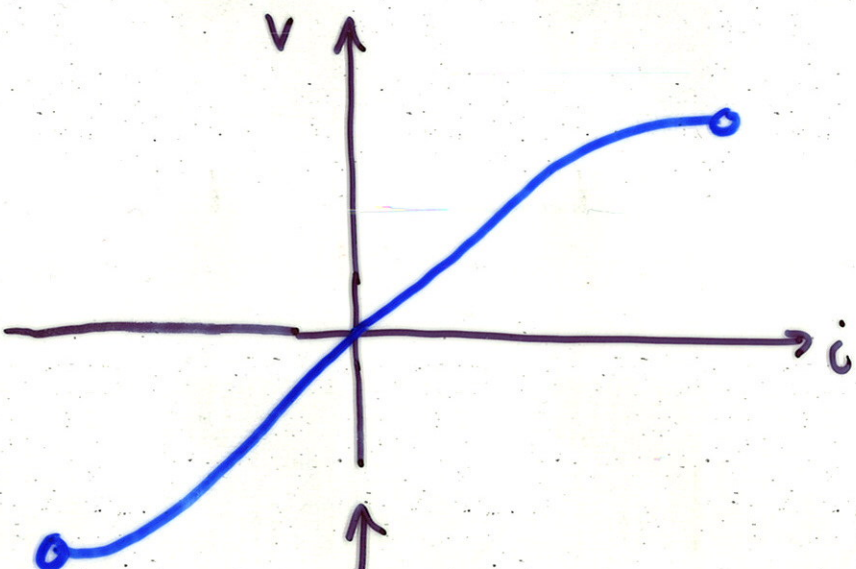
Circuit Modelling

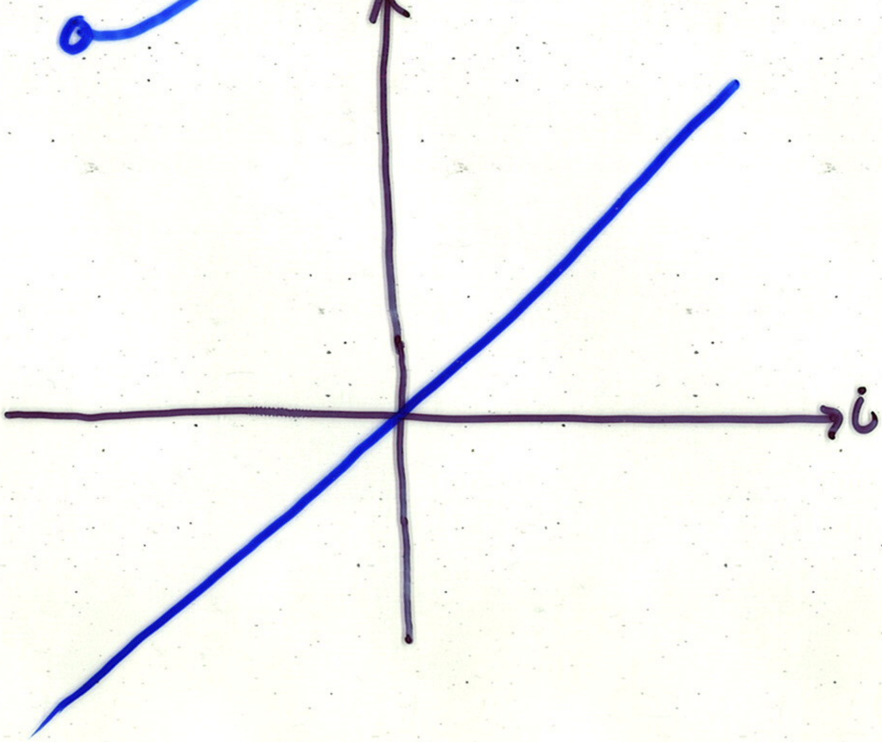
We would like something that is:

- reasonably accurate under certain known conditions
- simple enough to enable design + even innovation

