ECE 321 - Quiz #3 - Name ____________________

BJT Amplifiers & 2-Port Models

1) BJT Amplifier: DC Analysis. Determine the Thevenin equivalent of R1 and R2 as well as the Q-point. Assume ideal silicon transistors:

- |Vbe| = 0.7V
- $\beta = 40$
- R2 = 1100 + 100*(your birth month) + (your birth day). May 14th would give R = 1614 Ohms

R2 1100 + 100*mo + day	Vb	Rb	Vce	Ic
1614	**1.668V**	**1390**	**9.17V**	**311uA**

$$R_b = R_1 || R_2 = 1390\Omega$$

$$V_b = \left(\frac{R_2}{R_1+R_2}\right) 12V = 1.668V$$

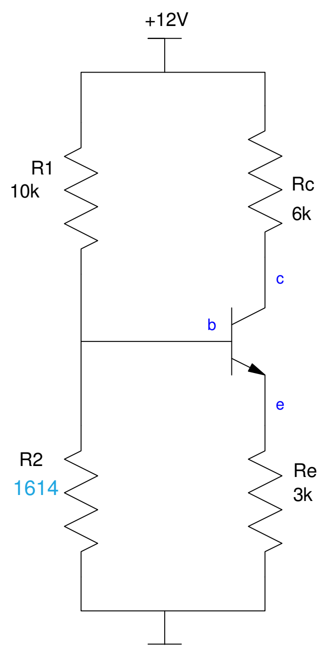
$$I_b = \left(\frac{1.668V-0.7V}{1390+41 \cdot 3k}\right) = 7.77\mu A$$

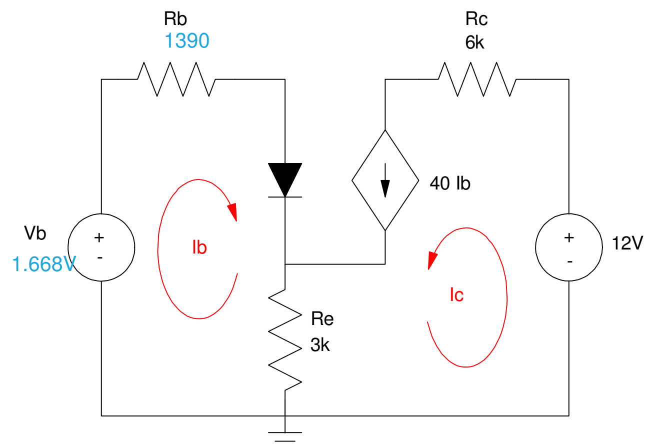
$$I_c = 40 I_b = 311.1\mu A$$

$$V_c = 12 - 6k \cdot I_c = 10.133V$$

$$V_e = 3k \cdot (I_b + I_c) = 0.9568V$$

$$V_{ce} = V_c - V_e = 9.17V$$





2) BJT Amplifier: DC Design. Determine R1 and R2 so that

- The Q point is Vce = 6.00V and
- The Q point is stabilized for variations in β

Assume

- Ideal silicon transistors (Vbe = 0.7V, $\beta = 40$)
- Rc = 1100 + 100*(birth month) + (birth day). May 14th gives Rc = 1614 Ohms

Rc 1100 + 100*mo + day	R1	R2	Vb	Rb
1614	**22.43k**	**4.86k**	**2.1395V**	**4k** << 41k

$$6V = R_c I_c + R_e(I_b + I_c)$$

$$I_c = \left(\frac{6V}{1614+3000\left(1+\frac{1}{40}\right)} \right) = 1.280mA$$

