Solution: Drawing the equivalent circuit,

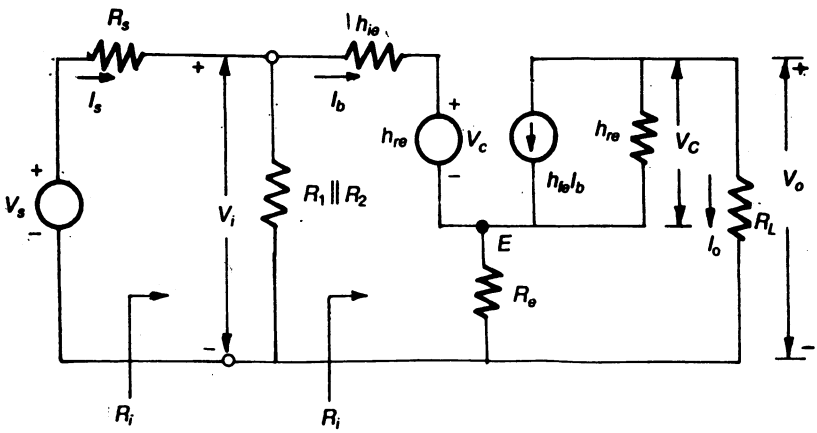

Fig. P. 5.15 (a)

From the circuit, we have,

$$-I_o = h_{fe}I_b + h_{oe}V_c \quad \ldots(i)$$

$$V_c = V_o - (I_b - I_o)R_e = V_o - (I_b - I_o) \times 10^3 \quad \ldots(ii)$$

and, $$V_o = +I_oR_L \quad \ldots(iii)$$

Substituting equations (ii) and (iii) in eq (i), we get

$$-I_o = 50\,I_b + 25 \times 10^{-6}\,(0.5 \times 10^3 \times I_o - 10^3 I_b + 10^3 I_o)$$

$$= 49.75\,I_b + 0.15\,I_o$$

or, $$I_o = -43.3\,I_b \quad \ldots(iv)$$

Also, $$V_i = h_{ie}I_b + h_{re}V_c + (I_b - I_o)R_e \quad \ldots(v)$$

From eq. (ii)

$$V_c = I_oR_L - (I_b - I_o) \times 10^3$$

$$= -43.3 \times 5 \times 10^3 I_b + 44.3 \times 10^3 I_b$$

then from eq. (v),

$$V_i = 1.1 \times 10^3 I_b + 2.5 \times 10^{-4}\,(-26.1 \times 10^4 I_b) + 44.3 \times 10^3 I_b$$

$$= 45.3 \times 10^3 I_b$$

Or, $$R_i' = \frac{V_i}{I_b} = 45.3 \text{ K}$$

then, $$R_i = R_i' \parallel (9.1 \text{ K}) = \frac{45.3 \text{ K} \times 9.1 \text{ K}}{54.4 \text{ K}} = 7.58 \text{ K}$$

Problem 5.18:
(a) For the two-transistor amplifier circuit shown (supply voltages are not indicated) calculate A_I, A_v, A_{V_s}, and R_i. The transistors are identical, and their parameters are given in Table 5.1.

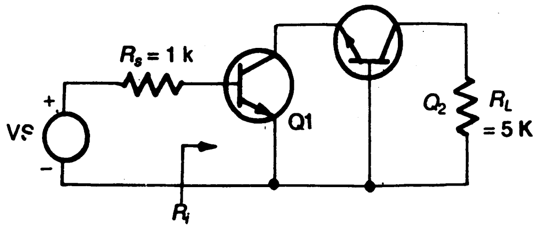

Fig. P. 5.18

Solution:

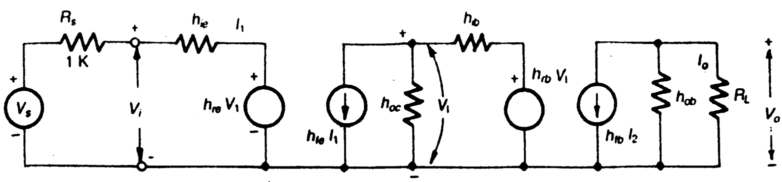

Fig. P. 5.18 (a)

From the circuit,

$$V_i = h_{ie}I_1 + h_{re}V_1 \quad \text{...(i)}$$

$$V_1 = h_{ib}I_2 + h_{rb}V_o \quad \text{...(ii)}$$

$$V_o = -I_oR_L = -h_{fb}I_2R_L \; [\because \frac{1}{h_{ob}} \gg R_L] \quad \text{...(iii)}$$

