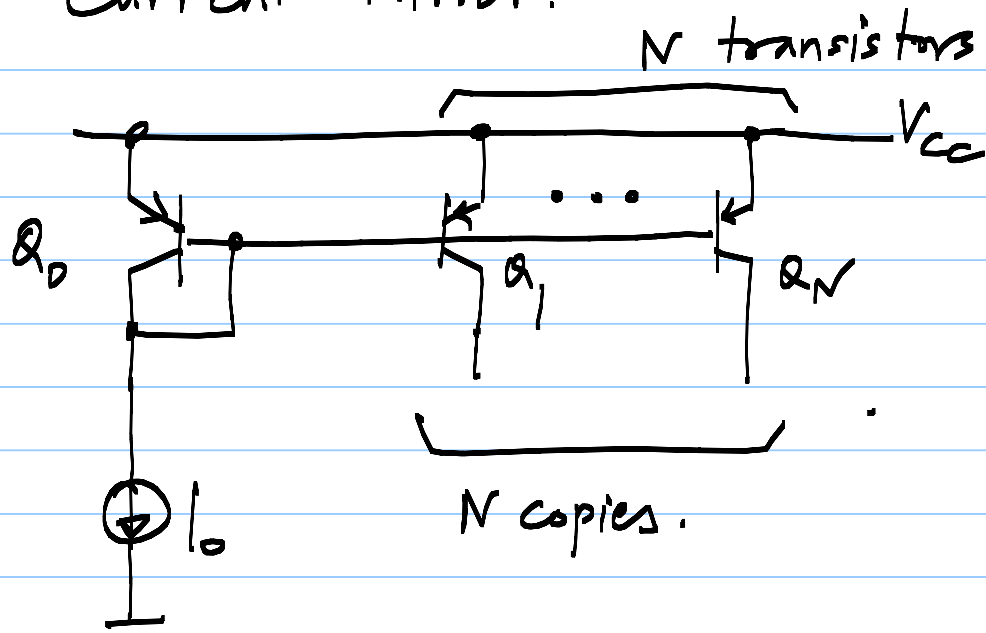
Problem set 8: Bipolar junction transistor circuits

Note Title — 11/15/2012

NPN:	PNP:
$V_{BE,ON} = 0.7V$	$V_{EB,ON} = 0.7V$
$V_{CE,SAT} = 0.7V$	$V_{EC,SAT} = 0.7V$
$V_{AN} = 25V$	$V_{AP} = 25V$
$\beta_N = 100$	$\beta_P = 100$

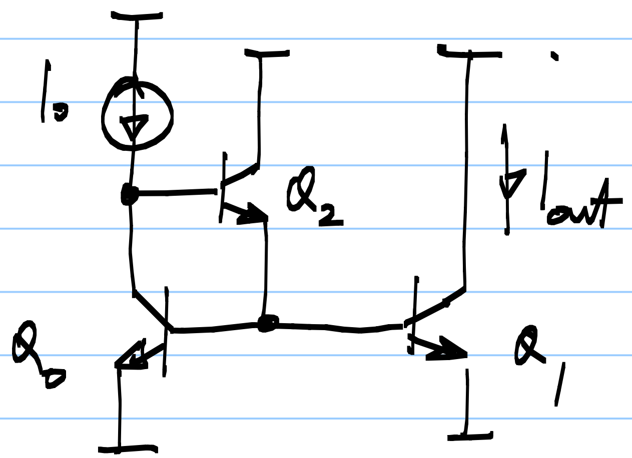
Use $\beta_N = \beta_P = \infty$ and $V_{AN} = V_{AP} = \infty$ for operating point calculations unless otherwise specified.

1. Current mirror:



Assuming $\beta_p = 200$, calculate the maximum number (N) of current sources that can be made while maintaining an error of 5% or less in the copied currents.

