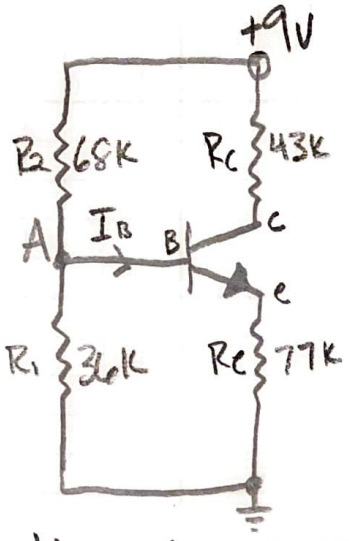
Gabriel Emerson gte0002 | BJT HW2 Due 2/22

1.) 5.82(a)



$V_{eq} = \frac{V_{cc} R_1}{R_1 + R_2} \Rightarrow 9\left(\frac{36K}{36K+68K}\right) = 3.115V$

$R_{eq} = \frac{R_1 R_2}{R_1 + R_2} \Rightarrow \frac{(68K)(36K)}{68K+36K} \Rightarrow 23.539K\Omega$

$I_B = \frac{V_{eq} - V_{BE}}{R_{eq} + (\beta_f + 1)R_e} = 0.878mA$

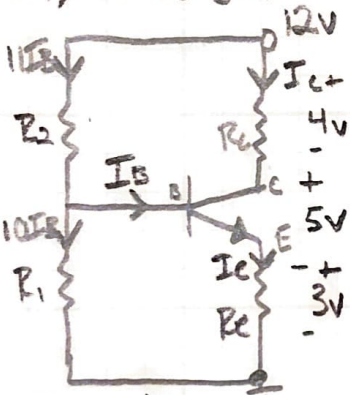
$I_C = \beta_f I_B = 100 \cdot 1.72mA = 88mA$

$V_{CE} = V_{cc} - R_c I_c - R_e I_e \Rightarrow V_{CE} = 2.813V$

$I_c = I_B(\beta_f + 1) \Rightarrow 101(88) = 89mA$

$Q_{point} = 88mA, 2.813V$

2.) 5.90(a)



$V_{BE} = \phi_t \ln\left(\frac{I_c}{I_s}\right) = 0.713V$

$I_B = \frac{I_c}{\beta_f} = \frac{1mA}{100} = 10mA$

$I_c = I_B(\beta_f + 1) = 1.01mA$

$R_c = \frac{3V}{1.01mA} = 2.97K\Omega$

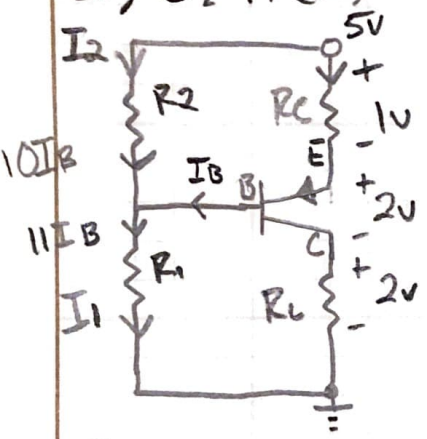
$R_c = \frac{4V}{1mA} = 4K\Omega$

$V_B = V_{BE} + V_E \Rightarrow 0.713 + 3.0 = 3.713V$

$R_1 = \frac{V_b}{10I_b} = \frac{3.713}{10(10mA)} = \boxed{37.13K\Omega}$

$R_2 = \frac{V_{cc} - V_b}{11I_B} = \frac{12 - 3.713}{11(10mA)} = \boxed{75.34K\Omega}$

3.) 5.91(a)



$V_{EB} = \phi_t \ln\left(\frac{I_c}{I_s}\right) = 0.0258 \ln\left(\frac{850}{10^{-15}}\right) = 0.709\,V$

$I_B = \frac{I_c}{\beta_f} = \frac{850m}{100} = 8.5\,mA$

$I_c = I_c + I_B \Rightarrow 850 + 8.5 = 858.5\,mA$

$I_2 = 10 I_B = 10(8.5) = 85\,mA$

$I_1 = 11 I_B = 11(8.5) = 93.5\,mA$

$R_e = \frac{V_{RE}}{I_E} = \frac{1}{858mA} = 1.165\,k\Omega \quad R_C = \frac{2}{850mA} = 2.352\,k\Omega$

