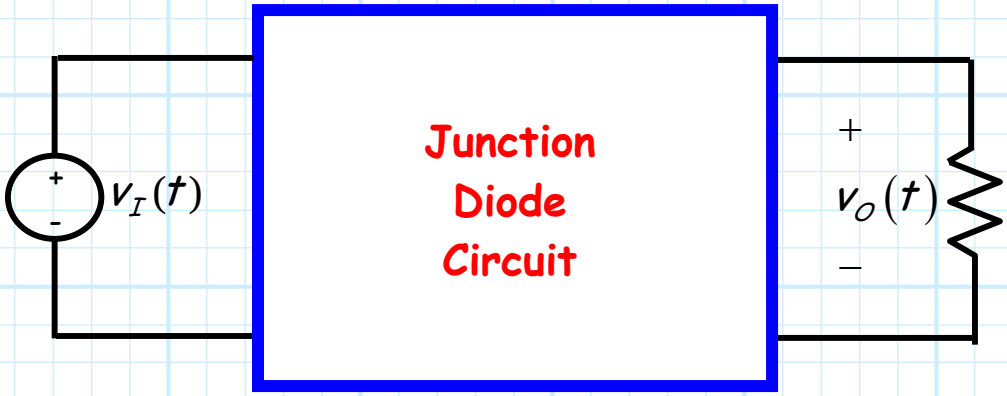
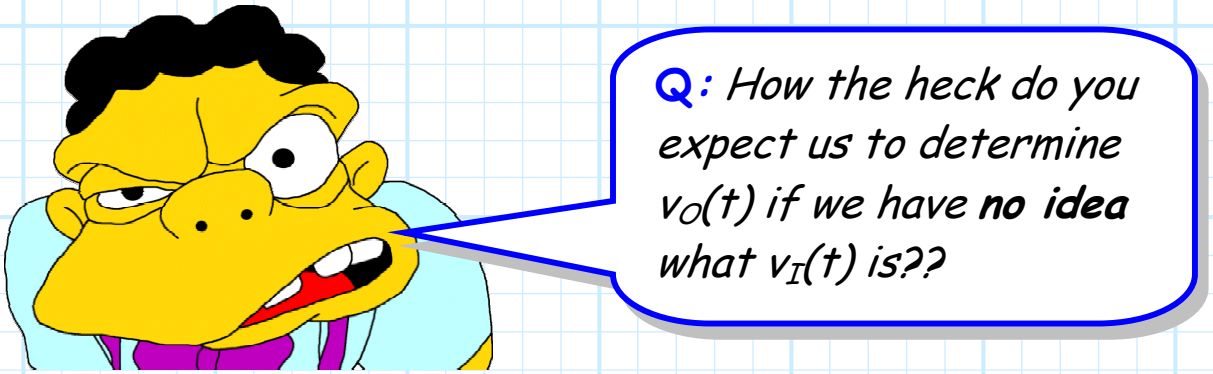
# The Transfer Function of Diode Circuits

For many junction diode circuits, we find that one of the voltage sources is in fact **unknown**! This unknown voltage is typically some **input** signal of the form $v_I(t)$, which results in an output voltage $v_O(t)$.




**A:** We of course cannot determine an **explicit** value or expression for $v_O(t)$, since it **depends** on the input $v_I(t)$. Instead, we will attempt to explicitly determine this **dependence** of $v_O(t)$ on $v_I(t)$!

