LOGIC BLOOM · NEET PHYSICS

Current Electricity

Class 12 · NCERT Chapter 3 · **Updated for the reduced NEET syllabus**

The chapter that quietly decides your Physics score. Every idea built from the circuit up, with the traps NEET keeps reusing marked as you go, and 13 worked questions in the Core, Working, Trap style.

7 Concept Sections | 11 Circuit Diagrams | 13 Worked Questions | Trap Alerts | Fact Sheet

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The simplest way to learn science.

Contents

0 What NEET Actually Asks Here

READ THIS BEFORE THE CHAPTER

3 to 4

questions in a typical NEET paper, from a 45-question Physics section

Circuits

reduction, cells and Kirchhoff carry the largest share of those questions

Formats

numerical and circuit-diagram based, with assertion-reason appearing more often

The pattern across recent papers is a drift away from one-line formula substitution and towards questions that make you reduce a circuit first and only then apply a formula. The arithmetic stays easy. The reading of the circuit is where marks are lost.

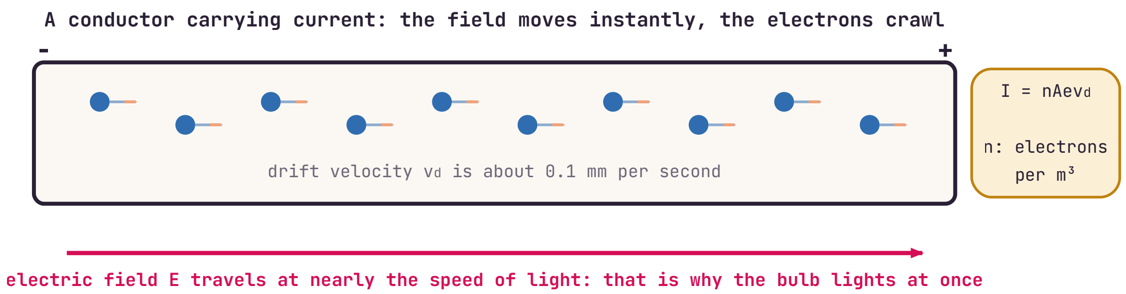
TRAP ALERT

⚠ TWO TOPICS HAVE BEEN REMOVED FROM THE NEET SYLLABUS

Potentiometer (principle, working, applications and numericals) and **carbon resistors with the colour code** are no longer part of the NEET syllabus. They still appear in older question banks and in the NCERT chapter itself, so you will meet them while revising. Do not spend time on them. Everything else in NCERT Chapter 3 is still examinable.

1 Current and Drift Velocity

Electric current is the rate of flow of charge, $I = q/t$. It is a scalar, even though we draw it with arrows. Inside a metal the carriers are free electrons, and they move against the direction of conventional current.



Electrons drift extraordinarily slowly, yet the bulb lights the instant you close the switch. The field, not the electron, carries the message.

MYTH CHECK

MYTH	THE SCIENCE
Electrons race through the wire at the speed of light, and that is why the bulb lights the moment you flip the switch.	Electrons drift at roughly a tenth of a millimetre per second. What travels at nearly the speed of light is the **electric field**, which sets electrons all along the wire moving at once, including the ones already inside the filament.

► PLAY

HAVING DIFFICULTY VISUALISING?

Watch electrons drift instead of imagining them.

The drift velocity game in the Playground lets you change current, thickness and material and see the electrons speed up or crowd together. Play it once and the formula stops being abstract. **logicbloom.co.in/download** · Free to start.

SCAN

★ THE CURRENT EQUATION

$$I = nAev_d$$

n is free electrons per unit volume, A the area of cross-section, and v_d the drift velocity.

THINK IT THROUGH

DRIFT VELOCITY, MOBILITY AND RELAXATION TIME

Between collisions an electron accelerates for an average time called the **relaxation time**, so $v_d = eE\tau/m$. **Mobility** is drift velocity per unit field, $\mu = v_d/E$. Current density $J = I/A = nev_d = \sigma E$. Note that drift velocity is proportional to current, so doubling the current doubles the drift velocity.