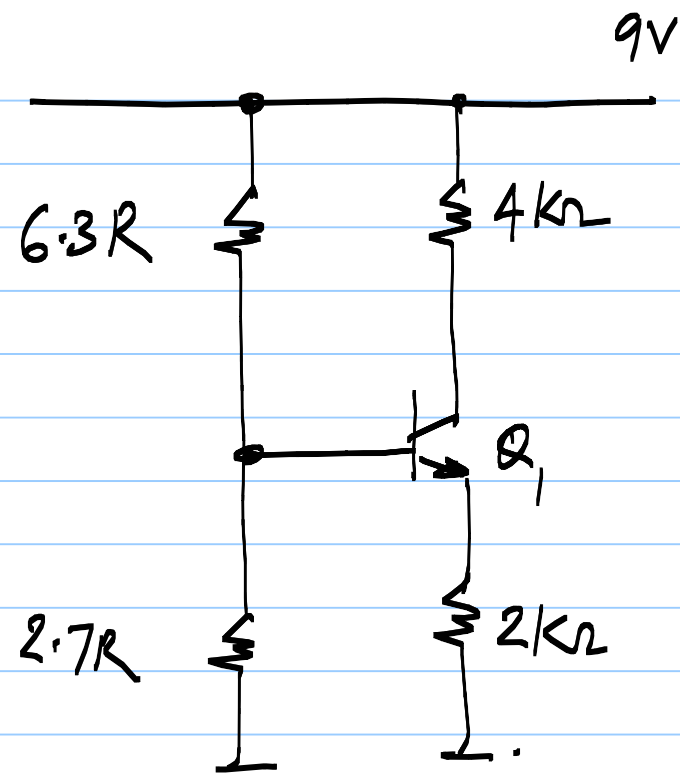
② **Improved current mirror:**



(a) Assuming a finite β_N, calculate I_{out}.

(b) With this arrangement, for $\beta_N = 200$, how many copies of the current can be realized with a 5% or smaller error?

