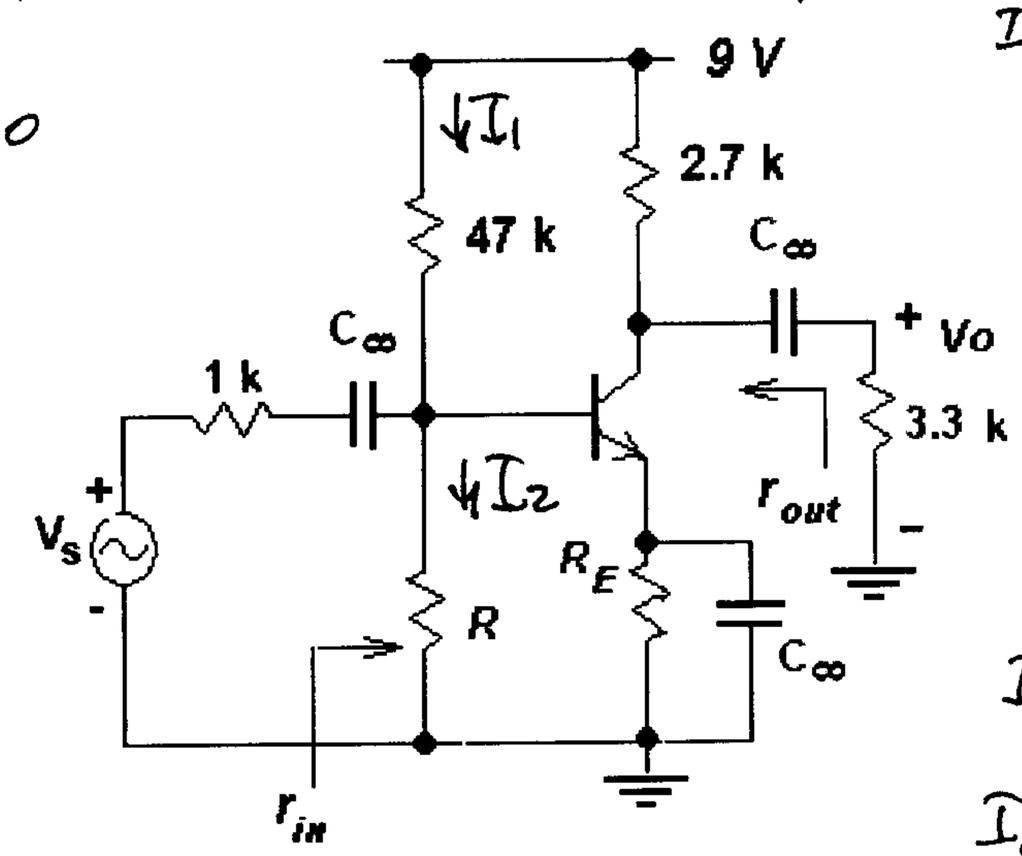
Electronics I * Midterm 2 * December 8, 2009 * 60 Minutes

I have neither given nor received unauthorized help with this exam, nor do I have reason to believe that anybody else has.

ID No: ERKAYA *Name:* SOLUTIONS *Signature:* _____

1) The BJT in the amplifier circuit below has I_C =1.5 mA and V_{CE} = 2.5 V. What should be the values of R and R_E? Calculate the input resistance, output resistance and voltage gain of the amplifier circuit. (Assume silicon BJT with β=200) $V_A = 250\,V$

