Physics 623
Single Transistor Amplifier: Lab worksheet

Please complete before coming to the lab on September 20

In this lab, we will learn about basic transistor characteristics and build the single transistor amplifier circuit of Figure 1. We will use \textit{npn} 2N1480 transistor. Please read sections 2.01 and 2.02 in Horowitz and Hill where the golden rules for the transistors are stated. Briefly, for \textit{npn} transistors (for \textit{pnp} reverse all polarities) these rules are:

(a) The collector must be more positive than the emitter, $V_{CE} > 0$.
(b) The base-emitter junction behaves like a diode, and therefore when forward biased $V_{BE} = 0.6\text{V}$.
(c) If the saturation is not reached, the transistor acts like a current amplifier, $I_C = \beta I_B$.

![Figure 1: Single stage transistor amplifier with \textit{npn} transistor 2N1480](image-url)
(1) Calculate the DC operating point (Q point) of the transistor using the following procedure:

(1a) Construct the Thevenin equivalent for the base bias circuit, and find the corresponding $V_{TH}$ and $R_{TH}$.

(1b) First assume that all of the golden rules above are satisfied. Further assume $\beta$ is very large, therefore $I_B = I_C/\beta \approx 0$. With this assumption find $V_B$.

(1c) Use $V_B$ and golden rule (b) to find $V_E$ and $I_E$.

(1d) Since $I_B \approx 0$, $I_C = I_E$. Use $I_C$ to get the voltage drop across $R_C$. Find $V_C$ and $V_{CE}$.

(1e) With these results, are you convinced that the golden rules for the transistor of Fig. 1 are indeed satisfied?
(2) Now we will calculate the DC operating point for a finite $\beta$. Assume $\beta = 40$. When the golden rules for a transistor are satisfied, for a base current $I_B$, the collector and emitter current values will be $I_C = \beta I_B$, and $I_E = (\beta + 1)I_B$.

(2a) By tracking the voltages in the ground-emitter-base-ground loop, derive the following relation:

\[ V_{TH} = I_B R_{TH} + V_{BE} + I_E R_E \]  \hspace{1cm} (1)

(2b) Use $V_{BE} = 0.6\,\text{V}$ and $I_E = (\beta + 1)I_B$, solve for $I_B$ in the above equation.

(2c) With $I_B$ known, calculate $I_C$, $V_C$ and $V_{CE}$. How different are your results when compared with question (1).

(3) We can estimate the AC response of the circuit by considering changes from the DC operating point. What is the AC voltage gain of the circuit: $A_v = \frac{V_{out}}{V_{in}}$. 