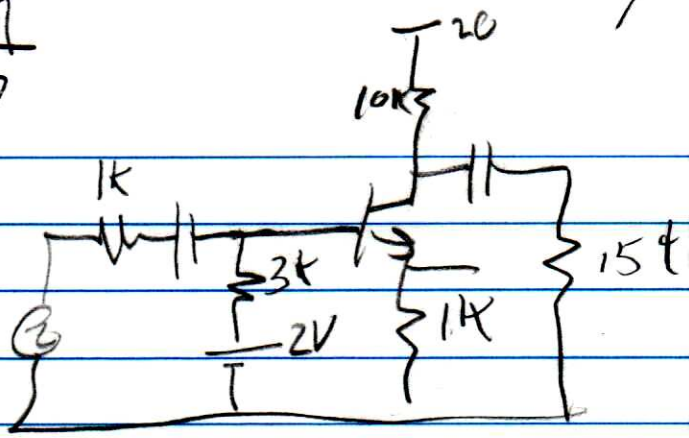
Old Exam I
ENEE 307

Part I $\beta = 200$



1) V_B, V_C, V_E DC

$$I_C = \frac{V_{BB} - V_{BE}}{\frac{R_B}{\beta} + R_E} = \frac{2 - 0.7}{\frac{3K}{200} + 1K} \approx \frac{1.3}{1K} = 1.3mA$$

$$V_B = 2V - \frac{1.3 \times 10^{-3}}{200} 3K \approx 2V$$

$$V_E = V_B - 0.7 = 1.3$$

$$V_C = V_{DD} - I_C R_C = 20 - (1.3mA)(10K) = 7V$$

2) $$\frac{v_o}{v_{in}} = \left(\frac{v_1}{v_{in}}\right)\left(\frac{v_o}{v_1}\right)$$

$$\frac{v_1}{v_{in}} = \frac{3K \| R_{TB}}{3K \| R_{TB} + 1K} \qquad R_{TB} = \frac{1}{g_m} + \beta \| 1K \approx 200K$$

$$\text{So } 3K \| R_{TB} \approx 3K$$

$$\frac{v_1}{v_{in}} \approx \frac{3K}{4K} = 0.75$$

$$\frac{v_o}{v_1} = \frac{R_C \| R_L}{\frac{1}{g_m} + R_E} \qquad \frac{(10)(15)}{25} = \frac{150K}{25} = 6K$$

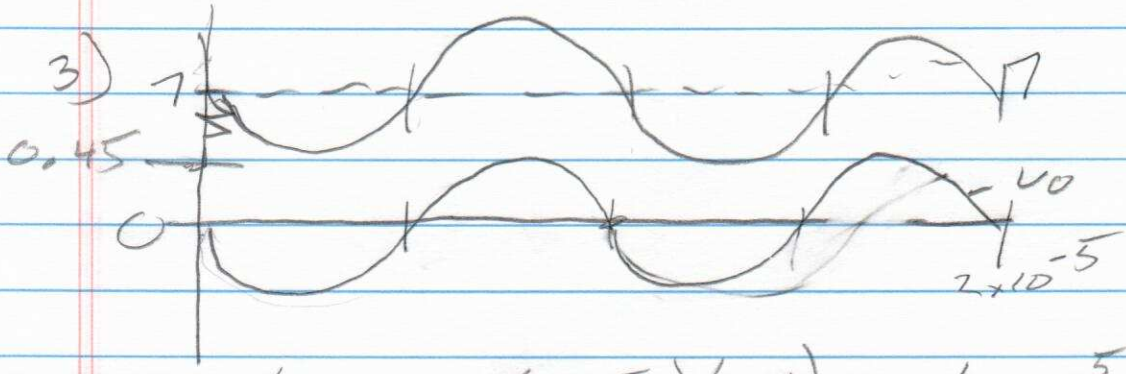
$$g_m = \frac{I_C}{V_t} = \frac{1.3mA}{0.026V} \qquad \frac{1.3 \times 10^{-3}}{2.6 \times 10^{-2}} = 0.5 \times 10^{-1} = 0.05$$

$$\frac{L}{S_n} = 20$$

$$\frac{V_o}{V_i} = \frac{-6k}{20+1k} \approx .6$$

So $\frac{V_o}{V_{in}} = (0.75)(-6) = \boxed{-4.5}$

3)



