



CURRENT ELECTRICITY / CONCEPT TOOLKIT

Start with what stays constant.

A formula becomes useful when we know its conditions. Use this reference, attempt the six questions, then check and retry.

Name: _____

First attempt: _____

Relationship	When and how to use it
$V = IR$	For an ohmic resistor with resistance R under the stated conditions.
$P = VI = I^2R = V^2/R$	Power dissipated in a resistor. At fixed V , power decreases as R increases. At fixed I , power increases as R increases.
$R_s = R_1 + R_2 + \dots$	Series: the same current flows through every resistor.
$1/R_p = 1/R_1 + 1/R_2 + \dots$	Parallel: the same potential difference acts across every branch.
$R = \rho L/A$	Uniform wire. If volume AL and resistivity ρ stay constant, R is proportional to L^2 .
$R_{\text{rated}} = V_{\text{rated}}^2/P_{\text{rated}}$	A lamp's rated resistance. Treating it as constant is an approximation for incandescent filaments, not a model for arbitrary LED lamps.

V : potential difference (V) · I : current (A) · R : resistance (Ω) · P : power (W)

ρ : resistivity ($\Omega \cdot \text{m}$) · L : wire length (m) · A : cross-sectional area (m^2)

Before substituting

Identify the source. Work out R_{eq} . State what stays constant. Decide whether the question asks for total power or one component's power.

Check the assumption

An ideal battery keeps its voltage fixed. An ideal current source keeps its total current fixed. They do not lead to the same power comparison.

Use the pack: questions on pages 2–3 · worked solutions on page 4 · error review and retry record on page 5. These are original practice questions, not claimed past-paper questions.



PRACTICE / FIXED VOLTAGE

Same source. Different circuit.

Show your reasoning and units. Use an ideal voltage source and constant resistor values in questions 1–3.

01 Two equal resistors

Two identical resistors consume 60 W in total in series across an ideal battery. They are reconnected in parallel across the same battery. Find the new total power and the power in each resistor.

What stays constant? _____ $R_s =$ _____ $R_p =$ _____

02 Transfer the idea to three resistors

Three identical resistors consume 30 W in total when all are in series across an ideal battery. Find the total power when all three are in parallel across that same battery.

Derive the power ratio before using the given 30 W.

03 Test the shortcut

A $3\ \Omega$ and a $6\ \Omega$ resistor are connected first in series and then in parallel across an ideal 12 V battery. Find total power in each connection. Is the parallel-to-series power ratio four?

Calculate both equivalent resistances. State why the equal-resistor shortcut does or does not apply.

Pause before checking. Can we explain the direction of the change before calculating its size?



PRACTICE / CHANGING THE CONDITIONS

Will the same reasoning still work?

The source, the material and the connection tell us what can be held constant.

04 A stretched wire

A uniform wire is stretched uniformly to twice its length without changing its volume or resistivity. It originally dissipates 20 W across an ideal constant-voltage source. Express the new resistance in terms of the original R , and find its new power.

Start with volume AL . What happens to the cross-sectional area?

05 Read lamp ratings carefully

Two incandescent lamps rated 100 W, 220 V and 60 W, 220 V are connected in series across 220 V. Use the constant rated-resistance approximation. Which lamp dissipates more power? Calculate both powers and state one limitation of the model.

Find each rated resistance first. Which quantity is shared in series?

06 Change the source

Two identical resistors dissipate 60 W in total in series across an ideal current source. They are reconnected in parallel to the same source, which maintains the same total current. The resistor values stay constant. Find the new total power.

Compare your reasoning with question 1. Is voltage still fixed?

- ☐ We stated what stays constant before choosing a power formula.
- ☐ We distinguished total power from one resistor's power.



WORKED SOLUTIONS / CHECK AFTER ATTEMPTING

The condition decides the method.

Compare each step with your own working. Record the first point where your reasoning differed.

01 · Fixed voltage, two equal resistors

$R_s = 2R$ and $R_p = R/2$. At the same V , $P = V^2/R_{eq}$.

$P_p/P_s = (2R)/(R/2) = 4$. **Total power = 240 W.**

The equal parallel branches share total power equally: **120 W each.**

02 · Fixed voltage, three equal resistors

$R_s = 3R$; $R_p = R/3$. Power ratio = $(3R)/(R/3) = 9$.

New total power = $9 \times 30 = 270$ W. For n identical resistors at the same ideal voltage, the ratio is n^2 .

03 · Unequal resistors

$R_s = 3 + 6 = 9 \Omega$; $R_p = (3 \times 6)/(3 + 6) = 2 \Omega$.

$P_s = 12^2/9 = 16$ W; $P_p = 12^2/2 = 72$ W.

Ratio = 4.5. The factor of four requires two equal resistors.

04 · Fixed volume, fixed resistivity, fixed voltage

AL is unchanged. If $L' = 2L$, then $A' = A/2$.

$R' = \rho(2L)/(A/2) = 4R$. At constant V , $P' = P/4$.

New power = 5 W. Holding current fixed would give a different result.

05 · Rated resistance is an approximation

$R_{100} = 220^2/100 = 484 \Omega$; $R_{60} = 220^2/60 \approx 806.67 \Omega$.

Series current $I = 220/(484 + 806.67) \approx 0.17045$ A.

$P_{100} = I^2 R_{100} \approx 14.06$ W; $P_{60} \approx 23.44$ W.

The 60 W-rated lamp dissipates more power in this model. Real filament resistance changes with temperature, so these numerical powers are approximate.

06 · Fixed total current

The source keeps I fixed; its terminal voltage changes. Use $P = I^2 R_{eq}$.

$P_p/P_s = (R/2)/(2R) = 1/4$.

New total power = $60/4 = 15$ W. The fixed-voltage shortcut from question 1 does not apply.

Carry this forward: the same network change can increase or decrease power. Identify what the source holds constant.



CLOSE THE LOOP / RECORD AND RETRY

A correction is useful when we can use it.

Choose questions that exposed a gap. Cover the solutions and retry them on another day.

Question / first attempt	First incorrect step Concept · condition · calculation	Correction in our own words	Retry date / result

Example entry: Q1 · held current fixed by mistake · the ideal battery keeps voltage fixed, so compare with V^2/R_{eq} · retry tomorrow without the solution.

Understanding check

- ☐ We can explain why questions 1 and 6 give different power changes.
- ☐ We can derive the n^2 result and state its conditions.
- ☐ We can explain why stretching the wire gives $4R$.
- ☐ We can separate a lamp's power rating from its actual power in a new circuit.

Our next completed action

On _____, at _____,
we will retry question(s) _____
with the solutions covered.

After the retry

What can we now explain independently?
What still needs another attempt?

For a daily action routine, use 7-day study kickstart. Continue with practice and lessons at jeephysics.com.