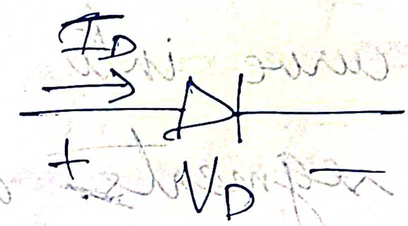
The Diode Curve

Using Quantum mechanics we can determine the current-~~voltage~~ voltage relationship of a real diode to be

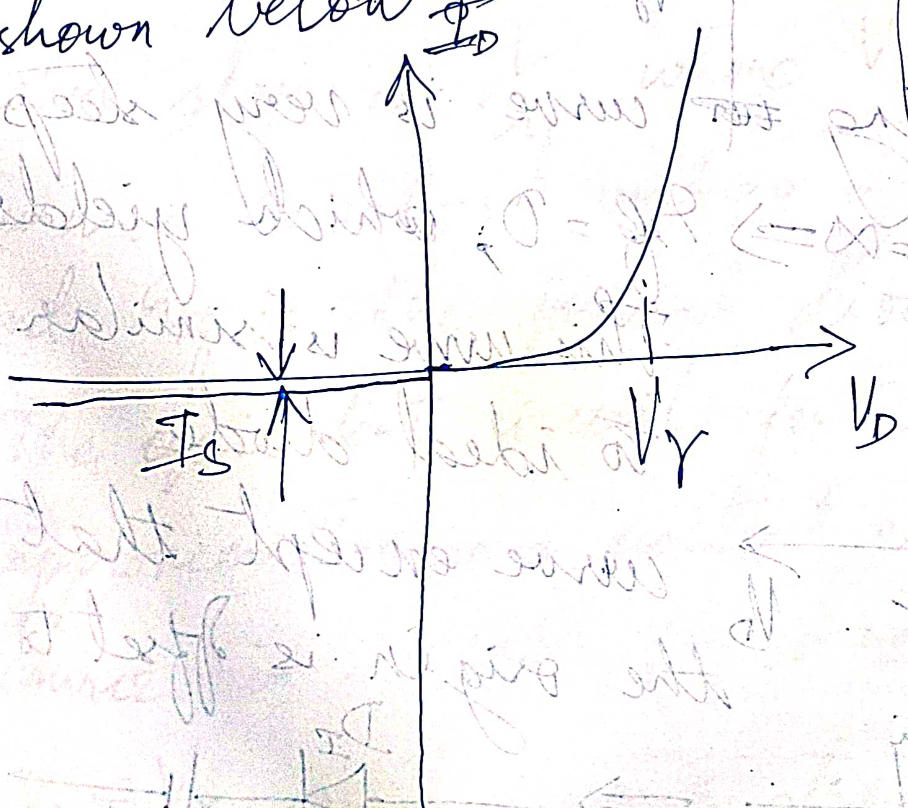
$$I_D = I_S\left[\exp\left(\frac{V_D}{V_T}\right) - 1\right] \text{ A} \quad (1)$$

where $V_T = \frac{kT}{q} = 26\text{mV}$ @300K



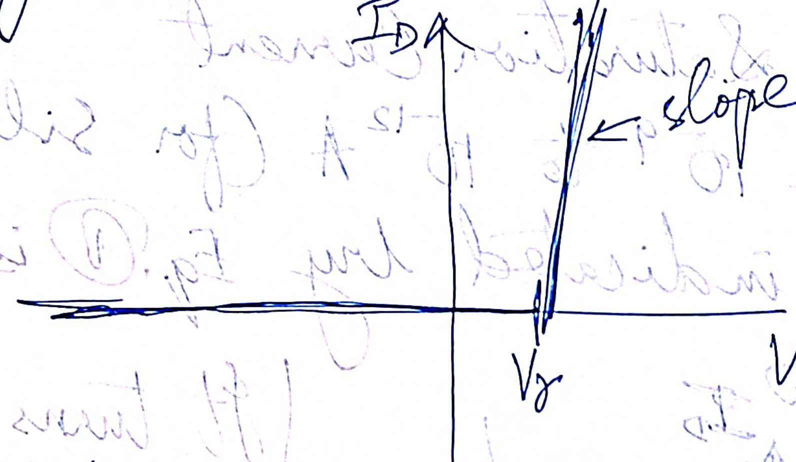
and I_S = Saturation Current
$= 10^{-9}$ to 10^{-12} A (for Silicon)

