ELECTRONICS - I   Midterm 2   - 60 minutes

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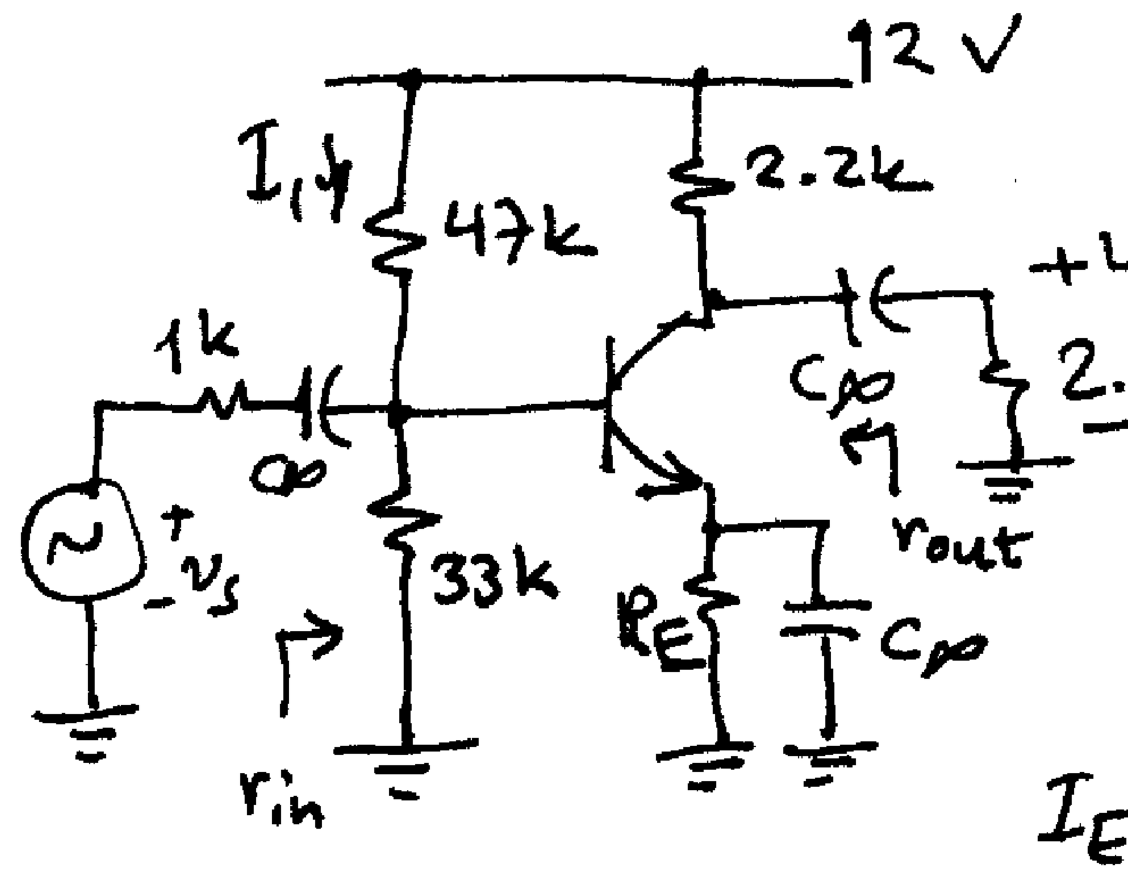
1) The silicon BJT in the amplifier below has 2 mA collector current. $\beta = 250$, $V_A = 350V$. a) What must be the value of R_E?
b) Obtain a small-signal equivalent circuit for the amplifier.
c) Find the voltage gain $\frac{v_o}{v_s}$, r_{in} and r_{out}.