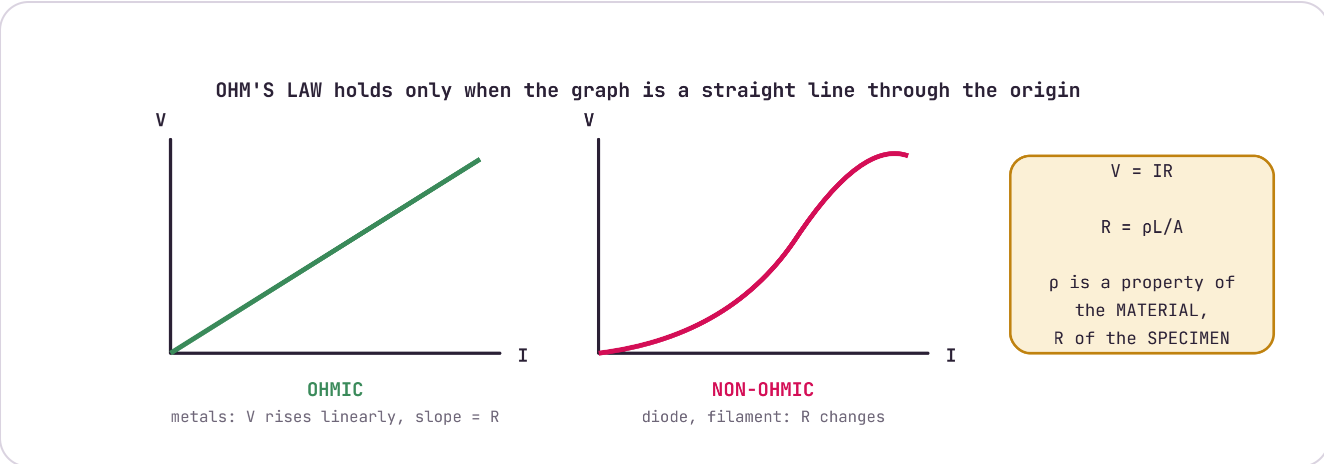
TRAP ALERT

⚠ THE CLASSIC DRIFT VELOCITY TRAP

Drift velocity is of the order of a fraction of a millimetre per second, but the bulb glows immediately. The signal travels as an **electric field** at nearly the speed of light, setting electrons all along the wire into motion at once. NEET asks this as an assertion-reason question almost every other year.

2 Ohm's Law, Resistance and Resistivity

Ohm's law says that for a conductor at constant temperature, current is proportional to potential difference: $V = IR$. The catch is the phrase **at constant temperature**. A filament bulb heats up and stops obeying it.

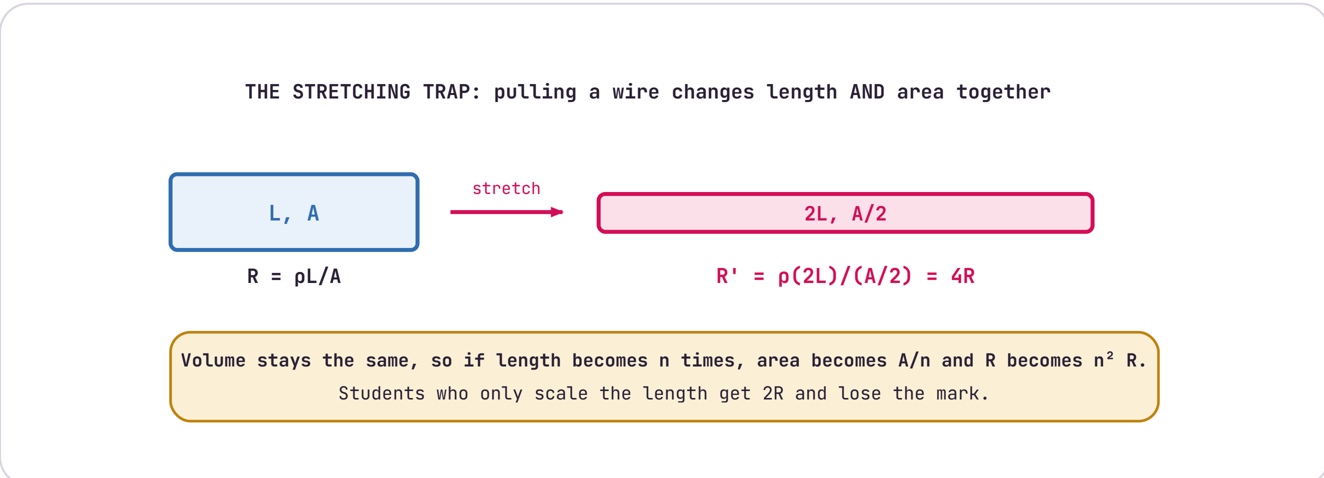


Ohmic conductors give a straight line through the origin. Anything curved, like a diode or a hot filament, is non-ohmic.

★ RESISTANCE VERSUS RESISTIVITY

$$R = \rho\frac{L}{A} \qquad \sigma = \frac{1}{\rho}$$

Resistivity ρ depends only on the material and temperature. Resistance R also depends on the shape.



The single most repeated numerical idea in this chapter: stretching conserves volume, so length and area change together.

▶ PLAY

CIRCUITS NOT CLICKING YET?

Stretch the wire yourself and watch R climb.

In the Playground you can drag a wire longer and thinner and see the resistance update live, then take the 10-question loop on resistivity right after. **logicbloom.co.in/download** · Free to start.

SCAN

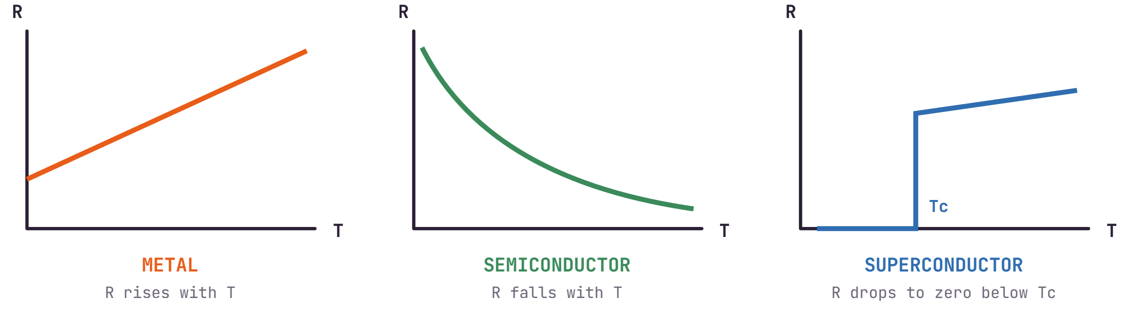
TRAP ALERT

⚠ THE STRETCHING AND CUTTING TRAPS

Stretched to n times its length: area becomes A/n, so **R becomes n^2R**. **Cut into n equal parts:** each piece has R/n, and joining all n in parallel gives **R/n^2**. Both follow from the volume staying constant. Candidates who scale only the length get a factor of n instead of n^2.

