Chapters 20–21

Terms

Be able to define or discuss the following terms and ideas, with their SI units if appropriate.

1. surface charge gradient
2. drift speed
3. electron current
4. current (i.e. conventional current)
5. mobile electron density
6. resistance
7. resistivity
8. voltage
9. Ohm's law
10. Model of a "real" battery; emf; internal resistance
11. elements connected in series in a circuit
12. elements connected in parallel in a circuit
13. equivalent resistance
14. voltage divider
15. current divider
16. power
17. brightness of a bulb
18. Kirchhoff's Current Law (conservation of charge for a node)
19. Kirchhoff's Voltage Law (conservation of energy for a loop)
20. charging capacitor
21. discharging capacitor
22. capacitance
23. dielectric constant
24. time constant; exponential decay
25. equivalent capacitance

Equations

Understand the meaning and know the SI units of all symbols in these equations; know how to perform each mathematical operation, such as trig functions; know how to solve for any unknown quantity; understand how changing one quantity affects another quantity (if all other quantities remain constant); be able to apply one or more equations to solve a problem.

- Ohm's Law

$$\Delta V = IR$$

- Current

$$I = neAv_d$$

- Resistance

$$R = \frac{\rho L}{A}$$

- model of a real battery: emf and internal resistance

$$\Delta V_{bat} = \epsilon - Ir$$

- Equivalent resistance for resistors in series

$$R_{eq} = R_1 + R_2$$

- Equivalent resistance for resistors in parallel

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2}$$

- Voltage Divider (resistors in series)

$$V_1 = V_{total}\left(\frac{R_1}{R_1 + R_2}\right)$$

- Current Divider

$$I_1 = I_{in}\left(\frac{\frac{1}{R_1}}{\frac{1}{R_1} + \frac{1}{R_2}}\right)$$

- Power

$$P = I\Delta V$$

- Kirchhoff's Current Law for a node

$$I_{in} = I_{out}$$

- Kirchhoff's Voltage Law

$$\text{sum of voltages around a closed loop} = 0$$

- Charging capacitor

$$Q = Q_{max}\left(1 - e^{\frac{-t}{\tau}}\right)$$

- Discharging capacitor

$$Q = Q_{max}e^{\frac{-t}{\tau}}$$

- Magnitude of the charge on each plate of a capacitor

$$Q = C\Delta V$$

- Capacitance

$$C = \frac{K\epsilon_0 A}{d}$$

- Equivalent capacitance of capacitors in series

$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2}$$

- Equivalent capacitance of capacitors in parallel

$$C_{eq} = C_1 + C_2$$

Skills

1. Know how the physical characteristics of a filament (e.g. cross-sectional area and length) affects its resistance.
2. Combine a set of series and parallel resistors into a single equivalent resistor.
3. Predict the brightness of a given light bulb in a circuit by calculating the power of the resistor.
4. Know that the loss of electrical potential energy of charge as it flows through a resistor is converted to thermal energy.

5. Use the method of substitution to calculate the current through each resistor and voltage across each resistor for a DC circuit with a battery and resistors.
6. Use Kirchhoff's Laws to calculate the current through each resistor and voltage across each resistor for a DC circuit with a battery and resistors.
7. Sketch graphs of Q vs. t, ΔV_C vs. t, I vs. t, and ΔV_R vs. t for a charging capacitor in an RC circuit.
8. Sketch graphs of Q vs. t, ΔV_C vs. t, I vs. t, and ΔV_R vs. t for a discharging capacitor in an RC circuit.
9. Apply Kirchhoff's Voltage Law to an RC circuit to relate the voltage across the capacitor, the voltage across the resistor and the voltage across the battery in an RC circuit for a charging capacitor.
10. Know that the voltage across the capacitor and the voltage across the resistor are equal for capacitor discharging through a resistor.
11. Combine a set of series and parallel capacitors into a single equivalent capacitor.

Lab Skills

1. Be able to measure current in a particular part of a circuit using an ammeter.
2. Know that for a simple DC circuit with one battery, as the resistance in the circuit is increase, the current through the battery decreases.
3. Graph voltage vs. current for a resistor, and use a curve-fit to measure resistance.
4. Graph current vs. resistance, and use a curve-fit to determine the voltage across the resistor.