W8. DC Circuits

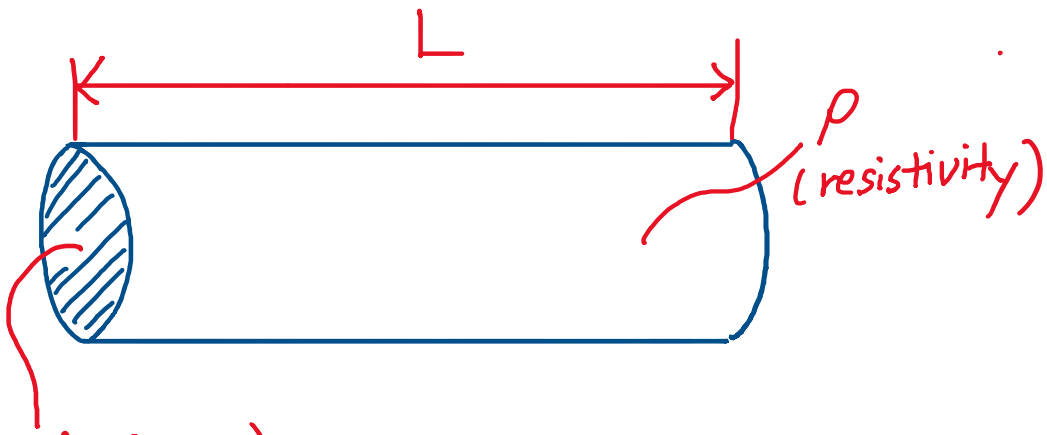
- Resistance
- Ohm’s law
- Power
- Kirchhoff’s law
- Equivalent circuit

Resistance

$$R = \rho \frac{L}{A}$$

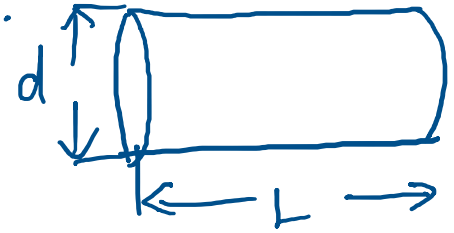
$$\sigma = \frac{1}{\rho}$$

conductivity

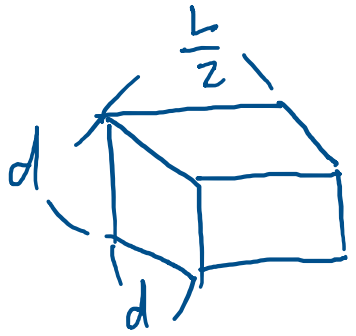


Four resistors are made out of the same materials. Rank the resistors A, B, C, and D from least to greatest resistance

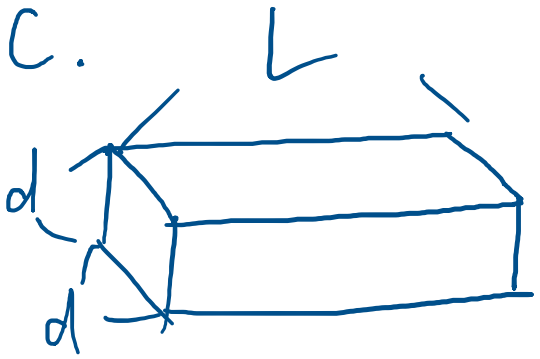
A.



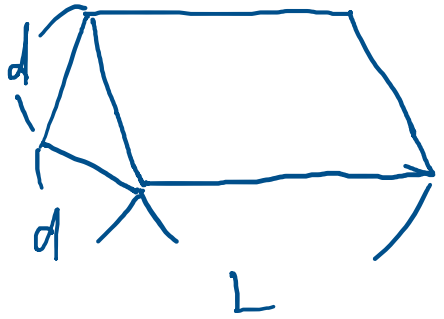
B.



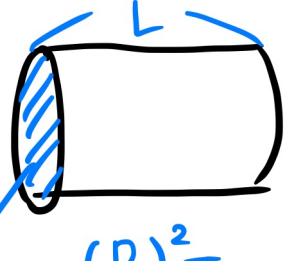
C.



