Midterm 1 for Algebra-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: $\vec{E} = -\frac{\Delta V}{\Delta x}$
16. Capacitance: $Q = CV$
17. Parallel plate capacitor: $C = \frac{\epsilon_0 A}{d}$
18. Adding two capacitors in series: $C_{tot}^{-1} = C_1^{-1} + C_2^{-2}$
19. Adding two capacitors in parallel: $C_{tot} = C_1 + C_2$
20. Definition of current: $I(t) = \frac{\Delta Q}{\Delta t}$
21. Drift velocity: $v_d = \frac{I}{nAq}$
22. Ohm's law: $V = IR$
23. **Adding two resistors in series** $R_{tot} = R_1 + R_2$
24. **Adding two resistors in parallel** $R_{tot}^{-1} = R_1^{-1} + R_2^{-2}$

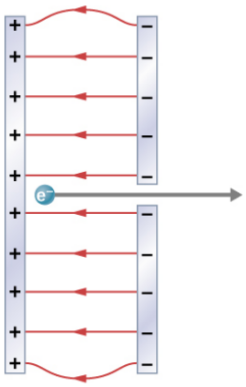

Figure 1: A device accelerating a **positively charged** particle to the right.

1. **Chapter 18, Electrostatics**

   (a) Suppose two electrons approach each other until they are 10^{-14} m apart. What is the force between them?

   (b) A charge $q_1 = 40\mu$C is located at (-4,0) m and a charge $q_2 = 20\mu$C is located at (2,0) m. What is the magnitude and direction of the electric field between them?

   (c) In Fig. 1, assume a proton is being accelerated to the right. (a) If the electric field is $E = 2000$ N/C to the right, what is the force on the proton? (b) Using Newton's Second Law, show that the acceleration is $a = (q/m)E$. (c) Recall that an object that is accelerating travels a distance d in a time t according to $d = \frac{1}{2}at^2$. How far has the proton travelled in 1 μs?

2. **Chapter 19, Voltage**

   (a) An arch of electricity sends 2.0 C of charge through a potential of 10^5 Volts. What energy was dissipated?

   (b) Consult again Fig. 1. (a) If the plates are 100 cm apart, and the field is still 2000 N/C, what is the voltage difference between the plates? (b) Draw the voltage as a function of distance between the plates.

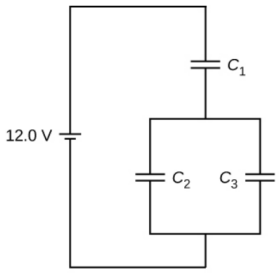

Figure 2: A circuit of capacitors.

3. **Chapter 19, Capacitance**

   (a) Find the charge stored when 3.0 V is applied to an 30.0 pF capacitor.

   (b) Find the charge stored when 3.0 V is applied to two 30.0 pF capacitors *in parallel*.

   (c) Consult Fig. 2. If $C_1 = 50.0$ pF, $C_2 = 25.0$ pF, and $C_3 = 25.0$ pF, and $V = 12.0$ Volts, what is the total charge?

4. **Chapter 20, Current and Ohm's law**

   (a) Suppose two resistors $R_1 = 1\text{k}\Omega$ and $R_2 = 10\text{k}\Omega$ are connected *in parallel* to a 5.0 V battery. What is the current that flows from the battery?

   (b) Consider Fig. 3, in which six 10kΩ resistors are connected to a 9V battery. (a) What is the total resistance? (b) What is the current flowing from the battery?

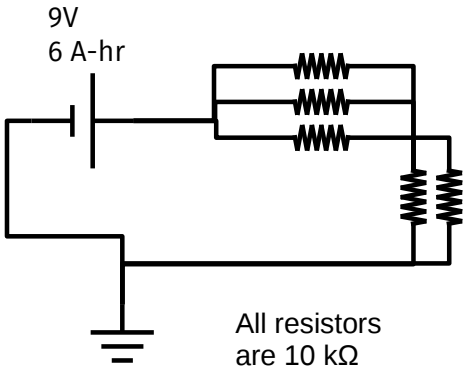

Figure 3: A circuit made of two sets of parallel resistors.