and,

$$I_2 = -h_{oe}V_1 - h_{fe}I_1 \quad \text{...(iv)}$$

Substituting equation (ii) and (iii) in eq. (iv), we have

$$I_2 = -h_{fe}I_1 - h_{oe}\,(h_{ib}I_2 + h_{rb}V_o)$$

$$I_2 = -h_{fc}I_1 - h_{oe}\,(h_{ib}I_2 - I_oR_Lh_{rb})$$

$$= -50\,I_1 - h_{oe}\,[h_{ib}I_2 - h_{fb}I_2R_Lh_{rb}]$$

Putting,

$$h_{oe} = 24 \times 10^{-6}\ \mu A/V$$

$$h_{ib} = 21.6\ \Omega$$

$$h_{fb} = -0.98$$

$$h_{rb} = 2.9 \times 10^{-4}$$

$$R_L = 5K$$

$$h_{ie} = 1.1\ K$$

and, $V_1 = h_{ie}I_1$

or, $R_{i_2} = \dfrac{V_1}{I_1} = h_{ie}$

and, voltage gain for stage II

$$A_{V_2} = \frac{A_{I_2} \times R_L}{R_{i_2}} = \frac{-50 \times 0.7}{1.1} = -31.9$$

Now, $\gamma_o = h_{oe} - \dfrac{h_{fe}h_{re}}{h_{ice} + R_s} = 0$

then, $R_{o_2} = \dfrac{1}{\gamma_o} = \infty$

Stage I: In this stage, circuit drawn is shown below.

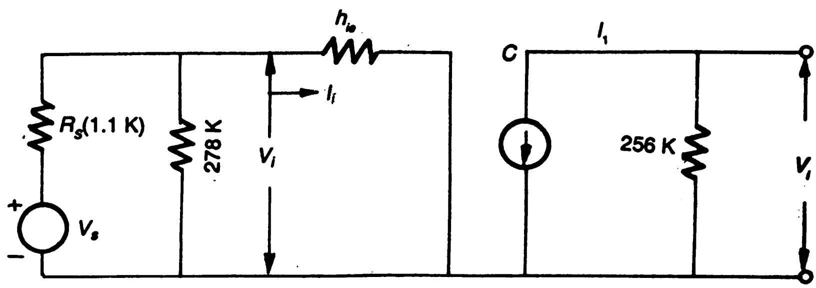

Fig. P. 5.21 (b)

Since $h_{oc}R_L = h_{oe}\left[R_{c_1} \| (R_{12} \| R_{22}) \| R_{12}\right]$

$$= \frac{1}{40} \times [6\ \text{K} \parallel 4.46\ \text{K} \parallel 1.1\ \text{K}] = 0.02 \leq 0.1$$

So, we can use appropriate analysis for this stage also.

Now drawing the equivalent circuit

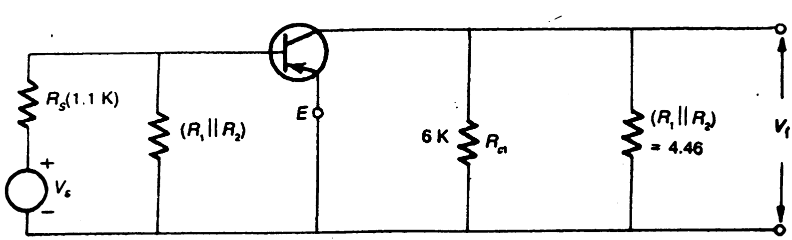

Fig. P. 5.21 (d)

Problem 5.24:
For the bootstrap circuit shown, calculate $A_I \equiv I_o/I_i$, R_i and A_v. The transistor parameters are $h_{ie} = 2$ K, $h_{fe} = 100$, $1/h_{oe} = 40$ K, and $h_{re} = 2.5 \times 10^{-4}$.

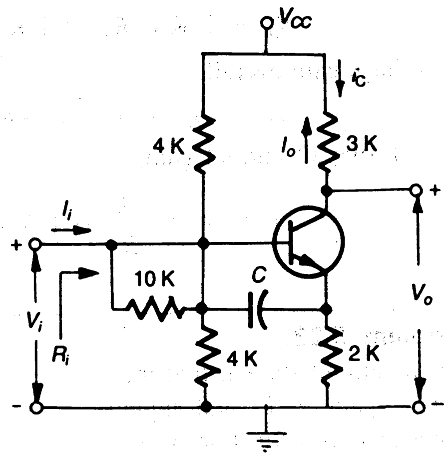

Fig. P. 5.24

Solution: The Ckt. is viewed from emitter side, and the effective emitter resistance is,

$$R'_e = (2\text{ K} \parallel 4\text{ K} \parallel 4\text{ K}) = 1\text{ K}$$

Since,

$$h_{oe}(R_c + R'_e) = \frac{4}{40} = 0.1$$

Hence, we can use the approximate analysis for the convenience

Thus,
$$A'_I = \frac{I_o}{I_b} = -h_{fe} = -100$$

$$R'_i = \frac{V_i}{i_b} = h_{ie} + (1 + h_{fe})R'_e$$

$$= 2\text{ K} + 101 \times 1 = 103\text{ K}$$

Now the voltage gain from base to emitter :

$$A'_v = \left(1 - \frac{h_{ie}}{R_i}\right) = 1 - \frac{2}{103} = 0.9806$$

Now applying Miller's theorem to 10 K

we find,
$$R_1 = \frac{10}{1 - 0.9806} = 515\text{ K}$$