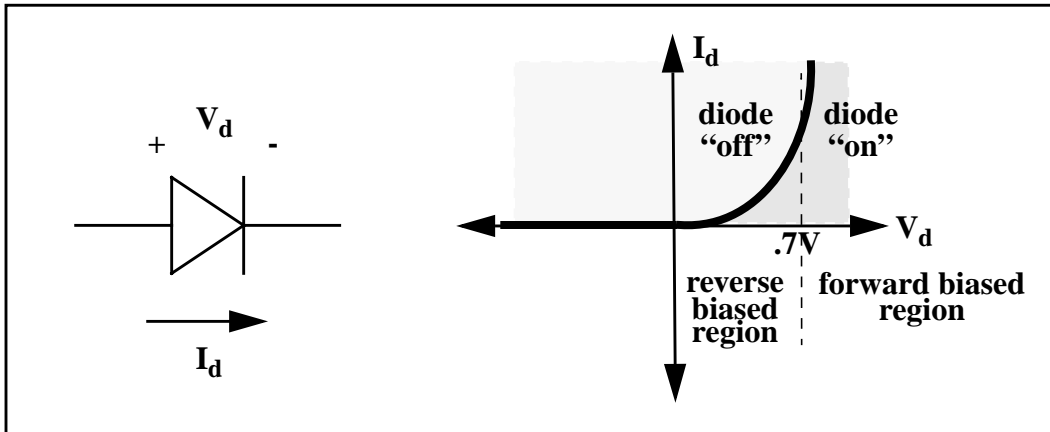


# Diodes

Recall from before that semiconductors have a very small forbidden zone between the valence and conduction band. A small electric field potential is able to raise electrons from the valence to conduction band. The first semiconductor device we will look at that uses this behavior is called a diode.

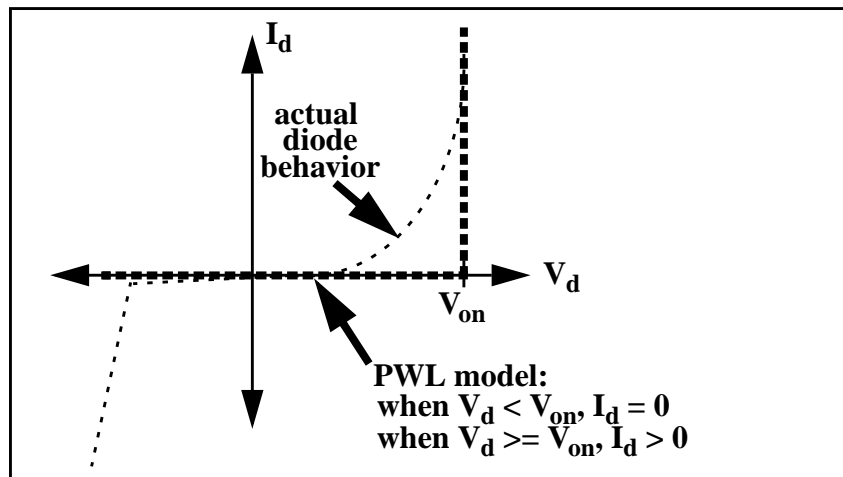
A Diode is the simplest semiconductor device. It exhibits the characteristic that it allows current to flow through them in only one direction. The symbol for a silicon diode and its V-I characteristic curve is shown below.



Typical silicon diodes exhibit a turn-on voltage of approximately 0.7 volts. Germanium (another semiconductor material) diodes begin to turn-on at about 0.35 volts. Schottky diodes turn on as low as 0.2 volts and LEDs turn on at about 2 volts. Before reaching the turn-on voltage, no significant current flows.

## A diode model

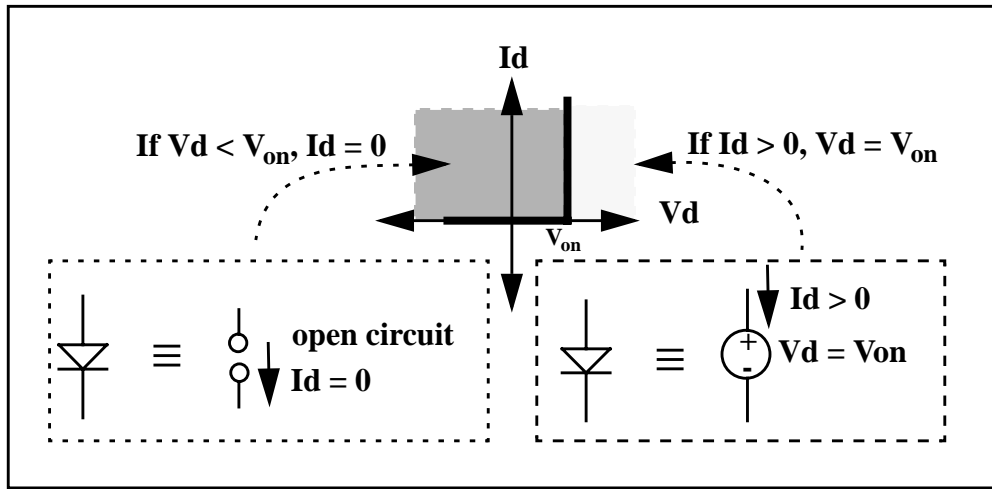
For our purposes a simple piecewise linear model (PWL) describes diode behavior well. The difference in the actual diode characteristic curve and the PWL model can be seen below..