3 Resistance and Temperature

Heat a metal and its atoms vibrate harder, so electrons collide more often and resistance rises. Heat a semiconductor and you free many more carriers, so resistance falls. These opposite behaviours are a standing favourite for assertion-reason questions.



Three materials, three very different responses to temperature. Know the shape of each graph, not just the words.

★ TEMPERATURE COEFFICIENT

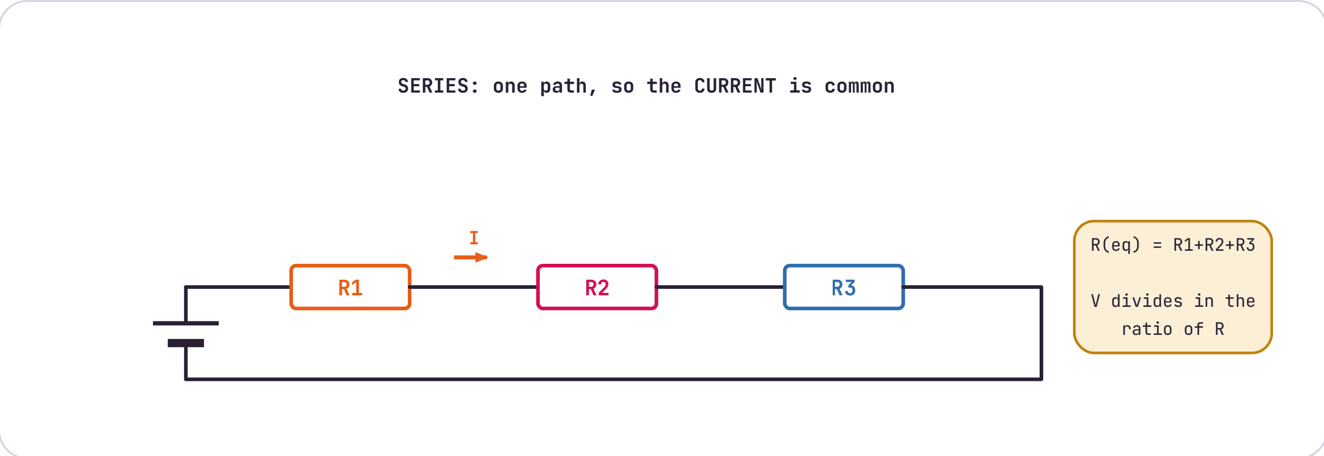
$$R_T = R_0(1 + \alpha\,\Delta T)$$

α is positive for metals, negative for semiconductors and electrolytes.

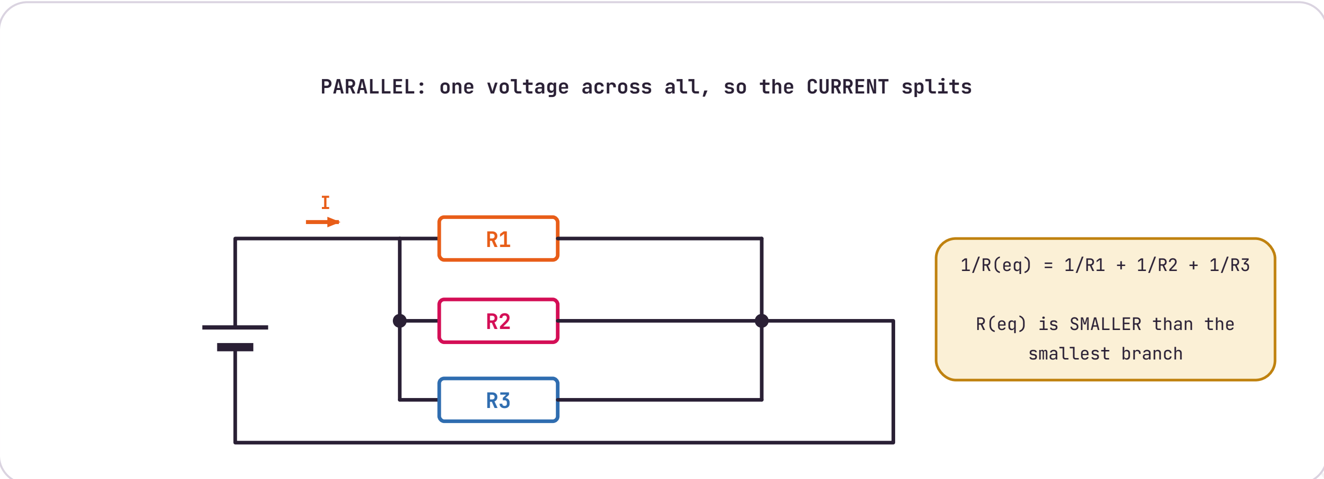
Metals	α positive: resistance rises with temperature
Semiconductors	α negative: resistance falls sharply with temperature
Alloys such as nichrome and manganin	α very small, which is why they are used in standard resistors
Superconductors	resistance becomes exactly zero below a critical temperature

4 Series and Parallel Combinations

Almost every circuit question begins by reducing a network to a single resistance. Two rules do all of it, and the trick is knowing which quantity stays common.



Series: a single path. The current through every element is identical, and the voltage divides.



Parallel: several paths between the same two points. The voltage is identical, and the current divides.

