



$V_E = -0.7 \text{ V}$ ,  $\beta = 50$   
Find  $I_E, I_B, I_C, V_C$

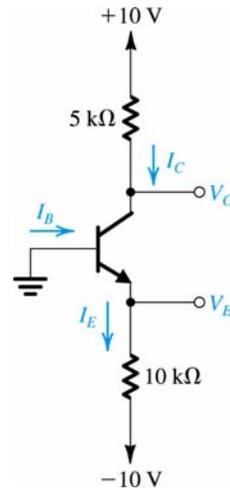


Figure E6.14

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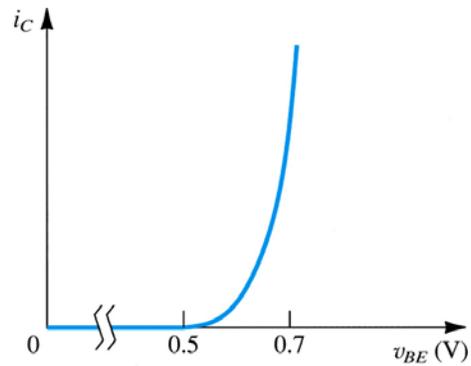
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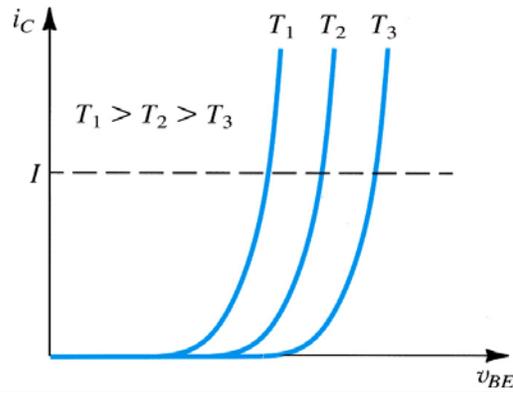
## Graphical Representation

Just like regular diodes, the BE voltage determines the collector current

$$i_C = I_s e^{v_{BE}/V_T}$$



At a constant collector current, the BE voltage decrease by  $-2 \text{ mV}/^\circ\text{C}$