③

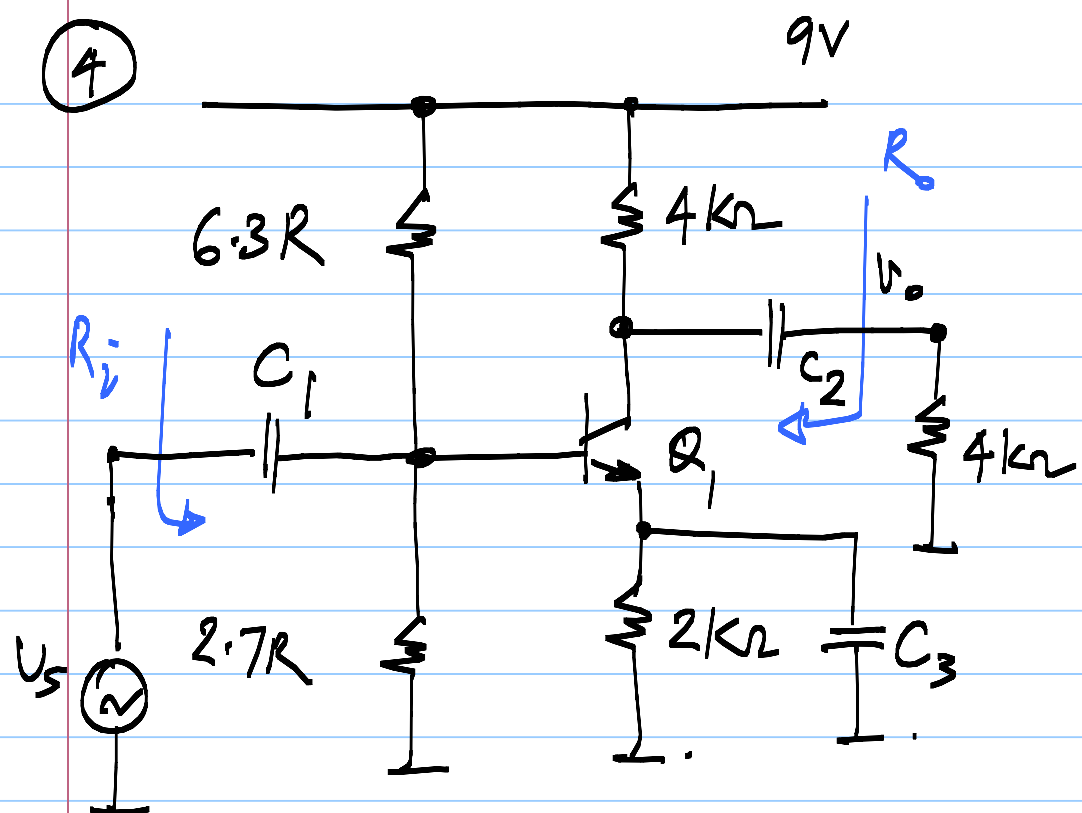


(a) operating point:

Calculate I_C, $V_{CE,SAT}$ of Q_1

(b) Assuming $\beta_F = 100$, calculate R such that the shift in base voltage (compared to $\beta_F = \infty$) is 50mV or less.

(4)



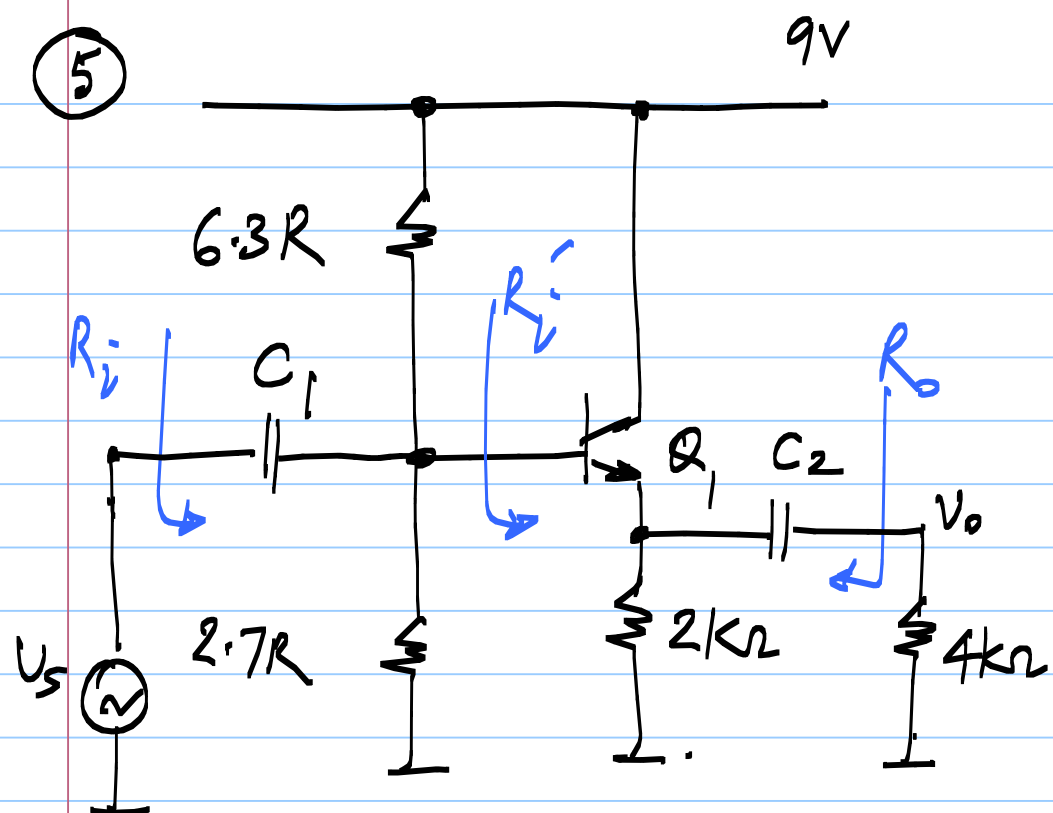
($\beta_N = 100$)

