Which Bulb Glows Brighter in Series?

Physics | JEE Main & Advanced

Don't Memorize. Visualize.

Two bulbs rated for the same voltage, joined in series: the **lower wattage** bulb glows brighter. It has the larger resistance, and in series the same current flows through both, so it takes more power.

RATING

"220 V, 100 W" means: joined across 220 V, the bulb takes 100 W.

Only at its rated voltage does it take its rated power.

RESISTANCE OF A BULB

From the rating, $R = \frac{V^2}{P}$. JEE takes it as fixed, whatever the voltage.

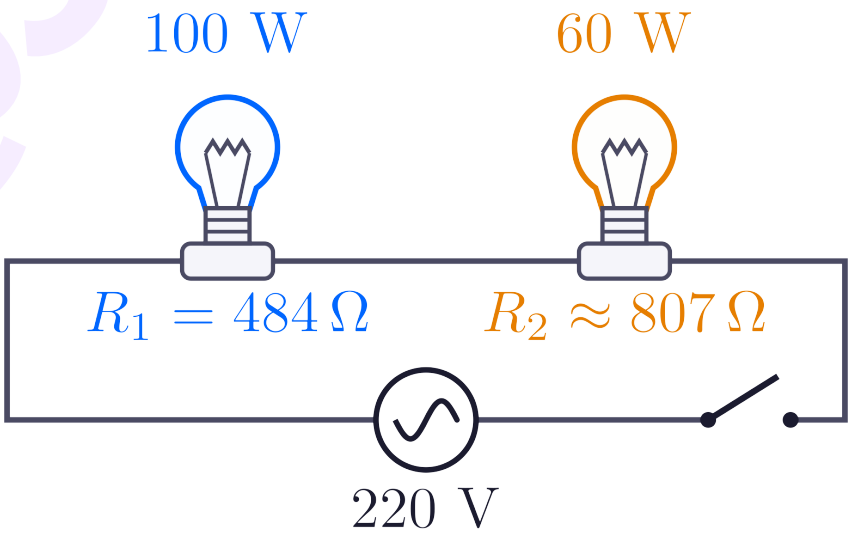
A real filament's resistance changes as it heats up.

From the rating to the resistance

Both bulbs are rated for 220 V. At its rated voltage a bulb takes its rated power, $P = \frac{V^2}{R}$, so its resistance is $R = \frac{V^2}{P}$:

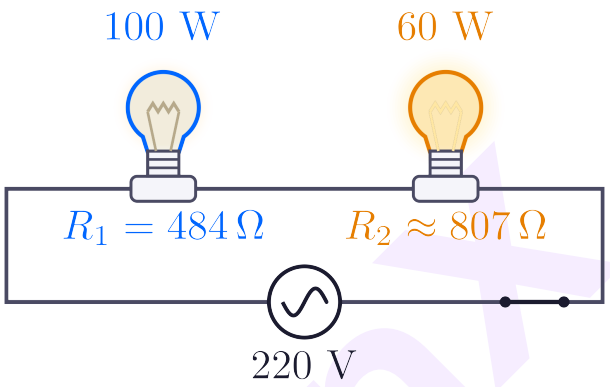
$$R_1 = \frac{220^2}{100} = 484\ \Omega, \qquad R_2 = \frac{220^2}{60} = \frac{2420}{3} \approx 807\ \Omega.$$

The 60 W bulb has the **larger** resistance: at the same rated voltage, a lower wattage always means a larger resistance.



Joined in series

In series there is one path, so the **same current** I flows through both bulbs. The power in each is $P = I^2R$, so the larger resistance takes more power.
Brightness follows power, so the 60 W bulb glows brighter: in the figure each glow is in proportion to its power.



$$P_1 = I^2R_1 \approx 14.06\ \text{W}, \qquad P_2 = I^2R_2 \approx 23.44\ \text{W}.$$

Where the numbers come from

$I = \dfrac{220}{484 + \frac{2420}{3}} = \dfrac{15}{88}\ \text{A} \approx 0.170\ \text{A}$, the same in both. Then $P_1 = \left(\dfrac{15}{88}\right)^2 \times 484 = \dfrac{225}{16} = 14.0625\ \text{W}$ and $P_2 = \dfrac{375}{16} = 23.4375\ \text{W}$. Neither bulb gets its rating: together they take only 37.5 W. In series the powers are in the ratio of the resistances, $\dfrac{P_2}{P_1} = \dfrac{R_2}{R_1} = \dfrac{100}{60}$.