5:30



$I_C \cong I_E$ $\quad (R_E + R_C)I_C + V_{CE} = 9V$

$$R_E = \frac{9 - V_{CE}}{I_C} - R_C$$

$$= \frac{9 - 2.5}{1.5} - 2.7 = 1.63k$$

$$V_B = I_E R_E + V_{BE}$$

$$= 1.5 \times 1.63 + 0.7 = 3.15V$$

R	26.93k
R_E	1.63k
r_{in}	2.78k
r_{out}	2.7k
v_o / v_s	-65.52

$$I_1 = \frac{9 - 3.15}{47} = 0.1245\,mA$$

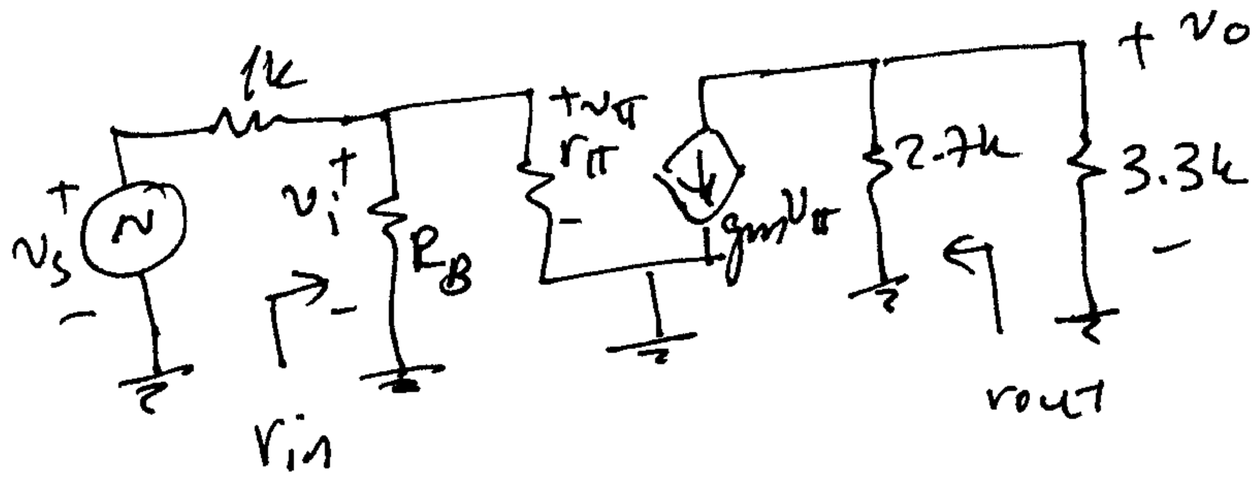
$$I_B = \frac{1.5}{200} = 0.0075\,mA$$

$$I_2 = I_1 - I_B = 0.1170\,mA$$

$$R = \frac{V_B}{I_2} = \frac{3.15}{0.117}$$

$$= 26.93\,k\Omega$$

Small signal Eq. ckt: $r_o \cong \frac{V_A}{I_C} = \frac{750}{1.5} = 500k\Omega \gg R_C \Rightarrow$ ignore r_o



$$g_m = \frac{1.5}{0.025} = 60\,mA/V$$

$$r_\pi = \frac{\beta}{g_m} = \frac{200}{60} = 3.33k\Omega$$

$$R_B = R \| 47k = 26.93 \| 47 = 17.12k\Omega$$

$$r_{in} = r_\pi \| R_B = 3.33 \| 17.12 = 2.78k\Omega$$

$$r_{out} = 2.7k\Omega$$

$$\frac{v_o}{v_s} = \frac{v_o}{v_i}\,\frac{v_i}{v_s}$$

$$= -89.1 \times 0.735 = -65.52$$

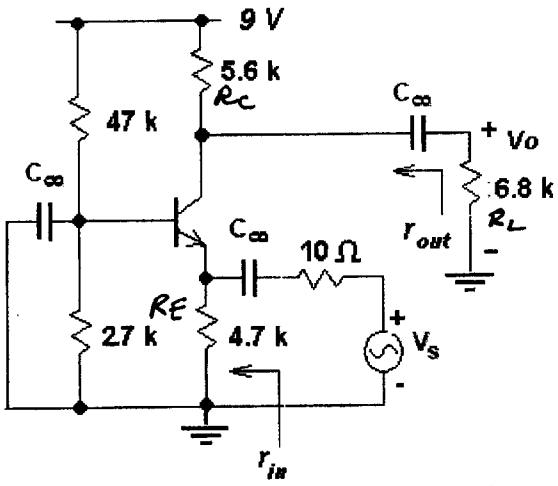
$$\frac{v_o}{v_i} = -g_m (2.7 \| 3.3)$$

$$= -60(2.7 \| 3.3) = -89.1$$

$$\frac{v_i}{v_s} = \frac{r_{in}}{R_s + r_{in}} = \frac{2.78}{1 + 2.78} = 0.735$$

5:40

2) Find the operating point for the silicon BJT in the amplifier circuit below. Calculate the input resistance, output resistance and voltage gain of the amplifier circuit. (Assume β=200, V_A = 500 V)



$V_{TH} = 9\frac{27}{47+27} = 3.28\ V$

$R_{TH} = (47 \| 27)\ k\Omega = 17.15\ k\Omega$

$I_c = \frac{\beta (V_{TH} - V_{BE})}{(\beta+1)R_E + R_{TH}}$

$= \frac{200(3.28-0.7)}{201 \times 4.7 + 17.15} = 0.54\ mA$

I_c	0.54 mA
V_{CE}	3.47
r_{in}	46.1 Ω
r_{out}	5.6 kΩ
$\frac{v_o}{v_s}$	54.39

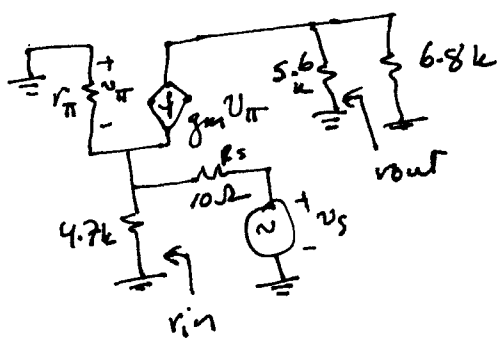
$I_c \cong I_E$,

$V_{CE} = 9 - 0.54(5.6+4.7) = 3.47V$

$g_m = \frac{I_c}{V_T} = \frac{0.54}{0.025}$

$= 21.6\ mA/V$

Small Signal Eq. Ckt:



$r_o \cong \frac{V_A}{I_c} = \frac{500}{0.54} = 926\ k\Omega$

$r_o \gg R_c$ → ignore r_o

$r_\pi = \frac{\beta}{g_m} = \frac{200}{21.6} = 9.26\ k\Omega$

$r_{in} = 4.7 \| \frac{9.26}{201}\ k\Omega$

$\cong 46.1\ \Omega$

$r_{out} \cong R_c = 5.6\ k\Omega$

$\frac{v_o}{v_s} = \frac{v_o}{v_i}\frac{v_i}{v_s}$

$\frac{v_i}{v_s} = \frac{r_{in}}{R_s + r_{in}} = \frac{46.1}{10+46.1} = 0.82$

$\frac{v_o}{v_i} = g_m(R_c \| R_L) = 21.6(5.6 \| 6.8) = 66.33$

$\frac{v_o}{v_s} = 66.33 \times 0.82 = 54.39$