Department of Computer Science and Engineering (CSE)
BRAC University

Practice Problem Set 6

CSE251 – Electronic Devices and Circuits

BJT Circuits

Logic Function Implementation, Modes of Operation, Method of Assumed States, Multistage Circuits, MOSFET-BJT Hybrid Problems

Course Description, COs, and Policies

Midterm and Final Questions

For any error or issues, contact purbayan.das@bracu.ac.bd

Problem 1

- Give a switch-BJT implementation of the following logic functions. A, B, C, D, E, and F are Boolean inputs.

I. $f = A.B.C + D.E$

II. $f = \overline{A.B.(C + D)}$

III. $f = A.B + \bar{A}.\bar{B}$

IV. $f = \overline{A.C} + \overline{B + C}$

V. $f = (A.B + C).D$

VI. $f = A.B + C.D$

VII. $f = A.B.C + D$

VIII. $f = (A + B).(C + D)$

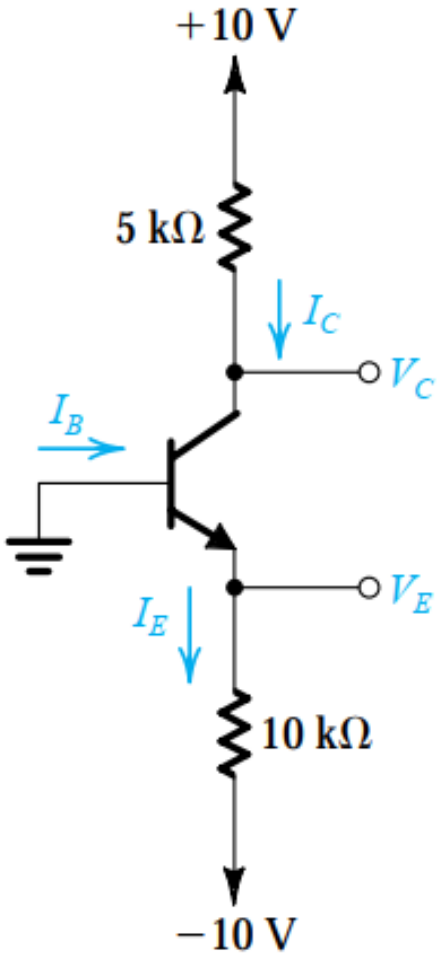
IX. $f = (A.B + C).D.(E + F)$

X. $f = A \oplus B$

XI. $f = \overline{C.(A + B)}.(A + \bar{B} + C)$

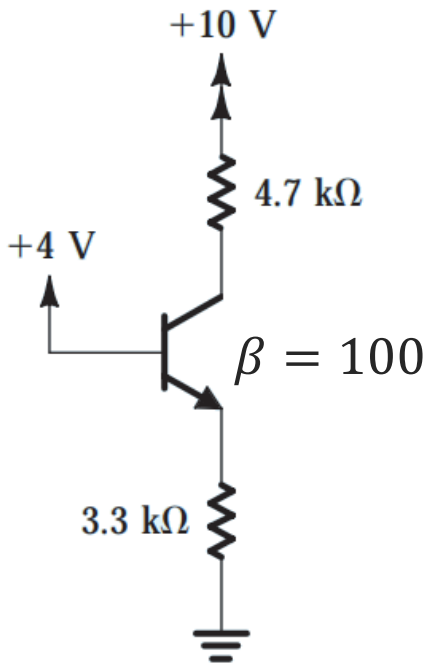
Problem 2

- For the adjacent circuit, V_E was measured and found to be $-0.7\ V$. If $\beta = 50$, determine I_E, I_B, I_C, and V_C.