CAREFUL

"The 100 W bulb is always brighter" is the trap. The rating tells you the power only at the rated voltage. In series neither bulb has 220 V across it: the voltage splits in the ratio of the resistances (82.5 V and 137.5 V here), and each power must be worked out from the current. Work out the resistances first, then decide.

Solved example

Two identical 100 W, 220 V bulbs are joined in series across 220 V. Find the power in each.

Resistance of each: $\dfrac{220^2}{100} = 484\,\Omega$; together $968\,\Omega$. **Total power** $= \dfrac{220^2}{968} = 50\ \text{W}$, shared equally (same current, same R).

25 W each (a quarter of the rating: each has half the voltage)

Key formulas

from the rating: $R = \dfrac{V_{\text{rated}}^2}{P_{\text{rated}}}$

any voltage V: $P = \dfrac{V^2}{R}$

series (same I): $P = I^2R \propto R$

series: $\dfrac{P_2}{P_1} = \dfrac{R_2}{R_1}$

Practice set

Easy to hard. Bulbs are rated for 220 V unless stated, and their resistance is taken as fixed. The answers start on the next page.

Q1. **Quiz from the Short.** The same two bulbs (100 W and 60 W), now in parallel across 220 V. Which bulb glows brighter? (A) the 100 W bulb (B) the 60 W bulb (C) both the same.

Q2. Find the resistance of a 40 W bulb.

Q3. A 100 W bulb and a 25 W bulb are joined in series across 220 V. Which one glows brighter, and how much power does it take?

Q4. A 60 W bulb is run on 110 V. How much power does it take?

Q5. A 100 W bulb is joined in series with a 484 Ω resistor across 220 V. Find the power in the bulb.

Q6. For the Short's pair (100 W and 60 W in series across 220 V), find the current and the voltage across each bulb.

Watch the animated lesson on YouTube

Which Bulb Glows Brighter in Series? (Short)

Scan the code to open the JEEVisionX channel on YouTube. This lesson is in the JEE Concepts Visualization Shorts playlist.

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Answers

Q1

(A) the 100 W bulb

In parallel each bulb is joined straight across 220 V, its rated voltage, so each takes its rated power: $\frac{220^2}{484} = 100$ W and $\frac{3 \times 220^2}{2420} = 60$ W. The 100 W bulb is brighter: the series answer turns round. In parallel the voltage is the same, so $P = \frac{V^2}{R}$ and the smaller resistance takes more power.

Q2

1210 Ω

$R = \frac{220^2}{40} = \frac{48400}{40}$.

Q3

The 25 W bulb; 16 W

$R = 484\ \Omega$ and $1936\ \Omega$, so $I = \frac{220}{2420} = \frac{1}{11}$ A. Then $P = I^2 R$ gives 4 W and 16 W: the 25 W bulb is brighter.

Q4

15 W

$R = \frac{220^2}{60}$, so $P = \frac{110^2}{R} = 60 \times \left(\frac{110}{220}\right)^2 = \frac{60}{4}$. Half the voltage gives a quarter of the power.

Q5

25 W

The bulb is $484\ \Omega$, the same as the resistor, so each has 110 V: $P = \frac{110^2}{484} = 25$ W. Or $I = \frac{220}{968}$ A and $P = I^2 \times 484$.

Q6

$I = \frac{15}{88}$ A ≈ 0.170 A; 82.5 V and 137.5 V

$I = \frac{220}{484 + \frac{2420}{3}} = \frac{15}{88}$ A. $V_1 = IR_1 = 82.5$ V, $V_2 = IR_2 = 137.5$ V; they add to 220 V.