Example: incandescent light bulb



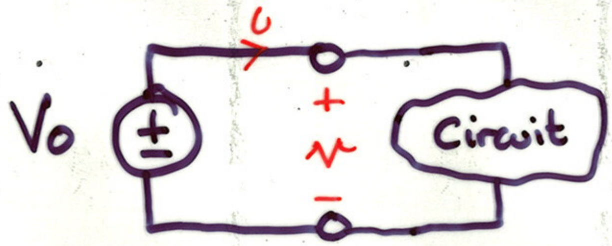
Reasonably accurate model

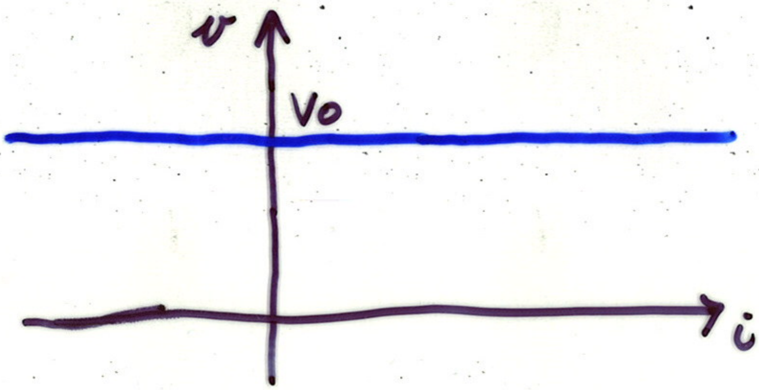


Model that we will use

IDEALIZED INDEPENDENT VOLTAGE SOURCE

e.g., an idealized model for a battery

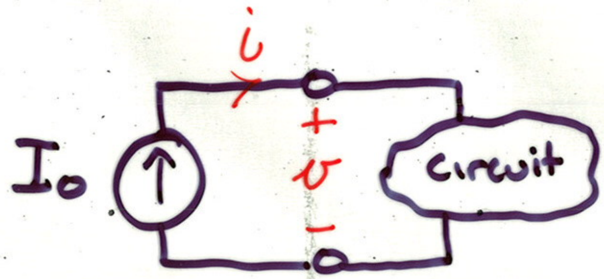


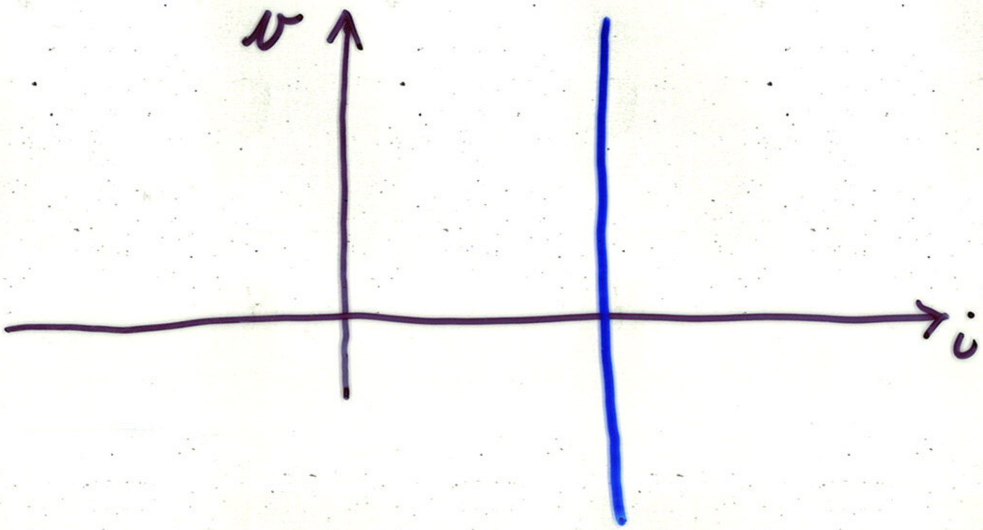


Same voltage, nomatter what the current

Think about power in this idealized model

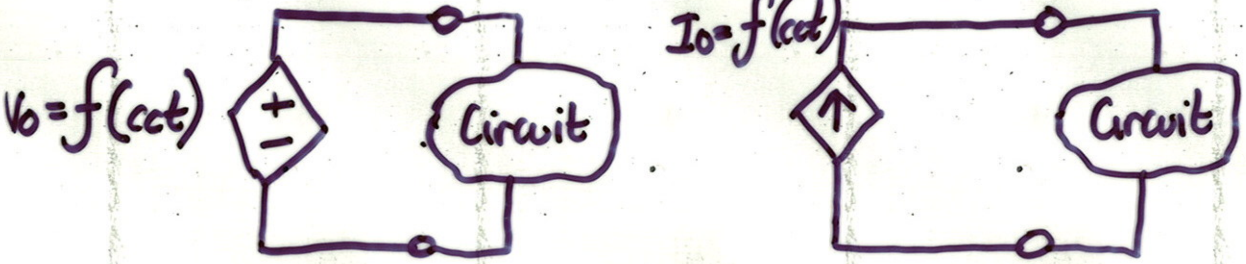