$V_B = V_{CC} - (V_{EB} + V_{RE}) = 5 - (0.709 + 1) = \boxed{3.291\,V}$

$R_1 = \frac{V_B}{I_1} = \frac{3.291}{93.5mA} = \boxed{35.198\,k\Omega}$

$R_2 = \frac{V_{CC} - V_B}{I_2} = \frac{5 - 3.291}{85mA} = \boxed{20.11\,k\Omega}$

5.) $I_C = 5.5\,mA$, $\tau_f = 0.25\,ps$, $Temp = 300k$

$g_m = \frac{1}{\phi_t} I_C = \frac{1}{0.0258} \cdot 5.5 = 213.178\,mS$

$C_{diff} = \tau_f g_m = 0.25 \cdot 213.178 = 53.3\,fF$

$f_{t\,max} = \frac{1}{2\pi \tau_f} = \frac{1}{2\pi(0.25)} = 636.6\,MHz$

5.82(a)

LTspice XVII - [5.90(a).asc]

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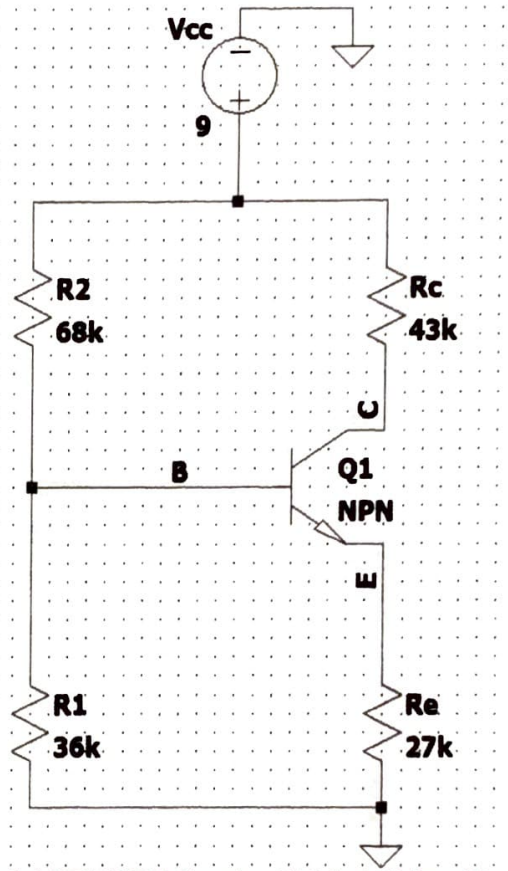
SPICE Error Log: C:\Users\bobog\Desktop\School\Digital Electronics\Homework\BJT HW2\5.90(a).l...

```
Circuit: * C:\Users\bobog\Desktop\School\Digital Electronics\Homework\B

Direct Newton iteration for .op point succeeded.
Semiconductor Device Operating Points:
                        --- Bipolar Transistors ---
Name:         q1
Model:        npn
Ib:        8.96e-07
Ic:        8.96e-05
Vbe:       6.52e-01
Vbc:      -2.06e+00
Vce:       2.71e+00
BetaDC:    1.00e+02
Gm:        3.46e-03
Rpi:       2.89e+04
Rx:        0.00e+00
Ro:        8.29e+47
Cbe:       0.00e+00
Cbc:       0.00e+00
Cjs:       0.00e+00
BetaAC:    1.00e+02
Cbx:       0.00e+00
Ft:        0.00e+00


vce: v(c)-v(e)=2.70729
ic: ic(q1)=8.95505e-005
vbe: v(b)-v(e)=0.652264
ib: ib(q1)=8.95503e-007
ie: -ie(q1)=9.0446e-005


Date: Sat Feb 20 14:57:32 2021
Total elapsed time: 0.066 seconds.
```




```
.model NPN NPN (is=1e-15 bf=100 br=5)
.meas op VCE param V(c)-V(e)
.meas op IC param Ic(Q1)
.meas op VBE param V(b)-V(e)
.meas op IB param Ib(q1)
.meas op IE param -Ie(q1)

.op
```

