FREE NOTES · NCERT + JEE/NEET LEVEL

Current Electricity

Current, drift velocity, Ohm's law, resistivity, temperature ka asar, power, cell ka EMF aur internal resistance, Kirchhoff's laws, Wheatstone bridge, meter bridge aur potentiometer.

01 Electric current
02 Drift velocity & mobility
03 Ohm's law
04 Resistivity
05 Temperature ka asar
06 Resistors: series & parallel
07 Electrical power
08 Cell: EMF & internal resistance
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01 Electric current

$$I = Q / t,\ I = dq/dt$$

Unit ampere (A) = C/s. Direction: positive charge ke behne ki (electrons ke ulta). Current **scalar** hai (direction hai par vector addition follow nahi karta).

Current density $j = I/A$ (A/m²), ye vector hai.

02 Drift velocity & mobility

Taar me free electrons bahut tez (≈10^5 m/s) random ghoomte hain par net movement 0. Field lagaane pe ek chhoti average velocity milti hai field ke ulte: **drift velocity**.

$$v_d = e E \tau / m$$

$$I = n e A v_d$$

τ = relaxation time (do takkar ke beech average time), n = free electrons per m³. $v_d \approx 10^{-4}$ m/s (bahut dheemi!).

PHIR BULB TURANT KAISE JALTA?

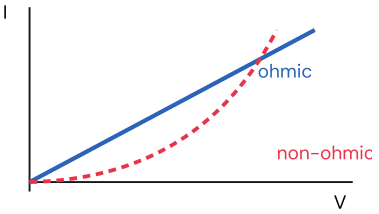
Electric field poori taar me light ki speed ke kareeb fail jaata hai, aur har jagah ke electrons ek saath chalna shuru kar dete hain. Electron khud switch se bulb tak nahi aata.

Mobility $\mu = v_d/E = e\tau/m$ (m²/V·s).

03 Ohm's law

STATEMENT

Temperature aur baaki physical conditions same rahein toh conductor me current, potential difference ke proportional: $V = IR$.



I–V graph: slope = 1/R

R = resistance, unit ohm (Ω). Graph seedhi line ⇒ **ohmic**. Vector form: $j = \sigma E$.

OHM'S LAW KAHAN FAIL

- Diode: V ki direction ulti karo toh current bahut alag (non-linear).
- Thyristor / GaAs: ek I ke liye kai V.
- Filament bulb: garam hone pe R badhta, graph curve.

04 Resistivity

$$R = \rho L / A$$

$\rho = m/(n e^2 \tau)$, conductivity $\sigma = 1/\rho$

ρ (Ω·m) sirf **material aur temperature** pe depend, size pe nahi. Metals ≈ 10^{-8}, semiconductors beech me, insulators ≈ 10^{14} Ω·m.

TAAR KHEENCHO (VOLUME SAME)

Length n guna ⇒ area 1/n ⇒ $R' = n^2 R$. Radius aadha (volume same) ⇒ length 4 guna ⇒ R 16 guna.

05 Temperature ka asar

$$\rho_T = \rho_0 \left[1 + \alpha \left(T - T_0\right)\right]$$

α = temperature coefficient of resistivity.

Material	Garam karne pe ρ	α	Kyun
Metals	Badhta	Positive	Atom zyada hilte, takkar zyada, τ ghatta
Semiconductors	Ghatta	Negative	Free charge carriers (n) badhte
Alloys (nichrome, manganin, constantan)	Bahut kam badlav	Bahut chhota	Standard resistors, heater element

06 Resistors: series & parallel

SERIES

$$R = R_1 + R_2 + \ldots$$

Same current. V baant-ta: bade R pe zyada V.

PARALLEL

$$1/R = 1/R_1 + 1/R_2 + \ldots$$

Same V. Current baant-ta: chhote R me zyada I. Do resistors: $R_1R_2/(R_1 + R_2)$.

Ghar ki wiring **parallel** me: har appliance ko poora 220 V, ek band ho toh baaki chalte rahein.

07 Electrical power

$$P = VI = I^2 R = V^2 / R$$

Unit watt. Energy = Pt. Commercial unit: 1 kWh = 3.6×10^6 J (bijli ka "1 unit").

BULB KE SAWAAL

- Bulb pe likha (P, V) ⇒ $R = V^2/P$. Zyada watt wale bulb ka R kam.
- **Series** me: kam watt wala bulb **zyada chamakta** (I same, P = I^2R, R zyada).
- **Parallel** me: zyada watt wala zyada chamakta (V same, P = V^2/R).

Power transmission high voltage pe karte hain: same power, kam current ⇒ taar me loss I^2R kam.

