Q8: Electric Current

(a) Discuss the distinctions between Resistance and Resistivity.

Answer:

- **Resistance (R):** Opposition to current in a specific conductor.

$$R = \frac{V}{I}, \quad R = \rho \frac{L}{A}$$

  Depends on **length, area, material.**

- **Resistivity (ρ):** Intrinsic property of material.

$$\rho = \frac{RA}{L}$$

  Independent of shape and size.

(b) From the data, determine which device does not obey Ohm's law.

Answer:

Device 2 does not obey Ohm's law because the **V–I ratio is not constant** (non-linear behavior).

(c) What does a non-linear (non-Ohmic) graph look like?

Answer:

- **Ohmic conductor:** Straight line through origin (V ∝ I).
- **Non-Ohmic device:** Curved V–I graph; slope changes with V.

(d) Describe how resistance changes with temperature for a conductor and a semiconductor.

Answer:

- **Conductor:** Resistance **increases** with temperature.
- **Semiconductor:** Resistance **decreases** with temperature.

(e) A current exists in a copper wire. Find (a) current density and (b) drift speed.

Answer:

- Area: $A = \pi r^2$
- **Current density:**

$$J = \frac{I}{A}$$

- **Drift speed:**

$$v_d = \frac{I}{nqA}$$

Q9: Capacitors

(a) Does capacitance change when (a) charge is doubled, (b) voltage is tripled?

Answer:

Capacitance remains the same in both cases.

$$C = \frac{Q}{V}$$

It depends only on geometry and dielectric.

(b) Find capacitance of spherical capacitor and equivalent parallel-plate area.

Answer:

- Spherical capacitor:

$$C = 4\pi\varepsilon_0 \frac{r_1 r_2}{r_2 - r_1}$$

- Parallel plate:

$$C = \varepsilon_0 \frac{A}{d}$$

(c) Are charges equal and opposite for unequal plates?

Answer:

Yes. Charge conservation requires equal magnitude and opposite sign.

(d) Effect on charge when connected to same battery.

Answer:

- (i) Plate separation increases → **Charge decreases**
- (ii) Inner radius of cylindrical capacitor increases → **Charge increases**
- (iii) Outer radius of spherical capacitor increases → **Charge increases**

(e) Effect of dielectric on electric field.

Answer:

Electric field **decreases**:

$$E = \frac{E_0}{k}$$

(f) Find equivalent capacitance and charge/voltage on each capacitor.

Answer:

- Reduce series and parallel combinations step-by-step
- Use:

$$Q = CV$$

- In series: **same charge**
- In parallel: **same voltage**

Magnetic Field:

(a) Why is it impossible to isolate the north and south poles of a magnet from each other?

Answer: Magnetic poles always exist in pairs. When a magnet is cut, each piece becomes a complete magnet with both north and south poles; isolated magnetic monopoles do not exist.

(b) How can we classify different magnetic materials according to their behavior in an external magnetic field?

Answer:

- **Diamagnetic:** Weakly repelled by magnetic field
- **Paramagnetic:** Weakly attracted by magnetic field
- **Ferromagnetic:** Strongly attracted; can be permanently magnetized

(c) What are the three basic differences between electric and magnetic forces?

Answer:

1. Electric force acts on stationary and moving charges; magnetic force acts only on moving charges
2. Electric force acts along the electric field; magnetic force acts perpendicular to velocity
3. Electric force can do work; magnetic force does no work

(d) Can a particle move through a region without being affected by both electric and magnetic fields? If yes, provide the specific velocity value with reasoning.

Answer: Yes. If electric and magnetic forces cancel:

$$qE = qvB \Rightarrow v = \frac{E}{B}$$

(e) Discuss the properties of the magnetic force acting on a charged particle in motion.

Answer:

- Acts perpendicular to velocity
- Changes direction of motion, not speed
- Does no work on the particle

(f) A particle of mass 10 g and charge 80 mC moves through a uniform magnetic field with constant velocity perpendicular to the field. Find the magnetic field.

Answer:

Force balance:

$$qvB = mg \Rightarrow B = \frac{mg}{qv}$$

(g) A proton moves in a magnetic field $\vec{B} = \beta(4\hat{i} + 2.5\hat{j})$ T with velocity $\vec{v} = (2\hat{i} + 5\hat{j})$ m/s. The magnetic force is 8.5×10^{-19} N. Find β.

Answer:

Using:

$$F = qvB\sin\theta$$

Solving gives:

$$\boxed{\beta \approx 0.10}$$