In other words, we seek to find an expression for $v_O$ in **terms** of $v_I$. Mathematically speaking, our goal is to determine the **function**:

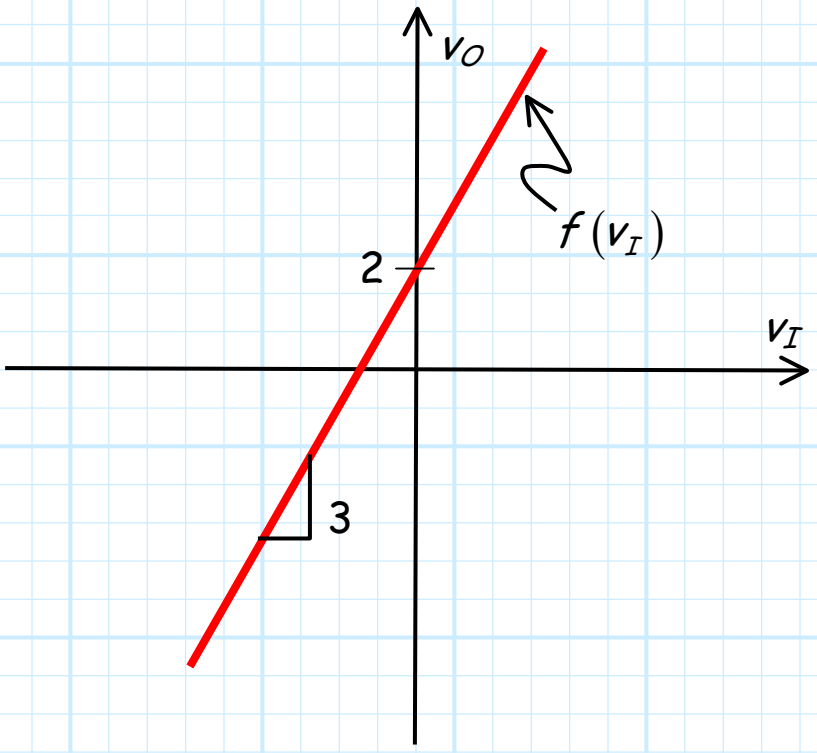
$$v_O = f(v_I)$$

We refer to this as the circuit **transfer function**.

Note that we can **plot** a circuit transfer function on a 2-dimensional plane, just as if the function related values $x$ and $y$ (e.g. $y = f(x)$). For **example**, say our circuit transfer function is:

$$\begin{aligned} v_O &= f(v_I) \\ &= 3v_I + 2 \end{aligned}$$

Note this is simply the **equation of a line** (e.g., $y = 3x + 2$), with slope $m$=3 and intercept $b$=2.



**Q:** *A **"function"** eh? Isn't a **"function"** just your annoyingly pretentious way of saying we need to find some mathematic **equation** relating $v_O$ and $v_I$?*

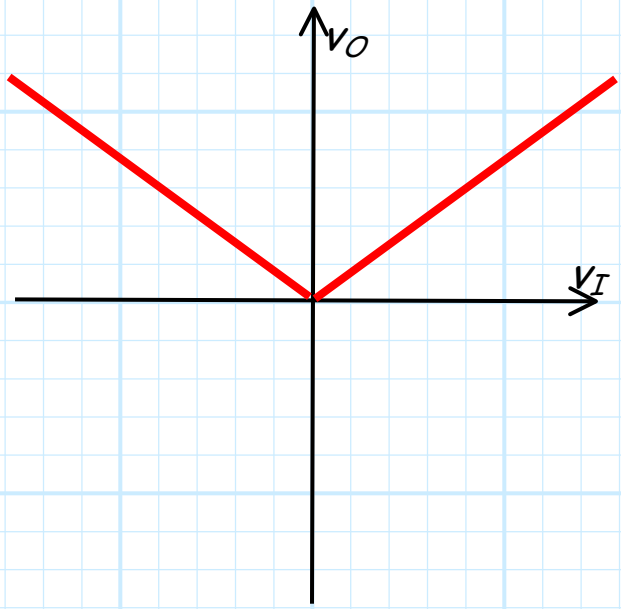
**A:** Actually **no**! Although a function **is** a mathematical equation, there are in fact **scads** of equations relating $v_O$ and $v_I$ that are **not** functions!

