ECE250 (KEH) BJT Formula Sheet (For Test 2)

BJT Modes of Operation:

Cutoff	BE junction off, BC junction off
Forward Active	BE junction on, BC junction off
Reverse Active	BE junction off, BC junction on
Saturation	BE junction on, BC junction on

For NPN BJT: Ie referenced flowing OUT of BJT, Ib and Ic both referenced flowing INTO BJT
$Vbe_{ON} = 0.7$ V, $Vce_{SAT} = 0.1$ V

For PNP BJT: Ie referenced flowing INTO BJT, Ib and Ic both referenced flowing OUT OF BJT
$Veb_{ON} = 0.7$ V, $Vec_{SAT} = 0.1$ V

For forward active NPN and PNP BJTs:

$$Ie = Ib + Ic \qquad \alpha = \frac{Ic}{Ie} \quad (0 < \alpha < 1') \qquad \beta = \frac{Ic}{Ib} = \frac{\alpha}{1-\alpha}$$

$$r_\pi = \frac{n \cdot V_T}{Ib_Q} \qquad ro = \frac{V_A}{Ic_Q} \qquad g_m = \frac{i_c(t)}{v_{be}(t)} = \frac{\beta}{r_\pi}$$

DC Q Point Stability Design Rules of Thumb: $(1+\beta)Re = 10R_{TH}$ and $V_{Re} = 1$ V

General Voltage Amplifier AC Model: $Avo = \left(\frac{v_{out}(t)}{v_{in}(t)}\right)$ ***RL = infinity*** $\qquad R_{in} = \frac{v_{in}(t)}{i_{in}(t)} \qquad R_{out} = \left(\frac{v_{test}}{i_{test}}\right)$ ***vin(t) -> 0***

For CE Amplifier: (*Note, you must know how to derive these, if asked on the test)*

$$Avo = \frac{-\beta \cdot \frac{Rc \cdot ro}{Rc + ro}}{r_\pi + (\beta+1) \cdot Re_1} \qquad R_{in} = \frac{1}{\frac{1}{R1} + \frac{1}{R2} + \frac{1}{r_\pi + (\beta+1)\cdot Re_1}} \qquad R_{out} = \frac{Rc \cdot ro}{Rc + ro}$$

DC Load Line: Ic intercept = (Vcc-Vee)/(Rc+Re)   Vce intercept = Vcc-Vee   Slope = -1/(Rc+Re)

Note: Vee = 0 in a single-ended dc power supply

AC Load Line Slope = -1/([Rc // ro // R_L] + Re1)   ***Note: Re1 is unbypassed portion of Re***

For CC (Emitter Follower) Amplifier: (Note, you must know how to derive these, if asked on the test)

$$Av_o = \frac{(\beta+1)\cdot\left(\frac{Re \cdot ro}{Re + ro}\right)}{r_\pi + (\beta+1)\cdot\left(\frac{Re \cdot ro}{Re + ro}\right)} \qquad Rbin = r_\pi + (\beta+1)\cdot\frac{1}{\frac{1}{Re} + \frac{1}{ro} + \frac{1}{R_L}} \qquad R_{in} = \frac{1}{\frac{1}{Rbin} + \frac{1}{R_1} + \frac{1}{R_2}}$$

Rout = (Re // ro) // (r_π + R_1 // R_2 // Rs) / (β + 1)   ***NOTE: For "Rin_no_R_L", leave R_L out of the Rbin formula.***

AC Load Line Slope = -1/(Re // ro // RL)

General Voltage Amplifier Model Voltage, Current, Power Gains:

Av = vout/vs = Rin / (Rs + Rin)*Avo*R_L / (Rout + R_L)   ***Note: For"Av" of CC Amp, replace Rin by Rin_no_RL***

$$Ai = \frac{i_{out}}{i_{in}} = \frac{\left(\frac{v_{out}}{R_L}\right)}{\left(\frac{v_s}{Rs + Rin}\right)} = Av \cdot \frac{Rs + Rin}{R_L} \qquad Ap = \frac{p_{out}}{p_{in}} = \frac{v_{out} \cdot i_{out}}{v_s \cdot i_{in}} = Av \cdot Ai$$