

PROBLEM 1 GRAPHICAL METHOD

GIVEN: A BJT has the characteristics given in the graphs (I_B - V_{BE} and I_C - V_{CE}) on PAGE 3. The BJT is connected in the following circuit.

REQUIRED:

A. Obtain the equations for the load lines corresponding to the input and output sides, in terms of R_C , R_B , V_{CC} and V_{in} .

Load Line for input side: $R_B I_B + V_{BE} - V_{in} = 0$ OR $I_B = -\frac{1}{R_B} V_{BE} + \frac{1}{R_B} V_{in}$
Load Line for output side: $R_C I_C + V_{CE} - V_{CC} = 0$ OR $I_C = -\frac{1}{R_C} V_{CE} + \frac{1}{R_C} V_{CC}$

B. The load lines drawn correspond to $R_C = 220 \Omega$, $R_B = 3.3 \text{ k}\Omega$. What is the value for V_{CC} and for $I_{C\text{short-circuit}}$? Note we must refer to 2nd Graph on page 3

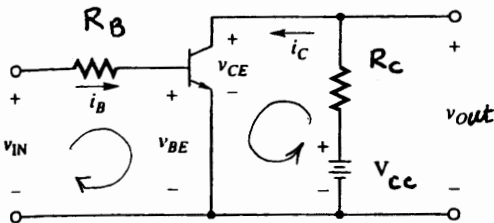
$V_{CC} = 1.0 \text{ V}$	$I_{C\text{short-circuit}} = 4.55 \text{ mA}$
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C. What values of V_{in} correspond to the 7 load lines drawn on the I_B - V_{BE} graph? Find values for V_{out} correspond to the 7 values for V_{in} and plot the Transfer Characteristic (V_{out} vs. V_{in}). Also obtain values for I_C/I_B . Look at graph on top horizontal intersection $\Rightarrow V_{in}$

$V_{in} \text{ (V)}$	0.4	0.6	0.7	0.8	0.9	1.0	1.2
$V_{out} \text{ (V)}$	1.0	1.0	1.0	0.82	0.50	0.01	0.004
I_C/I_B	%	%	%	100	100	$\frac{4.1 \text{ mA}}{66 \mu\text{A}} = 70$	$\frac{44 \text{ mA}}{125 \mu\text{A}} \approx 35$