D.



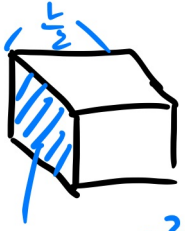
A.



$A = \left(\frac{D}{2}\right)^2 \pi$

$R_A = \frac{\rho L}{\left(\frac{\pi}{4} D^2\right)} = \frac{4}{\pi} \frac{\rho L}{D^2}$

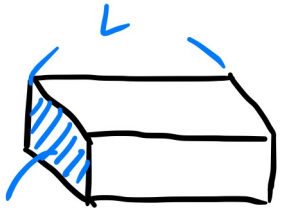
B.



$A = d^2$

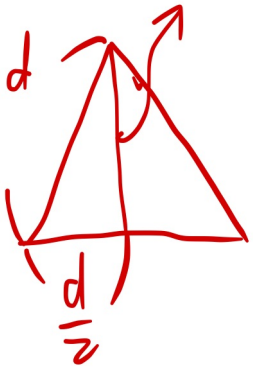
$R_B = \rho \frac{\frac{L}{2}}{d^2} = \frac{1}{2} \frac{\rho L}{d^2}$

C.

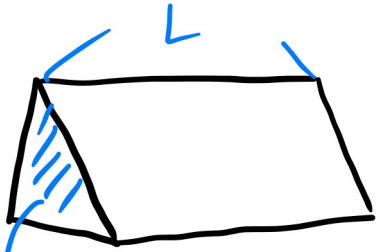


$A = d^2$

$R_C = \frac{\rho L}{d^2}$



D.

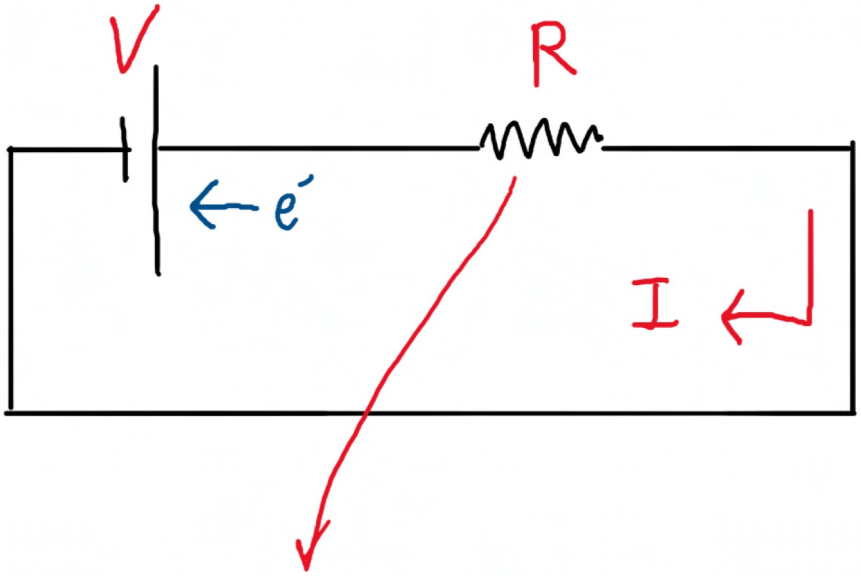


$A = d\left(\frac{\sqrt{3}}{2} d\right) \frac{1}{2} = \frac{\sqrt{3}}{4} d^2$

$R_D = \frac{\rho L}{\frac{\sqrt{3}}{4} d^2} = \frac{4}{\sqrt{3}} \frac{\rho L}{d^2}$