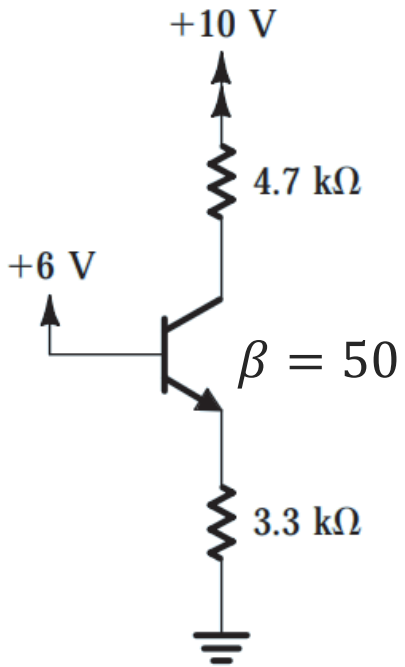


Problem 3

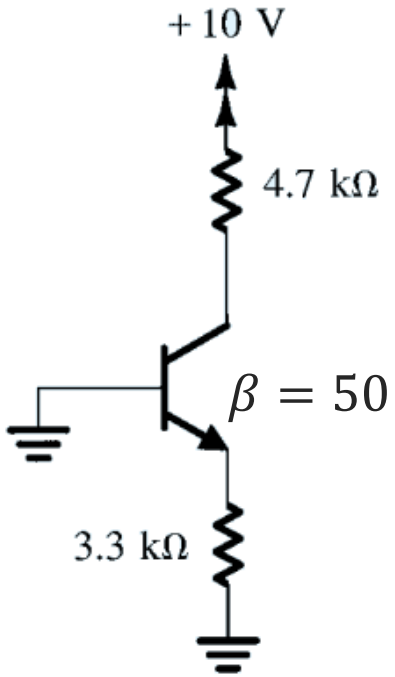
- Determine and verify the operating region for each of the transistors in the following circuits. Assume $V_{BE,\,active} = 0.7\,V$, $V_{BE,\,sat} = 0.8\,V$, and $V_{CE,\,sat} = 0.2\,V$.



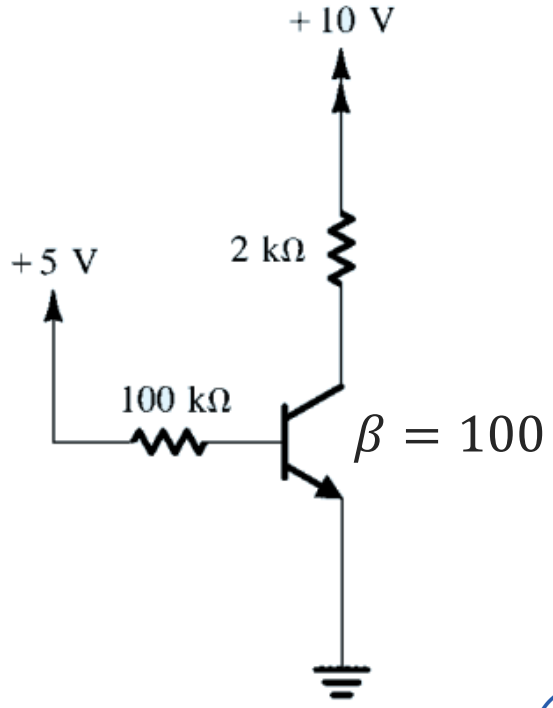
(a)



(b)



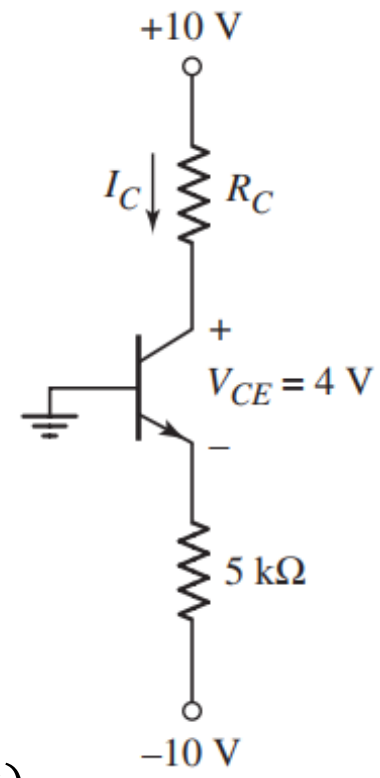
(c)



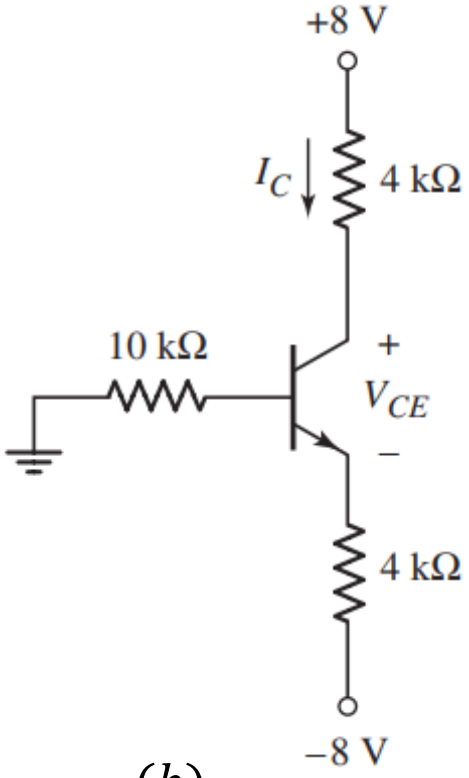
(d)

