HW#9 solution

1.

a) $\tau_1 = R_{in} C_{GS1} = 1\mu s \Rightarrow p_1 = 10^6 \text{ rad/sec}$

$\tau_2 = r_{o2} \cdot C_{GS3} = \dfrac{1}{0.01 \times 100 \times 10^{-6}} \times 1pF$

$= 1\mu s \Rightarrow p_2 = 10^6 \text{ rad/sec}$

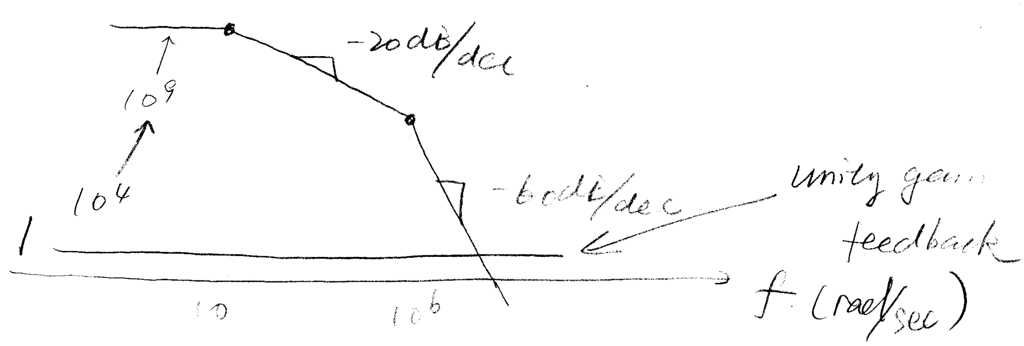
$\tau_3 = r_{o3} \cdot C_o = 0.1 \text{ sec} \Rightarrow p_3 = 10 \text{ rad/sec}$

b) bode plot shown below.

low frequency gain of the Amplifier:

$A_v = -(g_{m1} r_{o1}) \cdot (g_{m2} r_{o2}) \cdot (g_{m3} r_{o3})$

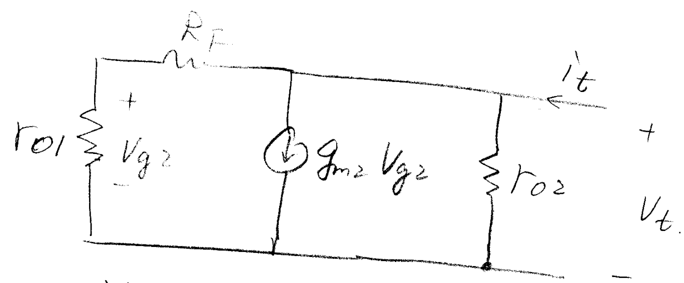
$= -(10^3)^3 = -10^9$



From the bode plot, the cross-over frequency would be above 10^7 rad/sec. Phase shift close to $-270°$ from that frequency. So the system would be unstable!

c) R_F only affects pole #2.

Can use ZVTC for pole #2



$$i_t = \frac{V_t}{r_{o2}} + \frac{V_t}{R_F + r_{o1}} + g_{m2} \underbrace{\frac{r_{o1}}{r_{o1} + R_F}}_{\approx 0.99}$$

$$\therefore R_{oc2} \cong \frac{r_{o2}}{2} \,//\, \frac{1.01}{g_{m2}}$$

$$= 500k\Omega \,//\, 1.01k\Omega \approx 1k\Omega$$

$\Rightarrow P_2 \cong 10^9$ rad/sec ; $P_1 = 10^6$, $P_3 = 10$ rad/sec

d) Gm of the first two stages

$$G_{m1,2} = -g_{m1}(R_F \parallel r_{o1}) \cdot g_{m2}$$

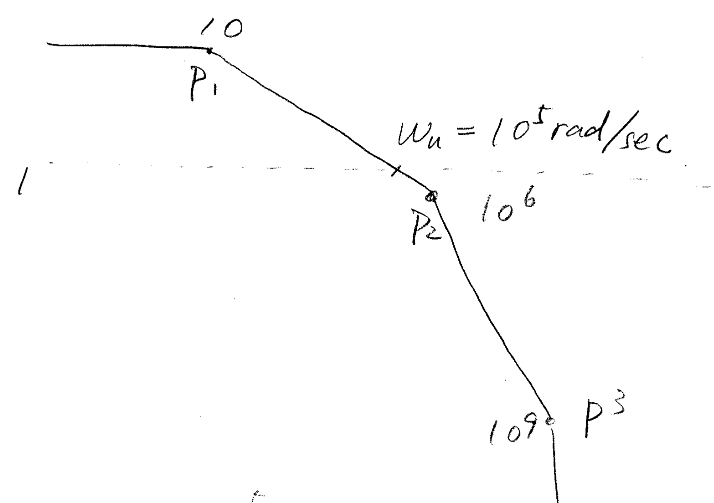
$$\approx -g_{m1} R_F \cdot g_{m2}$$

$$A_{v1,2} \cong g_{m1} R_F \cdot g_{m2} \cdot \frac{1}{g_{m2}} = g_{m1} \cdot R_F$$

Overall $A_v = -g_{m1} R_F \cdot g_{m3} r_{o3}$

$$= -10^4$$

e)



$\therefore W_u = 10^5$ rad/sec.