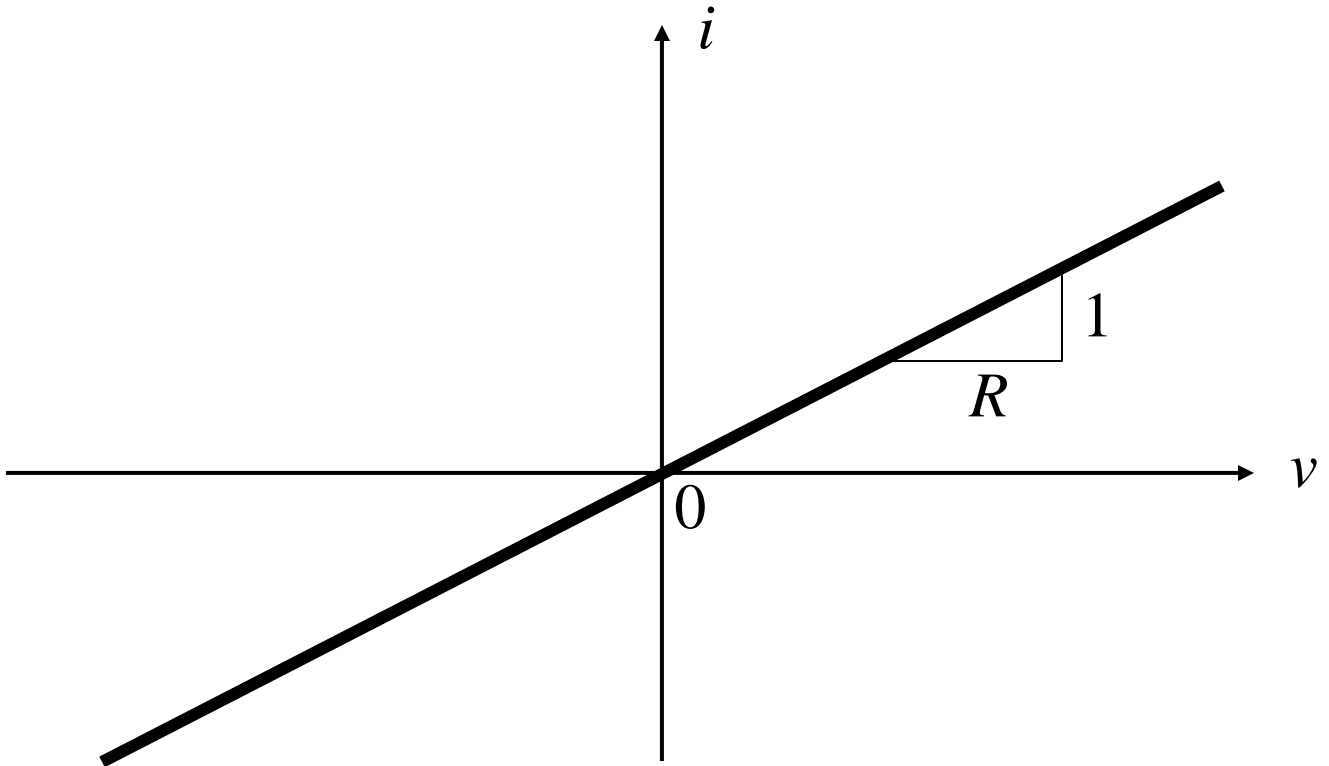# Ideal Circuit Elements

The externally measured behaviors of most physical devices $D$ can be realistically modeled by a circuit made of **ideal circuit elements**. A model is said to be realistic if the device's