IDEALIZED INDEPENDENT CURRENT SOURCE



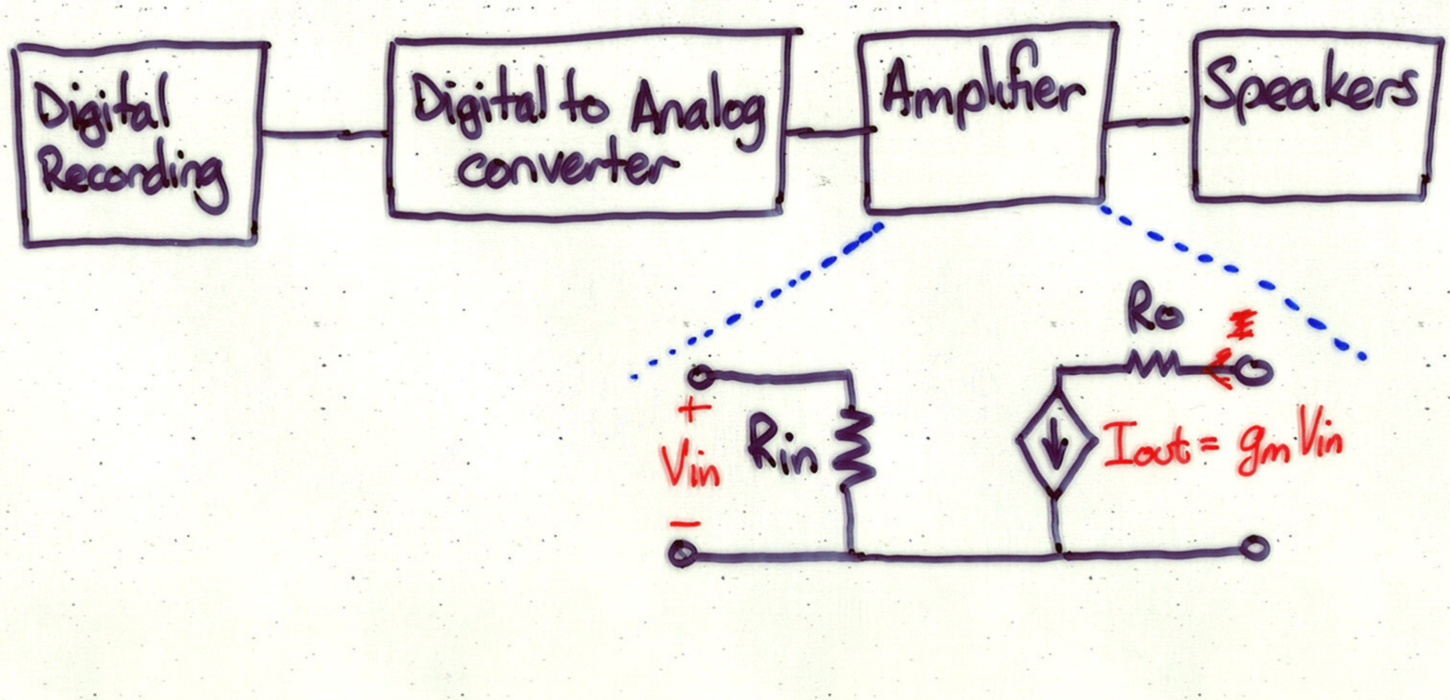


Same current no matter what the voltage

IDEALIZED DEPENDENT SOURCE



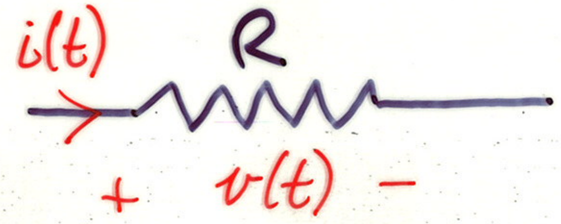
- Same graphs as before
- But now voltage or current is dependent on voltages and currents in rest of circuit
- Very useful in modelling amplifiers



RESISTANCE

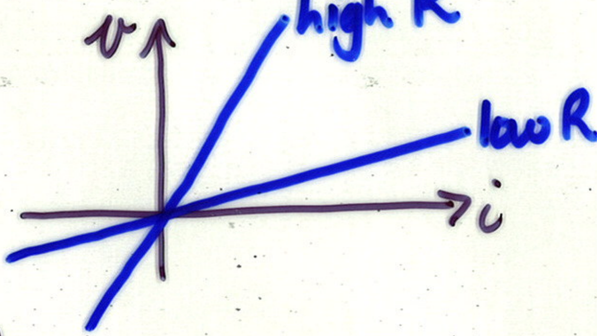
- impedes the flow of charge