5.90(a)

LTspice XVII - [5.90(a).asc]

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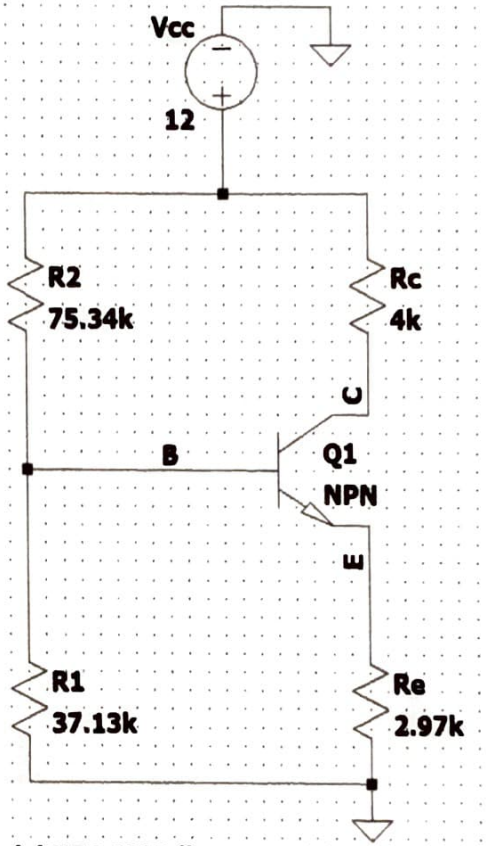
SPICE Error Log: C:\Users\bobog\Desktop\School\Digital Electronics\Homework\BJT HW2\5.90(a).l...

```
Circuit: * C:\Users\bobog\Desktop\School\Digital Electronics\Homework\B

Direct Newton iteration for .op point succeeded.
Semiconductor Device Operating Points:
                         --- Bipolar Transistors ---
Name:         q1
Model:        npn
Ib:        1.00e-05
Ic:        1.00e-03
Vbe:       7.15e-01
Vbc:      -4.29e+00
Vce:       5.00e+00
BetaDC:    1.00e+02
Gm:        3.86e-02
Rpi:       2.59e+03
Rx:        0.00e+00
Ro:        2.67e+05
Cbe:       0.00e+00
Cbc:       0.00e+00
Cjs:       0.00e+00
BetaAC:    1.00e+02
Cbx:       0.00e+00
Ft:        0.00e+00


vce: v(c)-v(e)=5.00352
ic: ic(q1)=0.000999545
vbe: v(b)-v(e)=0.714663
ib: ib(q1)=9.99544e-006
ie: -ie(q1)=0.00100954

Date: Sat Feb 20 14:53:52 2021
Total elapsed time: 0.067 seconds.
```




```
.model NPN NPN (is=1e-15 bf=100 br=5)
.meas op VCE param V(c)-V(e)
.meas op IC param Ic(Q1)
.meas op VBE param V(b)-V(e)
.meas op IB param Ib(q1)
.meas op IE param -Ie(q1)

.op
```

5.91(a)

LTspice XVII - [5.82(a).asc]

