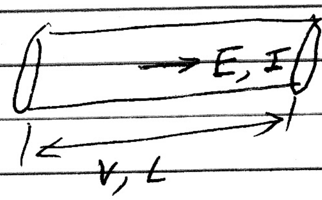
Lecture 26 iq23

1. Ohm's Law dissipated in (OL)
   - OL-1: J=sigma E, E=rho J
   - OL-2: V=IR
   - Series: R=R1+R2+...
   - Parallel: 1/R=1/R1+1/R2+ ...

2. Comments on selected homework in Ch20-h1.
   - 002 A circuit with3 identical bulbs
   - 008 A wire across a bulb
   - 012 Power dissipated in series case vs in parallel case.

Ohm's Law (OL)

OL-1:



$V = EL$, current density: $J = \frac{I}{A}$

$J = \sigma E$

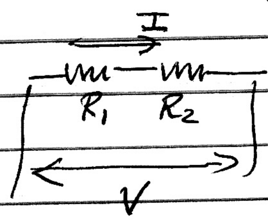
micro: $i = nA\mu E$, $I = |q|\, i$

$\therefore J = \frac{|q|\, i}{A} = \frac{|q|\, nA\mu E}{A} = \sigma E$, $\sigma = |q| n\mu$

Resistivity: $E = \frac{J}{\sigma} = \rho J$

OL2: $\frac{V}{L} = \rho \frac{I}{A}$, $V = \left(\frac{\rho L}{A}\right) I = RI$, $R = \frac{\rho L}{A}$.

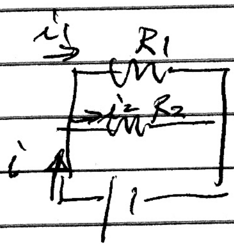
Series:



$V = I R_{12}$ ← Series

$V = V_1 + V_2$
$= IR_1 + IR_2$.
$\therefore R_{12}^{series} = R_1 + R_2$

//:

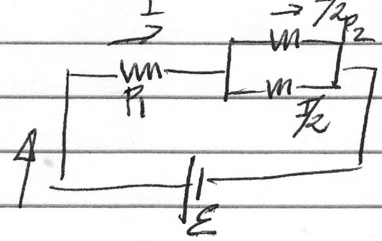


$i = i_1 + i_2$

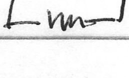
$\frac{V}{R} = \frac{V_1}{R_1} + \frac{V_2}{R_2}$

$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$.

Example: 2011-002



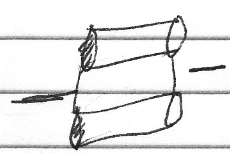
Identical bulbs with R.



// connection — $\frac{1}{R_{12}} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{2}{R}$

$\therefore R_{12} = \frac{R}{2}$

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



Double area

$A' = 2A \quad R' = \frac{\rho L}{A'} = \frac{\rho L}{2A} = \frac{R}{2}$

~~$R_{eff} = R + \frac{R}{2}$~~ $R_{123} = R + R_{23} = R + \frac{R}{2} = \frac{3}{2}R$

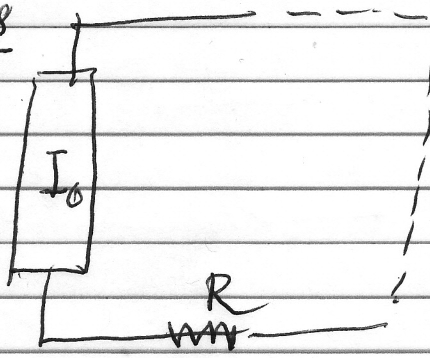
$\therefore I = \frac{\mathcal{E}}{\left(\frac{3}{2}R\right)}$

Brightness — Power $\quad P = \frac{(\Delta q)\,V}{\Delta t} = IV = I^2R$

Compare brightness: $P_1 = I^2R = \left(\frac{2}{3}\frac{\mathcal{E}}{R}\right)^2 R = \frac{4}{9}\frac{\mathcal{E}^2}{R}$,

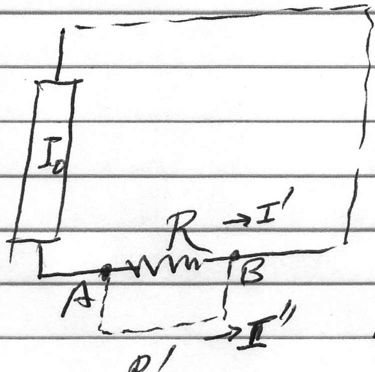
$P_2 = \left(\frac{I}{2}\right)^2 R = \frac{1}{9}\frac{\mathcal{E}^2}{R}$.

008



What happens when you "short" a resistor?

Given: R is the resistor of a light bulb. ✓



What happens when $R' \ll R$ is connected to the two terminals of this bulb?

Hint: $I_0 = I' + I''$

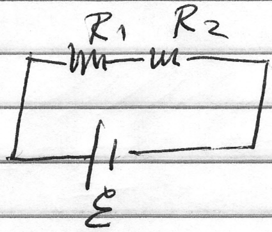
$$V_A - V_B = I'R = I''R'$$

$$\therefore I' = I''\left(\frac{R'}{R}\right).$$

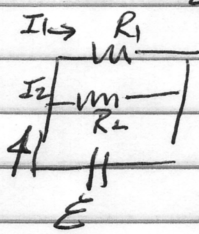
$$I_0 = I''\frac{R'}{R} + I'' \approx I''.$$

So with the wire connected $I' \approx 0$, $I'' \approx I_0$. The bulb turns dark

012.



vs



Connected:

Case I. $\mathcal{E} - IR_1 - IR_2 = 0$, $\therefore I\mathcal{E} = I^2R_1 + I^2R_2$

$\therefore$ Power delivered by the battery is the power consumed by the bulbs.

Case II: check $I\mathcal{E} \overset{?}{=} I_1^2R_1 + I_2^2R_2$

Again: Power delivered = Power consumed

$RHS = I_1\mathcal{E} + I_2\mathcal{E} = (I_1 + I_2)\mathcal{E} = I\mathcal{E}.$