behavior **predicted** from the model agrees, to within some acceptable tolerance, with actual measurements.
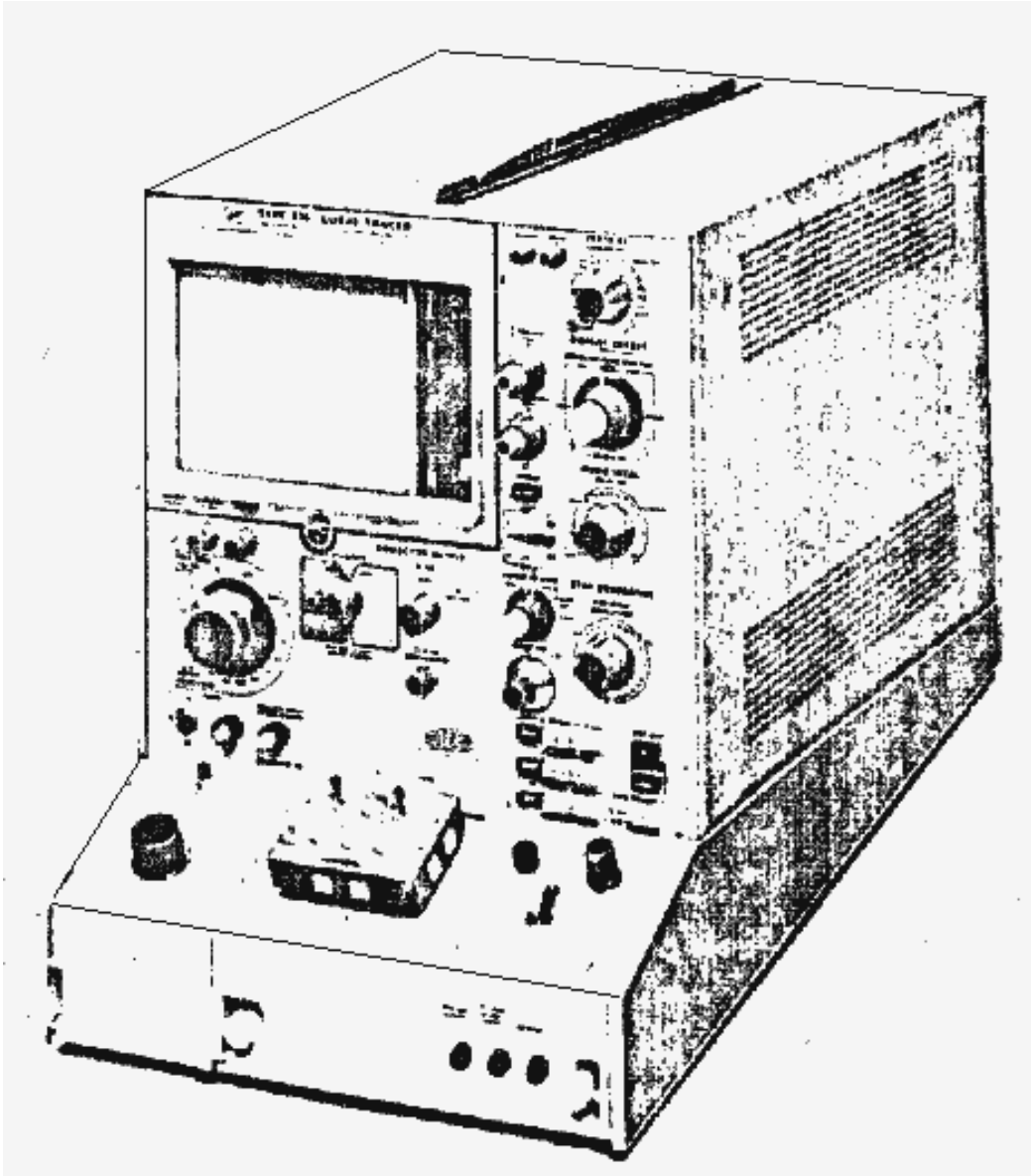
# Linear Resistor



## Ohm's Law

$$v = R\,i$$

The constant $R$ is called the **RESISTANCE**.