▶ PLAY

STRUGGLING TO SEE THE CIRCUIT?

Redraw it by dragging, not by squinting.

The circuit-reduction game snaps a messy network into series and parallel blocks step by step, so you learn to spot the pattern instead of guessing. **logicbloom.co.in/download** · Free to start.

SCAN

★ THE TWO COMBINATION RULES

$$\text{Series:}\quad R_{eq} = R_1 + R_2 + R_3$$

$$\text{Parallel:}\quad \frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

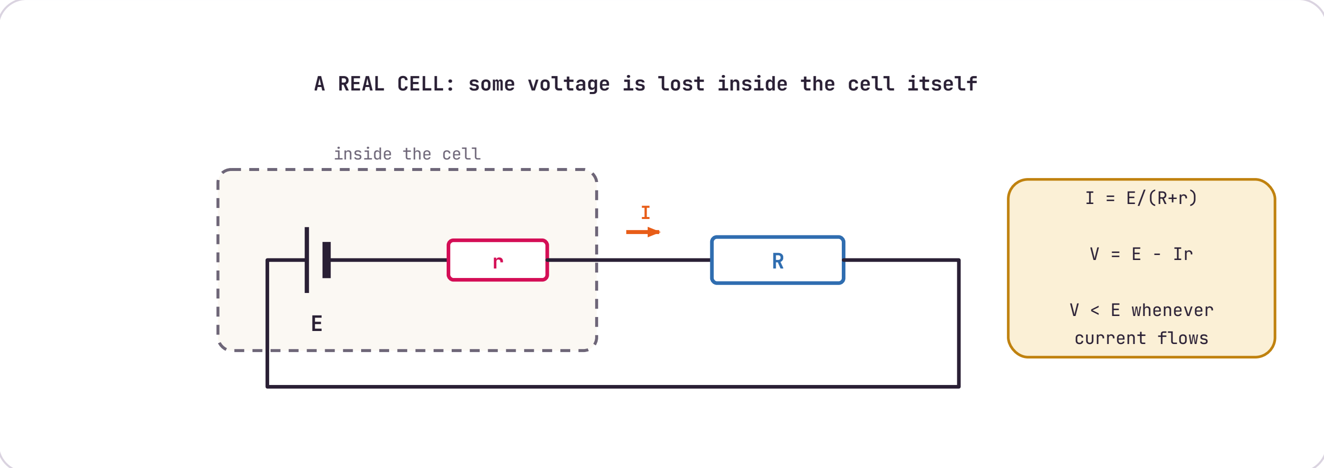
THINK IT THROUGH

TWO SANITY CHECKS WORTH MEMORISING

A series combination is always **larger** than the biggest resistor. A parallel combination is always **smaller** than the smallest one. If your answer breaks either rule, you have made an arithmetic slip. For just two in parallel, use the product over sum shortcut: $R = R_1 R_2/(R_1+R_2)$.

5 EMF, Internal Resistance and Cells

EMF (E) is the full voltage a cell can supply with no current drawn. The moment current flows, some voltage is dropped across the cell's own **internal resistance r**, and what the external circuit actually receives is the **terminal voltage V**.

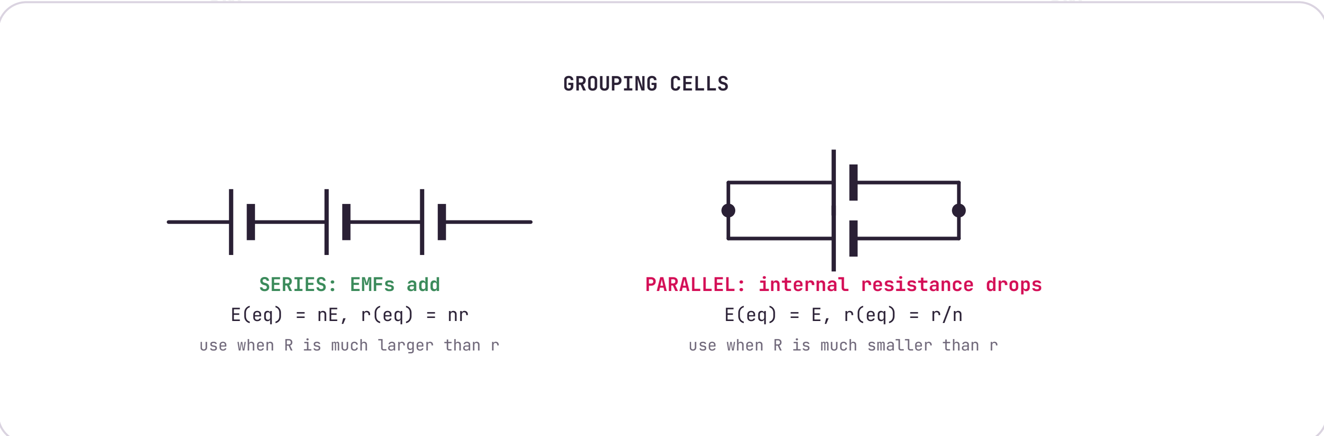


Every real cell carries a small resistance inside it. That is the entire reason terminal voltage is less than EMF.

★ TERMINAL VOLTAGE

$$I = \frac{E}{R+r} \qquad V = E - Ir$$

When the cell is being charged the current reverses, and V = E + Ir instead.



