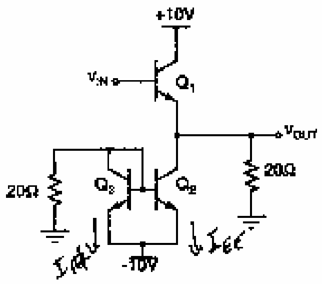
NAME: KEY   STUDENT NO.:

University of Puerto Rico
Electrical and Computer Engineering Department
INEL 4202 - Electronics II - Fall 2002 - Exam 1a - Prof. M. Toledo
THERE ARE TWO PROBLEMS - BE CLEAR OR LOOSE POINTS

1. The transistors in the circuit shown below are matched. Transistor Q_1 is dissiating an average power of 1w. Find the power being delivered to the load. Assume sinusoidal output. (30 points)



$$I_{ref} = \frac{10V - 0.7V}{20\Omega} = 465mA \simeq I_{EE}$$

Since $P_{DC} = 2V_{CC}\, I_{EE} = 2(10V)(.465A) = 9.3W$ ← dissipated in Q_1 & Q_2

and half of that is dissipated in Q_2;

$$P_{Q_2} = 4.65\,W$$

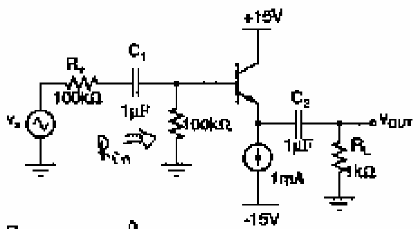
$$P_{Load} = P_{DC} - P_{Q_2} - P_{Q_1} = 9.3W - 4.65W - 1W$$

$$\boxed{P_{Load} = 3.65\,W}$$

Notice, however, that this implies an efficiency of $\frac{3.65W}{9.3W} \times 100\% \simeq 40\%$, which is larger than the max. for a class A amplifier (25%). What happens is that there is clipping at the output ($V_{peak} = \sqrt{2(3.65W)(20\Omega)} \simeq 12V$ for an output power of 3.65 W, and this is greater than V_{CC}). Still, the power dissipated in the load should be about 3.65 W.

NAME: STUDENT NO.:

2. For the amplifier shown below, assume $\beta = 100$, $C_\mu = 1pF$ and $C_\pi = 10pF$. Find
   (a) the midband gain. (10 points)
   (b) the low frequency poles. (20 points)
   (c) the high frequency poles. (40 points)



$g_m = \frac{1}{25}$ A/V

$r_\pi = 2.5K\Omega$

(a) $A_{mid} = + \frac{g_m R_E}{1 + g_m R_E} \cdot \frac{R_{in}}{R_s + R_{in}}$

$= \frac{\frac{1}{25}(1k)}{1 + \frac{1k}{25}} \cdot \frac{100k \,||\, (101 \times 1k + 2.5k)}{100k + 100k \,||\, (101k + 2.5k)} = \frac{1}{3} \cdot \frac{40}{41} \approx$ **0.325**

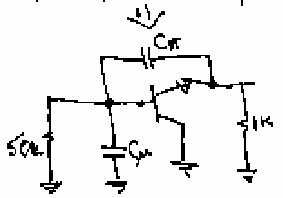
(b) C_1 sees $R_{eq_1} = 100k + 100k \,||\, 103.5k \approx 150k \Rightarrow \omega_{L_1} = \frac{1}{10^{-6}F \times 150k\Omega} \approx$ **6.7 rps**

C_2 sees $R_{eq_2} = 1k + \frac{r_\pi + R_b}{\beta + 1} = 1k + \frac{2.5k + 50k}{101} \approx 1520\Omega$

$\therefore \omega_{L_2} = \frac{1}{10^{-6}F \times 1520\Omega} =$ **658 rps**

(c)

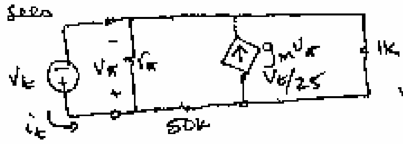
Eq. ckt. for high-freq. with C_π & C_μ drawn as external caps.



C_μ sees $50k \,||\, (r_\pi + (\beta+1)R_E) = 50k \,||\, 103.5k \approx$

$\omega_{p_\mu} = \frac{1}{10pF \times 33K\Omega} \approx$ **30M rps**

C_π sees



$V_t = V_\pi$

$V_t = 50k\, i_t + (i_t - \frac{V_t}{25})1k$

$\frac{V_t}{i_t} = (50k + 1k) / (1 + \frac{1k}{25}) = \frac{51k}{41}$

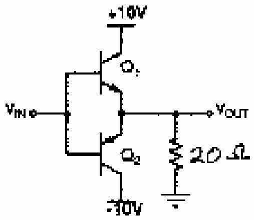
$R_{eq} = r_\pi \,||\, \frac{V_t}{i_t}$

$= 2.5k \,||\, 1244\Omega = 831\Omega \Rightarrow \omega_{p_\pi} = \frac{1}{831\Omega \times 10^{-11}F} =$ **120M rps**