Note
 $V_{out} = V_{CE}$

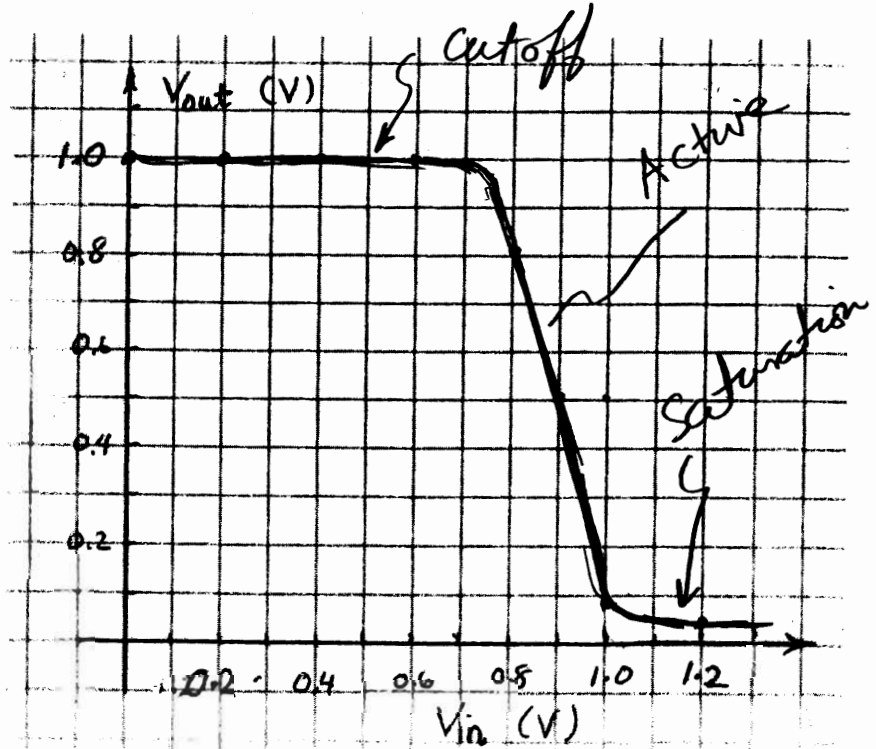
$\frac{4.1}{66} =$



$$\begin{cases} R_B I_B + V_{BE} - V_{in} = 0 \Rightarrow \\ I_B = -\frac{1}{R_B} V_{BE} + \frac{1}{R_B} V_{in} \end{cases}$$

$$\begin{cases} V_{CE} - V_{CC} + R_C I_C = 0 \Rightarrow \\ I_C = -\frac{1}{R_C} V_{CE} + \frac{1}{R_C} V_{CC} \end{cases}$$

$$I_{C\text{sc}} = \frac{V_{CC}}{R_C} = \frac{1.0 \text{ V}}{2.2 \text{ k}\Omega} = 4.55 \text{ mA}$$



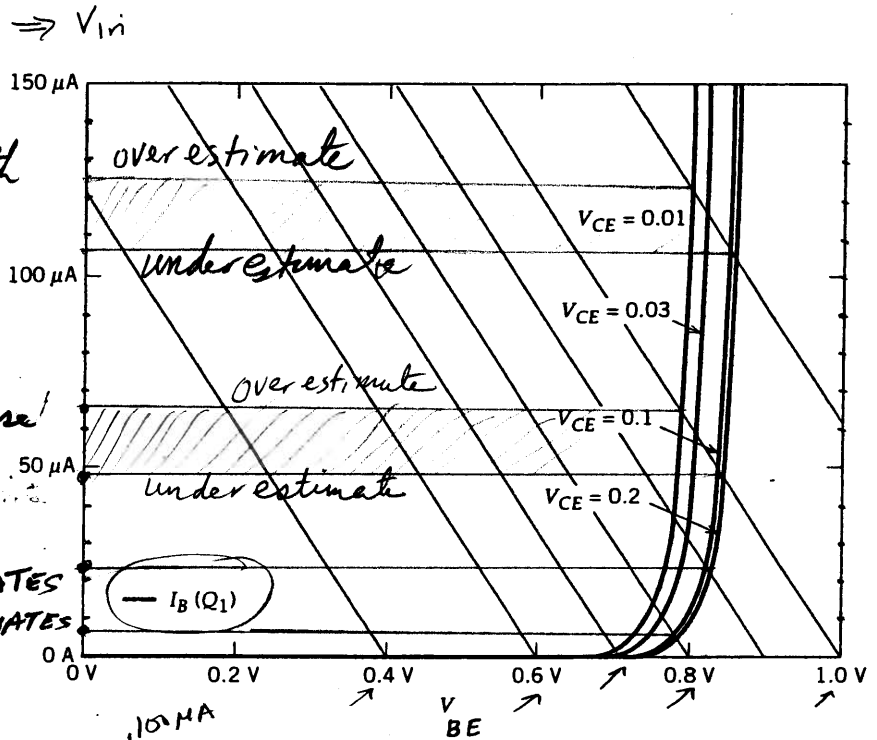
PROBLEM 1 continued

Horizontal Intersects $\Rightarrow V_{in}$

Now we use load line intersections with the diode V to find I_B .

