

EECE 310 – SAMPLE BJT PROBLEMS

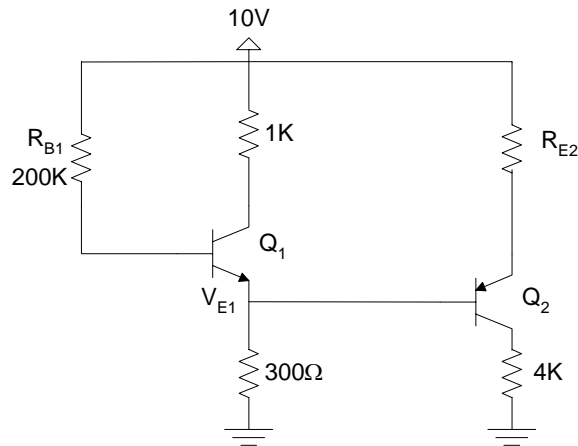
- Unless otherwise specified, assume that:
- $V_T = 25 \text{ mV}$
- $|V_{BE(\text{ACTIVE})}| = 0.7 \text{ V}$
- $|V_{CE(\text{SAT})}| = 0.2 \text{ V}$
- $\beta = 100$

- Capacitors are very large
- Body effect, Early effect, and channel-length modulation are negligible

1.

In the circuit shown below, assume $V_{E1} = 2.5 \text{ V}$, $\beta_1 = 100$ for the NPN BJT, and $\beta_2 = 20$ for the PNP BJT. Calculate I_{B1} in μA .

- a) 34 b) 29 c) 39 d) 31.5 e) 36.5



2.

In problem 1, find V_{C1} in V.

- a) 6.35 b) 6.1 c) 6.6 d) 6.85 e) 7.1

3.

In problem 1, find I_{E2} in mA.

- a) 7.69 b) 1.56 c) 3.61 d) 5.65 e) 9.74

4.

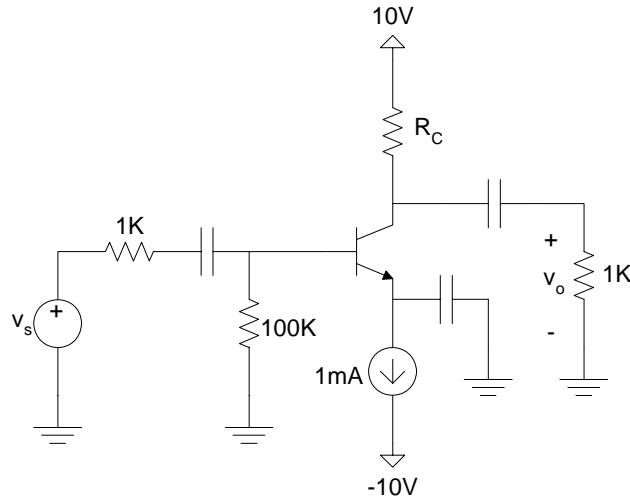
In problem 1, find R_{E2} in $\text{K}\Omega$.

- a) 0.819 b) 5.00 c) 0.596 d) 2.02 e) 1.20

5.

For the BJT amplifier shown below, find V_{CE} in V. Assume $R_C = 2500 \Omega$.

- a) 10.2 b) 9.71 c) 8.72 d) 9.21 e) 8.22



6.

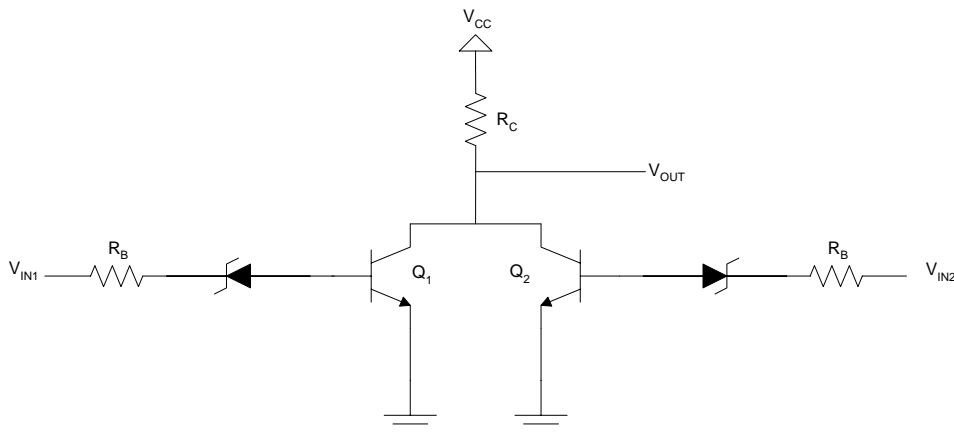
Find the voltage gain v_o/v_s in problem 5.