$$i = G\,v$$

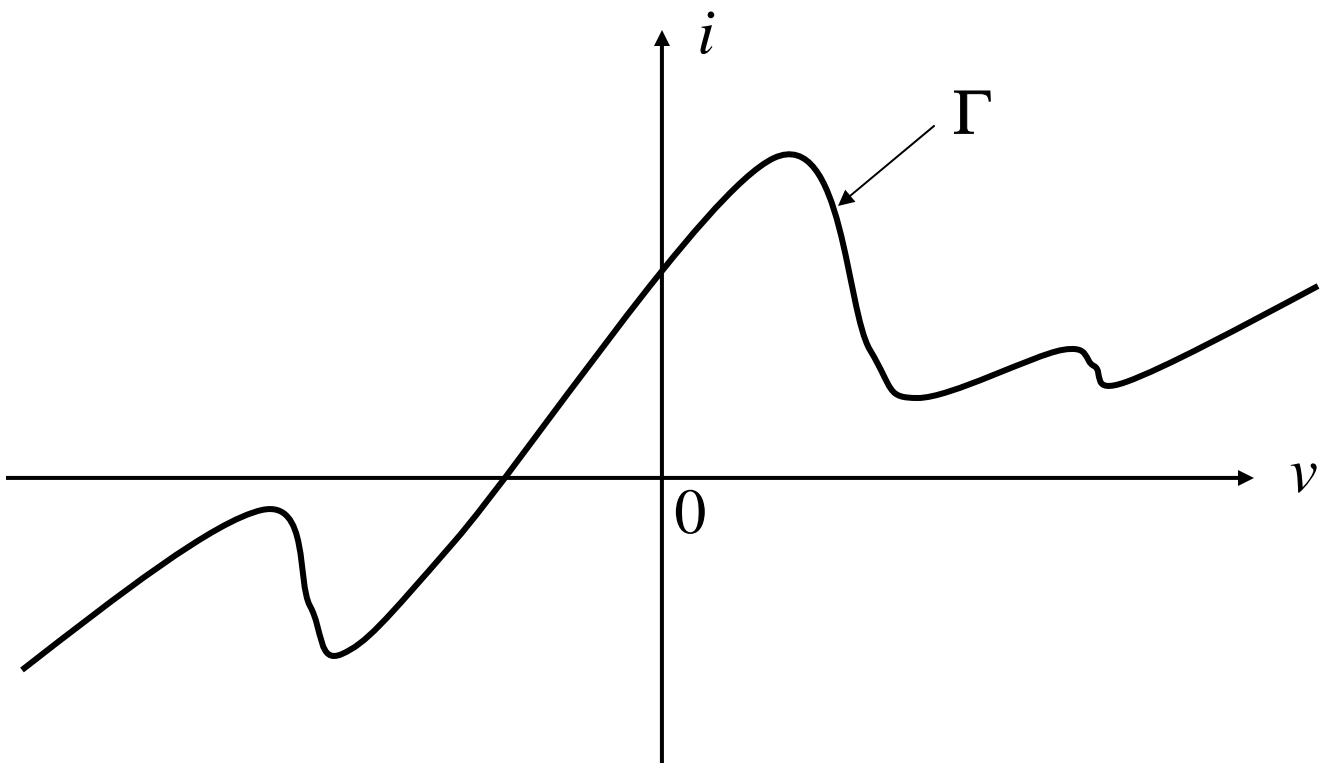The constant $G = 1/R$ is called the **CONDUCTANCE**.
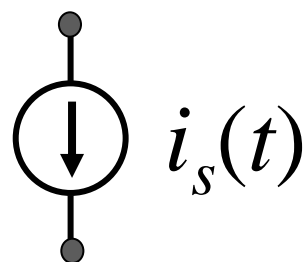
Tetronix Curve Tracer Model 576.

# 2-terminal Resistor

## *Definition*

A 2-terminal circuit element $R$ whose admissible pairs $\{v(t), i(t)\}$ follow a time-independent **loci** $\Gamma$, henceforth called a **constitutive relation** of $R$, in the voltage versus current plane, is called a **2-terminal resistor**.
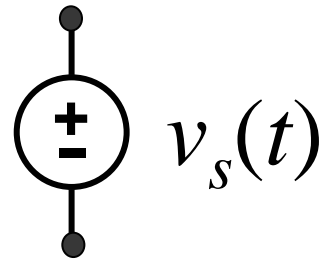
# **Current Source** $\downarrow$ $i_s(t)$

