In this lab we will be characterizing some of the device parameters of bipolar junction tranistors (BJTs). The learning goals are listed below:

1. Understand large signal models of NPN and PNP transistors, including regions of operation.
2. Relate large signal measurements of BJT behavior to small signal measurements.
3. Get practice biasing both NPN and PNP BJTs.

References: *Hays and Horowitz Lab Manual 94, 97*

# 1 Measurements of BJT Parameters

1. Measure the diode drop across the base-emitter and collector-base diodes of a 2N3904 diode using the diode mode of the Elenco multimeter. Explain why the collector-base diode drop is slightly smaller than the base-emitter drop. Hays and Horowitz has a relevant explanation on page 94.
2. Measure the $\beta, V_A, g_m, V_{ce,sat}$ and $r_\pi$ of a 2N3904 transistor and a 2N3906 transistor.

   Vary the base current over at least the three decades from 100μA to 100mA when measuring $\beta, g_m$ and $r_{pi}$. Be careful not to saturate your transistor when you take these measurements because $\beta, g_m$ and $r_\pi$ are only defined in the forward active region; consider monitoring the collector voltage as you take your data. Check your results for self consistency: what's the relation between $r_\pi$ and $g_m$? Also compare your results against datasheets. Note that $h_{fe}$ is commonly used synonym for $\beta$.

   Caluclating $V_A$ will require measurements of the change in $I_c$ as $V_{ce}$ is changed. Evaluate the range over which you need to take these measurements before starting them. Make sure you take enough measurements that you are confident in your results. Compare your results against datasheets.
3. Put your transistors in the lab's curve tracer and capture the curve tracer data. Extract the Early Voltage from the curve tracer data and compare it to the value extracted from your measurements.