$V_{out} = A_V V_{in} = (-4.5)(0.1)\sin(2\pi 10^5 t)$

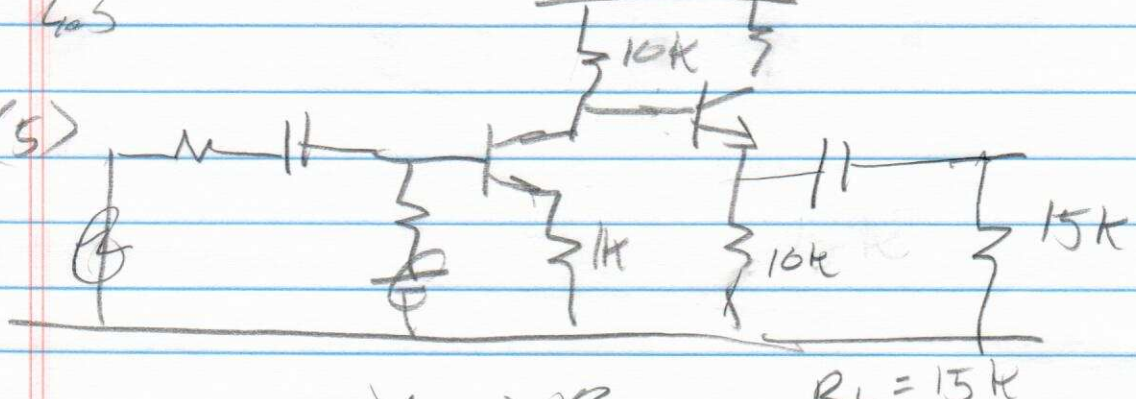
4) $V_C = 5V$

$V_B = 2V$, $V_{CC} = 20$ 5V swing $V_C - V_B$

$5 = V_{in\,max} A_V$

$\frac{5}{4.5} = V_{in\,max} = \boxed{1.11\ V}$

(5)



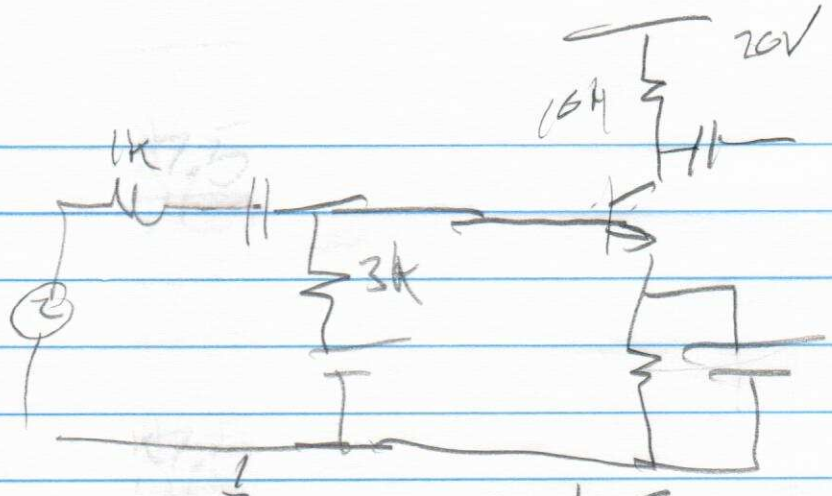
$R_L = 15k$

(6) $A_V = (0.75)(-10)\frac{R_L}{R_o + R_L}$ $R_o = \frac{10k}{\beta} = 50$

$$\frac{15K}{15K+50} \geq I$$

(6) $A = \frac{}{} = 7.5$

Part II



1) Same DC point as Part I

$I_C = 1.3mA$

$g_m = 0.05\ 1/\Omega$

$1/g_m = 20\ \Omega$

(1) $\frac{V_o}{V_{in}} = \left(\frac{V_1}{V_{in}}\right)\left(\frac{V_o}{V_1}\right)$