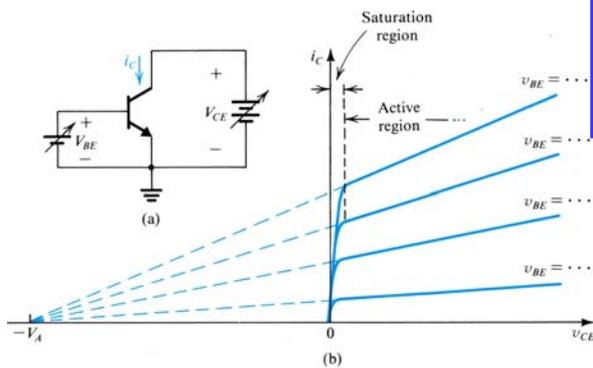
### Common Emitter $I_C$ - $V_{CE}$ C/C

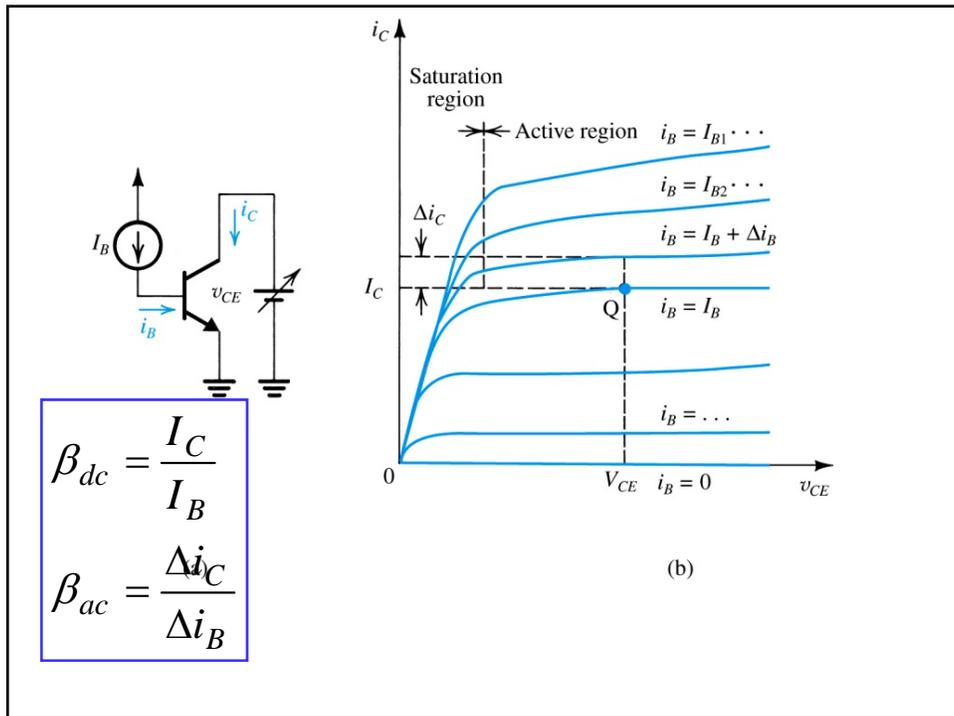
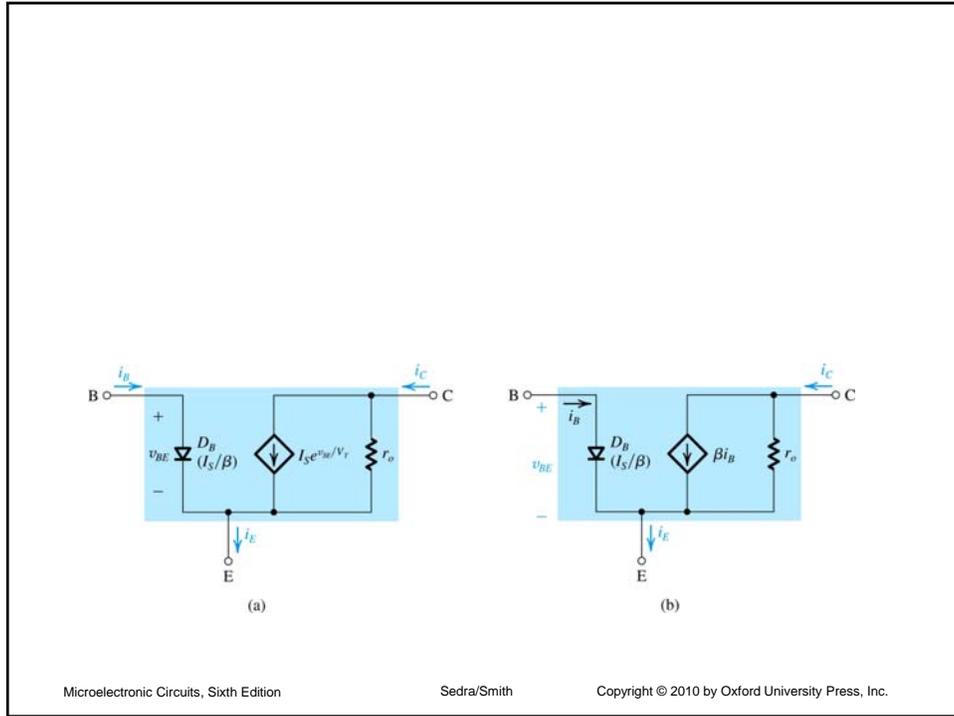
Practically, the collector current is not constant as we change CE voltage. This is called the **early Effect**.

