Lecture 1 : Ohm's Law

Describes resistors

$$V_A - V_B = IR$$

V in volts
I in amps
R in ohms

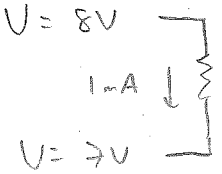
Note direction for positive I matters

Need to show on diagram. $I<0 \Rightarrow$ current flows opposite arrow

Often write $V = IR$, but be careful

V is really ΔV

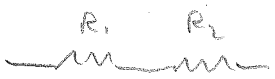
Example:



$IR = 1V$, but no point in circuit at $V = 1V$

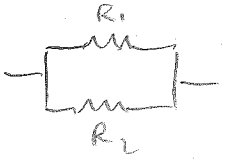
- Rules for combining resistors:

Series:



$$R_{TOT} = R_1 + R_2$$

Parallel



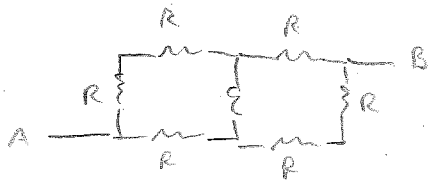
$$\frac{1}{R_{TOT}} = \frac{1}{R_1} + \frac{1}{R_2}$$

$$R_{TOT} = \frac{R_1 R_2}{R_1 + R_2} \equiv R_1 \| R_2$$

In fact, any network of resistors between two points is equivalent to a single R_{TOT}

→ Thevenin's Theorem (one version)

Example:

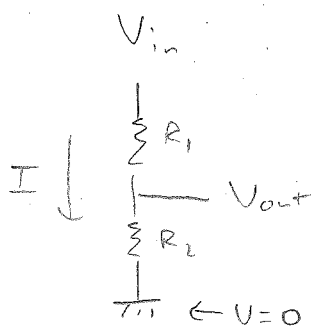


$\equiv$ A —[R_{TOT}]— B

$$R_{TOT} = \frac{7}{5} R$$

Solve by setting up $\Delta V = IR$ for each resistor, solve simultaneous equations.

- Important building block for electronics: Voltage Divider



Solve for V_{out}:

$$I = \frac{V_{in}}{R_{TOT}} = \frac{V_{in}}{R_1 + R_2}$$

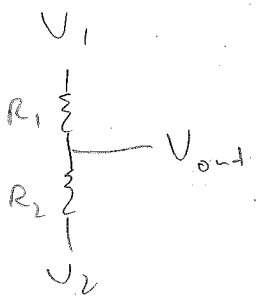
$$\boxed{V_{out} = IR_2 = V_{in} \frac{R_2}{R_1 + R_2}}$$

So $V_{out} \propto V_{in}$, attenuated by factor $\frac{R_2}{R_1 + R_2}$

Useful when you need to reduce a voltage

Will also generalize to other types of circuits

Can also have "three-point" divider:

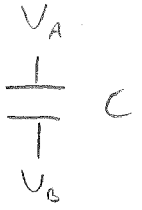


Get $$\boxed{V_{out} = \frac{V_1 R_2 + V_2 R_1}{R_1 + R_2}}$$

- Power dissipated by resistor $P = IV = I^2 R = \frac{V^2}{R}$

If P too large, resistor burns up!

- Next important circuit element: capacitor

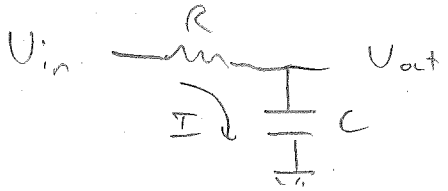


Satisfies

$$\Delta V = \frac{Q}{C} = \frac{1}{C}\int I\,dt$$

Q = charge

Example:



Assume V_{in} initially zero, then apply V_{in} = const

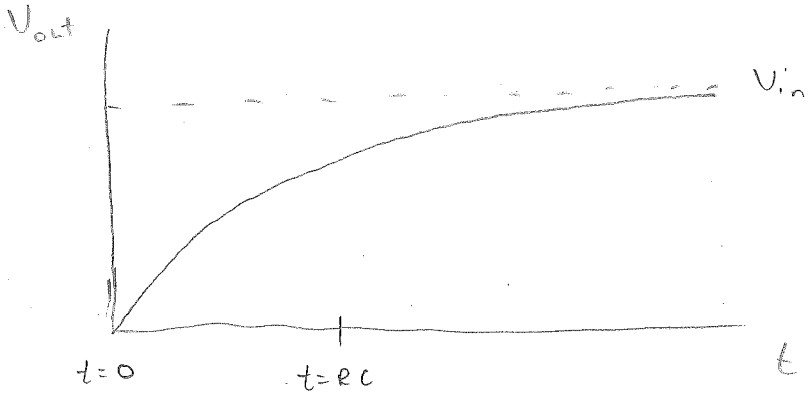
Have $V_{out} = \frac{1}{C}\int I\,dt \Rightarrow \dot{V}_{out} = \frac{I}{C}$

and $V_{out} = V_{in} - IR$

$= V_{in} - \dot{V}_{out} RC$

$\Rightarrow RC\,\dot{V}_{out} + V_{out} = V_{in}$

Solved by $V_{out}(t) = V_{in}\left(1 - e^{-t/RC}\right)$



Plumbing analogy:

Voltage = pressure
Current = flow
Resistor = thin tube (friction)
Capacitor = tank

} useful for intuition