$\Rightarrow B < C < A < D$

Ohm's law & power



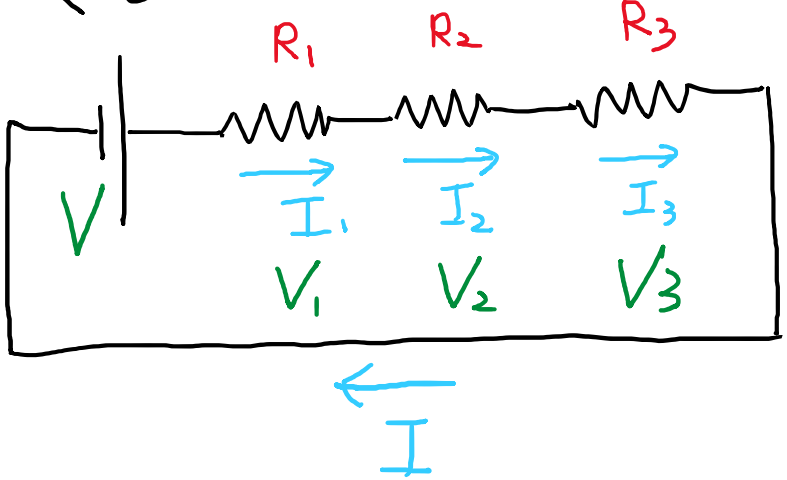
$$\left[\begin{array}{l} I = \dfrac{V}{R} \\ V = IR \\ R = \dfrac{V}{I} \end{array}\right] \qquad I = \frac{\Delta q}{\Delta t}$$

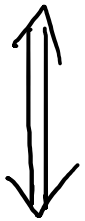
$$\text{Power} = IV \longrightarrow I_{@\text{ element}} \quad V_{@\text{ element}}$$

