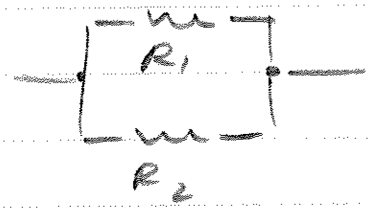
LEC 15 (PT 1)

RESISTORS IN SERIES & PARALLEL + CIRCUITS

- AS W/ CAPACITORS WE CAN CONNECT RESISTORS IN SERIES + PARALLEL:



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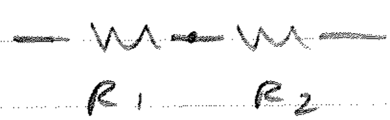
$$R = \left(\frac{1}{R_1} + \frac{1}{R_2}\right)^{-1}$$

PARALLEL

$R < R_1$

$R < R_2$



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$$R = R_1 + R_2$$

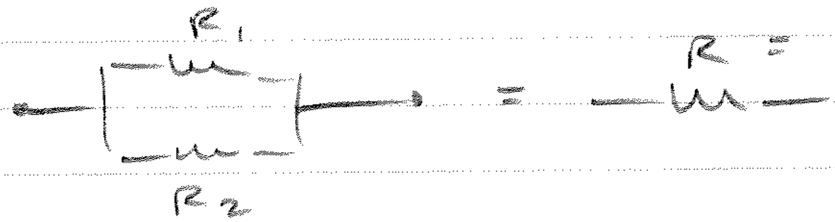
$R > R_1$

$R > R_2$

- CONCEPTUALLY:
    - PARALLEL: WE PROVIDE MULTIPLE PATHS FOR CURRENT TO FLOW, SO RESISTANCE DECREASES
    - SERIES: THE VOLTAGE ACROSS EITHER RESISTOR IS LESS THAN V, THE TOTAL VOLTAGE. SO CURRENT IS REDUCED: R INCREASES.

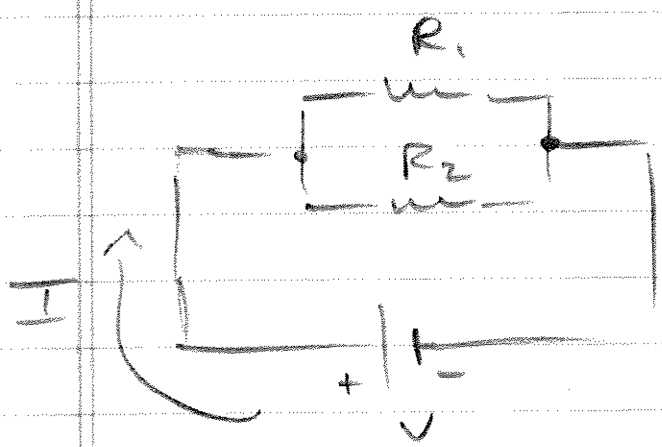
PARALLEL COMBO

TO SEE THAT



$$R = \left(\frac{1}{R_1} + \frac{1}{R_2}\right)^{-1}$$

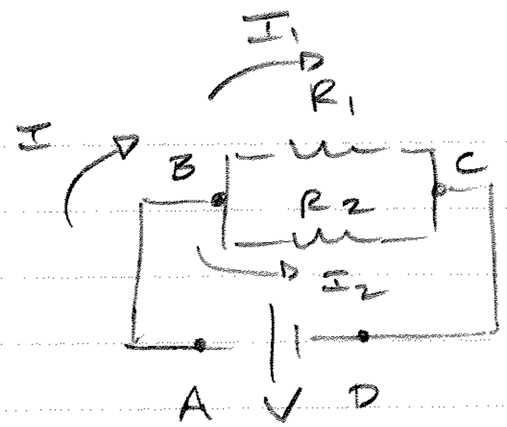
WE APPLY A VOLTAGE V ACROSS THE PARALLEL COMBO + DETERMINE THE CURRENT I THAT ENTERS THE COMBO:



- THE PARALLEL RESISTANCE IS THEN

$$R = \frac{V}{I}$$

- TO DETERMINE I, WE RECOGNIZE THAT THE VOLTAGE ACROSS EACH RESISTOR IS V:



VOLTAGE ACROSS R_1:

$$V_1 = V_B - V_C = V_A - V_D = V$$

($V_A = V_B$ & $V_C = V_D$ SINCE VOLTAGE DROP OVER A WIRE, I.E. A CONDUCTOR, IS ZERO)