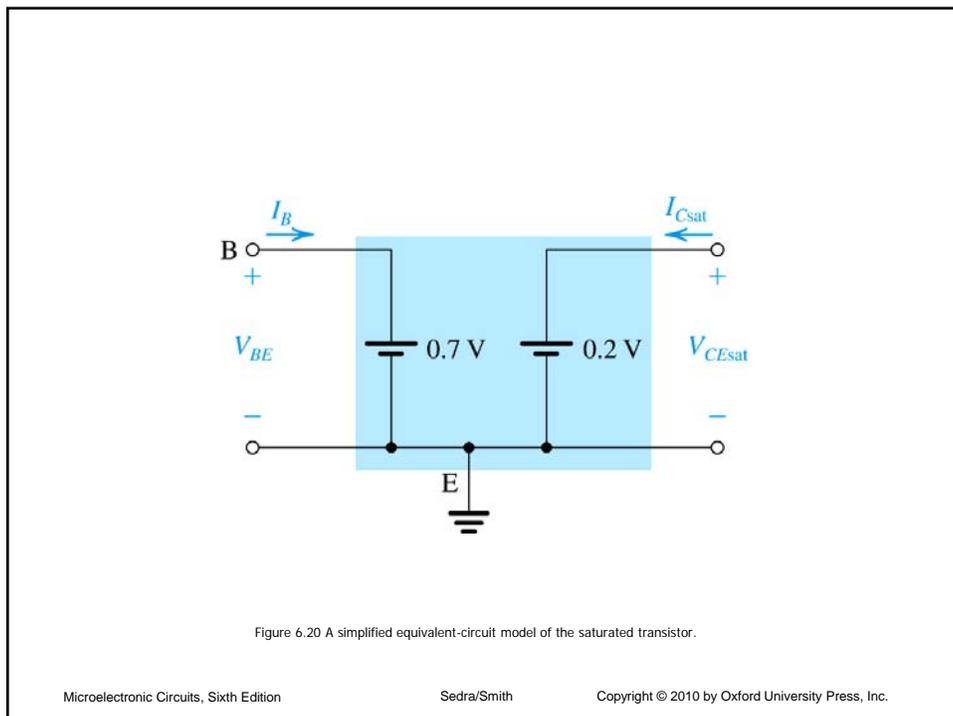
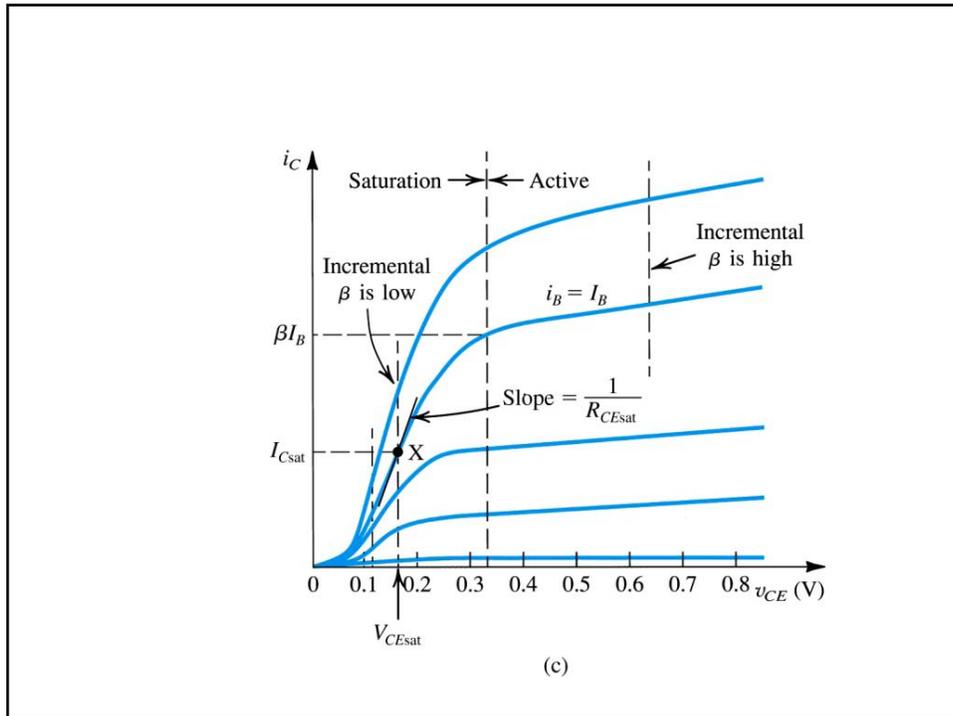
$$i_C = I_s e^{v_{BE}/V_T} \left( 1 + \frac{v_{CE}}{V_A} \right)$$