The curve indicated by Eq. (1) is shown below



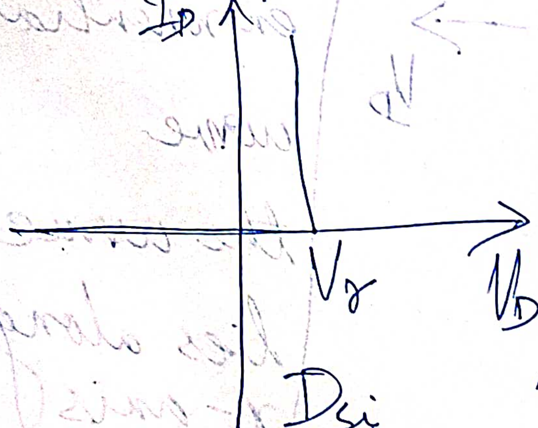
It turns out that for any exponential curve the curve lies along x-axis

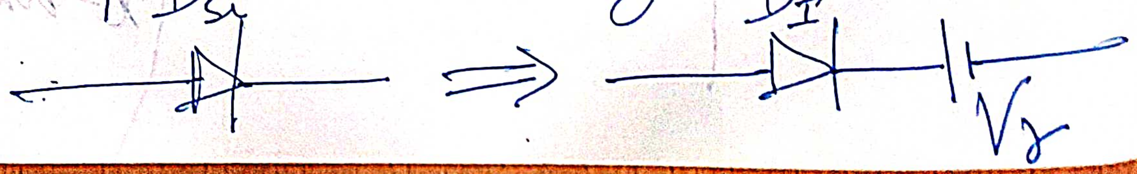
~~until~~ until a certain voltage called cut-in voltage and beyond which it rises very rapidly. Since every exponential curve has that property we can approximate the diode ~~curve~~ current characteristic curve into ~~two~~ two straight line segments as shown below:



If the rising ~~to~~ curve is very steep then slope $= \infty \Rightarrow r_f = 0$, which yields

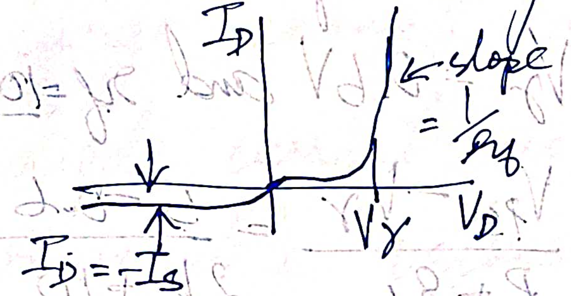
This curve is similar to ideal diode curve except that the origin is offset to V_γ

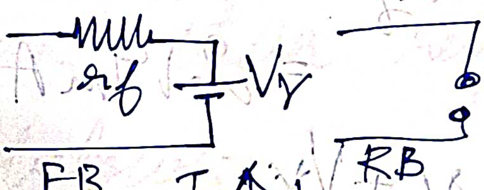


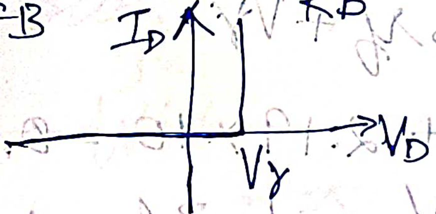


Piecewise Linear Model

Another simpler way to analyze diode circuits is to approximate the diode's current voltage characteristics using linear relationships or straight lines. The adjacent figure shows the diode approximations and their equivalents.

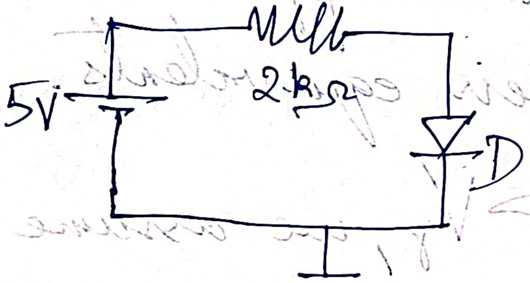






For $V_D > V_\gamma$, we assume a straight line ~~relationship~~ approximation whose slope is $\frac{1}{r_f}$ where V_γ is the turn-on or cut-in voltage of the diode, and r_f is the forward diode resistance. The equivalent circuit for this linear approximation is a constant voltage source in series with a resistor. For $V_D < V_\gamma$, we assume a straight line approximation parallel to the V_D axis at the zero current level. In this case the equivalent is an open circuit

