Name: _____ (please print)

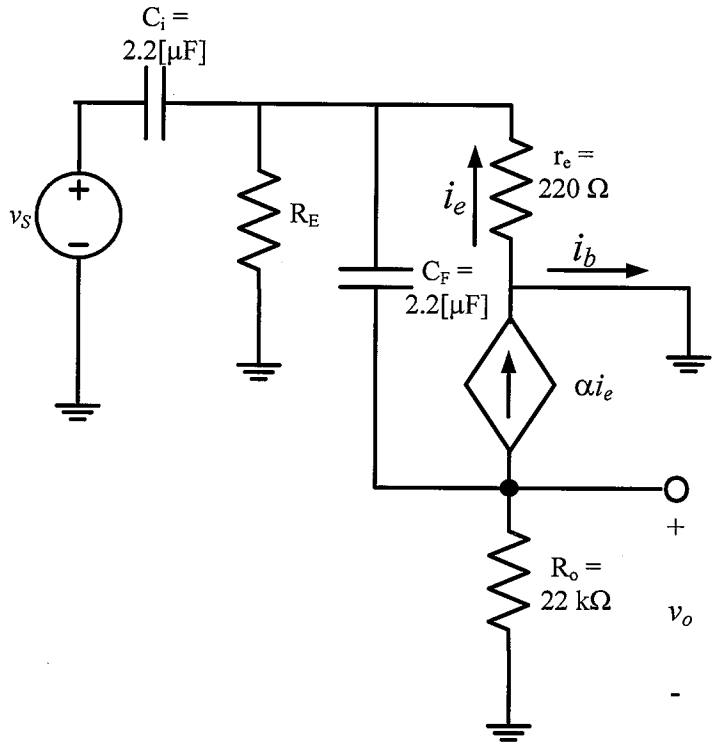
Signature: _____

ECE 3355
Quiz #2
June 21, 2017

1. You may have an 8 ½ x 11" crib sheet, but no other materials, and no communication devices of any kind.
2. Show all work necessary to complete the problem on these pages. If you go on to another page, indicate clearly where your work can be found. A solution without the work shown will receive no credit.
3. Show all units in expressions and figures.
4. Do not use red ink.
5. You will have 25 minutes to work on this quiz.

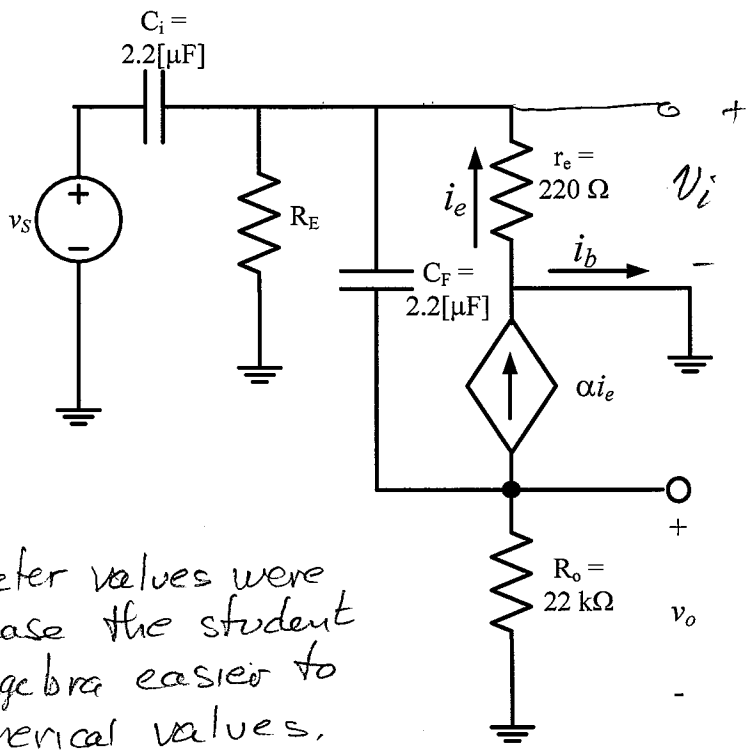
_____/25

In the circuit below, R_E is unknown, but it is very large compared to r_e. Find an expression for the transfer function $T(\omega) = V_o/V_s$. Note also that the current i_b is not 0.



Room for extra work

In the circuit below, R_E is unknown, but it is very large compared to r_e. Find an expression for the transfer function $T(\omega) = V_o/V_s$. Note also that the current i_b is not 0.



Some parameter values were provided in case the student found the algebra easier to do with numerical values.