$$r_o = \left[ \frac{\partial i_C}{\partial v_{CE}} \Big|_{v_{BE} \text{ constant}} \right]^{-1}$$

$$r_o = \frac{V_A + V_{CE}}{I_C} = \frac{V_A}{I_C}$$







## Cutoff

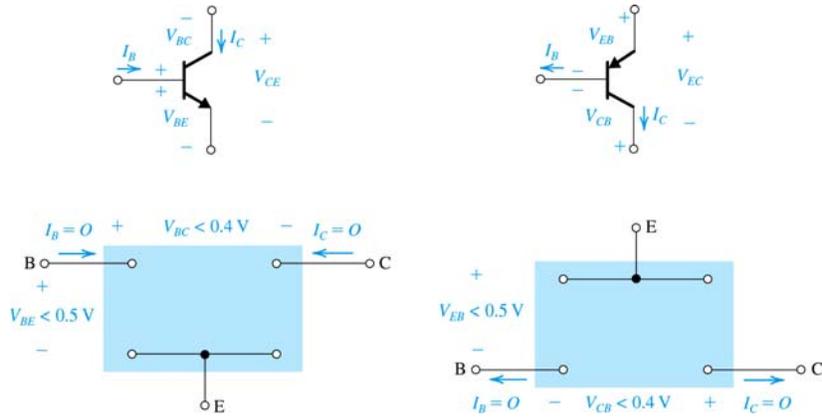


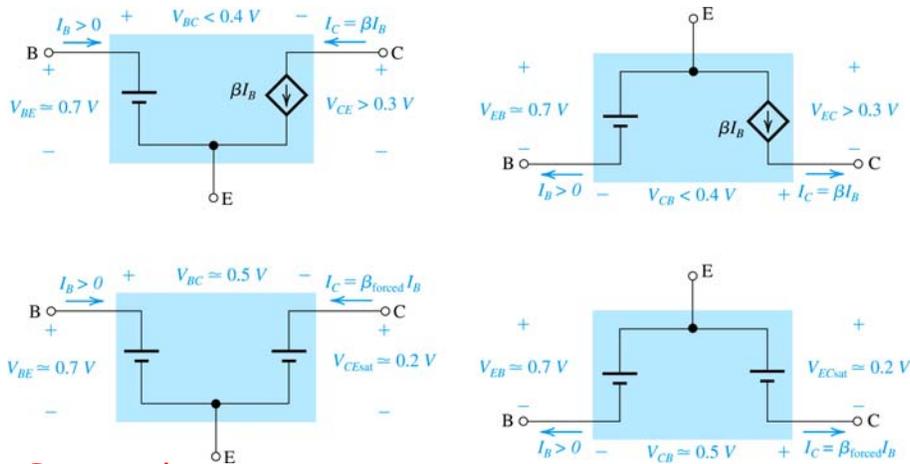
Table 6.3 Conditions and Models for the Operation of the BJT in Various Modes (continued)

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## Active



## Saturation

Table 6.3 (continued)

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Find  $V_{BB}$ , Assume  $V_{BE}=0.7V$  and  $\beta=50$   
 (a) Active mode with  $V_{CE}=5V$   
 (b) Edge of Saturation  
 (c) Deep in saturation  $\beta=10$