- a) -21.1 b) -21.9 c) -16.9 d) -18.8 e) -20.1

7.

Find the logic function of the RTL gate shown below. Assume $V_{CC} = 12\text{ V}$, $R_C = 1\text{ K}\Omega$, $R_B = 10\text{ K}\Omega$, and that the Zener diodes drop 4.7 V when conducting.

- a) NAND b) NOR c) AND d) NOT e) OR



8.

Find the output level (in V) that corresponds to LOW in the gate of problem 7.

- a) 0.5 b) 0.7 c) 1.2 d) 0.2 e) 1

9.

Find the output level (in V) that corresponds to HIGH in the gate of problem 7.

- a) 12 b) 11.3 c) 6.6 d) 4.7 e) 15

10.

Find the power drawn by the gate (in W) from the V_{CC} power supply when only one input is high in the circuit of problem 7.

- a) 0.0118 b) 0.222 c) 0.142 d) 2.05 e) 0.0148

11.

Find the value of V_{IL} (in V) for the gate of problem 7. The value of V_{IL} in this case is approximated by the value of input voltage at which the BJT starts conduction (the BJT is at the edge of the active region.)

- a) 0.7 b) 5.4 c) 1.4 d) 12 e) 4.7 V

12.

Find the base current of Q_1 (in mA) in the circuit of problem 7, when Q_1 is at the edge of the saturation region. Assume that V_{IN2} is low.

- a) 0.841 b) 0.075 c) 0.118 d) 0.148 e) 0.536

13.

Find the value of V_{IH} (in V) for the gate of problem 7. The value of V_{IH} in this case is approximated by the value of input voltage at which the BJT is at the edge of saturation.

- a) 6.58 b) 5.58 c) 6.88 d) 5.88 e) 8.55

14.

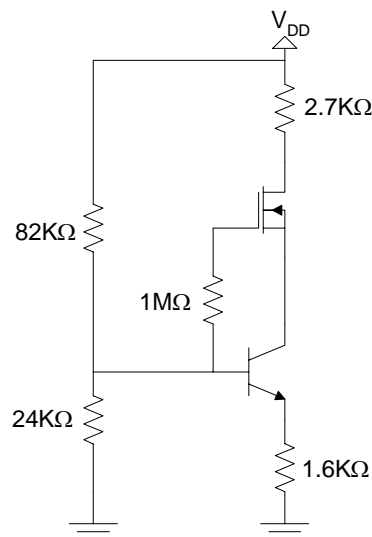
Find the base current of Q_1 (in mA) in the gate of problem 7 when the input voltage is $V_{IN1} = 7$ V. Assume that V_{IN2} is low.

- a) 0.06 b) 0.16 c) 0.26 d) 0.36 e) 0.46

15.

In the circuit shown below, the MOSFET is N-channel *depletion* with $k'(W/L) = 1$ mA/V² and $V_t = -6$ V. Find the base current of the BJT in μ A. Assume $V_{DD} = 16$ V.

- a) 14.96 b) 12.45 c) 11.19 d) 13.71 e) 16.22



16.

In problem 15, find the collector voltage (in V) of the BJT.

- a) 7.13 b) 7.39 c) 7.01 d) 7.26 e) 7.52

17.