- some energy converted
- sometimes that energy is useful
  - light bulb, oven, filter design
- sometimes wasteful
  - power transmission lines

MODEL



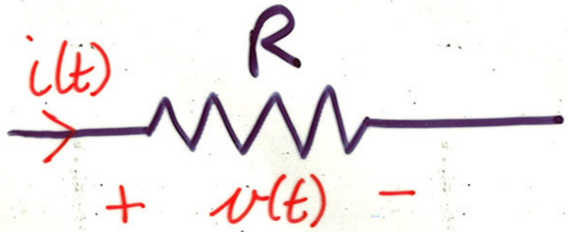
We will assume a linear relationship

$$v(t) = R\,i(t)$$



- R is measured in Ohms (Ω)
- R positive for passive resistors
- what is the power dissipated ?

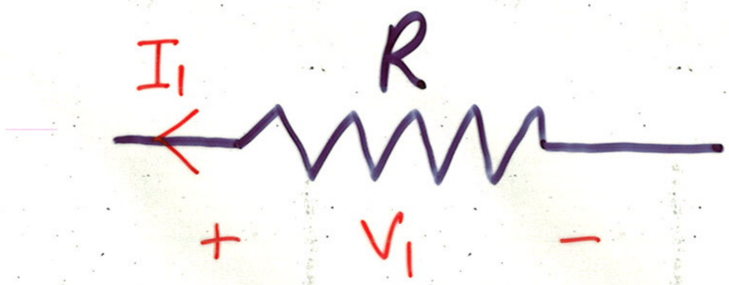
$$p(t) = v(t)\,i(t) = i(t)^2 R = \frac{v(t)^2}{R}$$