* Determine the diode voltage and current in the circuit shown in Fig. Also determine the power dissipated in the diode. Take $V_\gamma = 0.6V$ and $r_f = 10$



$$\rightarrow I_D = \frac{V_{PS} - V_\gamma}{R + r_f} = \frac{5 - 0.6}{2k + 10}$$

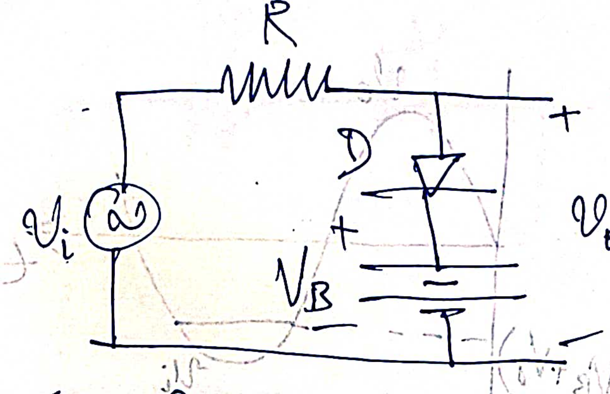
$$= 2.19 mA$$

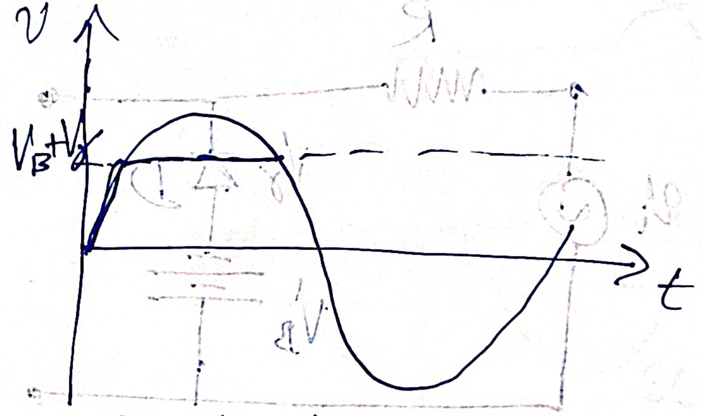
Diode voltage $V_D = I_D r_f + V_\gamma$

$$= 0.6 + 2.19 \times 10 = 0.62$$

Power dissipated $P = I_D \times V_D = 1.36 mW$

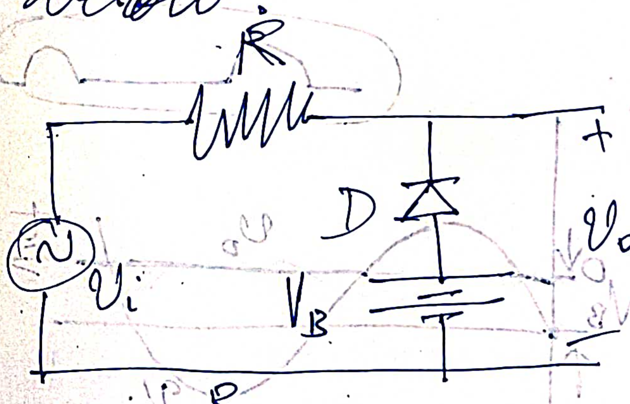
Clippers: In this section, we continue our discussion of non-linear circuit application of diodes. Diodes can be used in waveshaping circuits that either limit or clip portions of signal or shift the dc voltage level.

