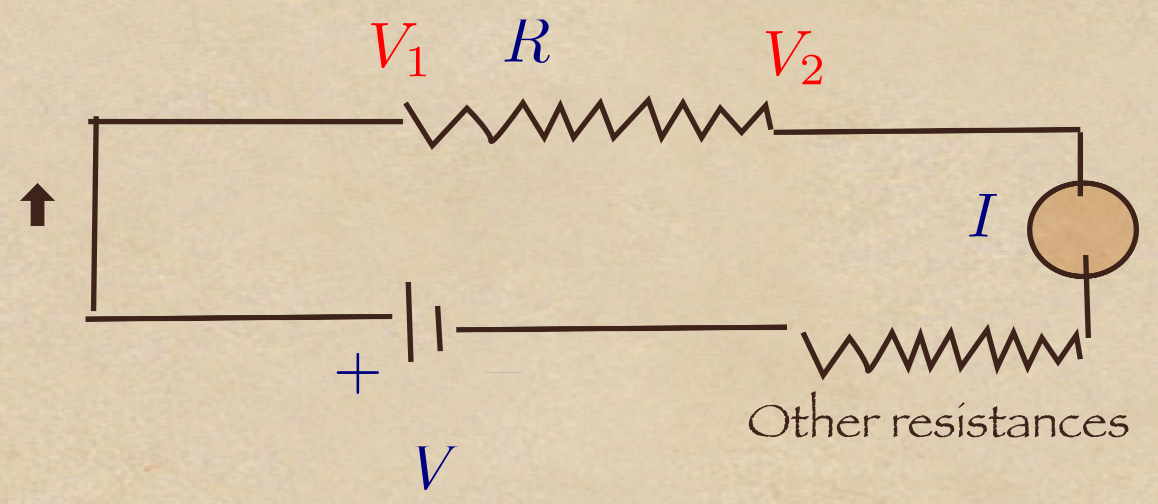
Lecture 16

May 9, 2012

Resistance and Ohm's law



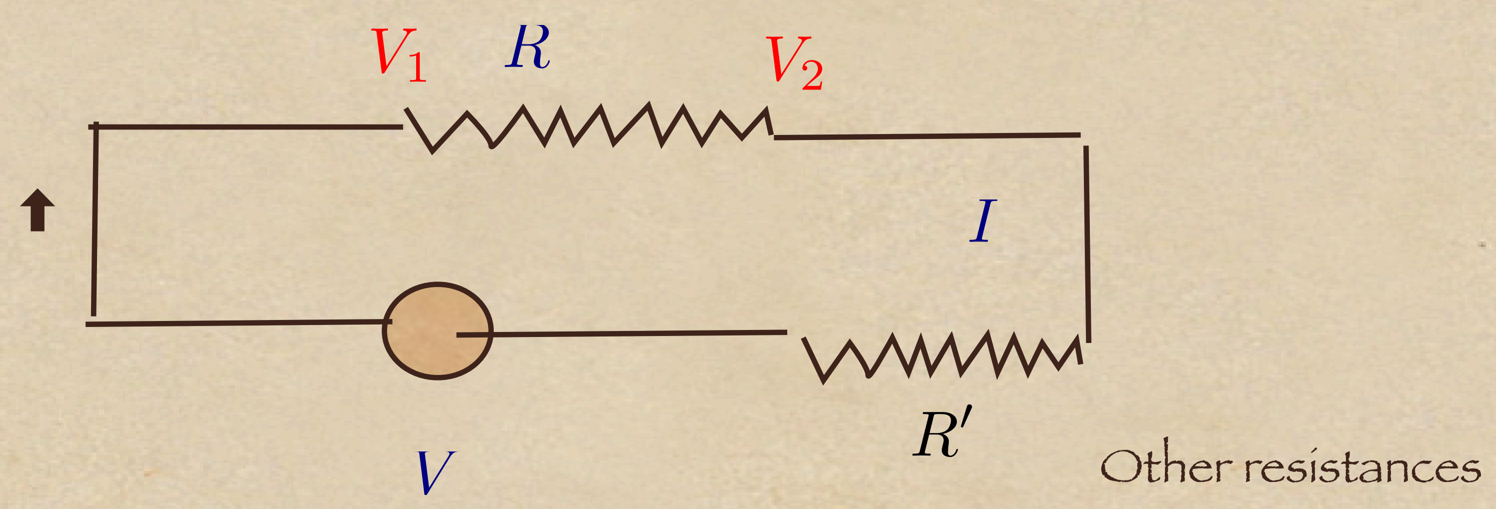
$[R] = Ohms \ \rightarrow \ \Omega$

$V_1 - V_2 = I \times R$ Potential drop across R and current I are connected by Ohm's law

$P = (V_1 - V_2) \times I = I^2 \times R$ Power dissipated in (Joule) heating across R

For AC current we can use the same picture as before
with battery replaced by V that stands for the power plant.

