Transistors

Lesson #8
Chapter 4

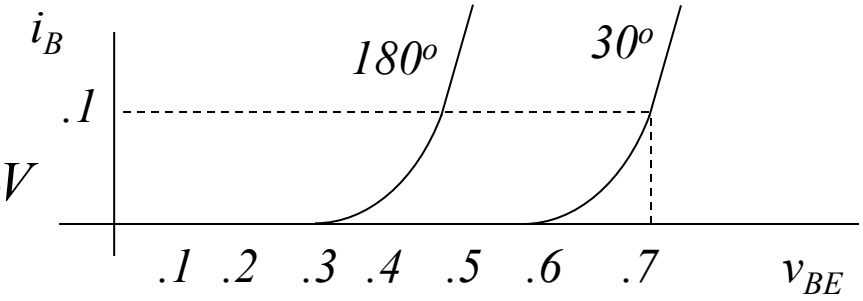
Homework

- Probs. 4.5, 4.8, 4.10, 4.14, 4.15, 4.19, 4.20, 4.21, 4.22

Homework Answers #1

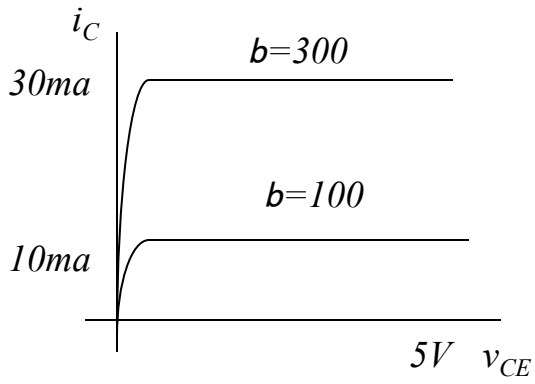
- Probs. 4.4

$$v_{BE} = .6V - (180-30)\times 2mV = .3V$$



- Probs. 4.5

$$i_C = \beta i_B = 100\times .1mA = 10mA$$
$$i_C = \beta i_B = 300\times .1mA = 30mA$$



Homework Answers #2

- Probs. 4.8

$$\beta = \frac{i_C}{i_B} = \frac{9mA}{.3mA} = 30$$

$$\alpha = \frac{\beta}{\beta+1} = \frac{30}{31} = .968$$

$$i_E = i_C + i_B = 9mA + .3mA = 9.3mA$$

- Probs. 4.10

$$I_E = I_{ES}(e^{-v_{BE}/V_T} - 1)$$

$$v_{BE} = V_T \times \ln(I_E / I_{ES} + 1) = 26mV \times \ln(10mA/10^{-13}A + 1) = .6585V$$

$$v_{BC} = -(v_{CE} - v_{BC}) = -(10V - .6585V) = -9.34V$$

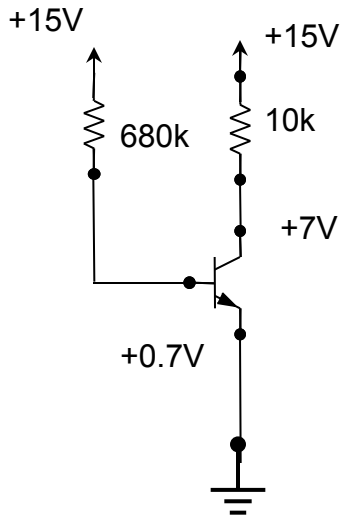
$$i_B = i_E - i_C = i_E - \beta i_B = \frac{i_E}{\beta+1} = \frac{10mA}{100+1} = 99.01\mu A$$

$$i_C = \beta i_B = 9.901mA$$

$$\alpha = \frac{\beta}{\beta+1} = \frac{100}{101} = .9901$$

Homework Answers #3

- Prob 4.14a



KVL for Base Circuit :

$$15 = i_B 680k + 0.7$$

$$i_B = \frac{15 - 0.7}{680k} = 21\mu A$$

KVL for Collector Circuit :