A 2-terminal element $D$ is called a current source with terminal source current $i_s(t)$ iff its terminal current is constrained to be $i_s(t)$, **independent** of its terminal voltage $v$ when connected to any external circuit.
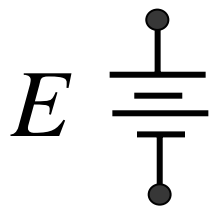
When $i_s(t) = I$ is constant, we call it a dc current source. or a battery.
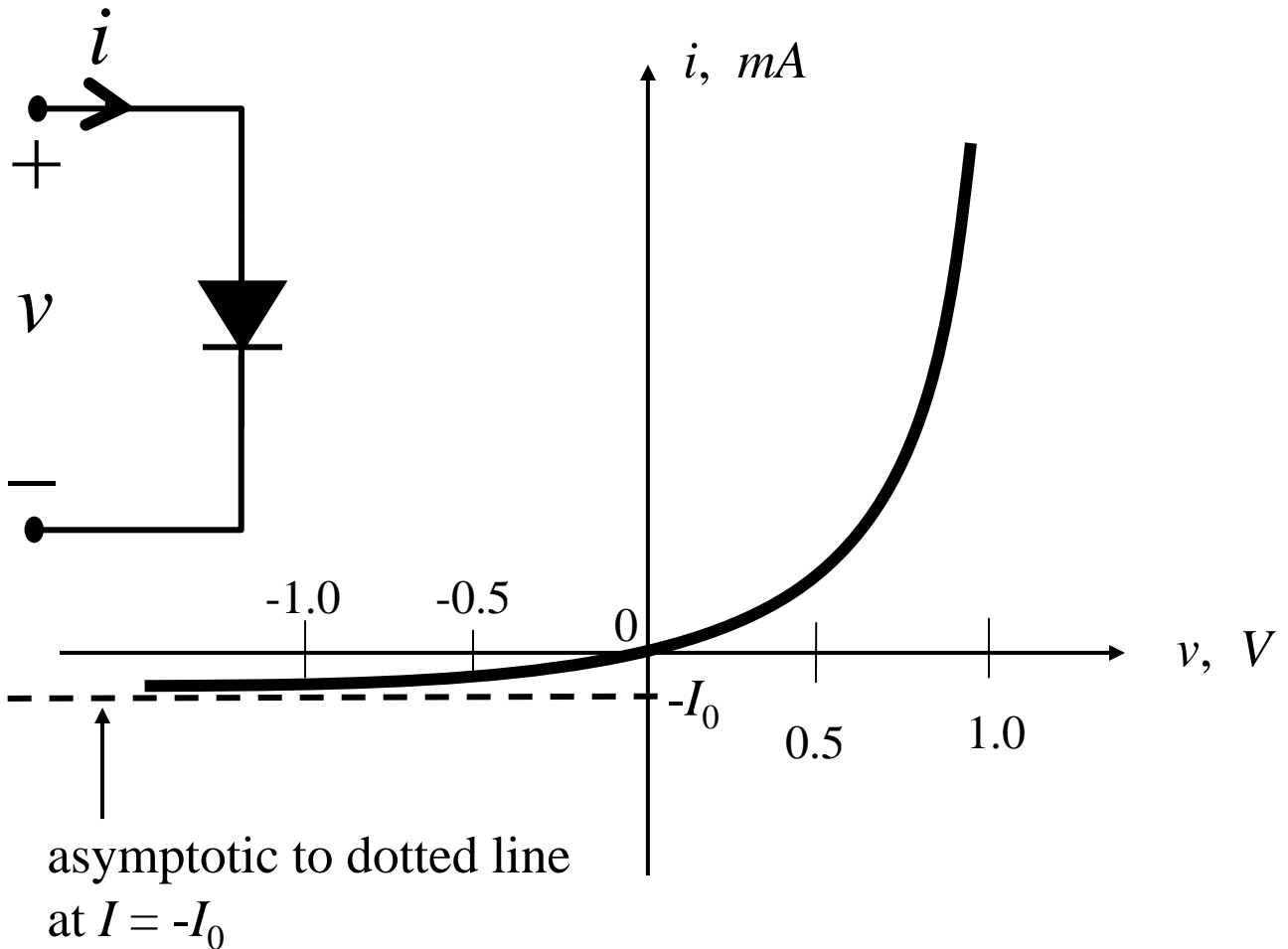
# **Voltage Source** $\pm$ $v_s(t)$

A 2-terminal element $D$ is called a voltage source with terminal source voltage $v_s(t)$ iff its terminal voltage is constrained to be $v_s(t)$, **independent** of its terminal current $i$ when connected to any external circuit.