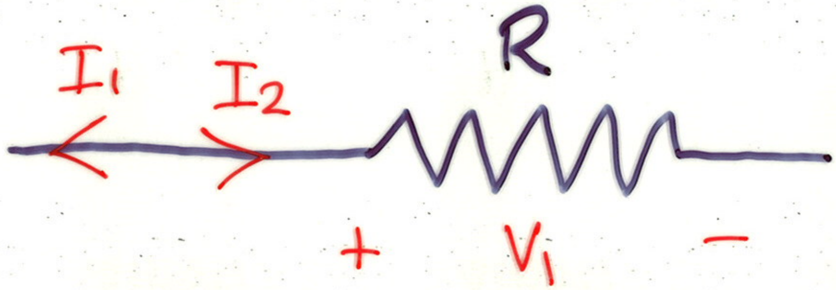
$v(t) = R\, i(t)$ $\qquad$ $i(t) = \dfrac{v(t)}{R}$

- What happens when R gets large
  - small current even when applied voltage is large
  - as $R \to \infty$, $i(t) \to 0$ if $v(t)$ is finite
  - open circuit

- What happens when R gets small
  - apply small voltage, get large current
  - as $R \to 0$, $i(t) \to \infty$ for non-zero $v(t)$
  - short circuit



Relate V_1 and I_1



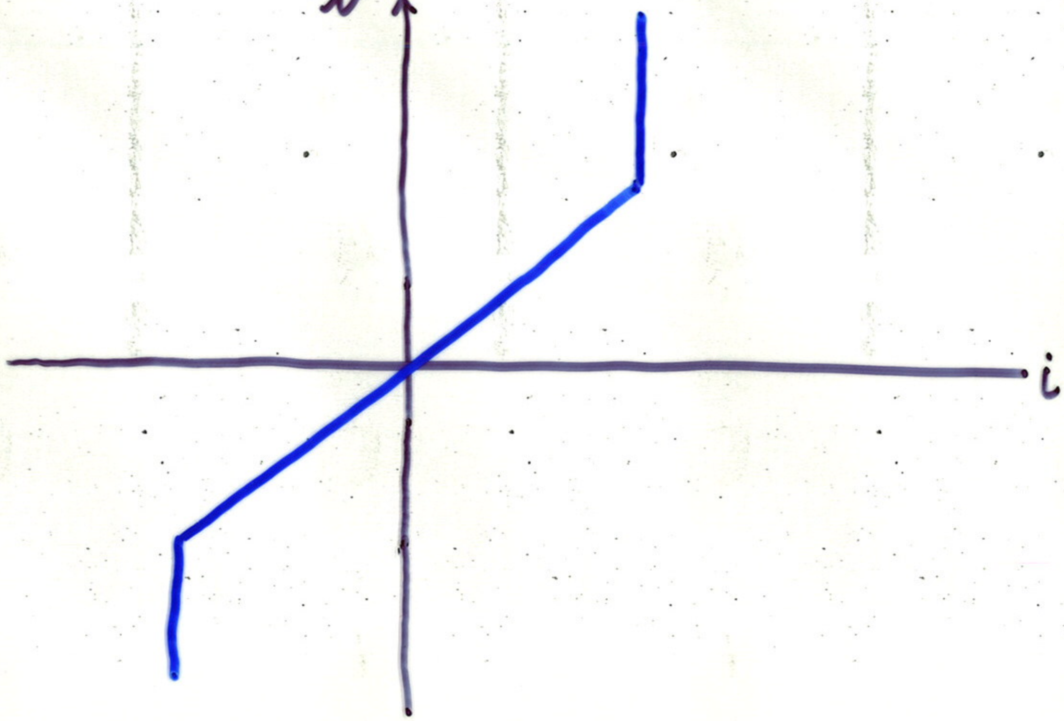
V_1 and I_2 obey passive sign convention

Ohm's Law: $V_1 = R I_2$

Model $I_2 = -I_1$

$\Rightarrow$ $V_1 = -R I_1$

A useful non-linear resistor



CONDUCTANCE

- Sometimes convenient to use conductance

$$G = \frac{1}{R}$$

- $i(t) = G\,v(t)$

- For open circuit [redacted] $G = 0$
- For short circuit [redacted] $G \to \infty$
- measured in Siemens (℧)
- used to be measured in mhos (℧)