Grouping cells: series multiplies the EMF, parallel divides the internal resistance.

n cells in series	$E_{eq} = nE$ and $r_{eq} = nr$, best when R is much larger than r
n cells in parallel	$E_{eq} = E$ and $r_{eq} = r/n$, best when R is much smaller than r
Maximum power transfer	the external power peaks when R = r, and that maximum is $E^2/4r$
Short circuit	if R = 0 then I = E/r, the largest current the cell can deliver

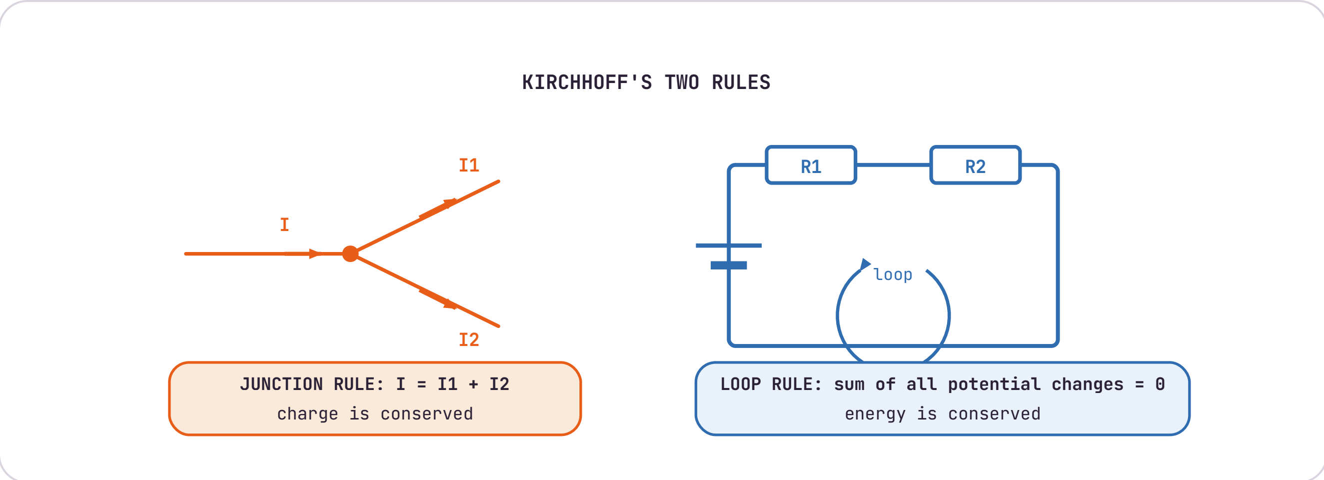
TRAP ALERT

⚠ TERMINAL VOLTAGE IS NOT A FIXED PROPERTY

V depends on how much current you draw. On open circuit (no current) V equals E exactly. That is why a voltmeter with very high resistance reads almost the true EMF, and why a cell measured while driving a heavy load appears weaker than it is.

6 Kirchhoff's Laws

When a network cannot be untangled into neat series and parallel blocks, two conservation laws take over. Both are simply conservation statements wearing circuit clothing.



The junction rule is conservation of charge. The loop rule is conservation of energy. NEET has asked exactly this identification as a statement question.

★ THE TWO LAWS

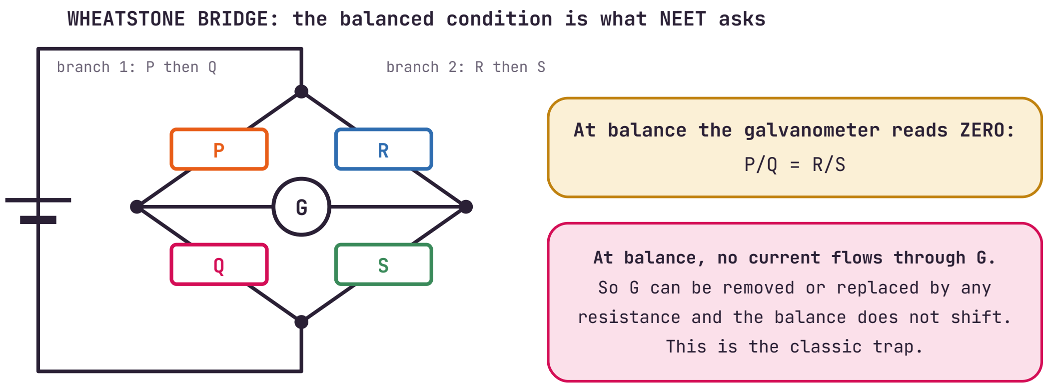
$$\text{Junction:} \quad \sum I = 0 \qquad \text{Loop:} \quad \sum \Delta V = 0$$

SIGN CONVENTION, WHICH IS WHERE MOST ERRORS HAPPEN

Pick a direction to walk around the loop. Crossing a resistor **along** the current gives -IR, and against it gives +IR. Entering a cell at the negative plate and leaving at the positive gives +E. If your final current comes out negative, the magnitude is still correct and the true direction is simply opposite to your guess.

7 The Wheatstone Bridge

The bridge is a direct application of Kirchhoff's laws, and it is the one experimental arrangement still fully examinable in this chapter for NEET.



Four resistances, a galvanometer across the middle, and a single condition that makes the galvanometer read zero.

▶ PLAY

BRIDGE CIRCUITS LOOK LIKE A MAZE?

Balance the bridge yourself and watch the needle fall to zero.

Drag the four resistances until the galvanometer reads zero, then let the game show you why the middle branch can be deleted. Practise it in Brain Gym straight after. **logicbloom.co.in/download** · Free to start.