Problem 4

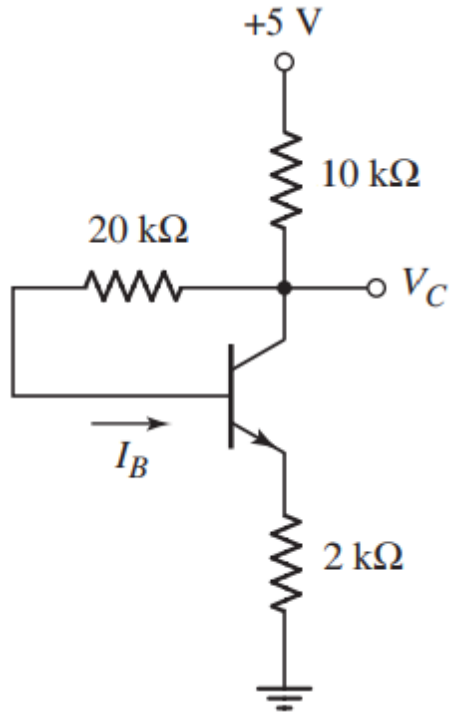
- For the NPN transistors in the following circuit, $\beta = 75$, $V_{BE,\,active} = 0.7\,V$, $V_{BE,\,sat} = 0.8\,V$, and $V_{CE,\,sat} = 0.2\,V$. Determine the labeled quantities.



(a)



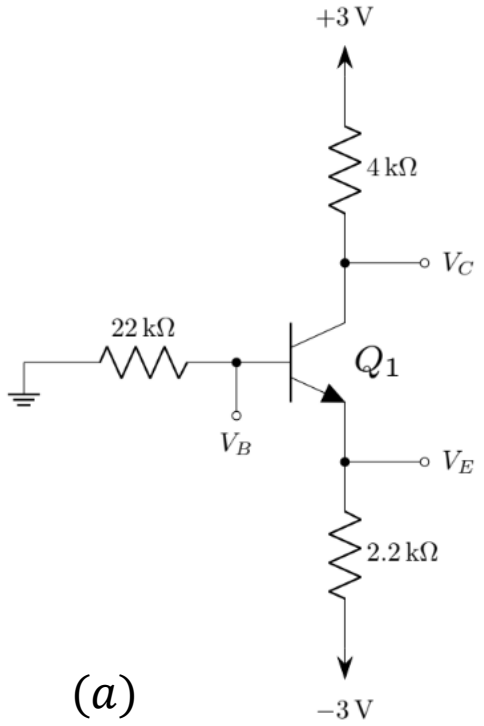
(b)



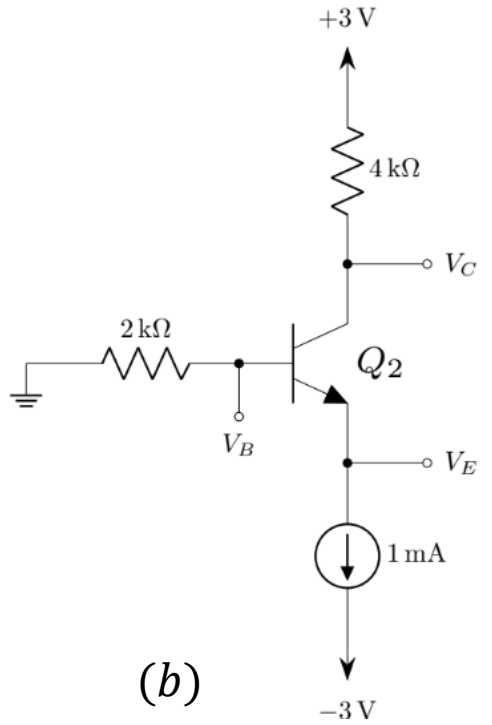
(c)

Problem 5

- For the transistors in the following circuits, $\beta = 100$, $V_{BE,\,active} = 0.7\,V$, $V_{BE,\,sat} = 0.8\,V$, and $V_{CE,\,sat} = 0.2\,V$.
  a) Show that the transistor is in neither cut-off, saturation, nor active mode.
  b) Determine V_B. V_C, and V_E. *[Hint for (b): $V_{BC} = V_{BE} - V_{CE}$]*