We can simplify a bit by noting that $R_E // r_e \simeq r_e$.

Relative to ground (which we will use as a reference node), we have two node voltages: V_i and V_o.

I have here substituted $I_e = -V_i/r_e$.

① $$\frac{V_o}{R_o} - \alpha\frac{V_i}{r_e} + \frac{V_o - V_i}{1/j\omega C_F} = 0$$

② $$\frac{V_i}{r_e} + \frac{V_i - V_o}{1/j\omega C_F} + \frac{V_i - V_s}{1/j\omega C_i} = 0$$

① $\Rightarrow$ $$V_i\left(-\frac{\alpha}{r_e} - j\omega C_F\right) = -V_o\left(\frac{1}{R_o} + j\omega C_F\right)$$

$$V_i = V_o\,\frac{1/R_o + j\omega C_F}{\alpha/r_e + j\omega C_F}$$

Room for extra work

$$\textcircled{2} \Rightarrow \quad V_o\, j\omega C_F - V_i\left(\frac{1}{r_e} + j\omega C_F + j\omega C_i\right) = -V_s\, j\omega C_i$$

We could plug in numbers to simplify ... we will for now just note that $C_i = C_F$ — we'll call this $C = 2.2\,\mu F$.

$$V_o\, j\omega C - V_i\left(1/r_e + 2j\omega C\right) = -V_s\, j\omega C$$

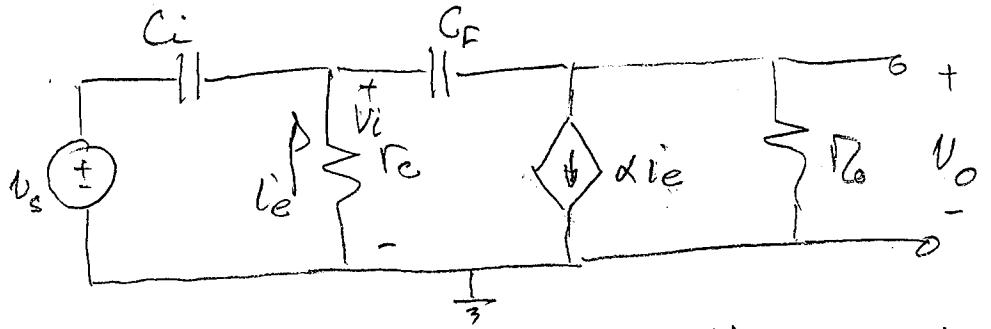
$$V_o - V_i\left(1/j\omega C r_e + 2\right) = -V_s$$

$$V_o - V_o\left(1/j\omega C r_e + 2\right)\frac{1/R_o + j\omega C}{\alpha/r_e + j\omega C} = -V_s$$

$$V_o\left[1 - \left(1/j\omega C r_e + 2\right)\frac{1/R_o + j\omega C}{\alpha/r_e + j\omega C}\right] = -V_s$$

$$\boxed{T(\omega) = \frac{V_o}{V_s} = \frac{-1}{1 - \left(1/j\omega C r_e + 2\right)\left(\frac{1/R_o + j\omega C}{\alpha/r_e + j\omega C}\right)}}$$

The circuit can be re-drawn in a more familiar form. Again ignoring R_E and setting $C_i = C_F \equiv C$:



$$\frac{V_i}{r_e} + \frac{V_i - V_o}{1/j\omega C_F} + \frac{V_i - V_s}{1/j\omega C_i} = 0 \qquad \frac{V_o}{R_o} - \alpha\frac{V_i}{r_e} + \frac{V_o - V_i}{1/j\omega C_F} = 0$$

These are the same node voltage equations!

Room for extra work

If we do not simplify by setting $C_F = C_i = C$...

$$V_o j\omega C_F - V_o \left(\frac{1/\!/R_b + j\omega C_F}{\alpha/r_e + j\omega C_F} \right) \left(\frac{1}{r_e} + j\omega (C_F + C_i) \right) = -V_s j\omega C_i$$

$$V_o \left[j\omega C_F - \left(\frac{1/\!/R_b + j\omega C_F}{\alpha/r_e + j\omega C_F} \right) \left(\frac{1}{r_e} + j\omega (C_F + C_i) \right) \right] = -V_s j\omega C_i$$

$$\frac{V_o}{V_s} = \frac{-j\omega C_i}{j\omega C_F - \left(\frac{1/\!/R_b + j\omega C_F}{\alpha/r_e + j\omega C_F} \right) \left(\frac{1}{r_e} + j\omega C_F + j\omega C_i \right)}$$