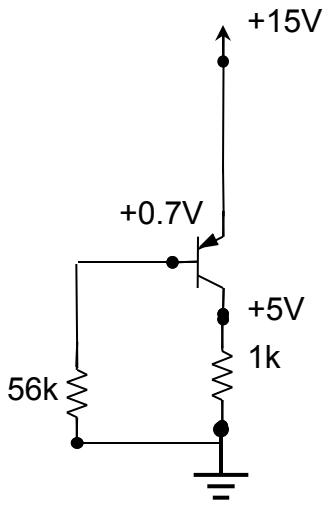
$$15 = i_C 10k + 7$$

$$i_C = \frac{15 - 7}{10k} = .8mA$$

$$\beta = \frac{i_C}{i_B} = \frac{.8mA}{21\mu A} = 38$$

Homework Answers #4

- Prob 4.14b



KVL for Base Circuit :

$$15 = i_B 56k + 0.7$$

$$i_B = \frac{15 - 0.7}{56k} = 0.255mA$$

KVL for Collector Circuit :

$$5 = i_C 1k$$

$$i_C = \frac{5}{1k} = 5mA$$

$$\beta = \frac{i_C}{i_B} = \frac{5mA}{0.255mA} = 19.6$$

Homework Answers #5

- Prob 4.15 An *npn* with V_{BE}=0.7V for I_E=10mA. Find V_{BE} if I_E=1mA and 1*m*A; Assume a temperature of 300K

$$I_E = I_{ES}(e^{\frac{V_{BE}}{V_T}} - 1) \Rightarrow I_{ES} = \frac{I_E}{e^{\frac{V_{BE}}{V_T}} - 1}$$

$$I_{ES} = \frac{10m}{(e^{\frac{0.7}{26m}} - 1)} = 2.03 \times 10^{-14}\, A$$

$$V_{BE} = V_T \ln(\frac{I_E}{I_{ES}} + 1) = 26m \ln(\frac{1m}{2.03 \times 10^{-14}} + 1)$$

$$= 0.64V$$

$$V_{BE} = V_T \ln(\frac{I_E}{I_{ES}} + 1) = 26m \ln(\frac{1\mu}{2.03 \times 10^{-14}} + 1)$$

$$= 0.58V$$

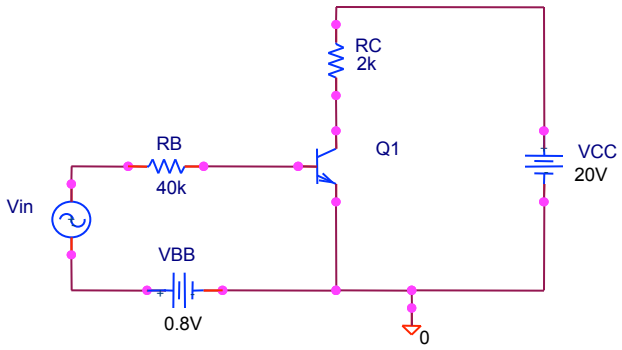
Homework #6

- Prob 4.19 What can cause distortion in BJT amplifiers

- Distortion occurs in BJT amplifiers mainly because of the the curvature of the input characteristic. Non-uniform spacing and curvature of the output characteristics also contributes to distortion. Also the if the BJT is driven into cutoff or saturation, clipping occurs.

Homework Answers #7

- Probs. 4.20



The Base circuit load line:

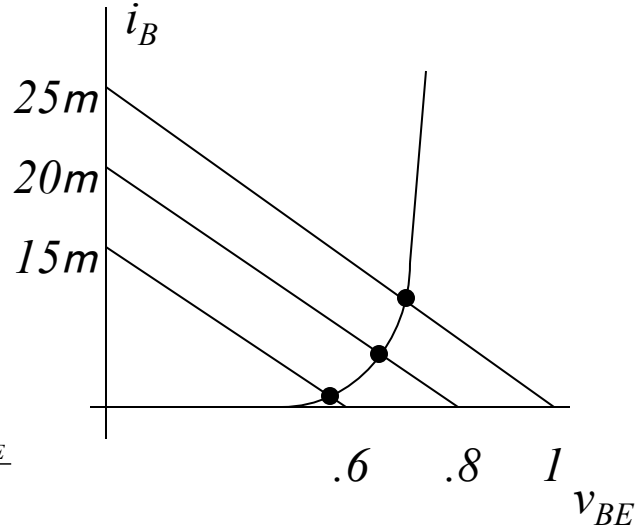
$$V_{in} + V_{BB} = i_B R_B + v_{BE}$$

$$i_B = \frac{V_{in} + V_{BB} - v_{BE}}{R_B}$$

$$i_{B\,MAX} = \frac{.2 + .8 - v_{BE}}{40k} = \frac{1 - v_{BE}}{40k}$$

$$i_{B\,avg} = \frac{0 + .8 - v_{BE}}{40k} = \frac{.8 - v_{BE}}{40k}$$

$$i_{B\,MIN} = \frac{-.2 + .8 - v_{BE}}{40k} = \frac{.6 - v_{BE}}{40k}$$

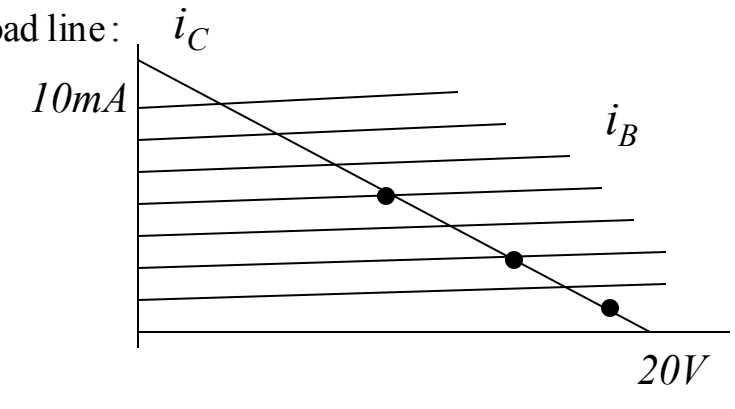


The Collector circuit load line:

$$V_{CC} = i_C R_C + v_{CE}$$

$$i_C = \frac{V_{CC} - v_{CE}}{R_C}$$

$$i_C = \frac{20V - v_{CE}}{2k}$$

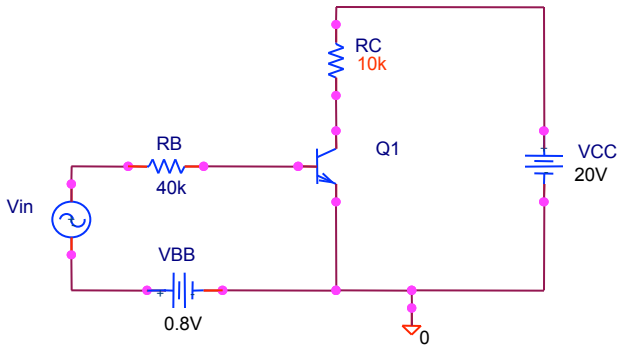


	Vin		
	0.2 V	0 V	-0.2 V
i_B (μA)	10	5.5	1.25
i_C (mA)	4	2.2	0.5
v_{CE} (V)	12	15.6	18.9

$$A_v = \frac{\Delta V_{CE}}{\Delta V_{in}} = \frac{12 - 18.9}{.2 - (-.2)} = -17.25$$

Homework Answers #8

- Probs. 4.21



The Base circuit load line:

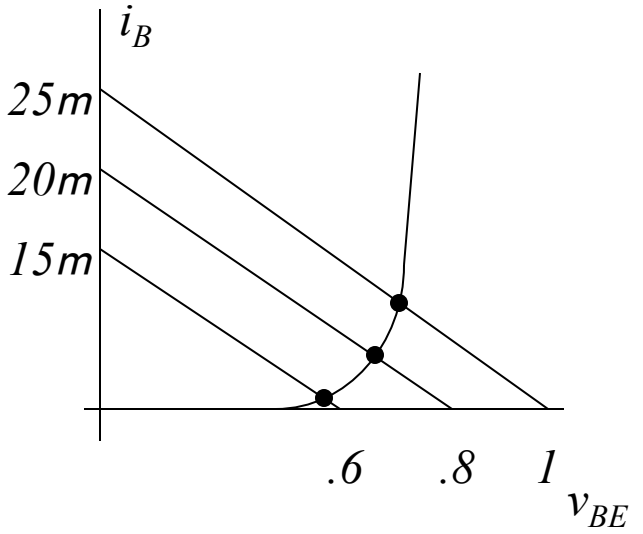
$$V_{in} + V_{BB} = i_B R_B + v_{BE}$$

$$i_B = \frac{V_{in} + V_{BB} - v_{BE}}{R_B}$$

$$i_{B\,MAX} = \frac{.2 + .8 - v_{BE}}{40k} = \frac{1 - v_{BE}}{40k}$$

$$i_{B\,avg} = \frac{0 + .8 - v_{BE}}{40k} = \frac{.8 - v_{BE}}{40k}$$

$$i_{B\,MIN} = \frac{-.2 + .8 - v_{BE}}{40k} = \frac{.6 - v_{BE}}{40k}$$



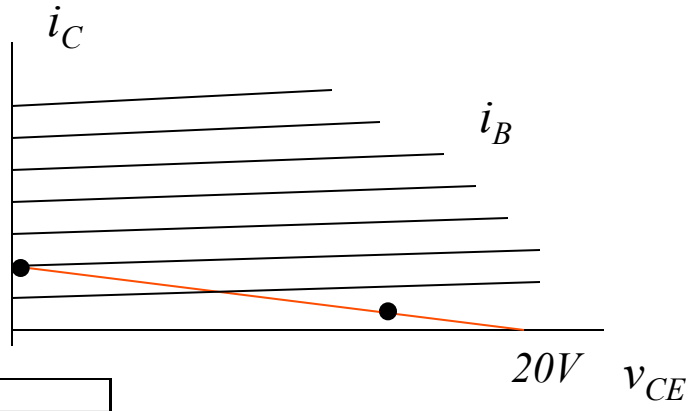
The Collector circuit load line:

$$V_{CC} = i_C R_C + v_{CE}$$

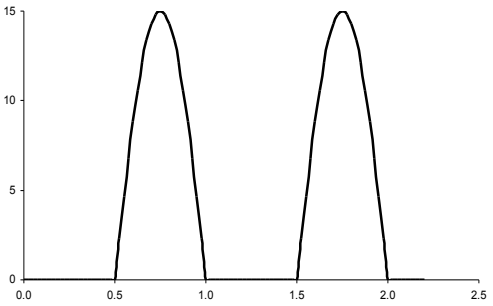
$$i_C = \frac{V_{CC} - v_{CE}}{R_C}$$

$$i_C = \frac{20V - v_{CE}}{10k}$$

2mA



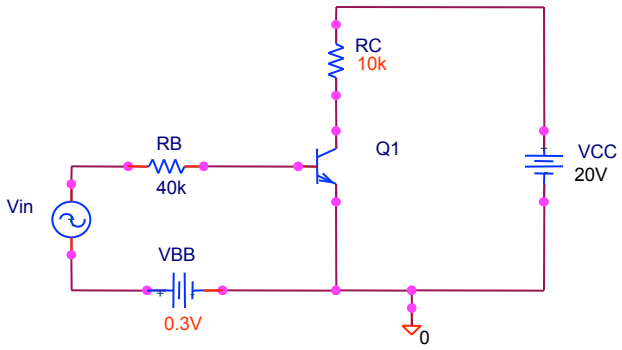
	Vin		
	0.2 V	0 V	-0.2 V
i_B (μA)	10	5.5	1.25
i_C (mA)	2	2	0.5
v_{CE} (V)	0.2	0.2	15



The Waveform is Clipped

Homework Answers #9

- Probs. 4.22



The Base circuit load line:

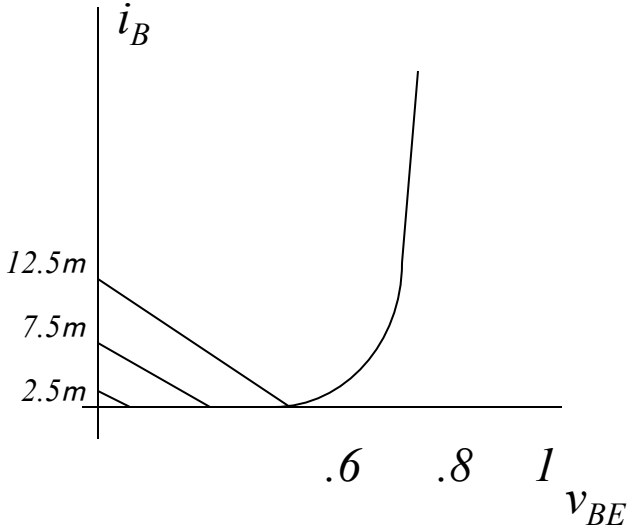
$$V_{in} + V_{BB} = i_B R_B + v_{BE}$$

$$i_B = \frac{V_{in} + V_{BB} - v_{BE}}{R_B}$$

$$i_{B\,MAX} = \frac{.2 + .3 - v_{BE}}{40k} = \frac{.5 - v_{BE}}{40k}$$

$$i_{B\,avg} = \frac{0 + .3 - v_{BE}}{40k} = \frac{.3 - v_{BE}}{40k}$$

$$i_{B\,MIN} = \frac{-.2 + .3 - v_{BE}}{40k} = \frac{.1 - v_{BE}}{40k}$$



The Base is biased too low and there is no signal generated in the base and, therefore, the collector circuit.