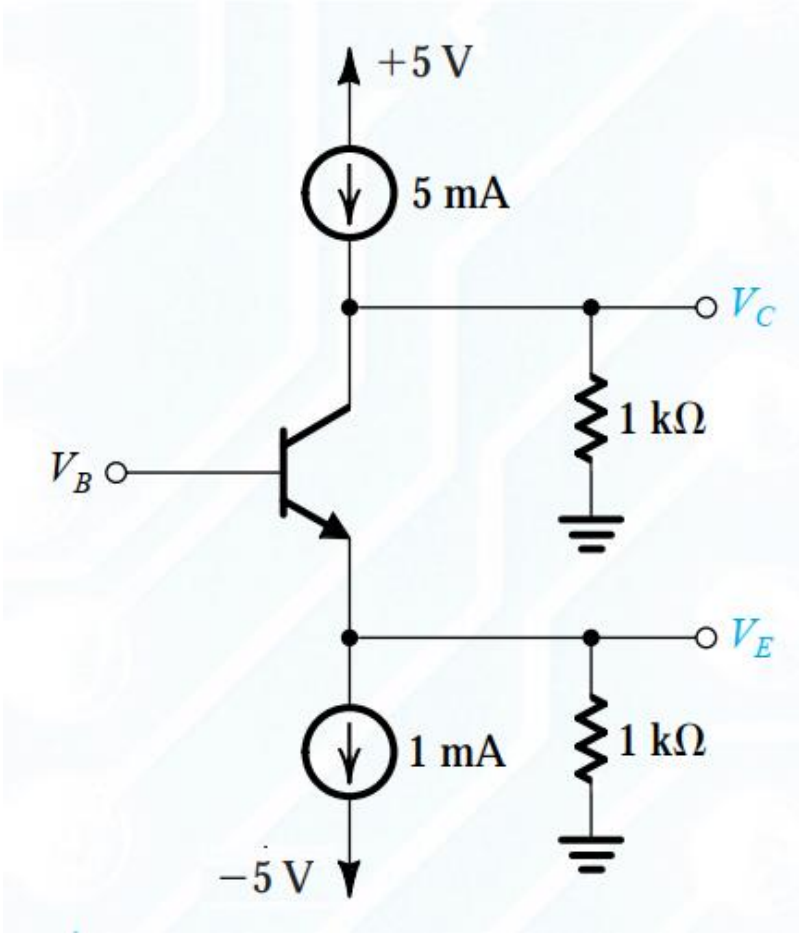
(a)



(b)

Problem 6

- For the adjacent circuit, assume $\alpha \approx 1$ and $\mathrm{V_{BE}} = 0.7\,V$ at the edge of saturation. What are the values of V_C and V_E if $V_B = 0\,V$? For what values of V_B does the transistor operates in
  I. cut-off and
  II. saturation.



Problem 7

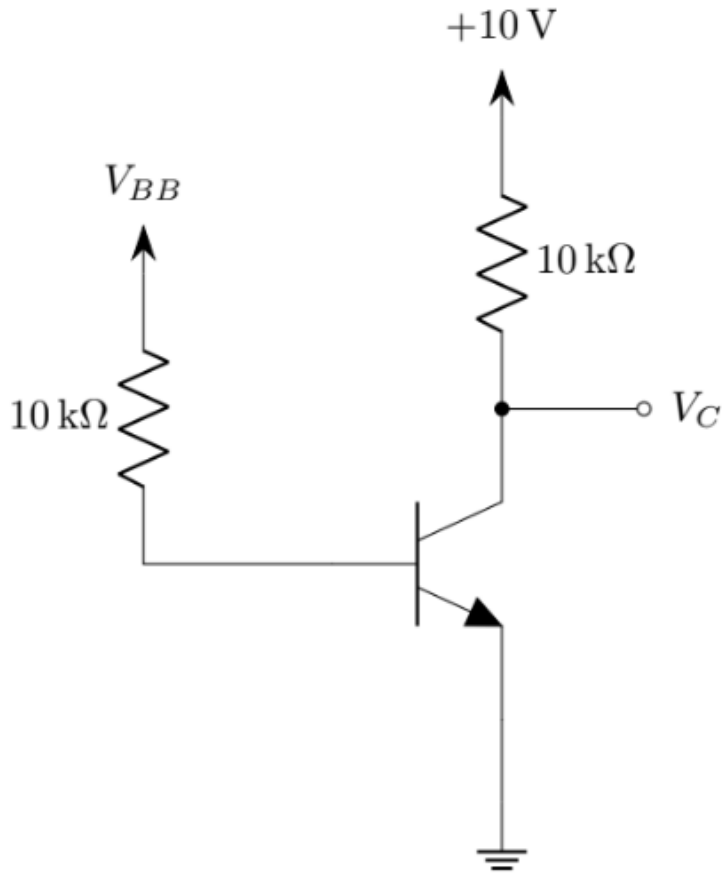
- For the adjacent circuit, assume that V_{BE} remains constant at $0.7\,V$ when the transistor is ON. The transistor β is specified to be 50. Determine the value of V_{BB} that results in the transistor operating:

  I. in the active region with $V_{CE} = 5\,V$,

  II. at the edge of saturation, and

  [Hint: at the edge of saturation, β is still 50 and assume $V_{CE} = 0.3\,V$.]