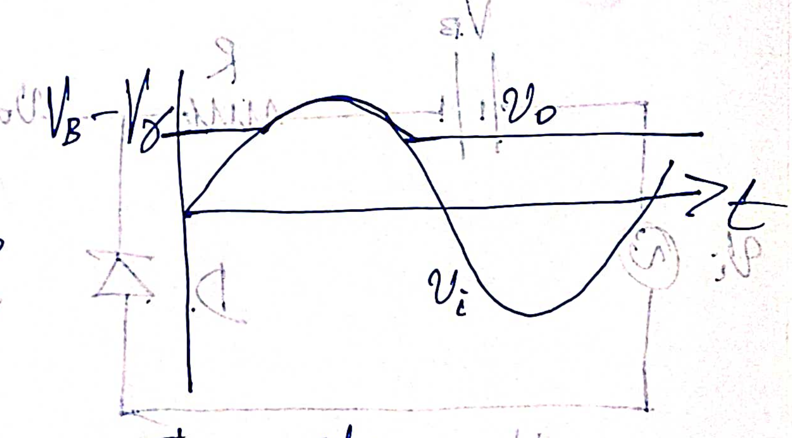


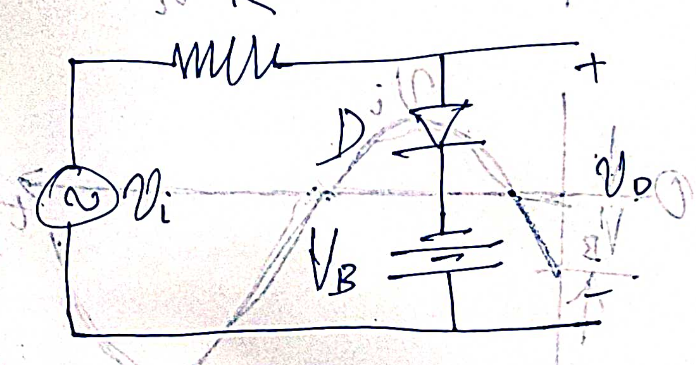


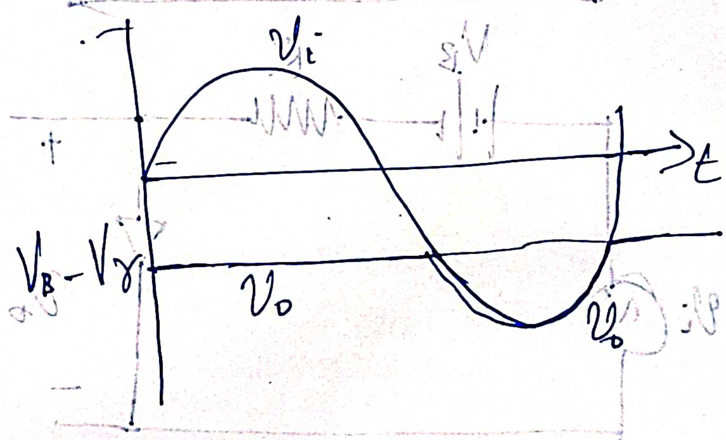
Single diode clipper   Output response

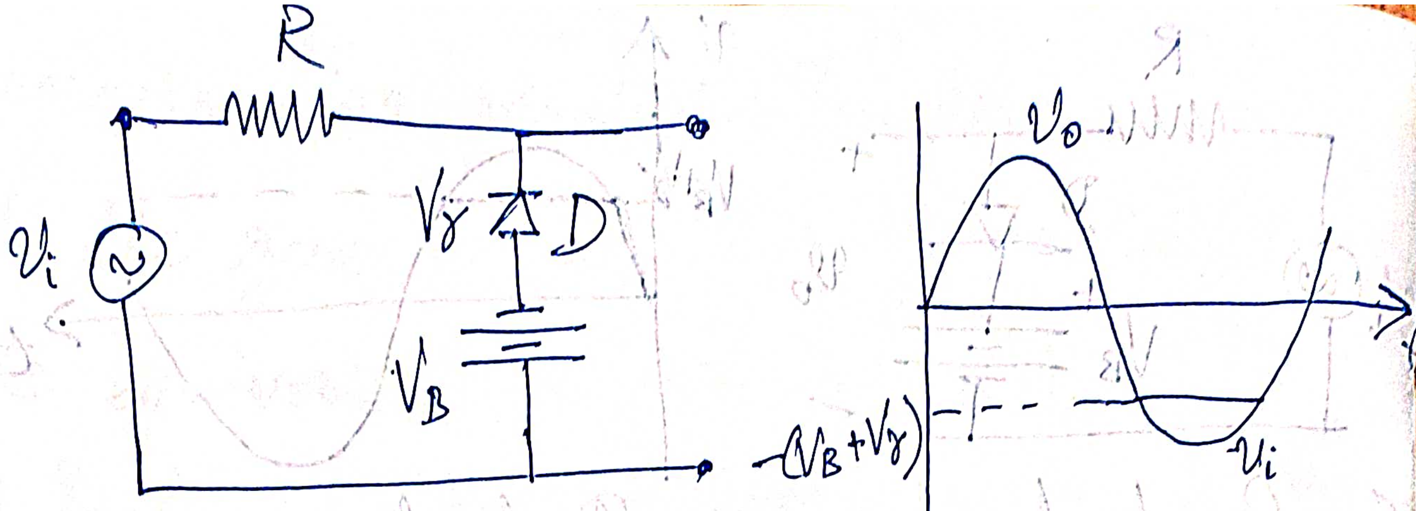
The resistor R is selected to be large enough so that the forward diode current is limited to be within reasonable values. Other clipper circuits and their responses are shown ~~tol~~ below:











Parallel Clipper