A CMOS inverter powered by a $V_{DD} = 2.5$ V supply uses an N-channel MOSFET with $k'_N(W/L)_N = 2$ mA/V², $V_{tn} = 0.7$ V, and a P-channel MOSFET with $k'_P(W/L)_P = 1$ mA/V², $V_{tp} = -0.8$ V. Find the output LOW voltage level (in V)

- a) 0.076 b) 0.131 c) 0 d) 0.101 e) 0.128

18.

The inverter in problem 17 is loaded by a load that sources 1 mA from V_{DD} into the output. What is the output voltage (in V) in this case? The input is HIGH.

- a) 0.303 b) 0.185 c) 0.155 d) 0.229 e) 0.134

19.

What is the dynamic power dissipation (in mW) of the CMOS inverter in problem 17 when it is loaded by a 1 pF capacitor and its input is a 16 MHz clock.

- a) 0.324 b) 0.1 c) 0.256 d) 0.144 e) 0.196

20.

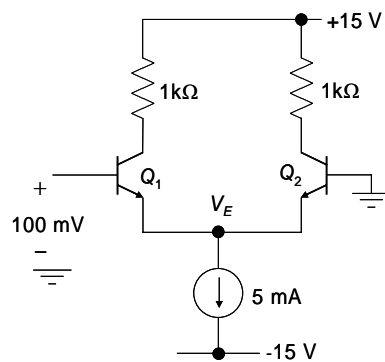
The propagation delay of the CMOS inverter in problem 17 is 1 ns when loaded by a 1 pF capacitor. What happens to the propagation delay when the load capacitance is reduced to 0.5 pF? The delay is

- a) unchanged b) increased to 2ns c) reduced to 0.5 ns
 d) increased to 4 ns e) reduced to 0.25 ns

21.

In the circuit shown below, the transistors are identical, have *very large* β , and $V_{BE} = 0.68 \text{ V}$ at $I_E = 1 \text{ mA}$. Determine the value of V_E when $I_E = 4 \text{ mA}$.

- a) 0.69 V b) 0.71 V c) 0.73 V d) 0.67 V e) 0.75 V



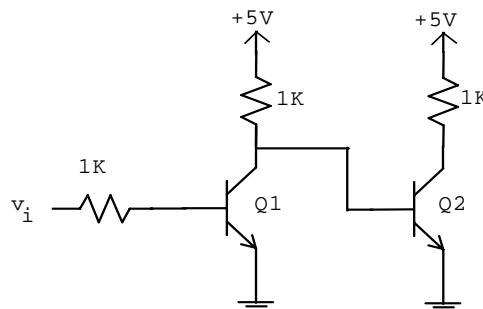
22.

Determine V_E with respect to ground in the circuit of problem 21.

- a) -0.63 V b) -0.64 V c) -0.66 V d) -0.62 V e) -0.65 V

23.

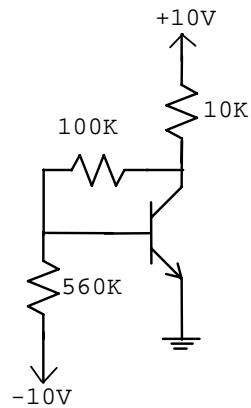
For the circuit shown, in what region of operation are the two BJTs operating when $v_i = 5 \text{ V}$? Assume $\beta_{\min} = 10$.



24.

In the circuit shown below, assume $\beta = 99$.

- Find the base current of the BJT.
- Find the value of V_{CE} .



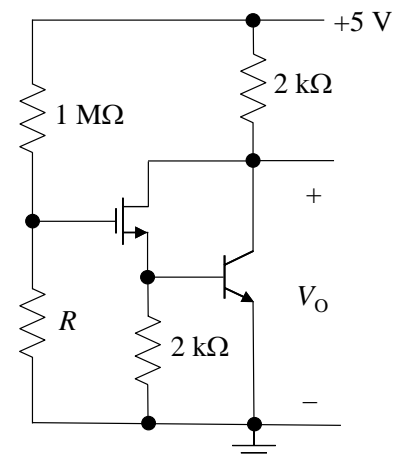
25.

A $10\text{ K}\Omega$ resistor is connected between the output of a CMOS inverter and ground. Find the resulting value of V_{OH} (when the input is zero volts.) Assume $V_{DD} = 5\text{ V}$, $V_{tn} = -V_{tp} = 1\text{ V}$, and $k'_n(W/L)_n = k'_p(W/L)_p = 0.1\text{ mA/V}^2$.