NAME: KEY STUDENT NO.:

University of Puerto Rico
Electrical and Computer Engineering Department
INEL 4202 - Electronics II - Fall 2002 - Exam 1b - Prof. M. Toledo
THERE ARE TWO PROBLEMS - BE CLEAR OR LOOSE POINTS

1. The transistors in the circuit shown below are matched. Transistor Q_1 is dissipating an average power of 0.1w. Find the power being delivered to the load. Assume sinusoidal output. (30 points)



Since

$$P_{Q_S} = 2 \times 0.1w = 0.2W = \frac{2}{\pi}\frac{V_{CC}}{R_L} v_{L\,peak} - \frac{v_{L\,peak}^2}{2R_L}$$

$$.2W = \frac{2}{\pi}\frac{10V}{20\Omega} v_{L\,peak} - \frac{1}{40\Omega} v_{L\,peak}^2$$

or

$$v_{L\,peak}^2 - \frac{40}{\pi} v_{L\,peak} + 40 * .2 = 0$$

$$v_{L\,peak}^2 - 12.7 v_{L\,peak} + 8 = 0$$

$$v_{L\,peak} = \frac{12.7 \pm \sqrt{12.7^2 - 4(1)(8)}}{2}$$

$$= 6.35 \pm 5.7$$

$v_{L\,peak}$ = .65V, 12.05 ⇒ select 0.65V because 12.4V is larger than V_{CC} = 10V.

$$\therefore P_L = \frac{v_{L\,peak}^2}{2R_L} = \frac{(.65)^2}{2(20)} = \boxed{\frac{.42}{40} w \simeq 10 mW}$$

NAME: STUDENT NO.:

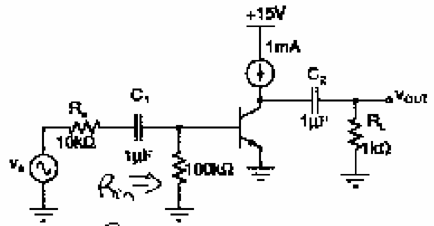
2. For the amplifier shown below, assume $\beta = 100$, $V_A = 50V$, $C_\mu = 1pF$ and $C_\pi = 10pF$. Find

   (a) the midband gain. (10 points)

   (b) the low frequency poles. (20 points)

   (c) the high frequency poles. (40 points)

Do not use Miller's theorem.



$g_m = \frac{1}{25}\ \frac{A}{V}$

$r_\pi = 2.5k\Omega$

(a) $A_{mid} = -(g_m R_L)\left(\frac{R_{in}}{R_s + R_{in}}\right) = -\frac{1}{25}(1k)\ \frac{100k \| 2.5k\Omega}{10k\Omega + 100k \| 2.5k\Omega}$

$\boxed{A_{mid} = -7.8\ V/V}$

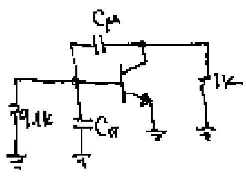
(b) $R_{eq_{C_1}} = 10k + 100k \| 2.5k = 12.4k\Omega$; $\omega_{P_{C_1}} = \frac{1}{10^{-6}F \times 12.4k\Omega} = \boxed{80 rps}$

$R_{eq_{C_2}} = 1k\Omega + r_o = 1k\Omega + \frac{V_A}{I_C} = 1k\Omega + 50k\Omega = 51k\Omega$

$\omega_{P_{C_2}} = \frac{1}{10^{-6} \times 51 \times 10^3} = \boxed{19.6\ rps}$

(c)

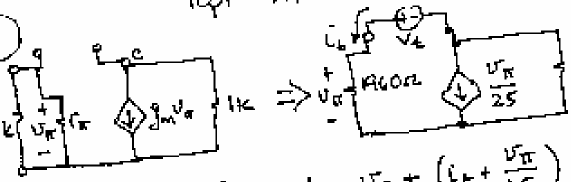
High freq. CKT w. C_π & C_μ drawn as external caps:



C_π sees $R_{eq_{C_\pi}} = 9.1k \| r_\pi = 9.1k \| 2.5k = 1960\Omega$

$\omega_\pi = \frac{1}{10pF \times 1960} = \boxed{51\ Mrps}$

C_μ



$v_\pi = 1960\, i_t$; $v_t = v_\pi + \left(i_t + \frac{v_\pi}{25}\right) 1k$

$v_t = 1960\, i_t + 1k\left(1 + \frac{1960}{25}\right) i_t$

$\frac{v_t}{i_t} = R_{eq_\mu} = 81.4k\Omega \Rightarrow \omega_\mu = \frac{1}{10^{-12}F \times 81.4k\Omega} = \boxed{12.3\ Mrps}$