9.7

(a) $V_{BB} = V_{CC}\dfrac{R_2}{R_1 + R_2} = 6.03\ \text{V}$

$R_{BB} = R_1 \| R_2 = 1158.35\ \Omega$

Applying KVL around the base-emitter loop:

$$V_{BB} = I_B R_{BB} + V_{BE} + I_E R_E$$

Substituting for I_B,

$$I_B = \frac{I_E}{\beta + 1}$$

We have

$$I_E = \frac{V_{BB} - V_{BE}}{R_E + R_{BB}/(\beta + 1)} = 48\ \text{mA}$$

The base current is:

$$I_B = \frac{I_E}{\beta + 1} = \frac{I_E}{101} = 0.475\ \text{mA}$$

The base voltage is

$V_B = V_{BE} + I_E R_E =$

$= 0.6 - 48\times10^{-3}\times100 = 5.4\ \text{V}$

Assuming active-mode operation, the collector current is

$$I_C = \beta I_B = 47.5\ \text{mA}$$

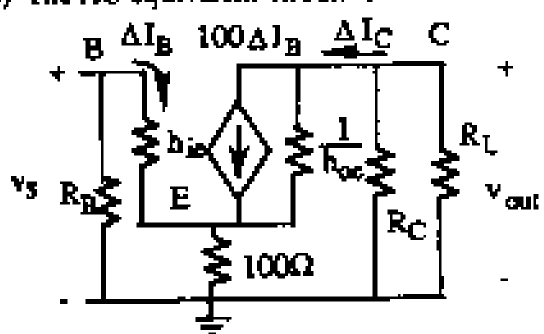
The collector voltage can now be determined to be

$$V_C = 10 - 47.5\times10^{-3}\times100 = 5.25\ \text{V}$$

Also

$$V_{CE} = V_C - V_E = 5.25 - 4.8 = 0.45\ \text{V}$$

b) The AC equivalent circuit is shown below



(c) $h_{ie} = \dfrac{\partial v_{BE}}{\partial i_B}\bigg|_{I_{BQ}} \approx \dfrac{0.6}{0.475\times10^{-3}} = 1.26k\Omega$

$R_B = R_1 \| R_2 = 1158.35\ \Omega$

$R_C \| R_L = 60\ \Omega$

Solving for ΔV_{CE} and v_{in} (see Fig. 9.20):

$$\Delta V_{CE} = 10^5(\Delta I_C - 100\,\Delta I_B)$$

$$v_{in} = \Delta I_B 1258 + 100(\Delta I_B + \Delta I_C)$$

$$0 = 60\,\Delta I_C + \Delta V_{CE} + 100\,(\Delta I_B + \Delta I_C)$$

Rearranging the above equations, we have

$$v_{in} = 1358\Delta I_B + 100\,\Delta I_C$$

$$0 = 100160\,\Delta I_C - 9999900\,\Delta I_B$$

$$\Delta I_C = v_{in}/113.58$$

The output voltage is

$v_{out} = -\Delta I_C 60 = -60\dfrac{v_{in}}{113.58} =$

$= -0.528\ v_{in}$

The voltage gain is

$$A_V = \frac{v_{out}}{v_{in}} = -0.528$$

(d) The input resistance is

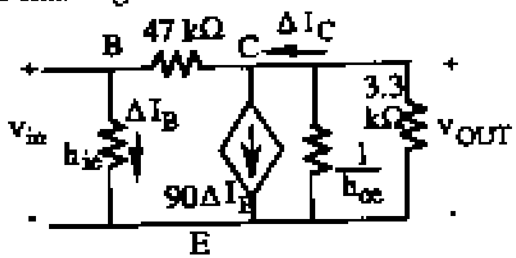
$$r_i = \frac{v_{in}}{\Delta I_B} = 11.4\ \text{k}\Omega$$

(e) The output resistance is

$$r_o = R_C \| (1/h_{oe}) = 99.9\ \Omega$$

9.8

The small signal circuit is shown below.



In the circuit

$$\Delta I_B = \frac{v_{in}}{h_{ie}}$$

$$\Delta I_C = -\frac{v_{out}}{3.3k\Omega \| \frac{1}{h_{oe}}}$$

Applying KCL at the collector, we have

$$\frac{v_{in} - v_{out}}{47\ k\Omega} = \frac{v_{out}}{2.36\ k\Omega} - 90\frac{v_{in}}{h_{ie}}$$

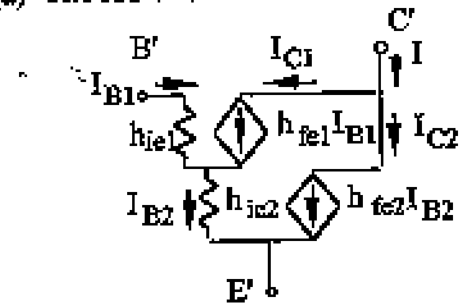
Solving the above equation, we have

$$A_V = \frac{v_{out}}{v_{in}} = \frac{1/47 - 90/1.3}{1/2.36 + 1/47}$$

$$= -155.5$$

9.15

(a) The AC circuit is shown below



The current gain is

$$A_i = \frac{I}{I_{B1}} = \frac{I_{C1} + I_{C2}}{I_{B1}}$$

$$= \frac{I_{C1}}{I_{B1}} + \frac{I_{C2}}{I_{B2}}$$

$$= h_{fe1} + \frac{h_{fe2} I_{B2}}{I_{B1}}$$

$$= h_{fe1} + h_{fe2}\frac{I_{E1}}{I_{B1}}$$

$$= h_{fe1} + h_{fe2}(h_{fe1} + 1)\frac{I_{B1}}{I_{B1}} = 9300$$

(b) We have

$$V_{in} = I_{B1} h_{ie1} + (I_{B1} + h_{fe1} I_{B1}) h_{ie2}$$

Therefore, the input resistance is

$$R_{in} = \frac{V_{in}}{I_{B1}} = h_{ie1} + (1 + h_{fe1}) h_{ie2}$$

$$= 1500 + 131 \times 200 = 27.7\ k\Omega$$