).

2. **Chapter 6, Gauss' Law**

   (a) Show that the field a distance z above an infinite line of charge with charge density λ (C/m) is $\vec{E}(z) = \frac{2k\lambda}{z}\hat{z}$. Use a Gaussian surface that has *cylindrical symmetry*.

3. **Chapter 7, Voltage**

   (a) A lightning bolt strikes a tree, moving 20.0 C of charge through a potential difference of 10^8 Volts. What energy was dissipated?

   (b) Consult again Fig. 1. If the plates are 6 cm apart, and the field is still 4.0×10^5 N/C, what is the voltage difference between the plates?

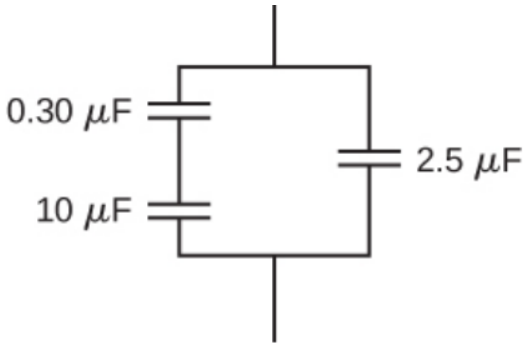

Figure 2: Three capacitors connected together.

4. **Chapter 8, Capacitance**

   (a) Find the charge stored when 5.0 V is applied to an 8.00 pF capacitor.

   (b) Find the charge stored when 5.0 V is applied to two 8.00 pF capacitors *in parallel*.

   (c) Find the charge stored when 5.0 V is applied to two 8.00 pF capacitors *in series*.

   (d) Find the total capacitance in the circuit diagram of Fig. 2.

5. **Chapter 9, Current and Ohm's law**

   (a) What current passes through a resistor with $R = 1$ kΩ, if the voltage applied is 12 V?

   (b) What current passes through two resistors with $R = 1$ kΩ, if the voltage applied is 12 V, and the resistors are connected *in series*? Draw a circuit diagram.

   (c) What current passes through two resistors with $R = 1$ kΩ, if the voltage applied is 12 V, and the resistors are connected *in parallel*? Draw a circuit diagram.