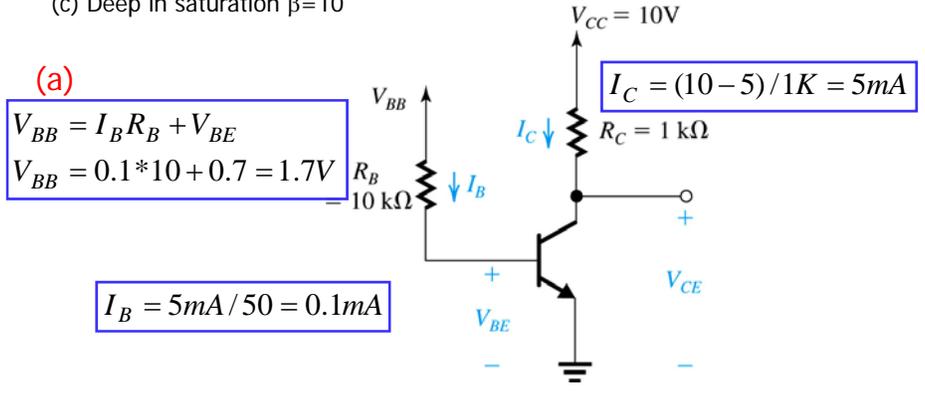


Figure 6.21 Circuit for Example 6.3.

Find  $V_{BB}$ , Assume  $V_{BE}=0.7V$  and  $\beta=50$   
 (a) Active mode with  $V_{CE}=5V$   
 (b) Edge of Saturation  
 (c) Deep in saturation  $\beta=10$

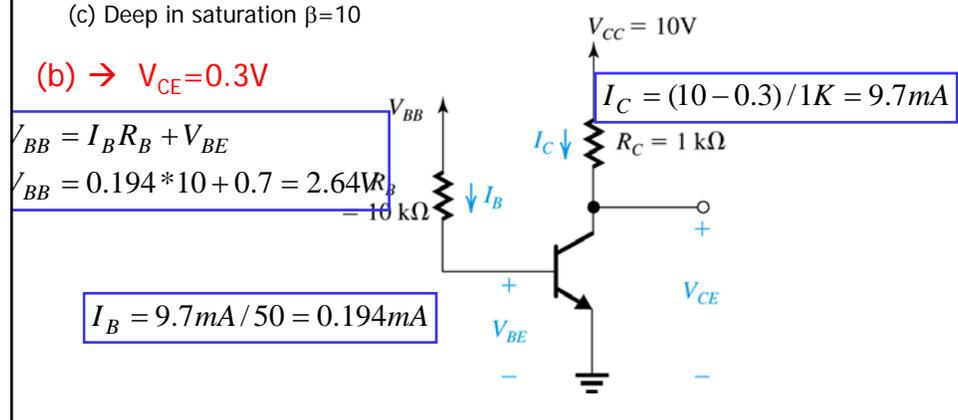


Figure 6.21 Circuit for Example 6.3.

Find  $V_{BB}$ , Assume  $V_{BE}=0.7V$  and  $\beta=50$   
 (a) Active mode with  $V_{CE}=5V$   
 (b) Edge of Saturation  
 (c) Deep in saturation  $\beta=10$