$$I_b = \frac{I_c}{40} = 31.99\mu A$$

To stabilize the Q-point

$$R_b << (1+\beta)R_e = 41k\Omega$$

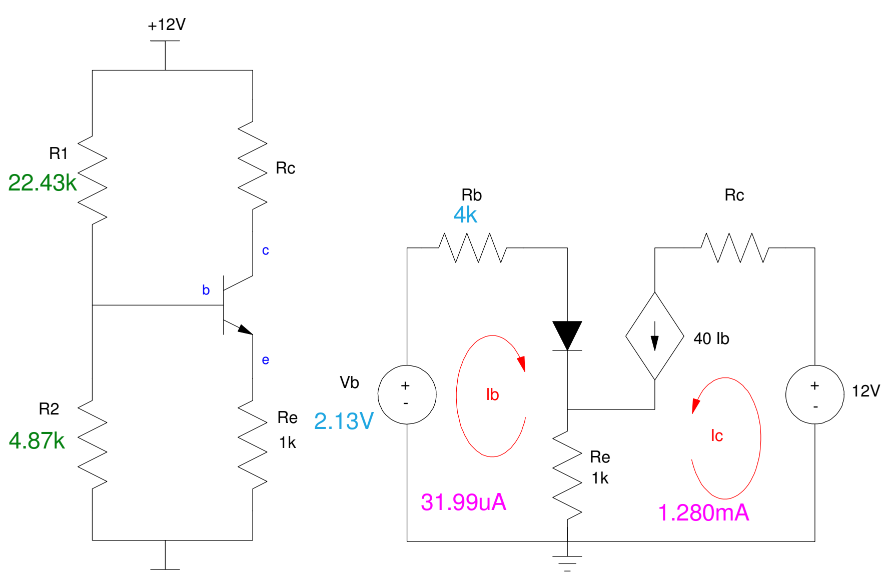
Let Rb = 4k

$$V_b = I_b R_b + 0.7 + R_e(I_e + I_c) = 2.1395V$$

Solve for R1 and R2

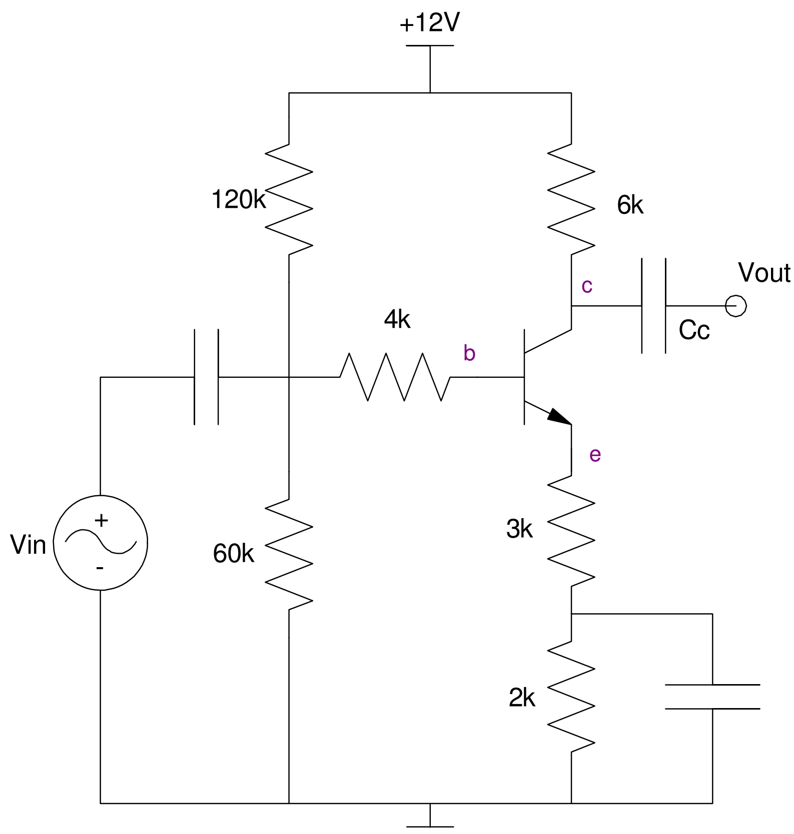
$$R_1 = \left(\frac{12V}{2.1395V}\right) 4k = 22.43k\Omega$$