  III. deep in saturation with $\beta_{forced} = 10$ and $V_{CE} = 0.2\,V$.



Problem 8

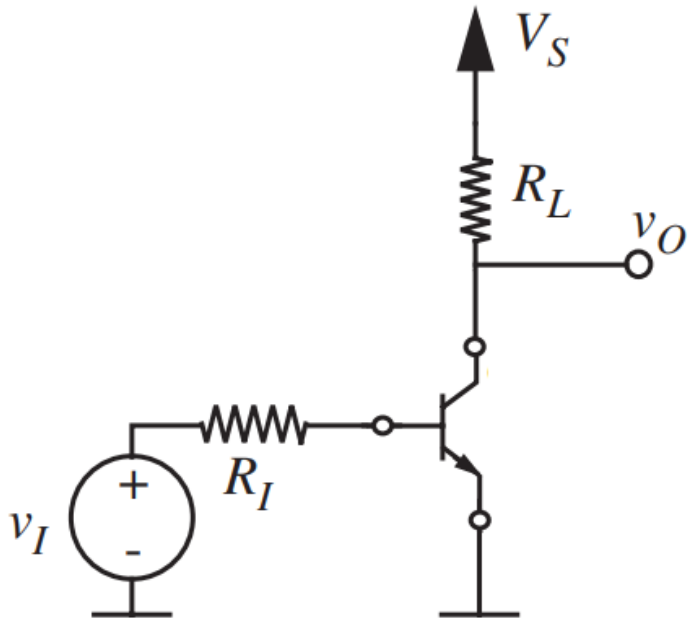
- For the following circuit, $V_S = 5\,V$, $R_L = 10\,k\Omega$, and $R_I = 500\,k\Omega$. Assume $\beta = 100$ for the transistor, $V_{BE,\,active} = V_{BE,\,sat} = 0.6\,V$, and $V_{CE,\,at\ the\ edge\ of\ sat} = V_{CE,\,sat} = 0.2\,V$.

I. Derive an expression relating v_O and v_I assuming the transistor is in active mode.

II. What is the highest value of v_I for which the transistor operates in cut-off.

III. What is the highest (or lowest) value of v_I for which the transistor operates in its active region (or enters into its saturation region). What are the corresponding range for v_O? *[$\beta = 100$ at the edge of saturation]*

IV. Based on the relation found in I and values of v_I and v_O found in II and III, draw the VTC ($v_O\ vs.\ v_I$) graph for the circuit.



Problem 9

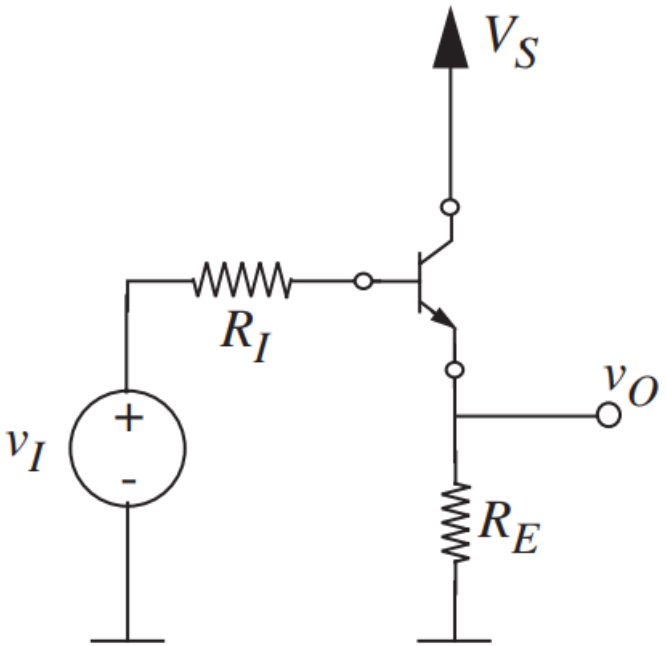
- For the following circuit, $V_S = 10\ V$, $R_E = 100\ k\Omega$, and $R_I = 10\ k\Omega$. Assume $\beta = 100$ for the transistor, $V_{BE,\,active} = V_{BE,\,sat} = 0.6\ V$, and $V_{CE,\,at\ edge\ of\ sat} = V_{CE,\,sat} = 0.2\ V$.