(c)  $\rightarrow V_{CE}=0.2V$

$$V_{BB} = I_B R_B + V_{BE}$$

$$V_{BB} = 0.98 \times 10 + 0.7 = 10.5V$$

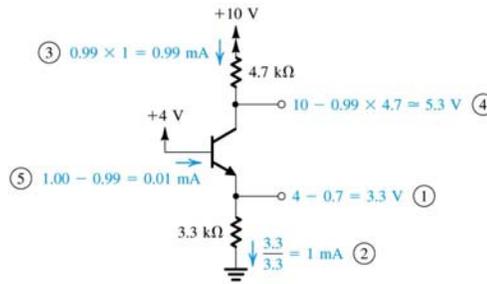
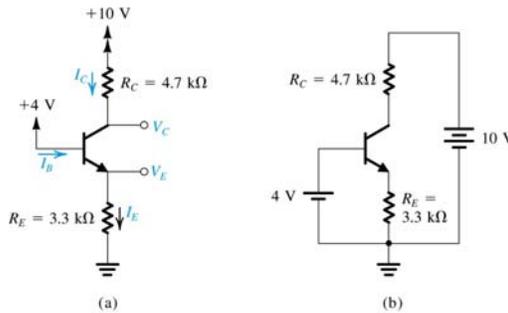
$$I_B = 9.8mA / 10 = 0.98mA$$

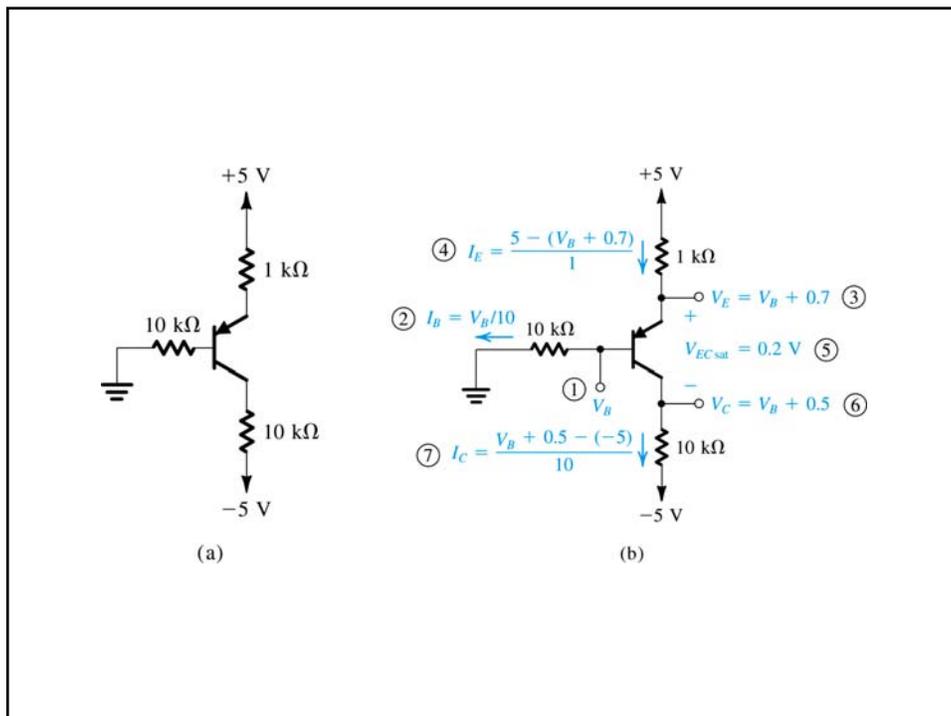
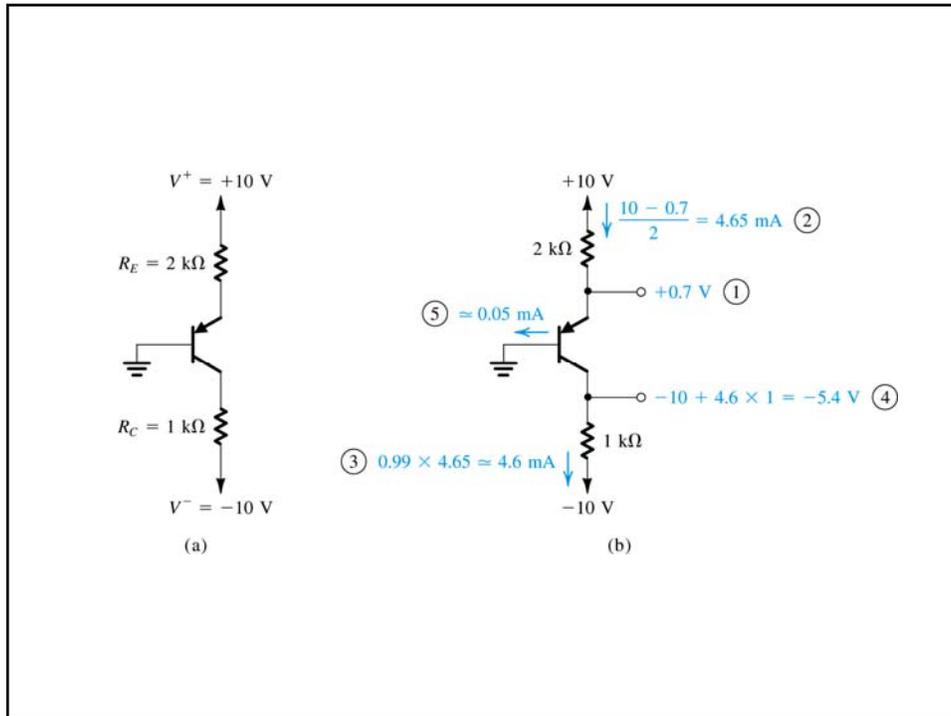
$V_{CC} = 10V$

