ECE 302 - HW#9 - SOLUTION - 30 POINTS

A) FROM TABLE "ON - CHARACTERISTICS" ON p. 2 FOR $I_C = 10mA$ AND $V_{CE} = 1V$

$$100 \leq \beta_F \leq 300$$

- FROM FIG. 15 ON p6, $\beta_F = 1$ AT $I_C = 10mA$, $V_{CE} = 1V$ AND β_F FOR 0.5 mA IS BETWEEN 0.6 AND 0.7 ON A LOG SCALE.

- THE 0.5mA CURVE IS 3.2cm OUT OF 3.9cm. ON A 1-10 LOG SCALE THIS IS $10^{3.2/3.9} = 6.61$. SO ON A 0.1 - 1. SCALE THIS IS 0.661

$$\therefore \quad 100(0.661) \leq \beta_F \leq 300(0.661)$$

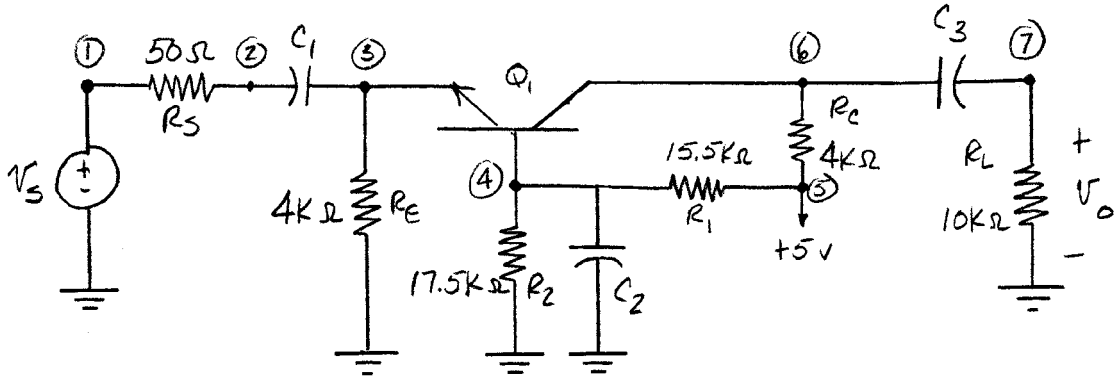
$$\boxed{66.1 \leq \beta_F < 198.3}$$

B) SINCE $V_{CE} = 1$ AND $V_{CC} = 5$, LET $V_{R_C} = V_{R_E} = 2V$ THEN $R_C \cong R_E = 2/0.5m = \boxed{4K\Omega.}$ $I_{B(MAX)} = I_C/\beta_{F(MIN)}$ $= 0.5m/66.1 = 7.56\mu A.$ LET $I_{R_1} \cong I_{R_2} = 20(7.56\mu)$ $= 151.3\mu A.$ THEN (SEE CH 3 p40)

$$R_2 = \frac{V_B}{I_{R_2}} = \frac{2+0.65}{151.3\mu} = \boxed{17.5K\Omega}$$

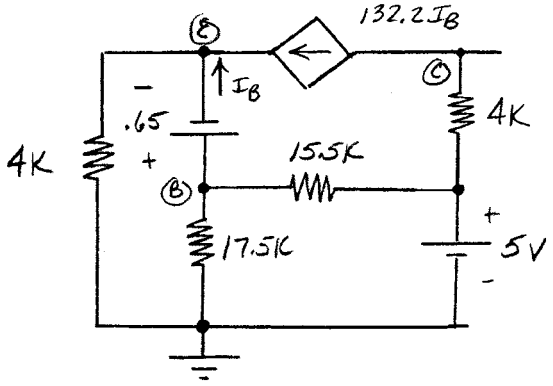
$$R_1 = \frac{V_{CC} - V_B}{I_{R_1}} = \frac{5-2.65}{151.3\mu} = \boxed{15.5K\Omega}$$

c) Common - Base Amplifier



FOR Q_1 : $V_{BE(on)} = 0.65\,V$, $\beta_F = \frac{66.1 + 198.3}{2} = 132.2$, $n_F = 1$