$\frac{V_1}{V_{in}} = \frac{3K \| R_{TB}}{1K + 3K \| R_{TB}}$ $\qquad R_{TB} = \frac{\beta}{g_m} = (200)(20) = 4K$

$3K \| 4K = 1.7K$

$\frac{V_1}{V_{in}} = \frac{1.7K}{1K + 1.7K} = \frac{1.7K}{2.7K} = \boxed{0.63}$

$\frac{V_o}{V_{in}} = \frac{-R_C}{\frac{1}{g_m} + R_E} = -g_m R_C = (0.05)(10K)$

$\frac{V_o}{V_{in}} = (-500)(0.63) = \boxed{-315}$

(2) $|P_L| = \sum_i \frac{1}{R_i C_i}$

R_1 (seen by C_1) $= 1k + 3k \| R_{TB} = 1k + 1.7k$

$= 2.7k$

$R_1 C_1 = (2.7k)(1 \times 10^{-7}) = 2.7 \times 10^{-4}$

$R_2 C_2 = \infty \rightarrow 10k + \infty = R_2 = \infty$

$R_2 C_2 = \infty$

$C_E \rightarrow R_E = 1k \| R_{TE}$

$R_{TE} = \frac{1}{g_m} + \frac{3k \| 1k}{\beta} =$

$\frac{3k \| 1k}{200} = \frac{0.75k}{20} = \frac{750}{200} = 3.75$

$R_{TE} = 23.75$

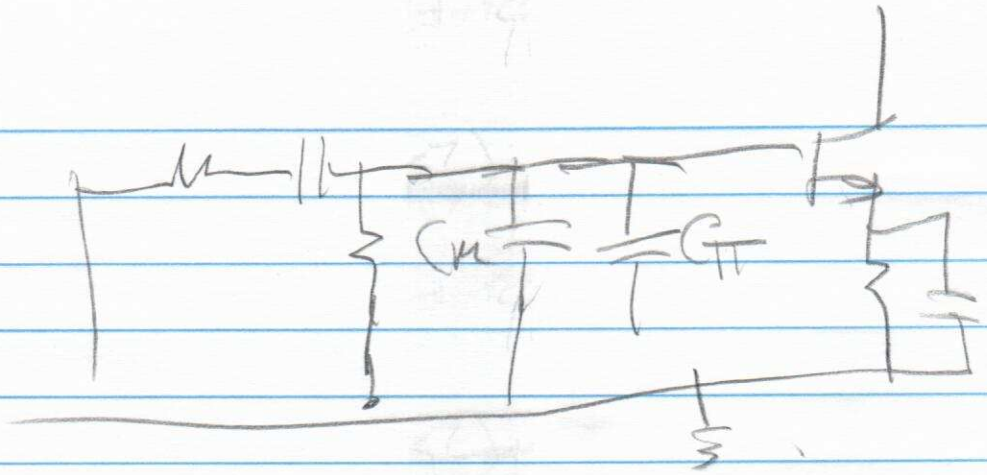
$R_{TE} \| R_E = 23.75 \| 1k \approx 23$

$C_E R_E = (23 \times 10^{-7}) = 2.3 \times 10^{-6}$

$P_L = \frac{1}{2.7 \times 10^{-4}} + \frac{1}{\infty} + \frac{1}{0.23 \times 10^{-6}} = \frac{1}{0.3} \times 10^6$

$P_L = .43 \times 10^6 \approx 4.3 \times 10^5$ 1/sec

3)