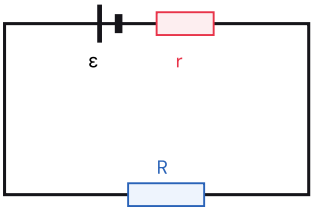
08 Cell: EMF & internal resistance

EMF (ε): jab cell se koi current na nikal raha ho tab uske terminals ke beech potential difference.
Internal resistance (r): cell ke electrolyte ka resistance.

$$I = \varepsilon / (R + r)$$

Terminal voltage $V = \varepsilon - Ir$ (discharging)

Charging: $V = \varepsilon + Ir$



Cell (ε, r) aur bahar ka load R

Situation	Result
Open circuit (R = ∞)	V = ε
Short circuit (R = 0)	$I_{max} = \varepsilon/r$
Max power to load	R = r, $P_{max} = \varepsilon^2/(4r)$

09 Cells ka combination

Combination	Equivalent EMF	Equivalent r
n cells series (same ε, r)	$n\varepsilon$	nr
m cells parallel	ε	r/m
Do alag cells parallel	$(\varepsilon_1 r_2 + \varepsilon_2 r_1)/(r_1 + r_2)$	$r_1 r_2/(r_1 + r_2)$
Ek cell ulta laga (series)	$\varepsilon_1 - \varepsilon_2$	$r_1 + r_2$

Series: zyada voltage chahiye tab. Parallel: zyada current, cell ka r bada ho tab.

10 Kirchhoff's laws

JUNCTION RULE (KCL)

Kisi junction pe aane wala current = jaane wala current: $\Sigma I = 0$. **Charge conservation**.

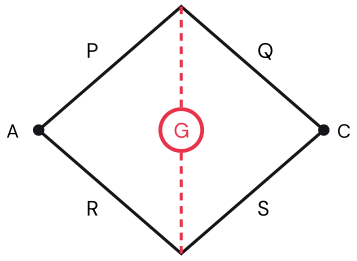
LOOP RULE (KVL)

Kisi bhi band loop me potential ke saare badlav ka sum 0: $\Sigma\varepsilon - \Sigma IR = 0$. **Energy conservation**.

SIGN CONVENTION

- Resistor ko current ki direction me paar karo: -IR. Ulta: +IR.
- Cell ko - se + terminal ki taraf paar karo: +ε. + se −: -ε.
- Current ki direction galat maani toh answer negative aayega, koi baat nahi.

11 Wheatstone bridge & meter bridge



Balanced: galvanometer me current 0

BALANCE CONDITION

$$P / Q = R / S$$

Balanced bridge me galvanometer wali branch ko hata sakte ho (koi current nahi).

METER BRIDGE

$$R/S = l / (100 - l)$$

1 m lambi uniform taar, l = balance length (cm). Unknown resistance nikaalne ke liye. Balance point beech me ho toh error kam.

12 Potentiometer (JEE)

Lambi uniform taar pe steady current, taar pe potential gradient $k = V/L$. Balance point pe **cell se koi current nahi** ⇒ asli EMF naapta (voltmeter se behtar).

Do cells compare: $\varepsilon_1/\varepsilon_2 = l_1/l_2$

Internal resistance: $r = R\,(l_1 - l_2)/l_2$

l_1 = bina R balance, l_2 = R shunt lagake. Taar lambi ⇒ k kam ⇒ zyada sensitive.

13 JEE Extra + Tricks

JEE LEVEL

- Balanced Wheatstone bridge (P/Q = R/S): beech ka resistor hata do. Cube me body diagonal ke aar-paar $R_{eq} = 5R/6$.
- Drift velocity $I = neAv_d$ (bahut kam, ~mm/s); taar khinchne pe (volume constant) $R \propto L^2$: n guna lambai $\Rightarrow R' = n^2R$.
- Cell se max power jab bahar ka R = andar ka r; $P_{max} = E^2/4r$.
- Cells: n series me $E_{eq} = nE$; m parallel me: E same, $r_{eq} = r/m$.
- Colour code trick: "**B B R O Y of Great Britain had a Very Good Wife**" = 0–9 (Black, Brown, Red, Orange, Yellow, Green, Blue, Violet, Grey, White).
- Potentiometer (JEE): $E_1/E_2 = l_1/l_2$; internal resistance $r = R(l_1 - l_2)/l_2$.