With the value of R calculated in the previous problem, calculate:

$\frac{v_o}{v_s}$, R_i, R_o and swing limits on v_s such that Q_1 stays within the active region and away from cutoff ($I_{sat} = 0$)

C_1, C_2, C_3 are very large

(5)



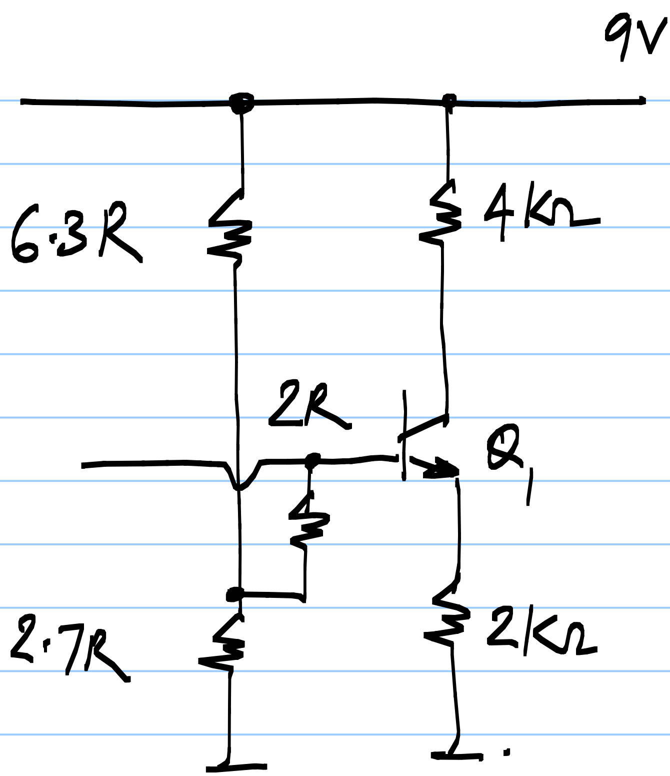
($\beta_N = 100$)

With the value of R calculated in problem (3) calculate:

$\frac{v_o}{v_s}$, R_i, R_i', R_o and swing limits on v_s such that Q_1 stays within the active region and away from cutoff ($I_{C,sat} = 0$)

C_1, C_2 are very large.

(6)