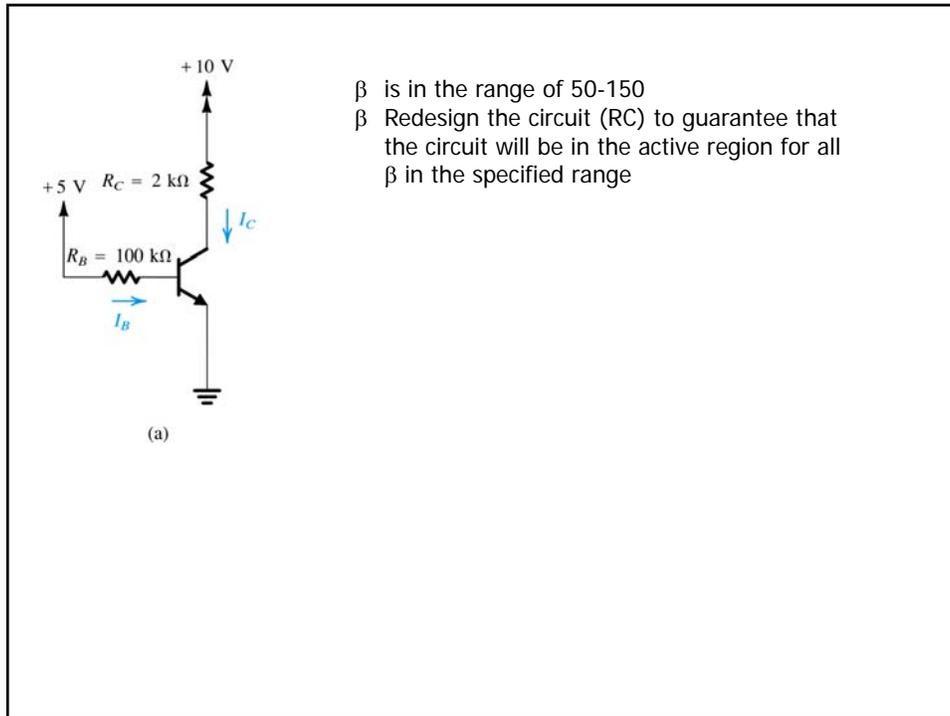
$$I_C = (10 - 0.2) / 1K = 9.8mA$$

Figure 6.21 Circuit for Example 6.3.

Find all branch currents and node voltages assuming  $\beta=100$







- $\beta$  is in the range of 50-150
- $\beta$  Redesign the circuit ( $R_C$ ) to guarantee that the circuit will be in the active region for all  $\beta$  in the specified range