14 Solved numericals

Q1. 2 A current 5 min. Kitna charge, kitne electrons?
$Q = 2 \times 300 = 600$ C. $n = 600/1.6 \times 10^{-19} = 3.75 \times 10^{21}$. **Ans: 600 C, 3.75×10^{21}**

Q2. Copper taar: $A = 10^{-6}$ m², I = 1.5 A, $n = 8.5 \times 10^{28}$. Drift velocity?
$v_d = I/(neA) = 1.5/(8.5 \times 10^{28} \times 1.6 \times 10^{-19} \times 10^{-6}) \approx 1.1 \times 10^{-4}$ m/s. **Ans: ≈ 0.11 mm/s**

Q3. 10 Ω ki taar ko kheench ke length 3 guna. Naya R?
$R' = n^2R = 9 \times 10 = 90$ Ω. **Ans: 90 Ω**

Q4. Cell ε = 2 V, r = 0.5 Ω, bahar R = 3.5 Ω. Current aur terminal voltage?
$I = 2/4 = 0.5$ A. $V = 2 - 0.25 = 1.75$ V. **Ans: 0.5 A, 1.75 V**

Q5. 100 W aur 60 W (220 V) bulbs series me 220 V pe. Kaun zyada chamkega?
$R_{100} = 484$ Ω, $R_{60} \approx 807$ Ω. Series me I same ⇒ zyada R = zyada power ⇒ 60 W wala. **Ans: 60 W bulb**

Q6. Meter bridge: left me 10 Ω, balance 40 cm pe. Right ka resistance?
$10/S = 40/60 \Rightarrow S = 15$ Ω. **Ans: 15 Ω**

Q7. Platinum taar 0 °C pe 5 Ω, 100 °C pe 5.4 Ω. α?
$\alpha = (5.4 - 5)/(5 \times 100) = 8 \times 10^{-4}$ /°C. **Ans: 8×10^{-4} /°C**

15 Common mistakes

- Drift velocity ko electron ki random speed samajhna.
- Resistivity ko length/area pe depend maan lena.
- Taar kheenchne pe R sirf n guna lena (n^2 guna hota).
- Series me zyada watt wala bulb zyada chamakta maan lena (ulta hai).
- Terminal voltage ko hamesha ε maan lena.
- Kirchhoff me sign convention galat lagana.

16 Formula sheet

Current	$I = dq/dt = neAv_d$
Drift velocity, mobility	$v_d = eE\tau/m,\ \mu = v_d/E$
Ohm's law	$V = IR,\ j = \sigma E$
Resistance	$R = \rho L/A,\ \rho = m/(ne^2\tau)$
Temperature	$\rho = \rho_0[1 + \alpha\Delta T]$
Series / parallel	$\Sigma R\ /\ 1/R = \Sigma 1/R$
Power	$P = VI = I^2R = V^2/R$
Cell	$I = \varepsilon/(R + r),\ V = \varepsilon - Ir$
Max power	$R = r,\ P = \varepsilon^2/4r$
Wheatstone	$P/Q = R/S$
Meter bridge	$R/S = l/(100 - l)$
Potentiometer	$\varepsilon_1/\varepsilon_2 = l_1/l_2$

17 Practice questions

1. Teen 6 Ω resistors: series aur parallel?
2. Same material ki do taaren, length 1 : 2, radius 2 : 1. Resistance ka ratio?
3. 4 cells (1.5 V, 0.5 Ω) series me, bahar 4 Ω. Current?
4. Heater 1000 W, roz 2 ghante, 30 din. Kitne units?
5. Battery ka short circuit current 10 A, EMF 5 V. r?

ANSWERS

1) 18 Ω, 2 Ω · 2) $R \propto L/r^2 \Rightarrow 1/4 : 2 = 1 : 8$ · 3) $6/(2 + 4) = 1$ A · 4) $1 \times 2 \times 30 = 60$ kWh · 5) 0.5 Ω

18 Quick revision: exam se pehle 5 minute

BASICS

- $I = neAv_d$; $v_d \approx 10^{-4}$ m/s.
- $R = \rho L/A$; ρ material + T pe.
- Metal α +, semiconductor α −.
- Kheencho n guna ⇒ R n^2 guna.

CIRCUITS

- Series ΣR (I same); parallel (V same).
- $P = I^2R = V^2/R$; 1 kWh = 3.6 MJ.
- Series me kam watt bulb chamakta.

CELLS

- $V = \varepsilon - Ir$.
- Max power: R = r.
- Series nε, nr; parallel ε, r/m.

LAWS & BRIDGES

- KCL: charge; KVL: energy.
- P/Q = R/S.
- Meter bridge R/S = l/(100 − l).

Doubt hai? padhaiadda.netlify.app pe AI Doubt Solver se poocho, ya is chapter ka mock test do.