I. Derive an expression relating v_O and v_I assuming the transistor is in active mode..

II. What is the highest value of v_I for which the transistor operates in cut-off.

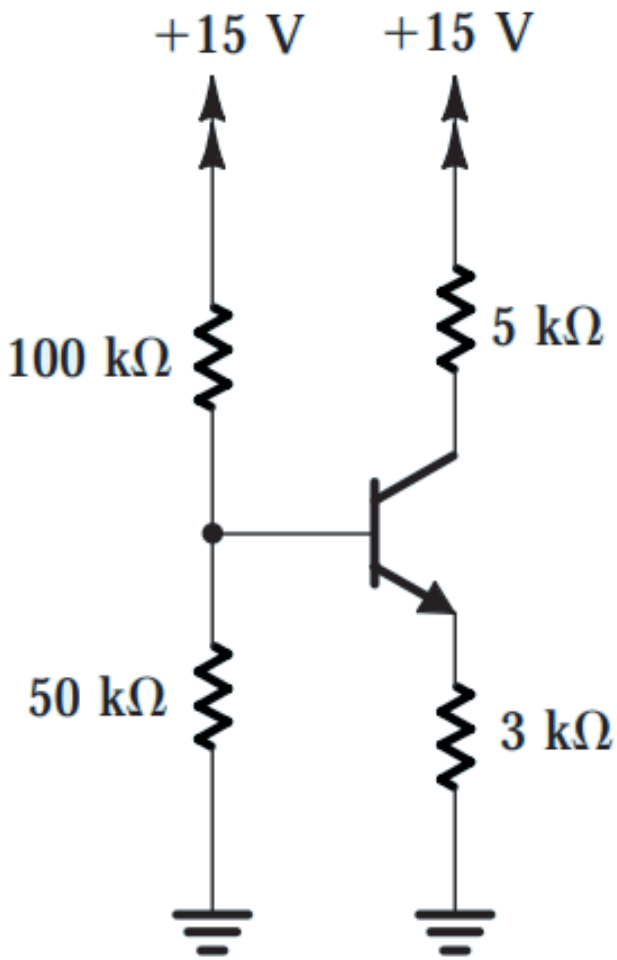
III. What are the highest (or lowest) values of v_I for which the transistor remains in its active region (or operates at the edge of saturation). What are the corresponding range for v_O? *[$\beta = 100$ at the edge of saturation]*

IV. Based on the expression found in I and values of v_I and v_O found in II and III, draw the VTC ($v_O\ vs.\ v_I$) graph for the circuit.



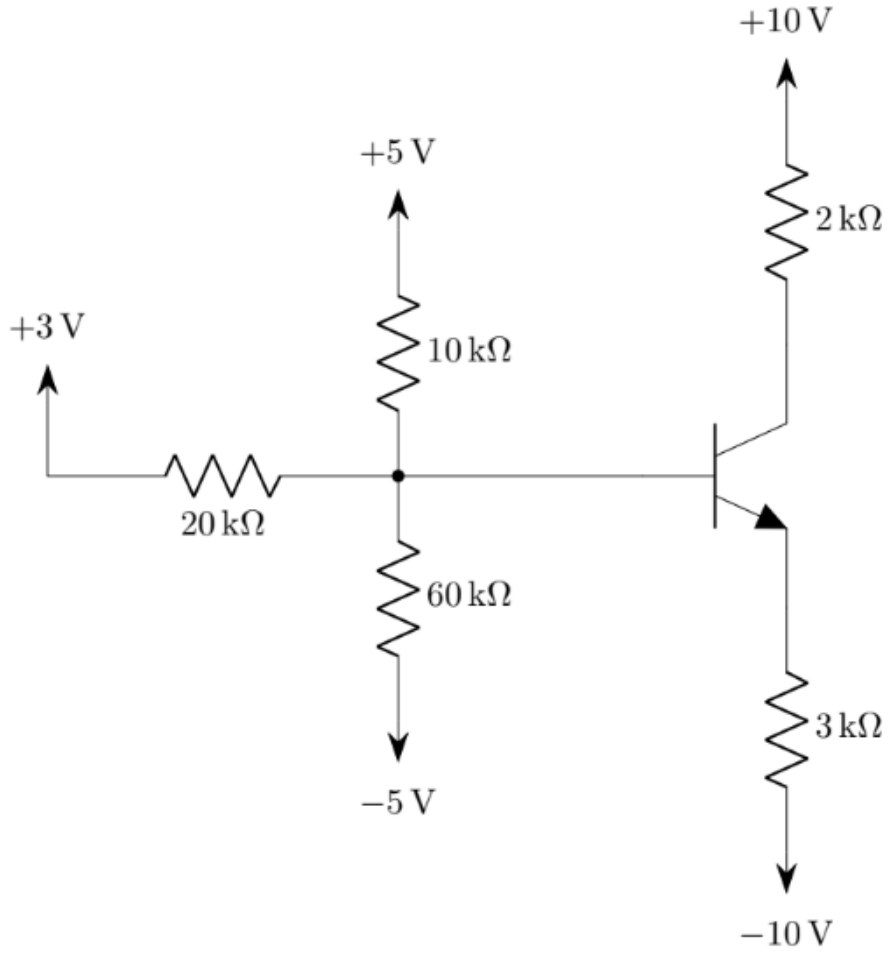
Problem 10

- For the NPN transistor in the following circuit, $\beta = 100$, $V_{BE,\,active} = 0.7\,V$, $V_{BE,\,sat} = 0.8\,V$, and $V_{CE,\,sat} = 0.2\,V$. Determine the current through the $50\ k\Omega$ resistor.