$$R_2 = 4.8679k\Omega$$

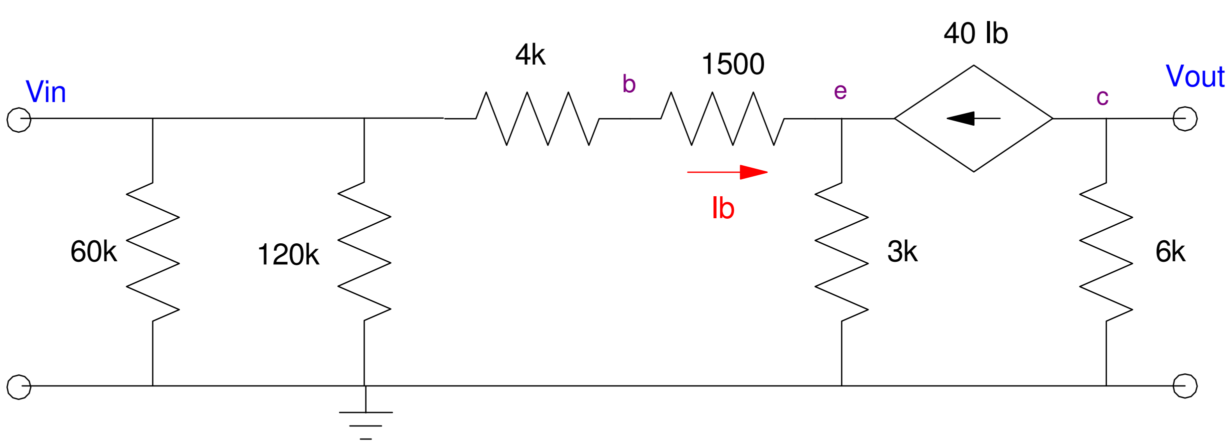


3) BJT: AC Analysis: Draw the small signal model for the following BJT amplifier. Assume

- $r_f = 1500\Omega$
- $\beta = 40$

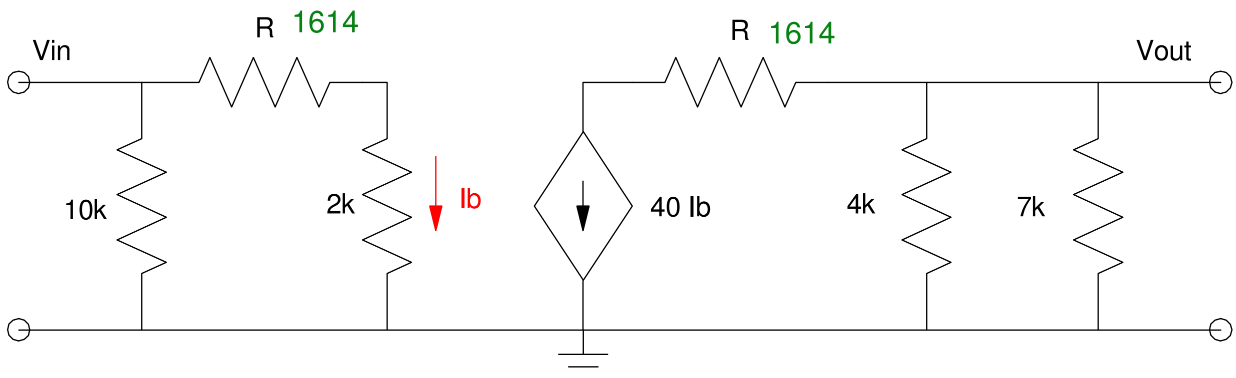


answer:



4) 2-Port Models. Determine the 2-port model for the following circuit:

R 1100 + 100*mo + day	Rin	Ain	Rout	Ao
1614	**2655** varies with R	**0**	**2524**	**-28.17** varies with R



$$R_{in} = 10k||(1614 + 2000) = 2655\Omega$$

$$A_{in} = 0$$

$$R_{out} = 4k||7k = 2524\Omega$$

$$A_o = -\left(\frac{1}{1614+2000}\right)(40)(4k||7k) = -28.17$$

5) 2-Port model (experimental): Determine the 2-port parameters based upon the following experimental data:

Case 1:
- Vin = 1mV @ 1kHz
- R1 = 0 Ohms
- R2 = 10M Ohms

results in Vout = 57mV

Case 2:
- Vin = 1mV @ 1kHz
- R1 = X Ohms
- R2 = 10M Ohms

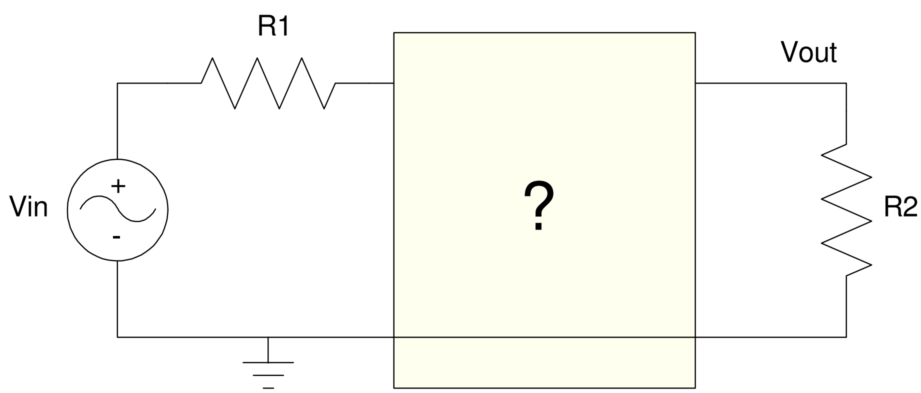
results in Vout = 43mV

Case 3
- Vin = 1mV @ 1kHz
- R1 = 0 Ohms
- R2 = X Ohms

results in Vout = 37mV

Assume
- X = 1100 + 100*(your birth month) + (your birth date) Ohms
- Ai = 0

X 1100 + 100*mo + day	Rin	Ai	Rout	Ao
1614	**4957**	**0**	**872**	**57**



Ao comes from case 1:

$$A_o \approx \left(\frac{57mV}{1mV}\right) 57mV$$

Rin comes from case 2:

$$V_{out} = \left(\frac{R_{in}}{R_1 + R_{in}}\right) 57mV = 43mV$$

$$R_{in} = \left(\frac{43mV}{57mV - 43mV}\right) 1614 = 4957\Omega$$

Rout comes from case 3

$$V_{out} = \left(\frac{R_2}{R_2 + R_{out}}\right) 57mV = 37mV$$

$$R_{out} = \left(\frac{57mV - 37mV}{37mV}\right) 1614 = 872\Omega 3$$

6) Assume X and Y are related by the following transfer function

$$Y = \left(\frac{100(s+m)}{(s^3+ms^2+ds+10)} \right) X$$

$$x(t) = 4 + 5\cos(mt) + d\sin(mt)$$

where

- m is your birth month (1..12), and
- d is your birth date (1..31)

Find y(t)

m birth month (1..12)	d birth date (1..31)	y(t)
5	**14**	$y(t) = 200 - 52\cos(5t) - 64\sin(5t)$

$$Y = \left(\frac{100(s+5)}{(s^3+5s^2+14s+10)} \right) X$$

$$x(t) = 4 + 5\cos(5t) + 14\sin(5t)$$

DC:

s = 0

$$Y = \left(\frac{100(s+5)}{(s^3+5s^2+14s+10)} \right)_{s=0} \cdot (4) = 200$$

AC:

s = j5

$$Y = \left(\frac{100(s+5)}{(s^3+5s^2+14s+10)} \right)_{s=j5} \cdot (5 - j14) = -52.00 + j64.00$$

$$y(t) = -52\cos(5t) - 64\sin(5t)$$

Total answer

$$y(t) = 200 - 52\cos(5t) - 64\sin(5t)$$