When $v_s(t) = E$ is constant, we will it a dc voltage source, or a battery. $E$
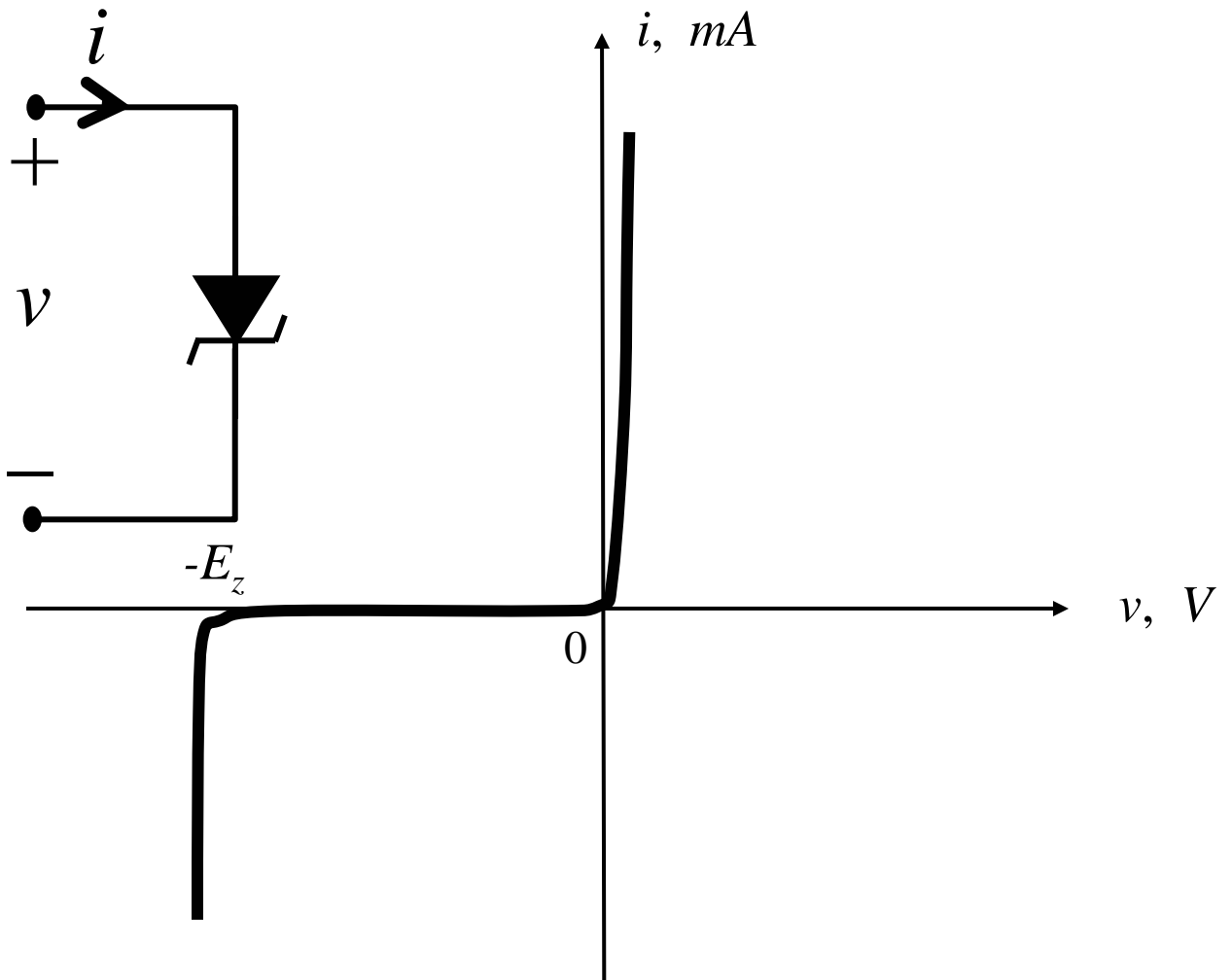
# pn junction diode

$i$

$+$

$v$

$-$

$i, \ mA$

-1.0    -0.5

0

$-I_0$

0.5        1.0

$v, \ V$

asymptotic to dotted line
at $I = -I_0$

approximating equation:

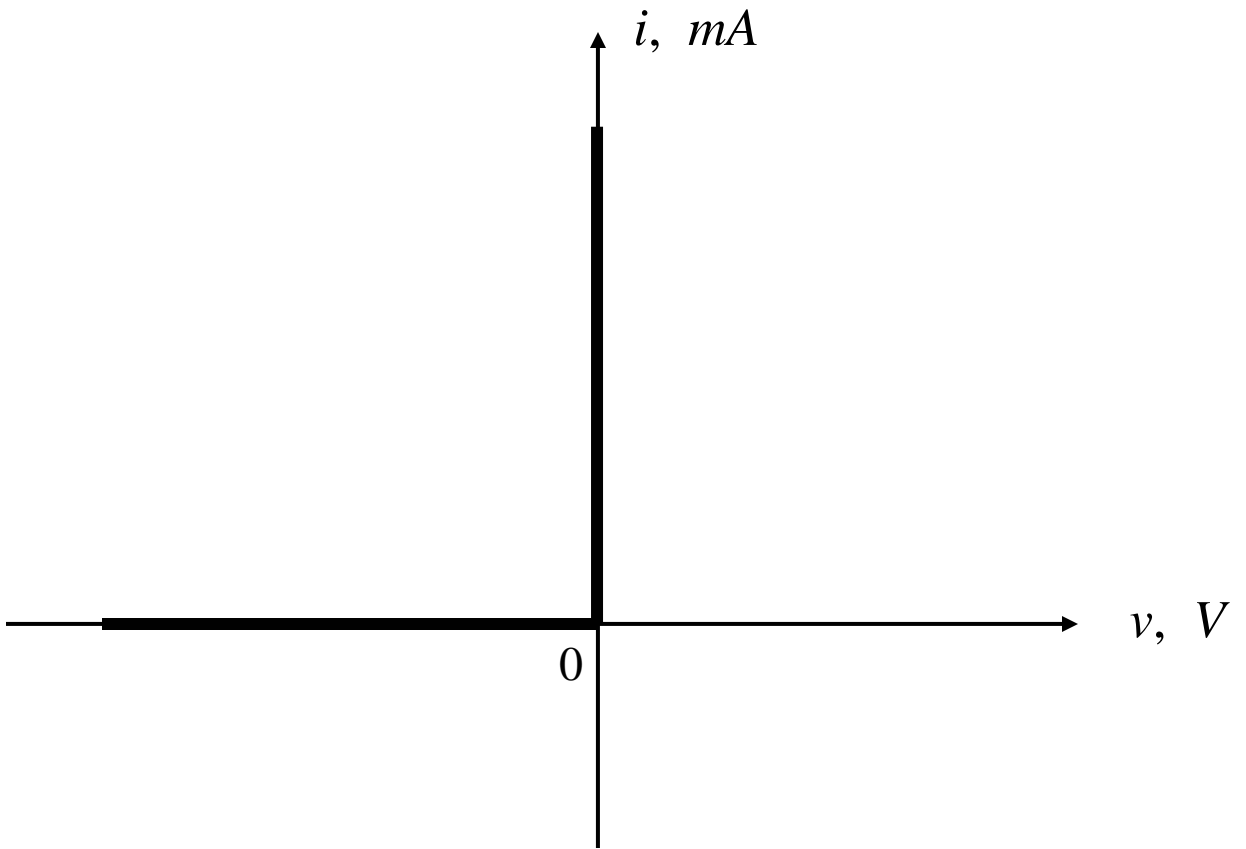$$i = I_0 \left( e^{\frac{v}{V_T}} - 1 \right)$$