R_E = 2.125k

r_{in} : 2.69k

r_{out} : 2.2k

v_o/v_s = -70.21



a) Ignoring the base current

$$I_1 \simeq \frac{12}{47+33} \text{ mA} = 0.15 \text{ mA}$$

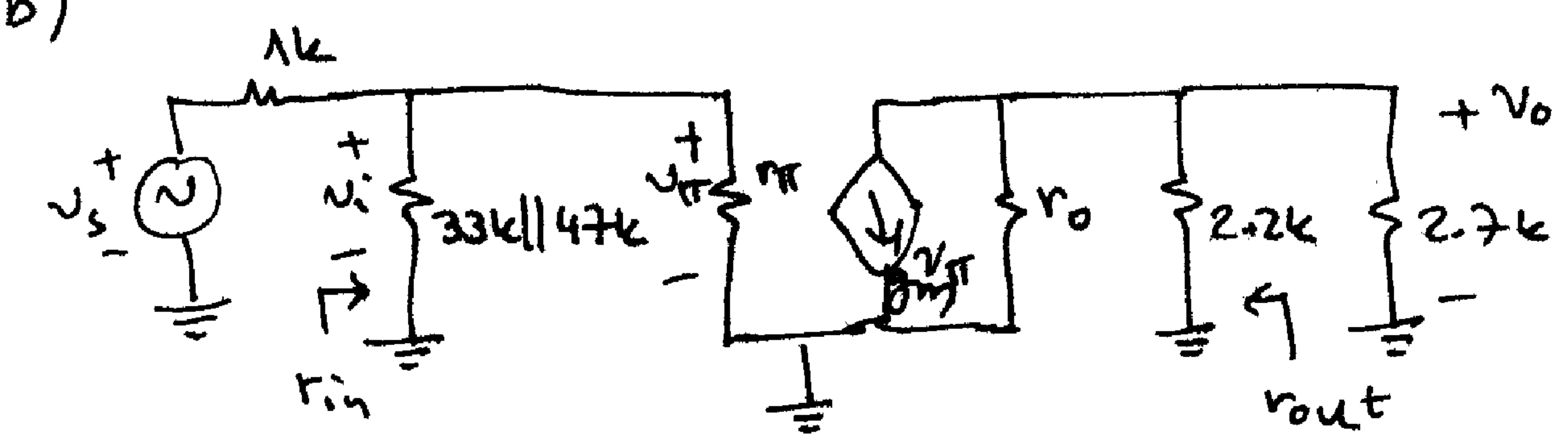
$$I_B = \frac{2}{250} = 0.008 \text{ mA} \qquad I_1 \gg I_B$$

$$V_E = V_B - V_{BE}$$

This means $V_B \simeq 12 \frac{33}{33+47} = 4.95V$, $V_E = 4.25V$

$$I_E = \frac{V_E}{R_E}, \quad R_E = \frac{V_E}{I_E} \simeq \frac{V_E}{I_c} = \frac{4.25}{2} = 2.125 \text{ k}\Omega$$

b)



$$g_m = \frac{I_c}{V_T} = \frac{2}{0.025} = 80 \text{ mA/V}$$

$$r_\pi = \frac{\beta}{g_m} = \frac{250}{80} = 3.125 \text{ k}\Omega$$

$$r_o \cong \frac{V_A}{I_c} = \frac{350V}{2mA} = 175 \text{ k}\Omega$$

c) $r_{in} = 33k \| 47k \| 3.125k = 2.69 \text{ k}\Omega$

$$r_{out} = r_o \| 2.2k = 175k \| 2.2k \simeq 2.2 \text{ k}\Omega$$

$$\frac{v_o}{v_i} = -g_m (r_o \| R_c \| R_L) = -80 \, (175 \| 2.2 \| 2.7) = -96.31$$