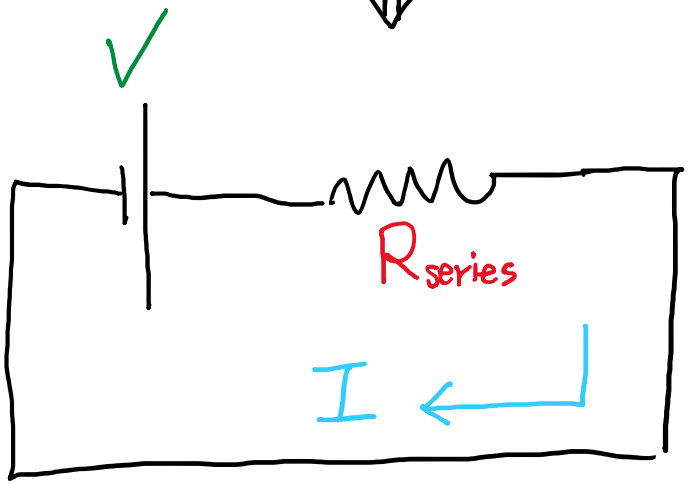
$$= \frac{V^2}{R}$$

$$= I^2R$$

< Series >





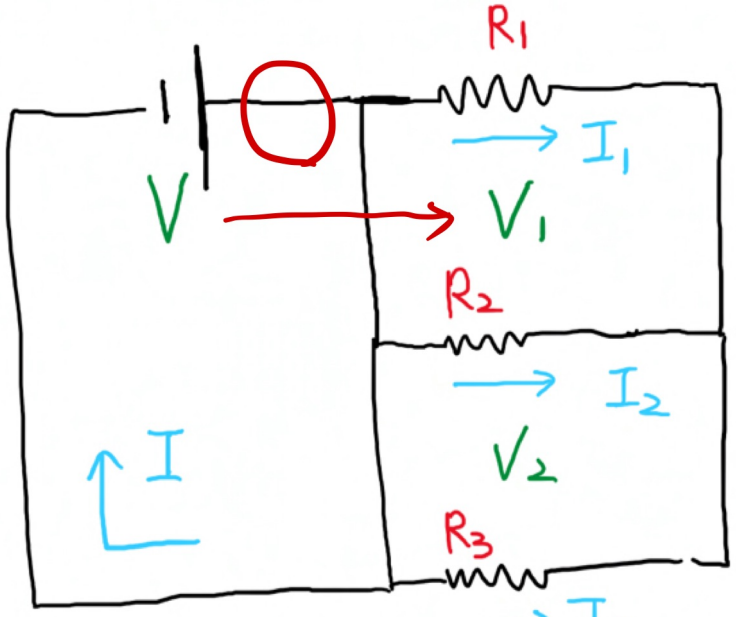


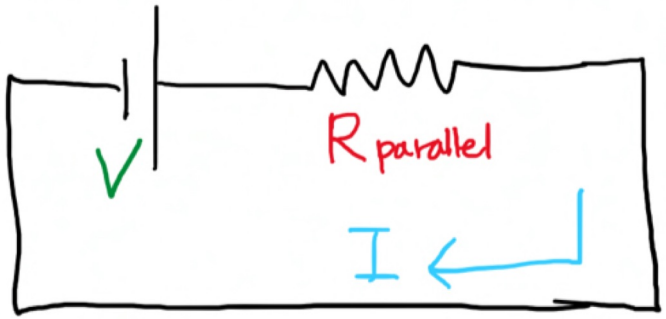
$$R_{series} = R_1 + R_2 + R_3$$

$$I_{series} = I_1 = I_2 = I_3$$

$$V_{series} = V_1 + V_2 + V_3$$

〈 Parallel 〉

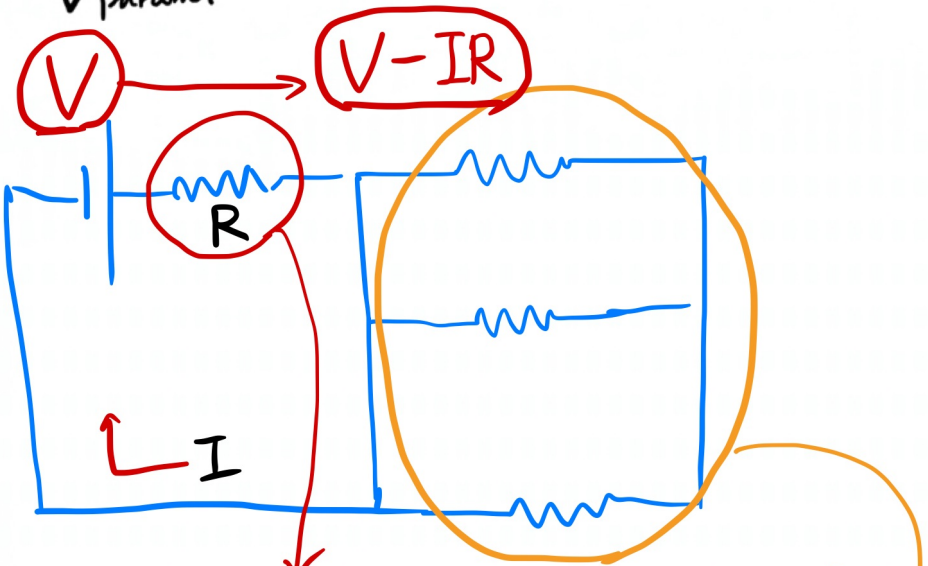




$$R_{parallel} = \left[\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}\right]^{-1}$$

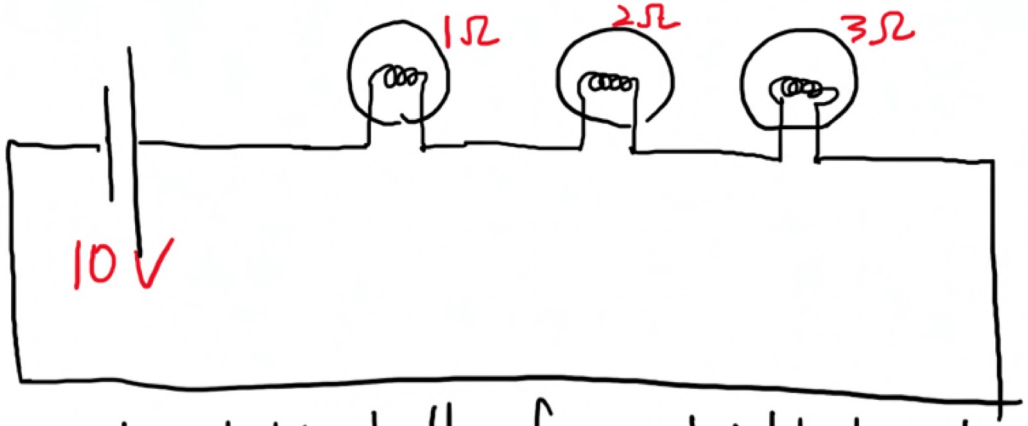
$$I_{parallel} = I_1 + I_2 + I_3$$

$$V_{parallel} = V_1 = V_2 = V_3$$



Voltage drops by IR after the element.