$C_T = 1 \times 10^{-14}\ F$

$C_M = 1 \times 10^{-14}\ F$

$C_M = C_M(1 + |A_V|)$

$C_M = 1 \times 10^{-14}(1 + 500) \approx 5 \times 10^{-12}$

$C_T = C_M + C_{in2}$ ~~C_M~~ $= 5 \times 10^{-12}$

$R_M = (3K \,||\, 1K) \,||\, R_{TB}$

$3K \,||\, 1K = 750$

$R_{TB} = 4K = 0.63K$

$750 \,||\, 4K$

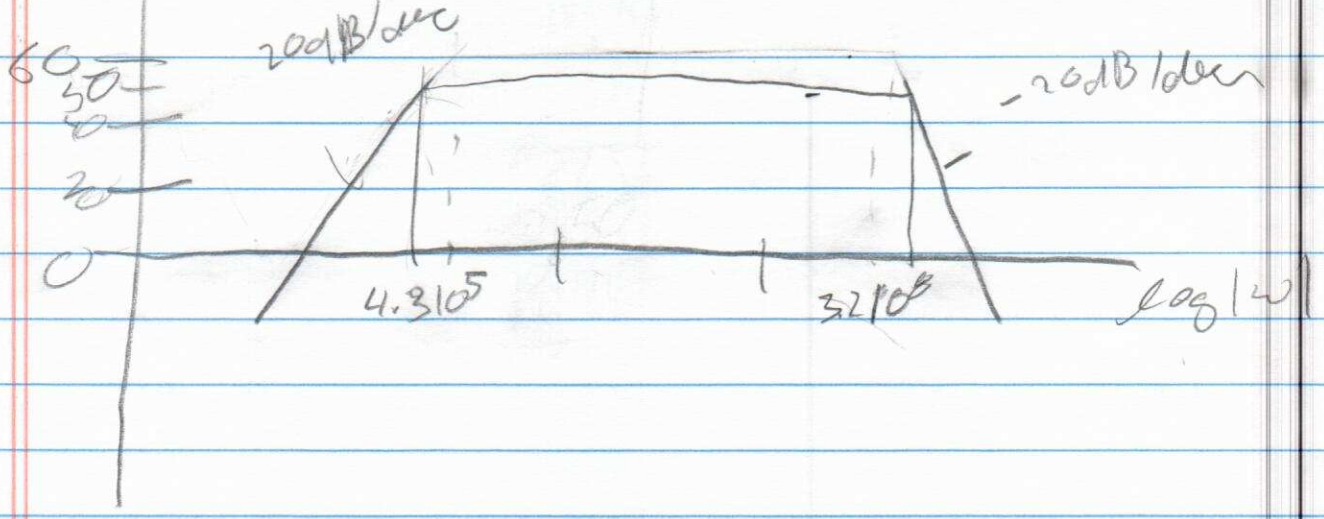
$R_M C_M = (0.63K)(5 \times 10^{-12})$

$= 3.15 \times 10^{-9}$

$f_{PM} = \frac{1}{3.15 \times 10^{-9}} = 3.2 \times 10^{8}\ 1/sec$

4) $\log|315| = 2.5$

$dB = (20)(2.5) = 50$



5) low C_1, C_2, C_E block AC – low gain Equivalent mid band C_1, C_2, C_{E2} all shorted C_{μ} & C_{π} open High $C_1, C_2 C_E$ shorted, C_{π}, C_{μ} short signal given BJT C_{μ} make Miller