$$\frac{v_i}{v_s} = \frac{r_{in}}{R_s + r_{in}} = \frac{2.69}{1+2.69} = 0.729$$

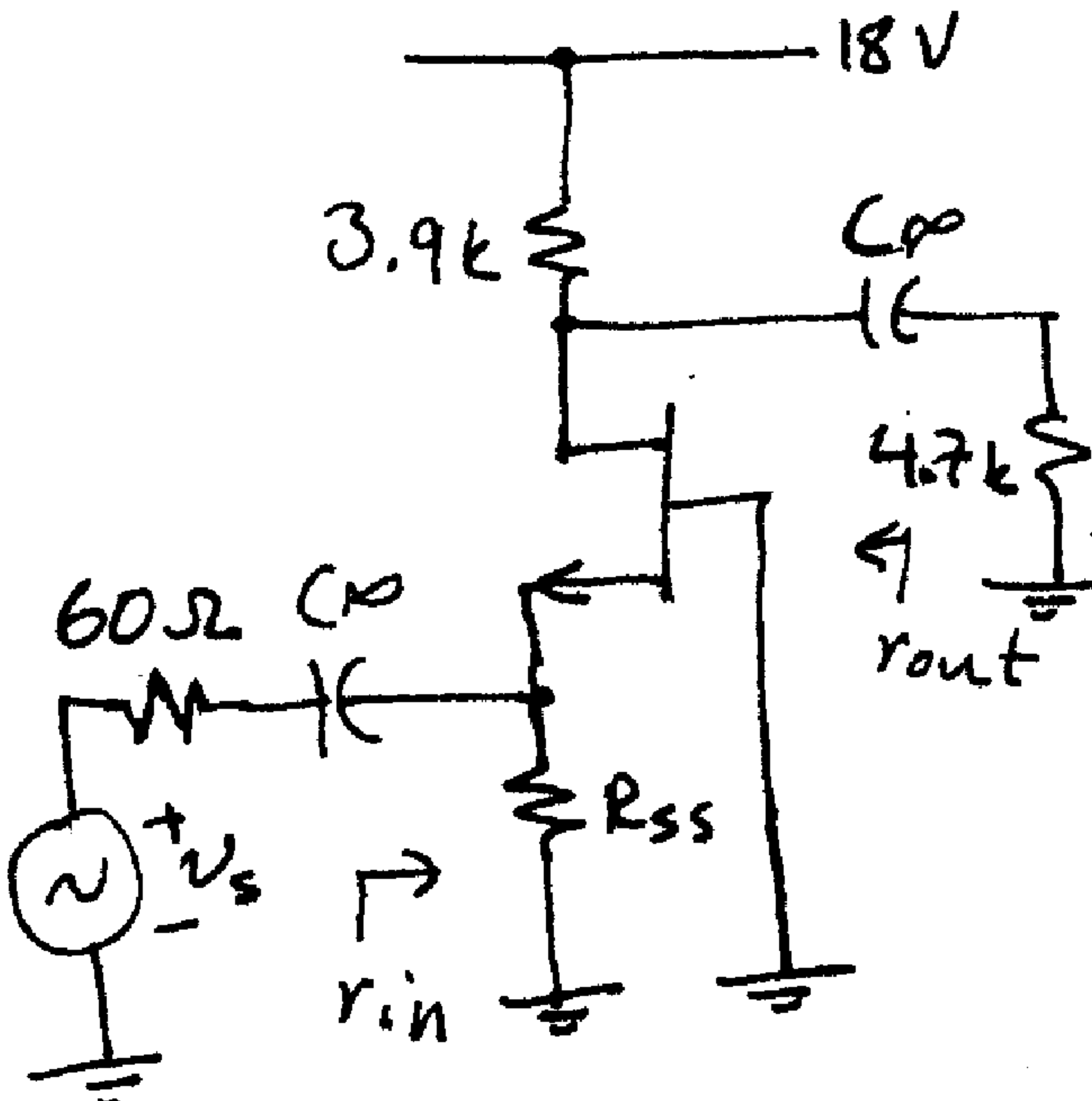
$$\frac{v_o}{v_s} = \frac{v_o}{v_i} \frac{v_i}{v_s} = -96.31 \times 0.729 = -70.21$$

2) The JFET in the ckt below has $I_{DSS} = 10\,mA$, $V_p = -1V$, $I_D = 1.5\,mA$

a) Find R_{SS}

b) Obtain a small-signal equivalent circuit for the entire amplifier

c) Find the voltage gain, input resistance, and output resistance.



