Students are allowed to detach this formula sheet for convenience

$$\beta = \frac{I_C}{I_B} \qquad \alpha = \frac{I_C}{I_E} \qquad \beta = \frac{\alpha}{1-\alpha} \qquad \alpha = \frac{\beta}{1+\beta} \qquad r_0 = \frac{V_A}{I_C}$$

$$g_m = \frac{I_C}{V_T} \qquad r_e = \frac{V_T}{I_E} \qquad r_\pi = \frac{V_T}{I_B} \qquad r_\pi = \frac{\beta}{g_m} \qquad r_e = \frac{\alpha}{g_m}$$

Transconductance; emitter resistance; input resistance at base; $(\beta+1)r_e$; $r_\pi \parallel \frac{1}{g_m}$; cuz $\alpha \approx 1$

$$A_{vo} = -g_m \times (R_C || r_o) \qquad Voltage\ gain = \frac{Total\ resistance\ in\ the\ collector}{Total\ resistance\ in\ the\ emitter}$$

$$A_{vo} = \frac{g_m R_C}{1+g_m R_E} \qquad I_C = I_S e^{V_{BE}/V_T} \qquad f_C = \frac{1}{2\pi RC} \qquad f_C = \frac{1}{2\pi\sqrt{LC}} \qquad |Z_C| = \frac{1}{2\pi fC}$$

$$\frac{I_o}{I_{REF}} = \frac{1}{1+\frac{2}{\beta}} \qquad \frac{I_o}{I_{REF}} = \frac{1}{1+\frac{2}{\beta^2}} \qquad R_{in} \approx \frac{1}{g_m} \qquad \frac{I_o}{I_{REF}} = \left[\frac{1}{1+\frac{2}{\beta}}\right]\left[\frac{1+\frac{V_{CE2}}{V_A}}{1+\frac{V_{CE1}}{V_A}}\right]$$

$$R_0 = [1 + g_m(R_E \parallel r_\pi)]r_0 \qquad I_0 R_E = V_T ln\left(I_{REF}/I_0\right) \qquad R_o = \frac{\beta r_o}{2}$$

or $A_{d2} - A_{d1} = g_m R_C$; $V_{be1} = -V_{be2}$; $V_{be1} = \frac{V_{id}}{2}$

$$\frac{i_{c1}}{i_{c1}+i_{c2}} = \frac{1}{1+e^{-\frac{v_{id}}{v_T}}}$$

input differential resistance

$$R_{id} = 2(\beta+1)(r_e + R_E)$$

$$\frac{i_{c2}}{i_{c1}+i_{c2}} = \frac{1}{1+e^{\frac{v_{id}}{v_T}}}$$

common mode input resistance

$$R_{iCM} = (\beta+1)(R_{EE} || \tfrac{r_0}{2})$$

$$A_d = A_{d1} - A_{d2} = -g_m R_C$$

$$A_{CM} \approx \frac{\Delta R_C}{2R_{EE}}$$

common mode rejection ratio

$$\text{CMMR} = 20\ log\left|\frac{A_d}{A_{CM}}\right| dB$$

$$|V_{OS}| = V_T\left(\frac{\Delta R_C}{R_C}\right) \qquad |V_{OS}| = V_T\left(\frac{\Delta I_S}{I_S}\right)$$

$\frac{V_{od}}{V_s} = \frac{V_{od}}{V_{id}} \times \frac{V_{id}}{V_s}$; overall voltage gain

$$I_{OS} = I_B\left(\frac{\Delta\beta}{\beta}\right) \qquad V_{OS} = \sqrt{\left(\frac{\Delta R_C}{R_C}\right)^2 + \left(\frac{\Delta I_S}{I_S}\right)^2} \qquad A_d = \frac{v_{C1}-v_{C2}}{v_d} = -g_m R_C$$

$$R_i = (\beta+1)(r_e + R_E) \qquad V_{BB} = V_{BE1}\left(1 + \frac{R_2}{R_1}\right) \qquad A_i = \frac{R}{2R_L}(1+\beta)$$