Q: WHICH IV CURVE SHOULD WE USE

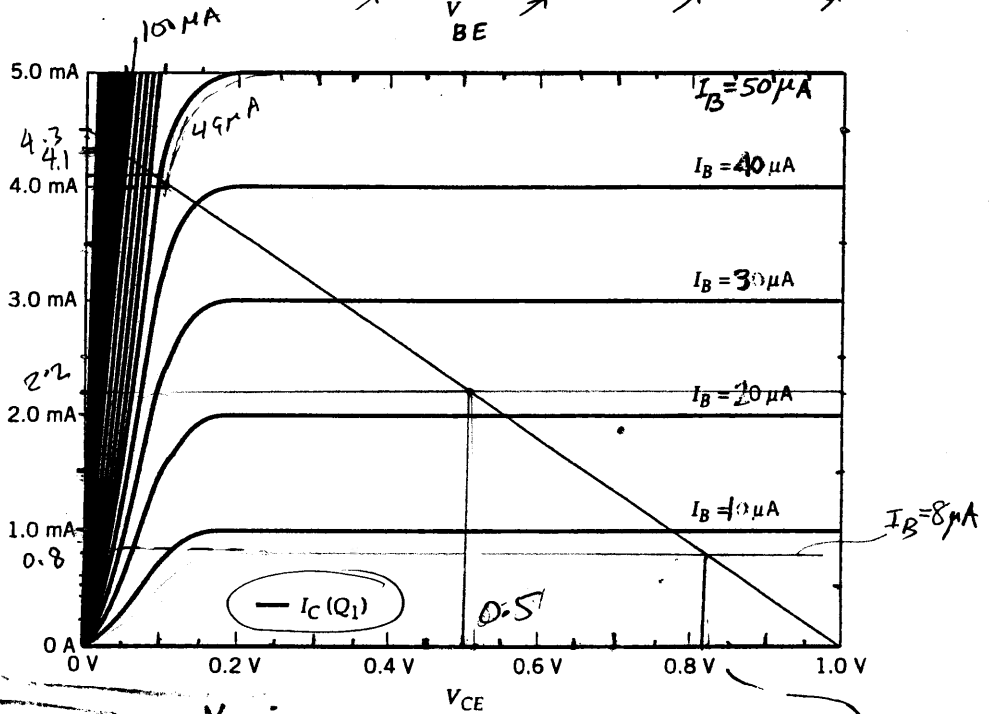
A: for $V_{CE} > 0.1$, we must use the rightmost for small values of V_{CE} this iv curve will UNDERESTIMATE I_B . & leftmost, OVERESTIMATES



From $I_C - V_{CE}$ graph it is obvious that small $I_B \Rightarrow$ large V_{CE} & large $I_B \Rightarrow$ small V_{CE} (see load line cross section with constant I_B curves)

ACCURATE

$V_{in} = 0.4V, I_B = 0 \Rightarrow I_C = 0$
 $V_{in} = 0.6V \Rightarrow I_B = 0 \Rightarrow I_C = 0$
 $V_{in} = 0.7V \Rightarrow I_B \approx 0, I_C \approx 0$



$V_{in} = 0.8V \Rightarrow I_B = 8 \mu A$
 $V_{in} = 0.9V \Rightarrow I_B = 22 \mu A$

$V_{in} = 1.0V \Rightarrow 1.49 \mu A < I_B < 66 \mu A$
 $V_{in} = 1.2V \Rightarrow 107 \mu A < I_B < 125 \mu A$

Now we use the bottom graph (I_C vs V_{CE})

$V_{in} = 0.8V, I_B = 8 \mu A \rightarrow I_C = 0.8 mA, V_{CE} = 0.82V$
 $V_{in} = 0.9V, I_B = 22 \mu A \rightarrow I_C = 2.2 mA, V_{CE} = 0.50V$
 $V_{in} = 1.0V \begin{cases} I_B = 49 \mu A \rightarrow I_C = 4.0 mA, V_{CE} = 0.89V \\ I_B = 66 \mu A \rightarrow I_C = 4.1 mA, V_{CE} = 0.8V \end{cases}$
 $V_{in} = 1.2V \begin{cases} I_B = 107 \mu A \rightarrow I_C = 4.3 mA, V_{CE} = 0.005V \\ I_B = 125 \mu A \rightarrow I_C = 4.4 mA, V_{CE} = 0.004V \end{cases}$