With the PWL model, we can break diode IV curve into just two straight lines and thus two rules for creating an equivalent circuit of a diode.

- 1) If there is less than  $V_{on}$  volts across the diode, it becomes an open circuit and no current flows through it.
- 2) If the diode has current flowing through it, it has a voltage of  $V_{on}$  volts across it.

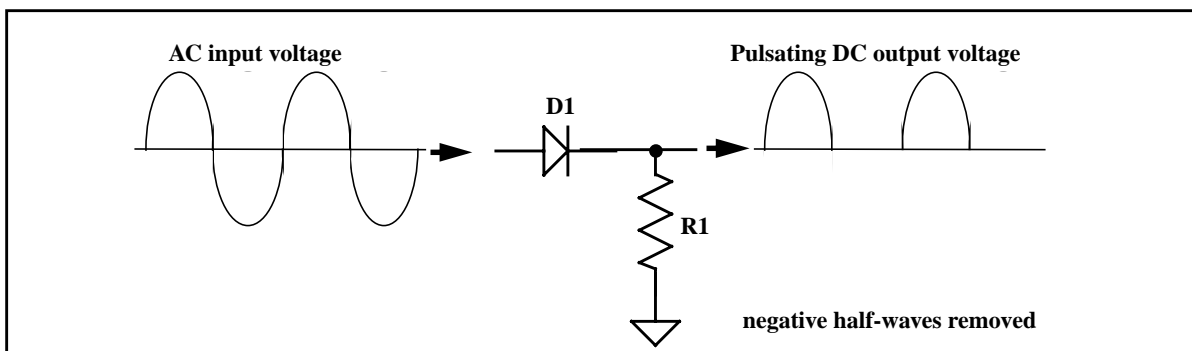
These two rules are expressed graphically below.



## Diodes as rectifiers

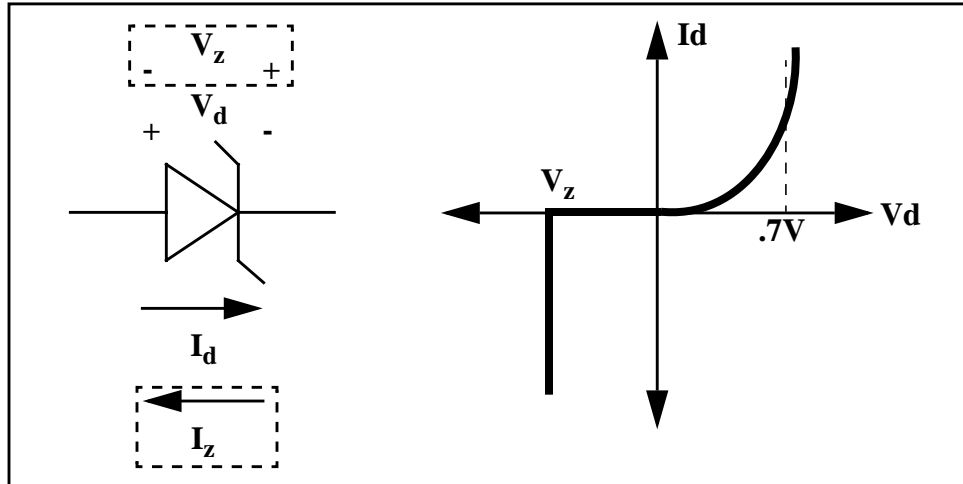
The unidirectional current behavior that diodes exhibit make them ideal for converting AC currents to DC. This function is also referred to as “rectification”. Rectification happens when only one polarity of a AC waveform such as a sine wave is produced from the full waveform. For a positive voltage rectifier, only the positive portion of the AC sine wave is produced from the entire waveform. This gives an output voltage that is always positive with respect to ground but pulsates. The pulsating is removed with a device called a capacitor to give a more constant DC voltage that has what is called a “ripple” component. The capacitor is a new element that we will look at shortly.

Below we see how a diode can behave as a rectifier, converting an AC input voltage to a pulsating DC voltage.



## Diodes as voltage regulators

Another common type of diode is called the “zener” diode. They are used to create constant voltages in cases where the voltage may naturally tend to vary. Unlike regular diodes, zener diodes are operated in the reverse bias region. More specifically, the zener is operated at what is called the reverse breakdown voltage. At this specific and well defined reverse voltage, the zener diode will begin to conduct current. This point is called the *zener voltage*.



Note that when  $V_z$  is reached, the curve becomes almost a vertical line. From previous discussions, we would recognize this as characteristic of an ideal voltage source. In fact, as long as we keep the zener operating with a small amount of current at  $V_z$ , the voltage across it will remain very constant. The characteristic of the zener diode in the reverse bias region is used to create a voltage reference for power supplies. We will shortly see how the zener is used in our battery charger circuit. Below is shown a simple zener voltage regulator circuit.