File Edit Hierarchy View Simulate Tools Window Help

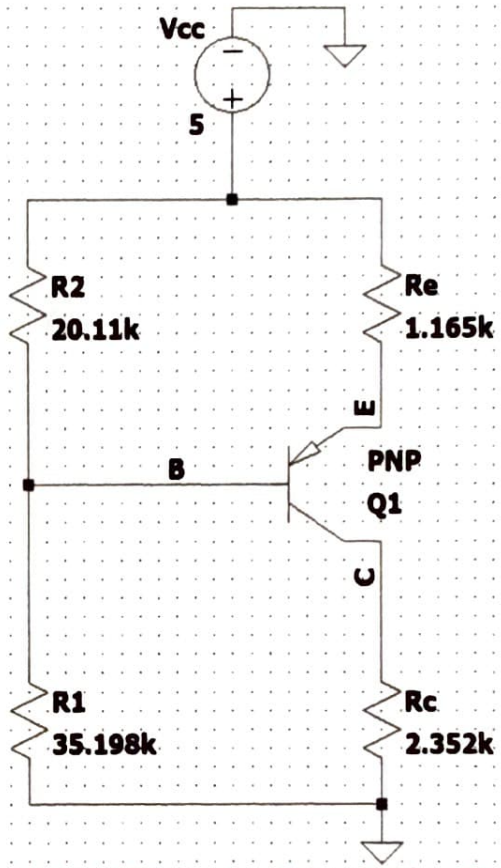
SPICE Error Log: C:\Users\bobog\Desktop\School\Digital Electronics\Homework\BJT HW2\5.82(a).l...

```
Circuit: * C:\Users\bobog\Desktop\School\Digital Electronics\Homework\B

Direct Newton iteration for .op point succeeded.
Semiconductor Device Operating Points:
                        --- Bipolar Transistors ---
Name:        q1
Model:       pnp
Ib:       -8.49e-06
Ic:       -8.49e-04
Vbe:      -7.10e-01
Vbc:       1.29e+00
Vce:      -2.00e+00
BetaDC:    1.00e+02
Gm:        3.28e-02
Rpi:       3.05e+03
Rx:        0.00e+00
Ro:        1.38e+35
Cbe:       0.00e+00
Cbc:       0.00e+00
Cjs:       0.00e+00
BetaAC:    1.00e+02
Cbx:       0.00e+00
Ft:        0.00e+00


vec: v(e)-v(c)=2.00436
ic: -ic(q1)=0.000848962
veb: v(e)-v(b)=0.71044
ib: -ib(q1)=8.48962e-006
ie: ie(q1)=0.000857451


Date: Sat Feb 20 15:05:11 2021
Total elapsed time: 0.064 seconds.
```




```
.model PNP PNP (is=1e-15 bf=100 br=5)
.meas op VEC param V(e)-V(c)
.meas op IC param -Ic(Q1)
.meas op VEB param V(e)-V(b)
.meas op IB param -Ib(q1)
.meas op IE param Ie(q1)

.op
```

Problem 6

LTspice XVII - 5.91(a).asc

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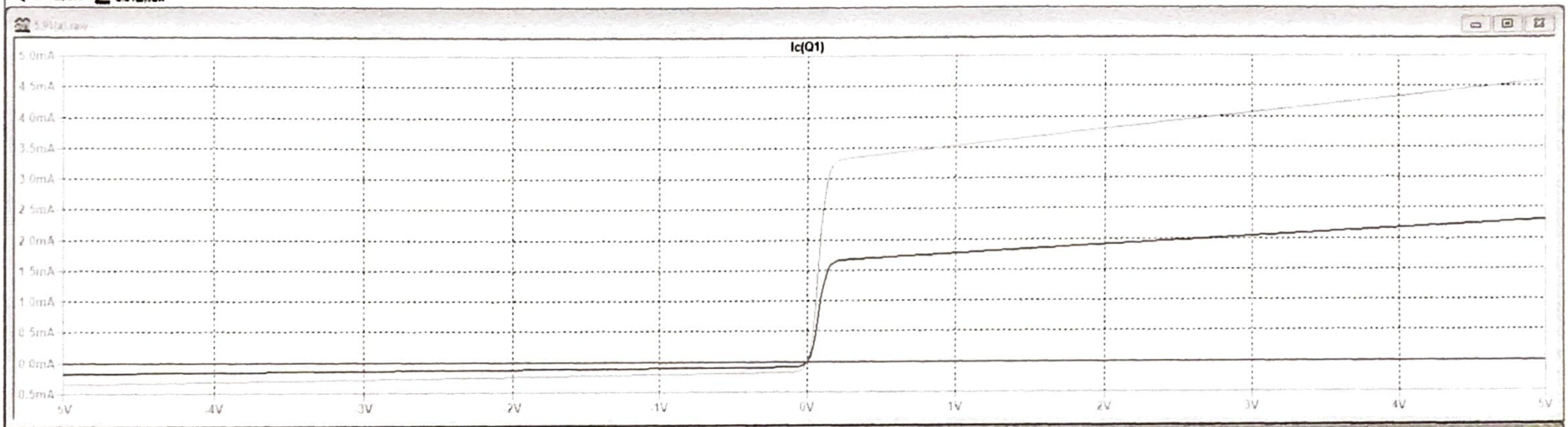
5.91(a).asc 5.91(a).raw



5.91(a).asc