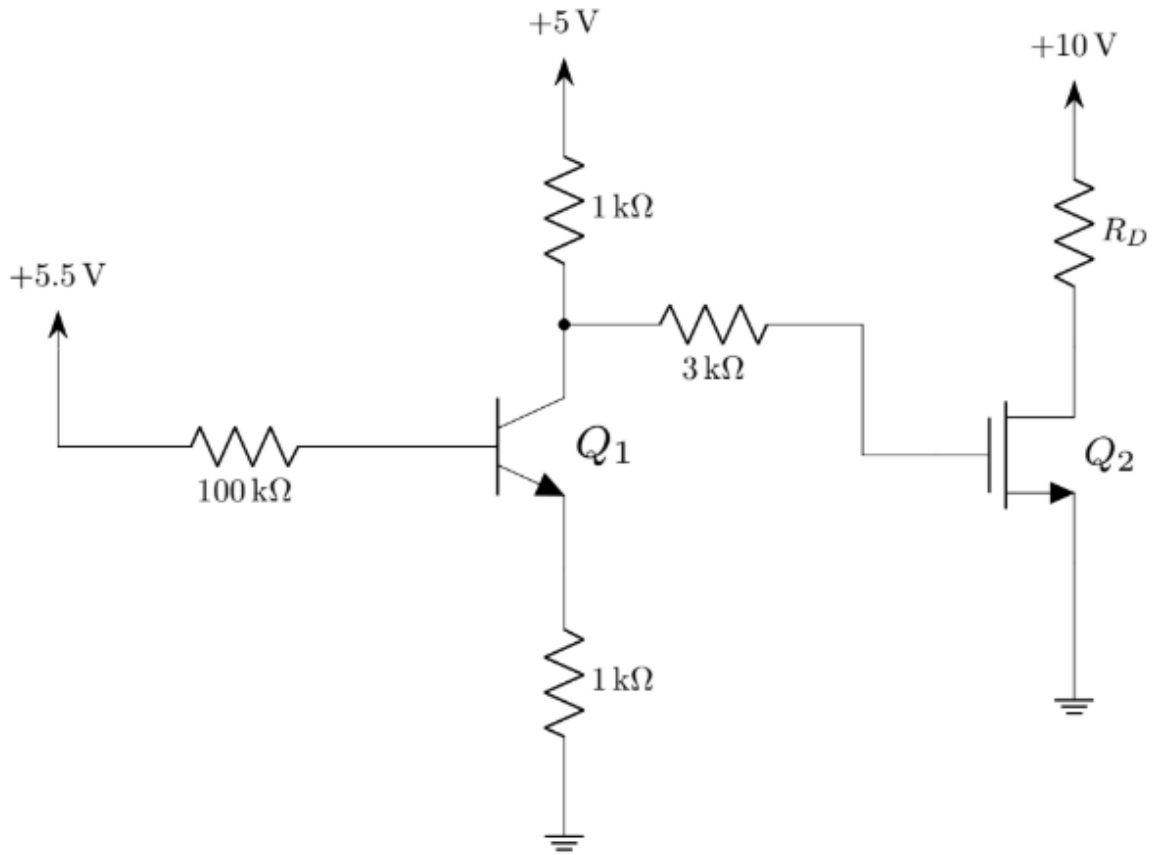
Problem 11

- For the NPN BJT in the adjacent circuit, $\beta = 100$, $V_{BE,\,active} = 0.7\,V$, $V_{BE,\,sat} = 0.8\,V$, and $V_{CE,\,sat} = 0.2\,V$. Determine the operating region of the transistor.