Voltage cross on parallel elements would be (V - IR)



Rank the light bulb from brightest to dimmest.

- Series connection ⇒ $I_{tot} = I_1 = I_2 = I_3$

$$I_{tot} = \frac{V_{tot}}{R_{tot}}$$

$$R_{tot} = R_1 + R_2 + R_3 = 6\Omega$$

$$I_{tot} = \frac{10V}{6\Omega} = 1.67\,A$$

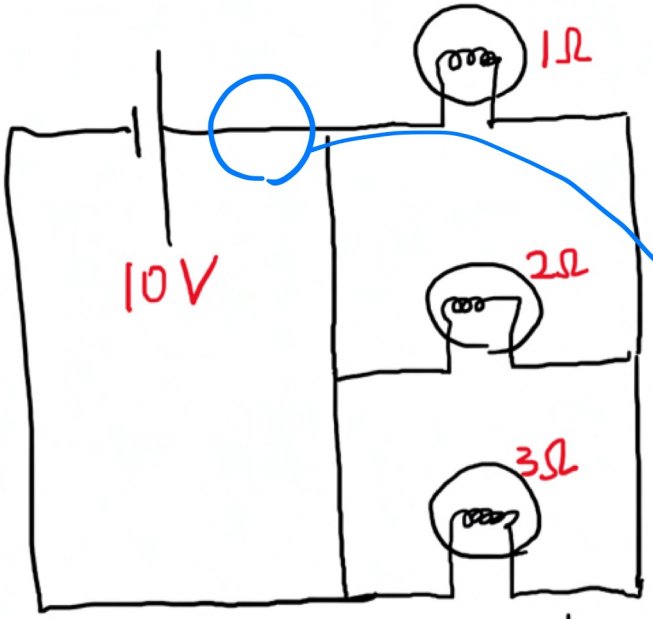
$P = I^2R$

$$P_1 = (1.67\,A)^2 \cdot 1\Omega = 2.79\,W$$

$$P_2 = (1.67\,A)^2 \cdot 2\Omega = 5.58\,W$$

$$P_3 = (1.67\,A)^2 \cdot 3\Omega = 8.37\,W$$

⇒ brightest 3Ω – 2Ω – 1Ω dimmest



Rank from brightest to dimmest.

⇒ Parallel connection

$$V = V_1 = V_2 = V_3$$

↳ $P = \frac{V^2}{R}$

No element → There is not a voltage drop from the source.

↓

$$V = 10V = V_1 = V_2 = V_3$$

$$P_1 = \frac{(10V)^2}{1\Omega} = 100W$$

$$P_2 = \frac{(10V)^2}{2\Omega} = 50W$$

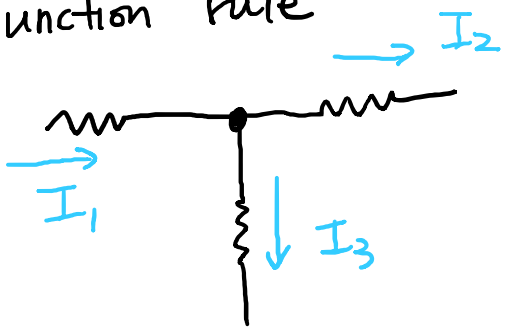
$$P_3 = \frac{(10V)^2}{3\Omega} = 33.3W$$

brightest — dimmest.