SCAN

★ THE BALANCE CONDITION

$$\frac{P}{Q} = \frac{R}{S}$$

TRAP ALERT

⚠ WHAT BALANCE REALLY MEANS

At balance **no current flows through the galvanometer**, so the branch containing it can be removed entirely or replaced by any resistance without disturbing the balance. Questions often hide a complicated-looking network that is really a balanced bridge, so the middle resistor can simply be deleted before you reduce the rest.

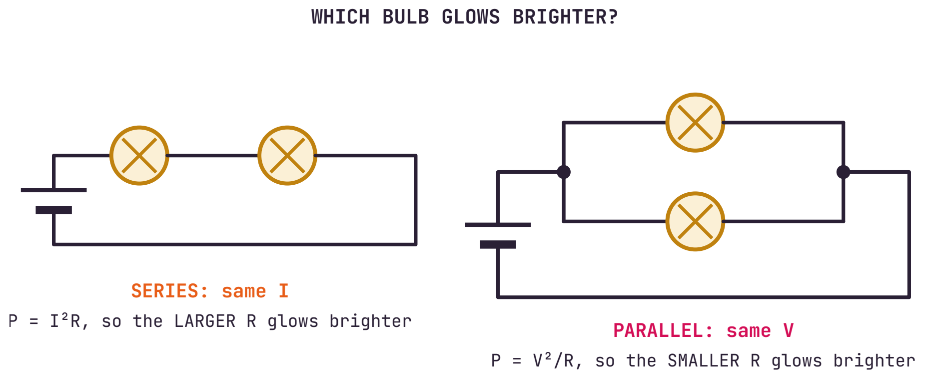
8 Electrical Power and Heating Effects

Every resistor converts electrical energy into heat. Which of the three power formulas you reach for depends entirely on what is held common in the circuit.

★ THREE FACES OF THE SAME FORMULA

$$P = VI = I^2R = \frac{V^2}{R}$$

Use I^2R when the current is common (series), and V^2/R when the voltage is common (parallel).



The same two bulbs, wired two ways, give opposite answers. Deciding what is common comes before choosing the formula.

Joule's law of heating	$H = I^2Rt$, the heat produced in time t
Rating on a bulb	a 60 W, 220 V bulb means $R = V^2/P$, so a lower wattage means a higher resistance
In series	the higher-resistance (lower-wattage) bulb glows brighter
In parallel	the lower-resistance (higher-wattage) bulb glows brighter, matching everyday wiring

MYTH CHECK

MYTH	THE SCIENCE
A 100 W bulb is always brighter than a 60 W bulb.	Only when they are in parallel, which is how houses are wired. Put them in series and it reverses: the current is now common, so $P = I^2R$, and the 60 W bulb has the larger resistance and glows brighter.

TRAP ALERT

⚠ THE BULB BRIGHTNESS TRAP

Household bulbs are wired in **parallel**, so the 100 W bulb is brighter than the 60 W bulb, exactly as you expect. Put those same two bulbs in **series** and the result flips: the 60 W bulb now glows brighter, because the current is common and it has the larger resistance.

9 Important Questions

Fourteen questions pitched at where NEET actually sits: every one needs at least two steps, and several turn on a single decision you have to get right before any formula is any use. They rise in difficulty. Try each before reading the working.

Q1 Where do the electrons crawl slowest

NEET

Two wires of the same material, of radii r and 2r, are joined end to end and carry a steady current. Find the ratio of the drift velocities, and of the current densities, in the thin and thick sections.

CORE Being joined end to end, both carry the **same current**. Since $I = nAev_d$, and n is the same material, $v_d \propto 1/A$.

WORKING

$$\frac{v_{thin}}{v_{thick}} = \frac{A_{thick}}{A_{thin}} = \frac{\pi(2r)^2}{\pi r^2} = \mathbf{4}$$

$$J = \frac{I}{A} \Rightarrow \frac{J_{thin}}{J_{thick}} = \mathbf{4} \text{ as well}$$

TRAP Drift velocity is not fixed by the material alone. The same charge per second has to squeeze through a smaller area in the thin section, so the electrons must move faster there. Current, by contrast, is identical in both.

Q2 A longer wire, the same battery

NEET+

A wire is connected across a battery of fixed potential difference V. It is replaced by a wire of the same material and the same area of cross-section but twice the length. What happens to the field inside, the drift velocity, and the current?

CORE The field inside is $E = V/L$, and $v_d = eE\tau/m$. So trace the chain from the field, not from the current.

WORKING

$$E \to \frac{E}{2} \Rightarrow v_d \to \frac{v_d}{2} \Rightarrow I \to \frac{\mathbf{I}}{\mathbf{2}}$$

$$\text{consistent with } R \to 2R \text{ and } I = V/R$$

TRAP This is not the stretching problem. The area was held fixed here, so R merely doubles. If the wire had been **stretched** to twice its length the area would have halved as well and R would have gone up four times. Read whether the area is free to change.

Q3 Two conductors on one graph

NEET

The V-I graphs of two conductors A and B are straight lines through the origin, making angles of 30° and 60° with the current axis. Find $R_A : R_B$.

CORE With V on the vertical axis, the slope of the line is the resistance.

WORKING

$$\frac{R_A}{R_B} = \frac{\tan 30^\circ}{\tan 60^\circ} = \frac{1/\sqrt{3}}{\sqrt{3}} = \frac{\mathbf{1}}{\mathbf{3}}$$

TRAP Check the axes before calling any slope a resistance. If the graph plots I against V instead, the slope is 1/R and the ratio inverts to 3:1. Examiners swap the axes deliberately.