$R_{SS} = \underline{400\,\Omega}$

$r_{in} = \underline{97.6\,\Omega}$

$r_{out} = \underline{3.9\,k\Omega}$

$\frac{v_o}{v_s} = \underline{10.24}$

a) $K = \frac{I_{DSS}}{V_p^2} = \frac{10}{1} = 10\,mA/V^2$

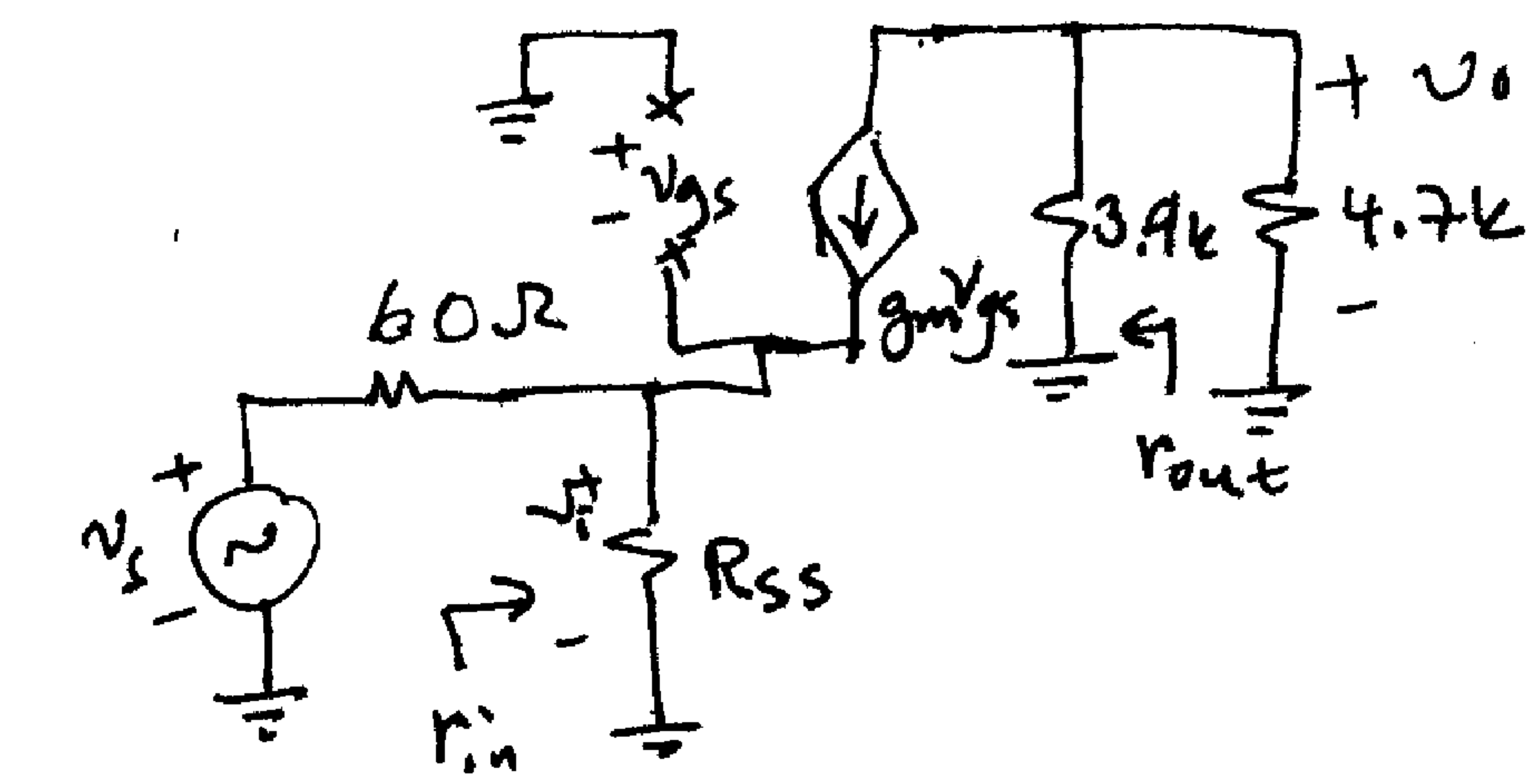
$I_D = K(V_{GS} - V_P)^2$

$V_{GS} = V_p + \sqrt{\frac{I_D}{K}} = -1 + \sqrt{\frac{1.5}{10}} = -0.61\,V$

$I_D R_{SS} + V_{GS} = 0 \rightarrow R_{SS} = \frac{-V_{GS}}{I_D} = \frac{0.61}{1.5} = 0.40\,k\Omega$

$g_m = 2\sqrt{K I_D} = 2\sqrt{10 \times 1.5} = 7.75\,mA/V$

b)



$r_{in} = R_{SS} \| \frac{1}{g_m} = 0.4 \| \frac{1}{7.75} = 0.0976\,k\Omega$

$= 97.6\,\Omega$

$r_{out} = 3.9k$

$v_i + v_{gs} = 0$, $v_i = -v_{gs}$

c) $\frac{v_o}{v_i} = g_m (3.9k \| 4.7k) = 7.75\,(3.9 \| 4.7) = 16.51$

$\frac{v_i}{v_s} = \frac{r_{in}}{R_s + r_{in}} = \frac{97.6}{60 + 97.6} = 0.62$

$\frac{v_o}{v_s} = \frac{v_o}{v_i} \frac{v_i}{v_s} = 16.51 \times 0.62 = 10.24$