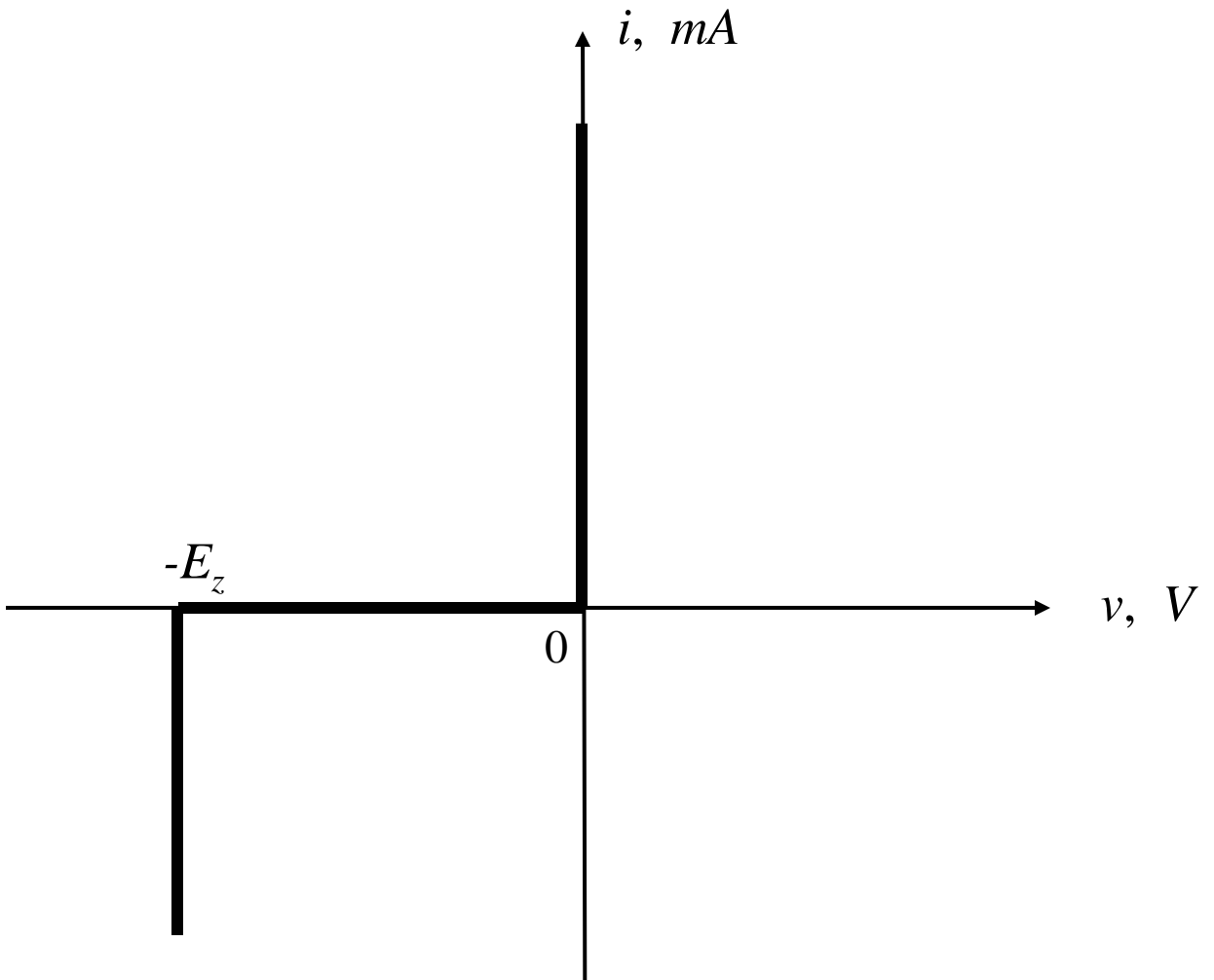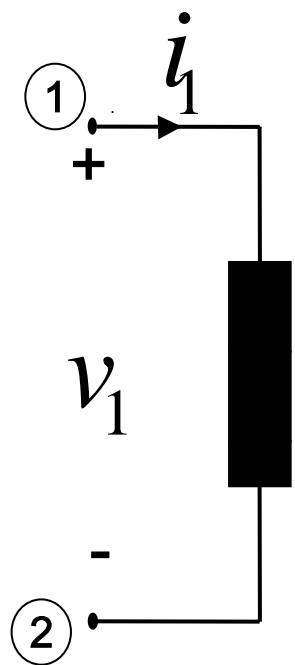where $I_0$ and $V_T$ are device parameters.