Q4 The heater that was cut up

NEET

A heating coil dissipates power P across a supply of fixed voltage V. It is cut into three equal pieces and all three are reconnected in parallel across the same supply. Find the new power.

CORE The voltage is fixed, so use $P = V^2/R$ and track only what happens to R.

WORKING

$$\text{each piece} = \frac{R}{3}, \quad \text{three in parallel} = \frac{R}{9}$$

$$P' = \frac{V^2}{R/9} = \mathbf{9P}$$

TRAP Nine times, not three. Cutting divides the resistance once, and paralleling the pieces divides it again. This is the power face of the R/n² result.

Q5 The same two wires, wired two ways

NEET+

Two wires of the same material and the same length have radii r and 2r. Find the ratio of the heat produced in the thin wire to that in the thick one when they are connected (a) in series and (b) in parallel across the same supply.

CORE $R \propto 1/r^2$, so $R_{thin} = 4R_{thick}$. Then decide what is common in each case before picking the formula.

WORKING

$$\text{Series: same } I,\ H = I^2Rt \Rightarrow \frac{H_{thin}}{H_{thick}} = \mathbf{4:1}$$

$$\text{Parallel: same } V,\ H = \frac{V^2t}{R} \Rightarrow \frac{H_{thin}}{H_{thick}} = \mathbf{1:4}$$

TRAP The answer inverts completely with the connection, from 4:1 to 1:4. Any question about heat or brightness is really a question about whether current or voltage is the shared quantity.

Q6 A resistance that ignores temperature

NEET+

A metal wire of resistance 10 Ω, with $\alpha = 4 \times 10^{-3}\ {}^\circ C^{-1}$, is joined in series with a carbon rod of $\alpha = -0.5 \times 10^{-3}\ {}^\circ C^{-1}$. What carbon resistance makes the total resistance independent of temperature?

CORE For the series total to be unchanged, the two changes must cancel: $R_1\alpha_1 + R_2\alpha_2 = 0$.

WORKING

$$10(4\times 10^{-3}) + R(-0.5\times 10^{-3}) = 0$$

$$R = \frac{10\times 4}{0.5} = \mathbf{80\ \Omega}$$

TRAP This only works because the two temperature coefficients have **opposite signs**. Metals have positive α and carbon negative, which is exactly why the pair is used to build resistors whose value holds steady as they warm up.

Q7 Reading a cell from two loads

NEET

A cell sends 0.5 A through a 4 Ω resistor and 0.25 A through a 9 Ω resistor. Find its EMF and internal resistance.

CORE Both readings obey $E = I(R + r)$, giving two equations in two unknowns.

WORKING

$$0.5(4 + r) = 0.25(9 + r)$$

$$2 + 0.5r = 2.25 + 0.25r \Rightarrow r = \mathbf{1\ \Omega}$$

$$E = 0.5(4 + 1) = \mathbf{2.5}\ \mathrm{V}$$

TRAP One reading is never enough: E and r are two unknowns. Any question that gives you two different loads is telling you to set up simultaneous equations rather than substitute once.

Q8 Two cells fighting each other

NEET+

A 6 V cell of internal resistance 1 Ω and a 4 V cell of internal resistance 2 Ω are connected in series but in **opposition**, across an external 3 Ω resistor. Find the current, and the terminal voltage of the 4 V cell.

CORE Opposing EMFs subtract, but every resistance in the loop still adds.

WORKING

$$I = \frac{6-4}{1+2+3} = \frac{1}{3}\ \text{A}$$

$$\text{The 4 V cell is driven backwards, so it is being CHARGED:}$$

$$V = E + Ir = 4 + \tfrac{1}{3}(2) = \mathbf{4.67}\ \text{V}$$

TRAP For a cell being charged the terminal voltage is **greater** than its EMF. The familiar V < E applies only to a cell that is discharging, and blindly writing V = E - Ir here gives 3.33 V.

Q9 The cell that does nothing

NEET+

A 6 V cell (r = 1 Ω) and a 4 V cell (r = 1 Ω) are connected in parallel across a 2 Ω resistor. Find the current delivered by each cell.

CORE Let the common terminal PD be V. Each cell delivers $(E-V)/r$, and the two must supply the load current.

WORKING

$$\frac{6-V}{1} + \frac{4-V}{1} = \frac{V}{2} \Rightarrow 10 - 2V = \frac{V}{2} \Rightarrow V = 4\ \text{V}$$

$$I_{6V} = \frac{6-4}{1} = \mathbf{2}\ \text{A}, \qquad I_{4V} = \frac{4-4}{1} = \mathbf{0}\ \text{A}$$

TRAP A cell sitting in a live circuit need not deliver anything. Here the common PD lands exactly on the 4 V cell's EMF, so it idles. Raise the external resistance and V rises above 4 V, at which point that cell starts being charged by the other one.

Q10 How should you wire 24 cells

NEET+

Twenty-four identical cells, each of EMF 1.5 V and internal resistance 0.5 Ω, are arranged in m parallel rows of n cells each to drive a 0.75 Ω load. Find the arrangement giving the maximum current, and that current.

CORE A row has EMF nE and resistance nr; m such rows in parallel give nr/m. The current peaks when the external resistance matches the total internal resistance, $R = nr/m$.