Part III

1) Find I_{C2}: KVL: $10k - 9.65k I_C - 0.7 - (-10) = 0$

$$\frac{20 - 0.7}{9.65} = \frac{19.3}{9.65} \approx 2mA$$

2) $V_{C1} = 10$

$V_{C2} = 10 - (5k)(1m) = 5V$

3) V_{O1} = Invert

V_{O2} = non inverting

4) $V_{O1} \Rightarrow A_V = 0$

V_{O2} $A_V = \frac{g_m R_C}{2}$

$$g_m = \frac{1mA}{0.026} = 0.04$$

$$\frac{V_O}{V_{in}} = \frac{(0.04)\,5k}{2} = (0.02)(5)k = \boxed{100}$$

Part IV

$I_D =$

$V_{GG} - V_{GS} = 0 \qquad V_{GS} = V_{GG}$

$$I_D = \frac{k_n W}{2L}(V_{GS} - V_{TH}) = \frac{(2\times10^{-4})5}{2}(3-1)^2$$

$$I_D = \frac{(1\times10^{-3})}{2}(4) = 2\times10^{-3}\ A$$

$V_G = 3V$

$V_S = 0$

1) $V_D = V_{DD} - I_D R_D = 20 - (2\times10^{-3})(6k) = 8V$

2) $A_V = \frac{V_o}{V_{in}} = \left(\frac{V_1}{V_{in}}\right)\left(\frac{V_o}{V_1}\right)$

$\frac{V_1}{V_{in}} = \frac{3}{4} = 0.75$

$\frac{V_o}{V_{in}} = -g_m R_D$

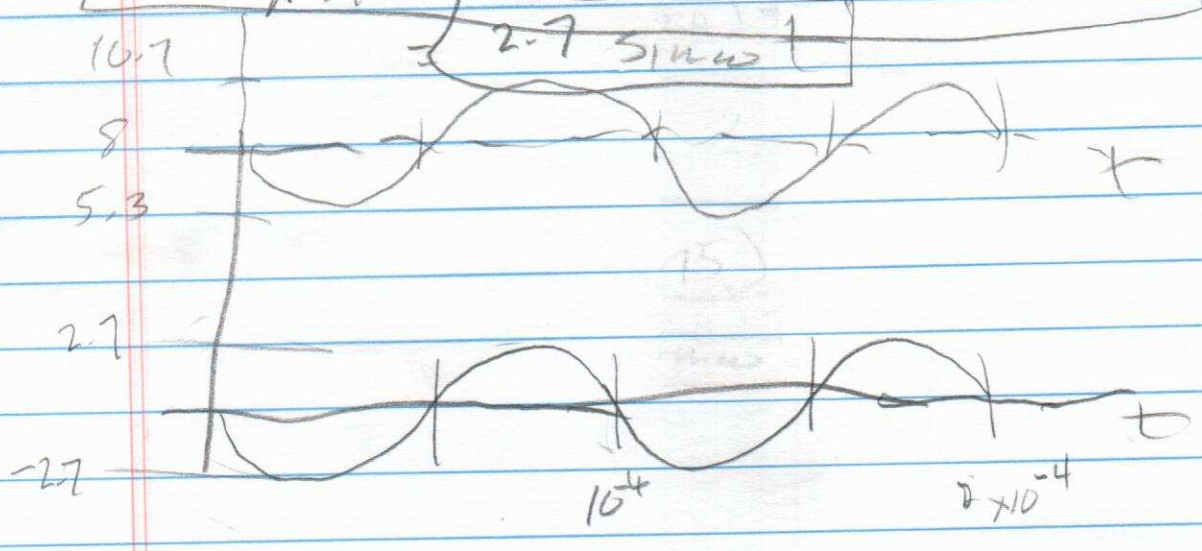
$g_m = \frac{\partial I_D}{\partial V_{GS}} = \frac{k_n W}{L}(V_{GS} - V_{TH}) = (2\times10^{-4})(5)(2)$

$g_m = 2\times10^{-3}$

$\frac{V_o}{V_i} = -(2\times10^{-3})(6k) = -12$

$A_V = (0.75)(-12) = -9$

$$\boxed{v_o = A\,V_{in} = (\epsilon_{12})(0.75)\,8.3\sin\omega t = \boxed{2.7\sin\omega t}}$$



(4) $A_v = (0.75)(g_m R_D \| R_L)$

$6k \| 15k = \frac{90k}{21} = 4.3k$

$A_v = \left(\frac{3}{k}\right)(-2\times10^{-3})(-4.3k) = \boxed{-6.45}$

(5) Saturation

$v_{DS} = 8$

$v_{GS} - v_{TH} = 2$

$v_{GS} > 2$ So sat