- STEP 1 : DC OPERATING POINT

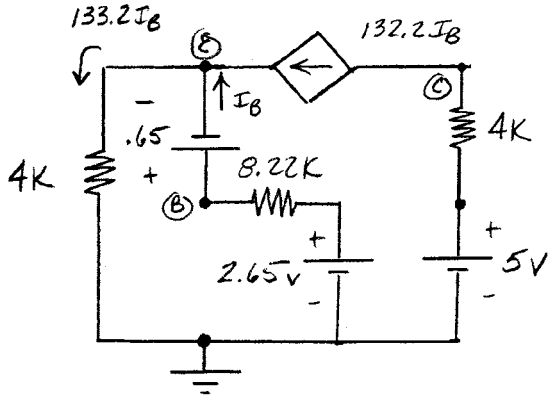


$$V_{TH} = 5\,\frac{17.5K}{15.5K + 17.5K}$$

$$= 2.65\,V$$

$$R_{TH} = 15.5K \,||\, 17.5K$$

$$= 8.22\,K$$



$$2.65 = 8.22K\, I_B + 0.65 + 4K(133.2\, I_B)$$

$$\therefore I_B = \frac{2.65 - 0.65}{8.22K + 4K(133.2)} = 3.7\mu A \quad \checkmark$$

$$I_C = 132.2\,(3.7\mu) = 488.7\mu A$$

$$V_{CE} = 5 - (488.7\mu)4K - (133.2)(3.7\mu)\,4K = 1.07V \quad \checkmark$$

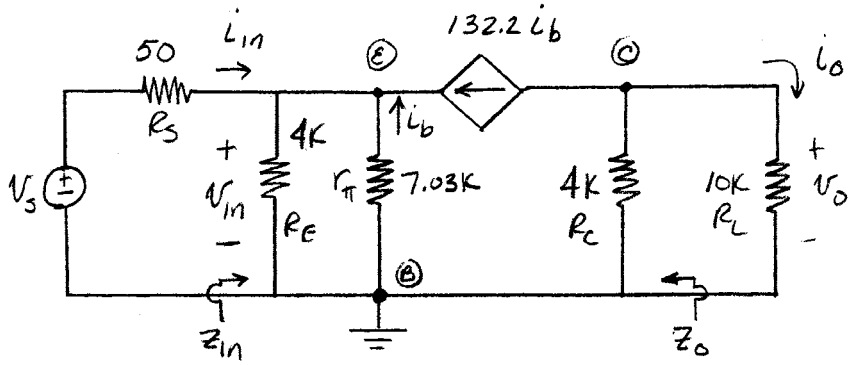
- ASSUMPTION CHECKS,

- STEP 2 : AC MODEL

$$r_\pi = \frac{n_F V_t}{I_B} = \frac{26m}{3.7\mu} = 7.03K\Omega$$

$$\beta_F = 132.2$$

- STEP 3 : AC MID-BAND ANALYSIS



1) A_V

$$V_o = -132.2\, i_b\,(4K \parallel 10K) = -377.7\, i_b$$

$$i_b = -V_{in} / 7.03K$$

$$V_o = -377.7\left(\frac{-V_{in}}{7.03K}\right) = 53.7\, V_{in}$$

$$A_V = \frac{V_o}{V_{in}} = \boxed{53.7}$$

2) Z_{in}

$$i_{in} = \frac{v_{in}}{4K} - i_b - 132.2 i_b = \frac{v_{in}}{4K} + 133.2 \frac{v_{in}}{7.03K}$$

$$= v_{in}\left[\frac{1}{4K} + \frac{133.2}{7.03K}\right]$$

$$\frac{v_{in}}{i_{in}} = Z_{in} = \frac{1}{\frac{1}{4K} + \frac{133.2}{7.03K}} = 4K \parallel \frac{7.03K}{133.2}$$

$$= 4K \parallel 52.8\Omega = \boxed{52.1\Omega}$$

3) A_I

$$A_I = A_V \frac{Z_{in}}{R_L} = 53.7 \frac{52.1}{10K} = .2798 = \boxed{279.8m}$$

4) G

$$G = A_V A_I = (53.7)(0.2798) = \boxed{15.02}$$

5) Z_o (SEE CH5, p21)

$$Z_o = R_c = \boxed{4K\Omega}$$