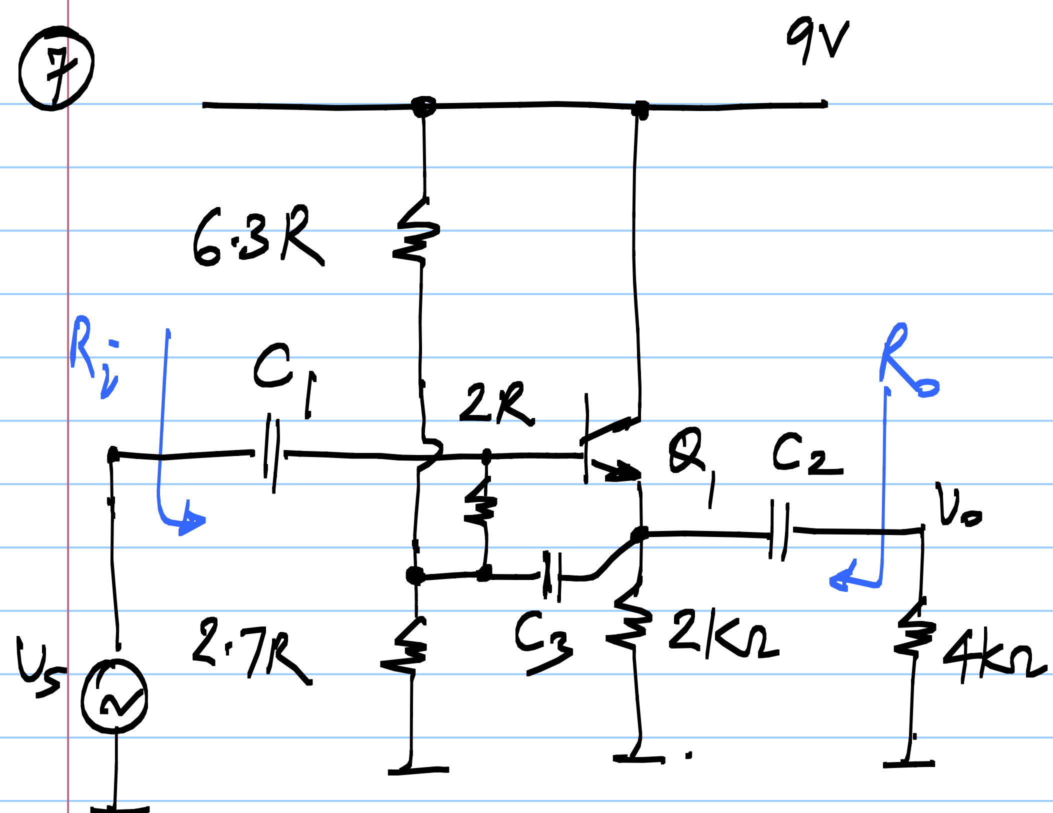


(a) operating point:

Calculate I_C, $V_{CE,SAT}$ of Q_1

(b) Assuming $\beta_N = 100$, calculate R such that the shift in base voltage (Compared to $\beta_N = \infty$) is 50mV or less.

⑦



($\beta_N = 100$)

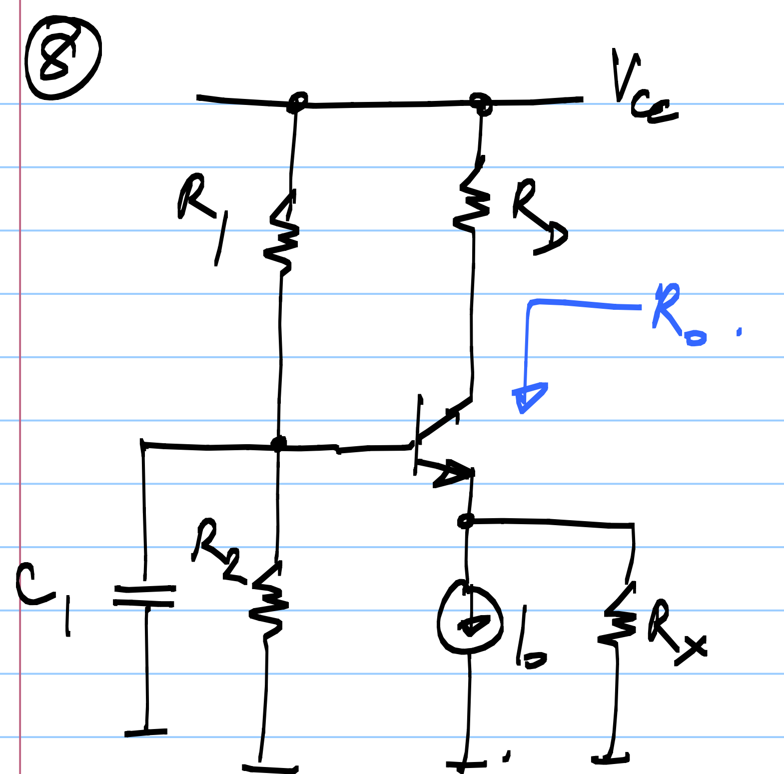
With the value of R calculated in problem ⑥ calculate:

$\frac{v_o}{v_s}$, R_i, R_o and swing limits on v_s such that Q_1 stays within the active region and away from cutoff ($I_{Csat} = 0$)

C_1, C_2, C_3 are very large; Compare to P⑤

[Repeat this for $R_x = \infty$ and finite R_x]

(8)



With finite β_F and V_A, calculate the output resistance R_o. This circuit could represent a common-base amplifier or a voltage controlled current source as seen from the output. Compare it to the analogous MOS transistor circuit.