# Zener diode



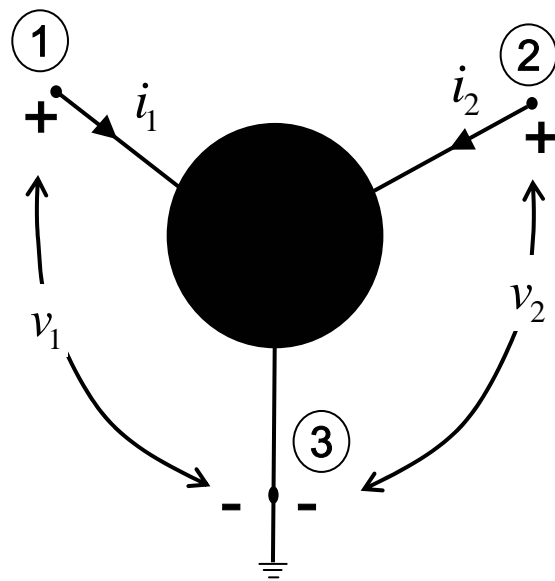$E_z$ is a parameter called the zener voltage.
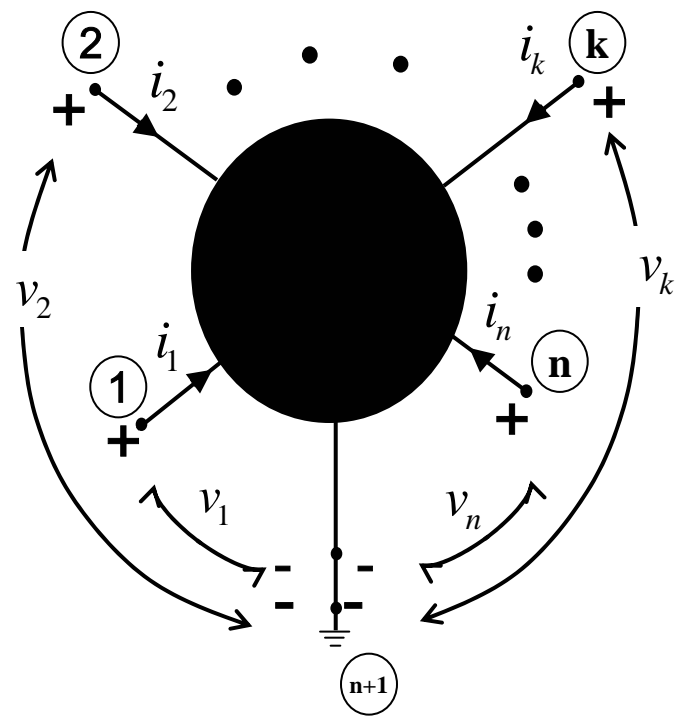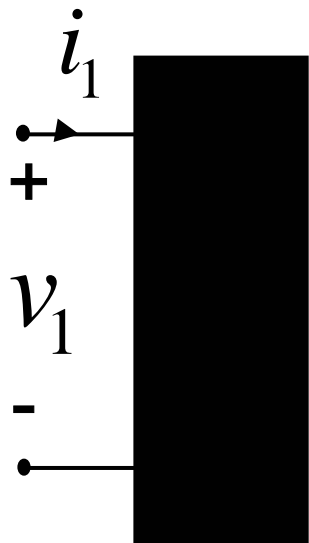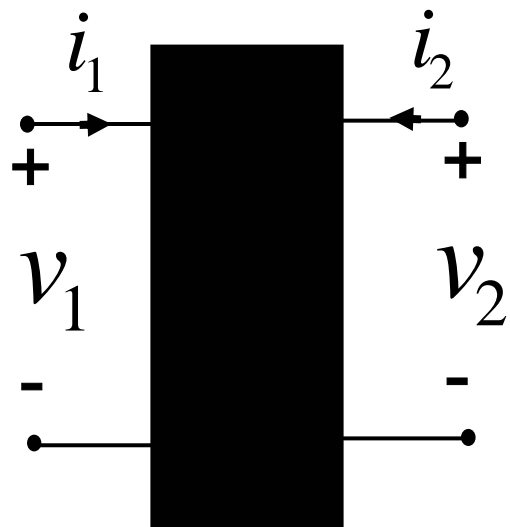
# ideal diode

# ideal Zener diode

(a)                                  (b)                                (c)

(a)

(b)

(c)