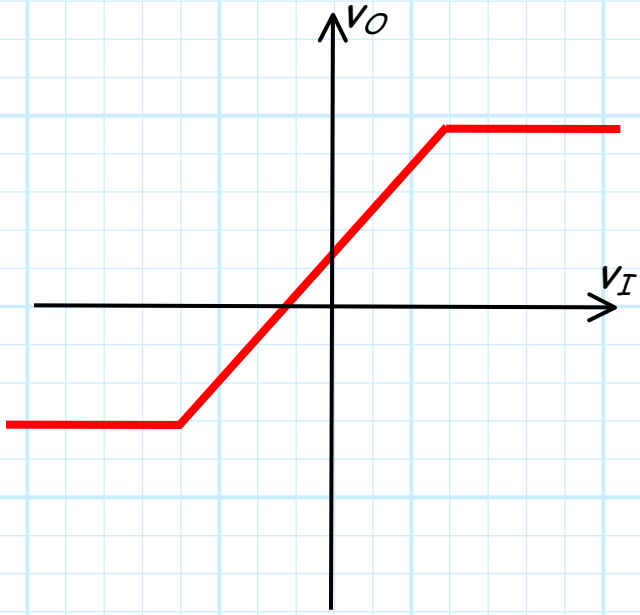
→ The set of all possible functions $y = f(x)$ are a **subset** of the set of all possible equations relating $y$ and $x$.

> A **function** $v_O = f(v_I)$ is a mathematical expression such that for **any** value of $v_I$ (i.e., $-\infty < v_I < \infty$), there is **one**, but **only** one, value $v_O$.

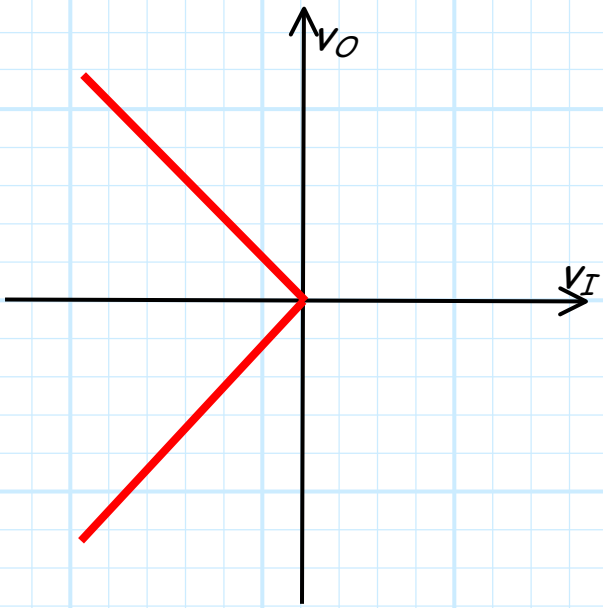
Note this definition of a function is consistent with our **physical** understanding of circuits—we can place **any** voltage on the input that we want (i.e., $-\infty < v_I < \infty$), and the result will be **one** specific voltage value $v_O$ on the output.

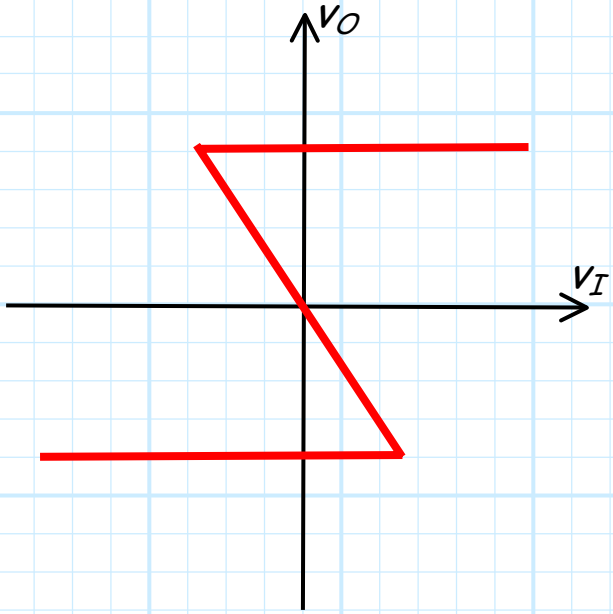
Therefore, examples of **valid** circuit transfer **functions** include:



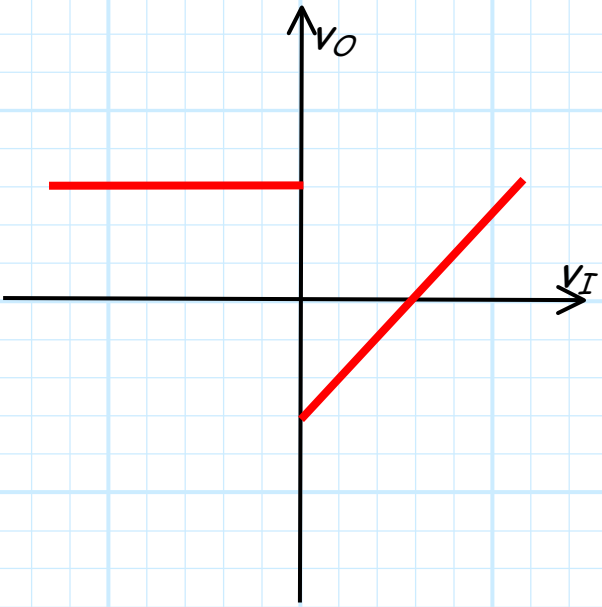




Conversely, the transfer "functions" **below** are **invalid**—they **cannot** represent the behavior of circuits, since they **are not** functions!

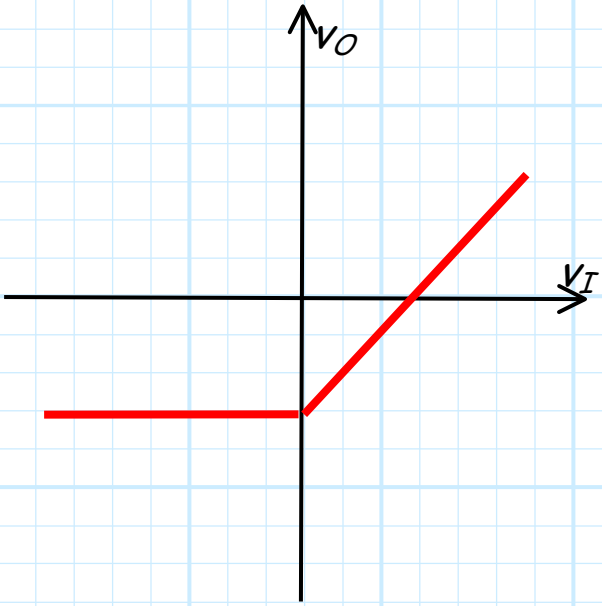


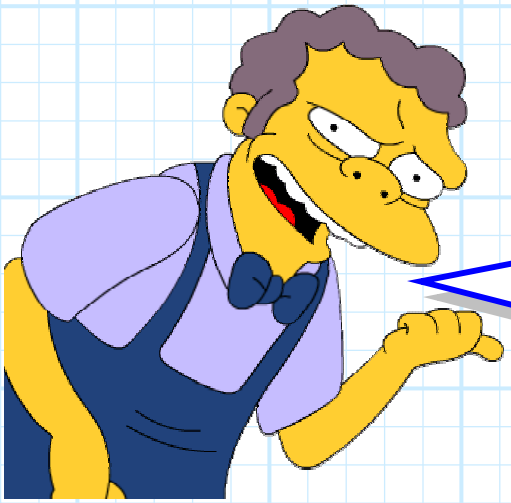
Moreover, we find that **circuit** transfer functions must be **continuous**. That is, $v_O$ **cannot** "instantaneously change" from one value to another as we increase (or decrease) the value $v_I$.




**A Discontinuous Function**
(*Invalid circuit transfer function*)




**A Continuous Function**
(*Valid circuit transfer function*)



*Remember, the transfer function of **every** junction diode circuit must be a **continuous function**. If it is **not**, you've done something **wrong**!*