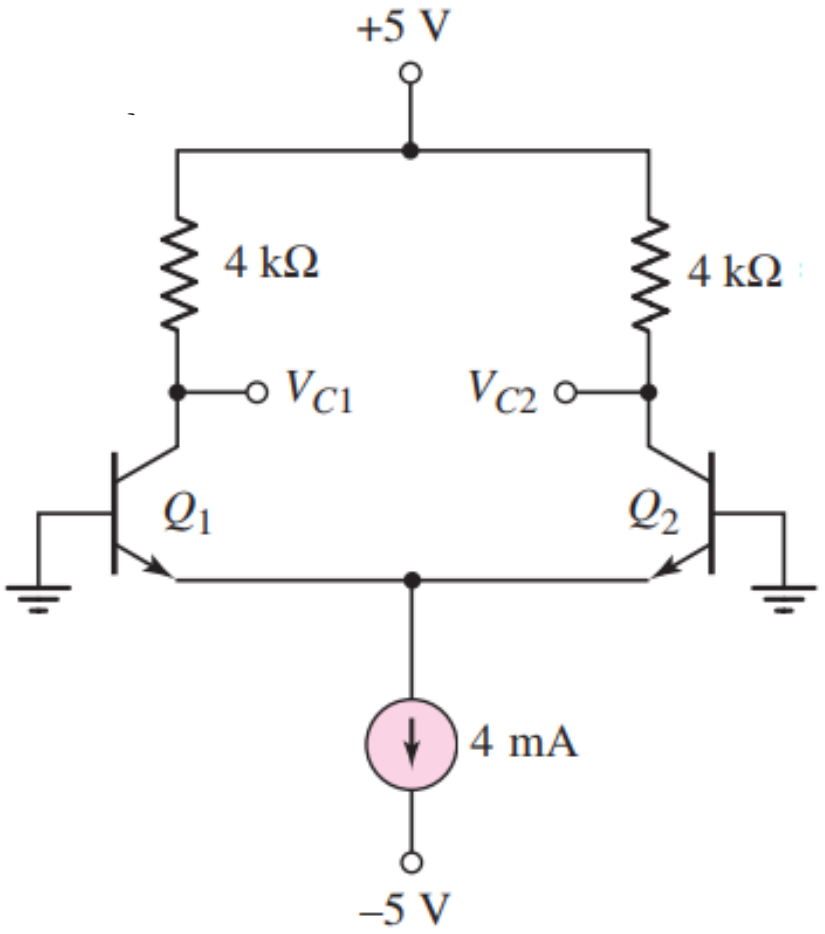
Problem 12

- For the transistor Q_1 in the adjacent circuit, $\beta = 100$, V_{BE} is constant at $0.7\,V$ when Q_1 remains ON, and $V_{CE,\,sat} = 0.2\,V$. For Q_2, $k_n' = 0.25\ {}^{mA}/_{V^2}$, $\left(\frac{W}{L}\right) = \frac{0.72\,\mu m}{0.18\,\mu m}$, and $V_{Tn} = 1\,V$. Determine the value of R_D so that Q_2 operates at the edge of saturation.



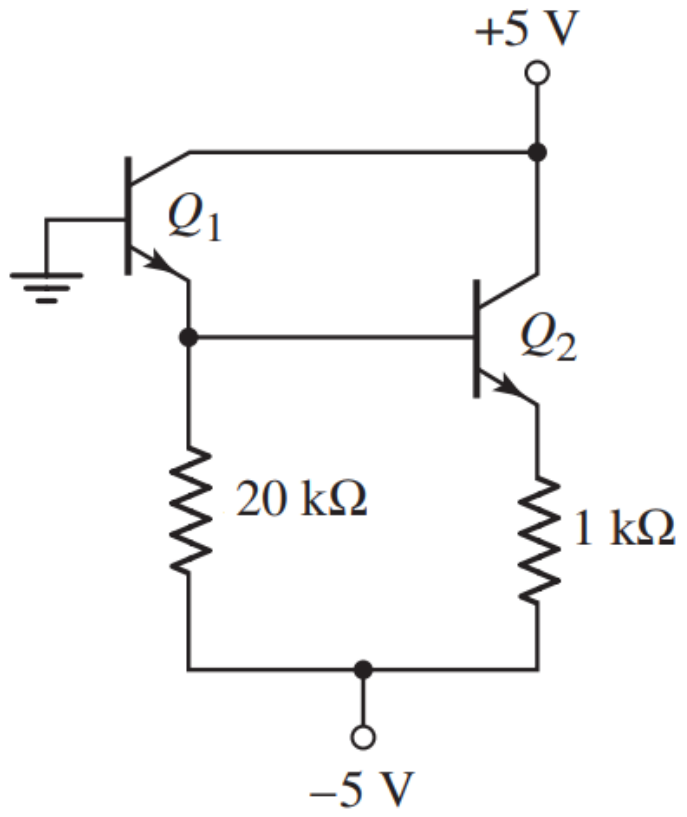
Problem 13

- The transistors in the adjacent circuit are identical. Here, $\beta = 100$, $V_{BE,active} = 0.7\,V$, $V_{BE,sat} = 0.8\,V$, and $V_{CE,sat} = 0.2\,V$. Determine V_{C1} and V_{C2}.



Problem 14

- The transistors in the following circuit are identical. Here, $\beta = 80$, $V_{BE,\,active} = 0.7\,V$, $V_{BE,\,sat} = 0.7\,V$, and $V_{CE,\,sat} = 0.2\,V$. Determine the base currents.



Problem 15

- The transistors in the adjacent circuit are identical. Here, $\beta = 120$, $V_{BE,active} = 0.7\,V$, $V_{BE,sat} = 0.7\,V$, and $V_{CE,sat} = 0.2\,V$. Determine V_o.