LIKEWISE:

$$V_2 = V$$

- BY OHM'S LAW, CURRENT THROUGH R_1 IS:

$$I_1 = V_1/R_1 = V/R_1$$
$$I_2 = V_2/R_2 = V/R_2$$

- THE TOTAL CURRENT FLOWING INTO THE PARALLEL COMBINATION IS THEREFORE THE SUM $I_1 + I_2$

$$I = I_1 + I_2 = V/R_1 + V/R_2$$
$$= V \cdot (1/R_1 + 1/R_2)$$

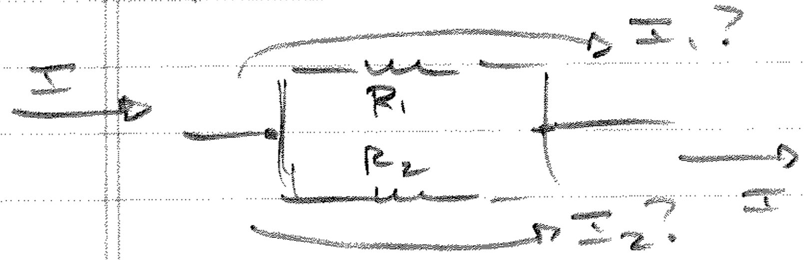
- TO DETERMINE R, WE DIVIDE V BY I

$$R = V/I = V/(V(1/R_1 + 1/R_2))$$

$$= \left(\frac{1}{R_1} + \frac{1}{R_2}\right)^{-1}$$

- AS WE CLAIMED ON PAGE (1)

- SO HOW IS CURRENT SPLIT UP WHEN IT IS SENT THROUGH A PARALLEL RESISTANCE?



- WELL, VOLTAGE DROP ACROSS R_1 MUST EQUATE VOLTAGE DROP ACROSS R_2'

$$V_1 = V_2$$
$$I_1 R_1 = I_2 R_2$$

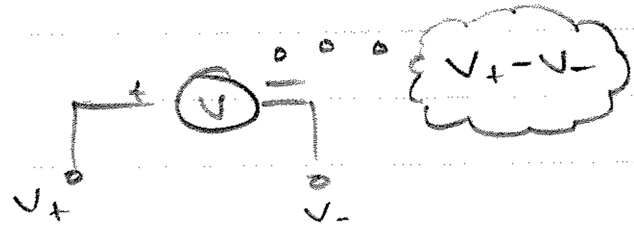
$$\longrightarrow \frac{I_1}{I_2} = \frac{R_2}{R_1}$$

- CURRENT, THEN, IS HIGHER THROUGH THE <u>SMALLER</u> RESISTANCE!

  "CURRENT TAKES PATH OF LEAST RESISTANCE"

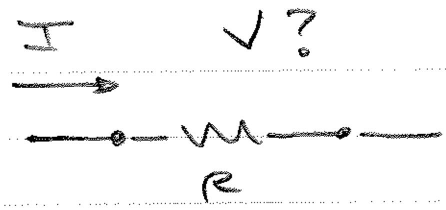
- APPLICATION: VOLTMETERS

  - VOLTMETER IS TWO TERMINAL DEVICE THAT MEASURES THE VOLTAGE DIFFERENCE BETWEEN ITS TWO TERMINALS:

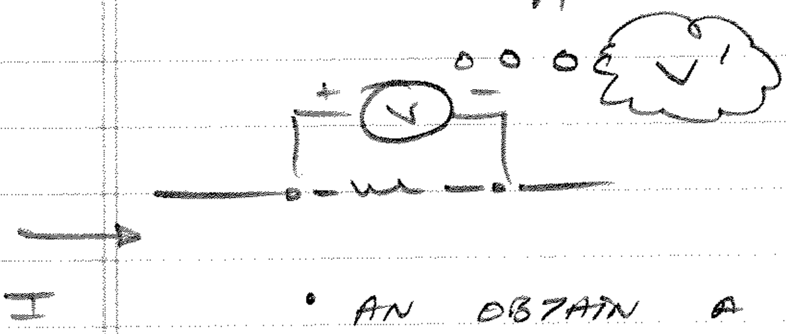


  - ELECTRICALLY, IT LOOKS LIKE A RESISTOR:

- A COMMON APPLICATION IS WHERE A FIXED CURRENT IS CONDUCTING ACROSS A RESISTOR AND WE WANT TO MEASURE THE VOLTAGE ACROSS THE RESISTOR:



- To do this, we connect the voltmeter across the resistance:



- an obtain a reading V'

- In general, $V' \neq V$, since the voltmeter has some resistance and will <u>divert</u> some of the total current.

  - The current I' through R will then in general be less than I, so that:

$$V' = I'R < IR = V$$

i.e. $V' < V$

- Therefore, we want to design voltmeters to have very <u>large</u> resistances so that they divert minimal current, and thus give an accurate reading (i.e. $V' \approx V$)