Now
R= transmission line resistance
R'= resistance of homes and communities (R' >> R)



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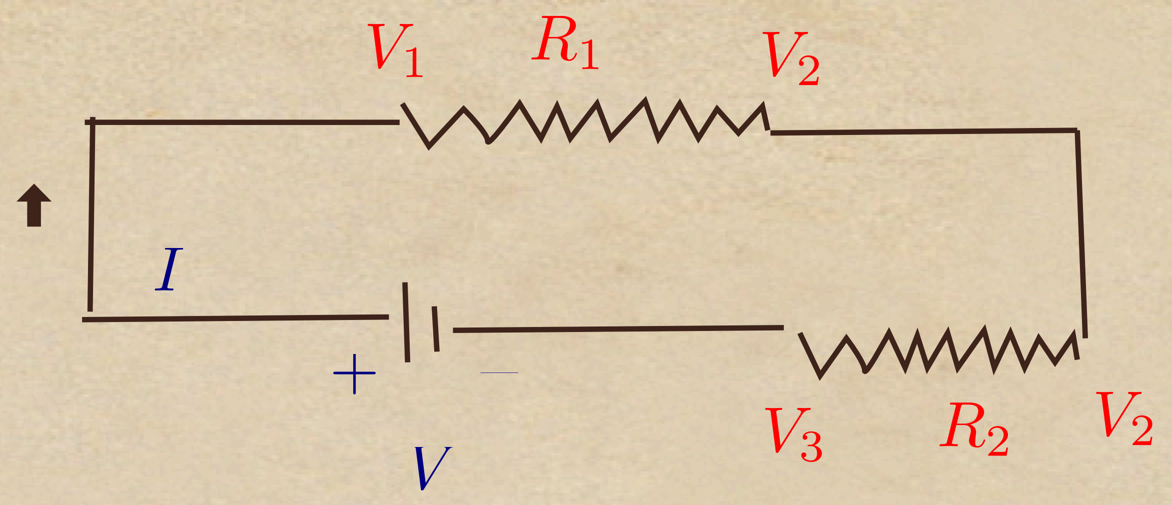
$P = (V_1 - V_2) \times I = I^2 \times R$ Power dissipated in (Joule) heating across R

$$I = V/(R' + R)$$
$$R' + R = R_{Total}$$

We next learn that
this is an example of
two resistances in SERIES

Resistors in "series"



Note that the current I
is common to both resistances.

$$V = V_1 - V_3, \quad (1)$$

$$V_1 - V_2 = I\ R_1, \quad (2)$$

$$V_2 - V_3 = I\ R_2, \quad (3)$$

Adding (2) and (3) we get on using (1)

$$V_1 - V_3 = V = I\ (R_1 + R_2), \quad (4)$$

Hence effective resistance is the sum of the two when placed in "series".

$$R_T = R_1 + R_2$$

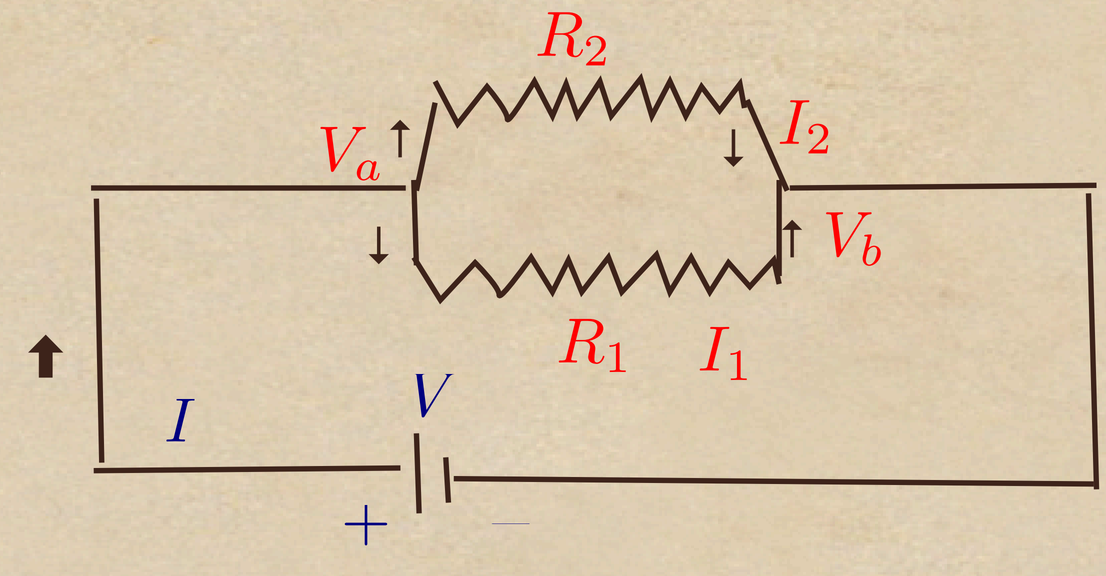
$$V = I \times R_T$$

$$P_1 = (V_1 - V_2) \times I = I^2 R_1 = V^2 \frac{R_1}{R_T^2}, \quad (5)$$

Power dissipated in the resistor

$$P_2 = (V_2 - V_3) \times I = I^2 R_2 = V^2 \frac{R_2}{R_T^2}, \quad (6)$$

Resistors in “parallel”



$$I = I_1 + I_2, \quad (1)$$

$$V = V_a - V_b, \quad (2)$$

$$V = I_1 \times R_1, \quad (3)$$

$$V = I_2 \times R_2, \quad (4)$$

Using (1) we write the total current as

$$I = V \times (\frac{1}{R_1} + \frac{1}{R_2}), \quad (5)$$

$$R_T = \frac{R_1 R_2}{R_1 + R_2}, \quad (6)$$

$$P_1 = V \times I_1 = \frac{V^2}{R_1}, \quad (7)$$

$$P_2 = V \times I_2 = \frac{V^2}{R_2}, \quad (8)$$

These 8 equations give the complete solution

Numerical problem

Comparing the two

Series

$$R_T = R_1 + R_2$$

$$P_1 = V^2 \frac{R_1}{R_T^2},$$ ← small

$$P_2 = V^2 \frac{R_2}{R_T^2},$$ ← most of power used

Parallel

$$R_T = \frac{R_1 R_2}{R_1 + R_2}, \quad (6)$$

most of power used → $$P_1 = V \times I_1 = \frac{V^2}{R_1}, \quad (7)$$

small → $$P_2 = V \times I_2 = \frac{V^2}{R_2}, \quad (8)$$

If we take

R_1 / R_2=very small