WORKING

$$\frac{0.5n}{m} = 0.75 \Rightarrow n = 1.5m, \qquad mn = 24$$
$$1.5m^2 = 24 \Rightarrow m = 4 \text{ rows of } n = 6 \text{ cells}$$

$$I_{max} = \frac{nE}{2R} = \frac{6(1.5)}{2(0.75)} = \mathbf{6}\text{ A}$$

TRAP Stacking all 24 in one series row is the instinctive answer and it is badly wrong: it gives only 2.8 A. Adding cells in series raises the EMF and the internal resistance at exactly the same rate, so beyond the matching point you gain nothing.

Q11 The voltmeter spoils its own reading

NEET+

Two 500 Ω resistors are joined in series across a 10 V supply. A voltmeter of resistance 1000 Ω is connected across one of them. What does it read?

CORE The voltmeter is not a bystander: it goes in parallel with that resistor and lowers the resistance of that section.

WORKING

$$500 \parallel 1000 = \frac{500 \times 1000}{1500} = 333.3\ \Omega$$
$$I = \frac{10}{333.3 + 500} = 12\text{ mA}$$

$$\text{reading} = 12\text{ mA} \times 333.3 = \mathbf{4}\text{ V}$$

TRAP An ideal voltmeter would show 5 V. A real one draws current and pulls down the very PD it is measuring, which is precisely why voltmeters are built with very high resistance.

Q12 Which bulb takes the voltage

NEET

A 40 W and a 100 W bulb, both rated 220 V, are connected in series across a 220 V supply. Find the potential difference across the 40 W bulb.

CORE Get each resistance from its rating, $R = V^2/P$, then divide the supply in the ratio of resistances.

WORKING

$$R_{40} = \frac{220^2}{40} = 1210\ \Omega, \qquad R_{100} = \frac{220^2}{100} = 484\ \Omega$$

$$V_{40} = 220 \times \frac{1210}{1210+484} = \mathbf{157.1}\ \mathrm{V}$$

TRAP The 40 W bulb swallows over 70 percent of the supply and glows brightest, while the 100 W bulb sits at 63 V and stays dim. A wattage rating describes the bulb only at its rated voltage.

Q13 Hidden balanced bridge

NEET+

In a Wheatstone network the arms are P = 4 Ω and Q = 8 Ω in the first branch, R = 6 Ω and S = 12 Ω in the second, with a 10 Ω resistor bridging the galvanometer position. Find the equivalent resistance across the supply.

CORE Test the balance condition before attempting any reduction.

WORKING

$$\frac{P}{Q} = \frac{4}{8} = \frac{1}{2}, \quad \frac{R}{S} = \frac{6}{12} = \frac{1}{2} \Rightarrow \text{balanced}$$

$$\text{So the 10 } \Omega \text{ carries no current and is removed:}$$

$$P+Q = 12\ \Omega, \qquad R+S = 18\ \Omega$$

$$R_{eq} = \frac{12 \times 18}{12+18} = \frac{216}{30} = \mathbf{7.2\ \Omega}$$

TRAP Two traps stacked here. First, check the balance condition before reaching for Kirchhoff's laws. Second, once balanced, the series pairs are the two arms lying **along the same branch** (P with Q, and R with S), not the two arms that happen to sit on the same side of the figure.

Q14 Swapping the battery and the galvanometer

NEET+

Assertion: In a balanced Wheatstone bridge, interchanging the positions of the battery and the galvanometer leaves the bridge balanced. **Reason:** The balance condition does not involve the source at all. Judge both statements.

CORE Write the balance condition and look at what appears in it.

WORKING

$$\frac{P}{Q} = \frac{R}{S}$$

only the four arms appear, no EMF and no galvanometer resistance

Both true, and the Reason correctly explains the Assertion

TRAP Worth carrying as a standing fact. It also explains the earlier result that the galvanometer branch can be removed or replaced by any resistance at balance: nothing about the two diagonals enters the condition.

★ Current Electricity · Fact Sheet

Every formula for revision day. Print this page alone.

CURRENT & DRIFT

$I = q/t = nAev_d$

$v_d = eE\tau/m$, $\mu = v_d/E$
$J = I/A = \sigma E$.

OHM AND RESISTIVITY

$V = IR$, $R = \rho L/A$

$\sigma = 1/\rho$
ρ is material, R is specimen.

STRETCH & CUT

Stretched to n times: $R \rightarrow n^2R$

Cut into n, joined parallel:
$R \rightarrow R/n^2$.

TEMPERATURE

$R_T = R_0(1 + \alpha\Delta T)$

Metals α positive
Semiconductors α negative.

COMBINATIONS

Series: $R = R_1+R_2+R_3$

Parallel: $1/R = \Sigma 1/R_i$
Two: $R_1R_2/(R_1+R_2)$.

CELLS

$I = E/(R+r)$, $V = E - Ir$

Series: nE, nr
Parallel: E, r/n.

MAX POWER

External P is maximum

when $R = r$
$P_{max} = E^2/4r$.

KIRCHHOFF

Junction: $\Sigma I = 0$ (charge)

Loop: $\Sigma\Delta V = 0$ (energy)
Along current: -IR.

WHEATSTONE

Balance: $P/Q = R/S$

Then G carries no current
and can be removed.

POWER & HEAT

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

$H = I^2Rt$
Series: bigger R brighter.

BULB RATINGS

$R = V^2/P$

Parallel: higher W brighter
Series: lower W brighter.

NOT IN NEET NOW

Potentiometer and carbon

resistor colour codes are
off the syllabus.

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