1Ω — 2Ω — 3Ω

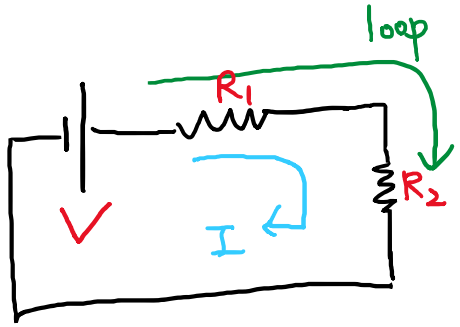
Kirchhoff's rule

- Junction rule

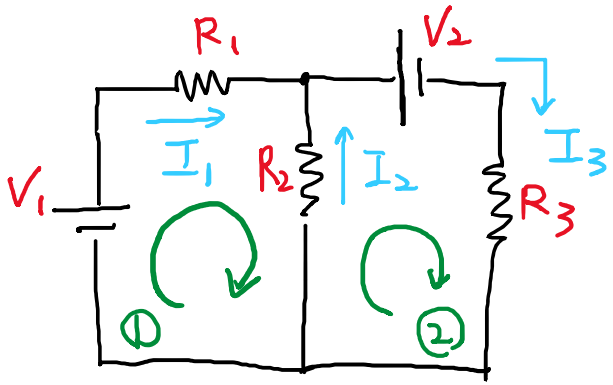


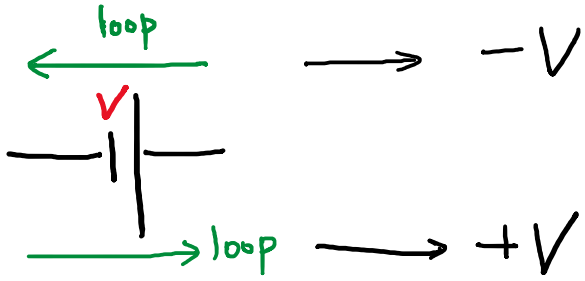
$$\Rightarrow \quad I_1 = I_2 + I_3$$

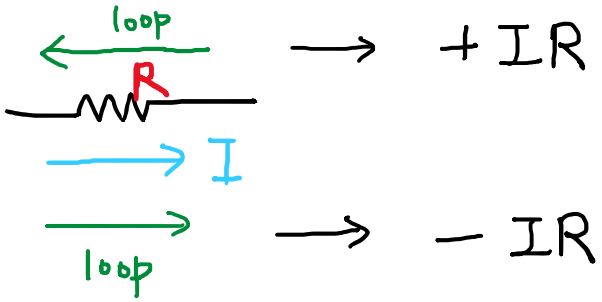
- Loop rule



$$\Rightarrow \quad \Sigma V_{loop} = V - IR_1 - IR_2 = 0$$







$$\Downarrow$$

①

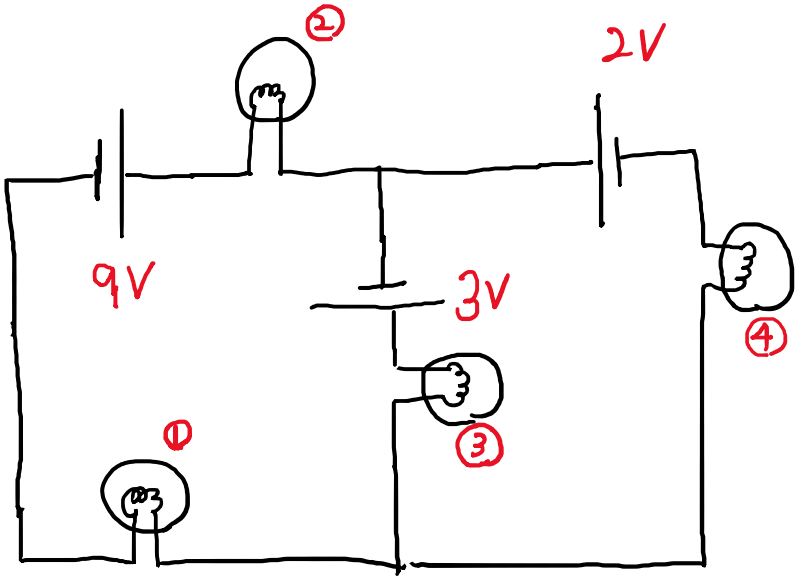
$$+V_1 - I_1R_1 + I_2R_2 = 0$$

②

$$-I_2R_2 - V_2 - I_3R_3 = 0$$

$$\left.\begin{array}{l} \\ \\ \\ \\ \\ \end{array}\right]$$

$$\oplus \quad I_1 + I_2 = I_3$$



Identical light bulbs with resistance 2Ω. Rank from the brightest to dimmest.