26.

Refer to the circuit shown on the right. Determine R so that the DC output $V_O = 2\text{ V}$, assuming β to be *very large*, $V_{BE} = 0.8\text{ V}$, $k'_n(W/L) = 0.2\text{ mA/V}^2$, and $V_t = 1\text{ V}$.

- | | |
|---------------------------|--------------------------|
| a) $4.36\text{ M}\Omega$ | b) $3.17\text{ M}\Omega$ |
| c) $10.54\text{ M}\Omega$ | d) $6.14\text{ M}\Omega$ |
| e) none of the above | |



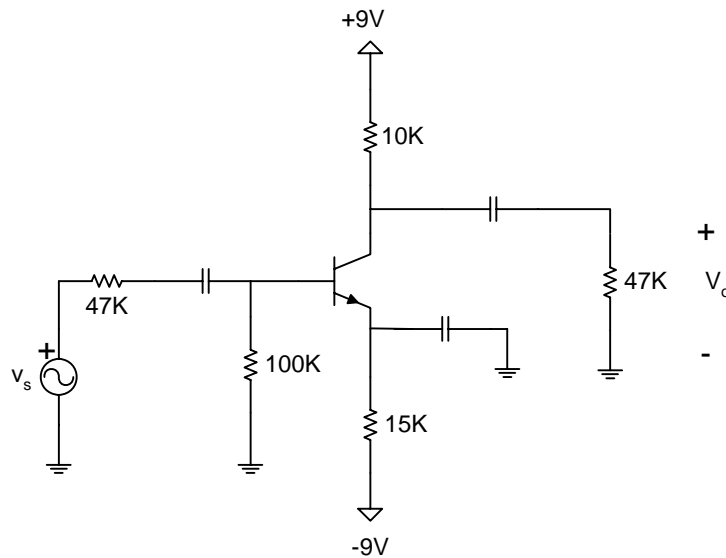
27.

In the previous problem, find the collector current of the BJT.

- 1.5 mA
- 0.5 mA
- 1.1 mA
- 2.1 mA
- none of the above

28.

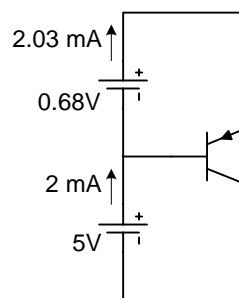
Consider the BJT amplifier shown below. The BJT has $V_A = 75 \text{ V}$.



- Find the value of α for this BJT.
- Perform a DC analysis to determine: I_B , I_C , I_E , V_{BE} , V_{BC} , V_{CE} . Neglect the Early effect in the DC analysis. Verify your assumptions.
- Find the small signal quantities g_m , r_π , r_e , and r_o .
- Find the voltage gain of this amplifier, v_o/v_s .
- If v_{be} is limited to 10 mV peak-to-peak, find the maximum peak-to-peak variation in the collector voltage. Would the BJT remain active for such peak-to-peak variation in collector voltage? What is the corresponding peak-to-peak variation in v_s ?
- Find the maximum peak-to-peak variation in collector voltage to keep the BJT active. Neglect distortion.

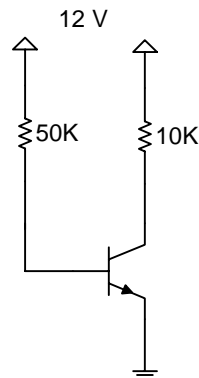
29.

For the BJT shown in the circuit, determine the values of β and I_S .



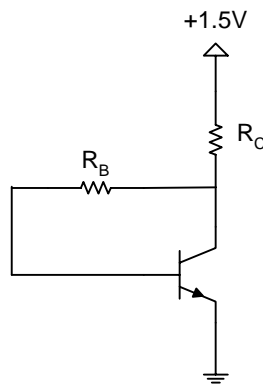
30.

In what region is the BJT shown in the circuit operating? Assume that β varies between 50 and 200. Justify your answer.



31.

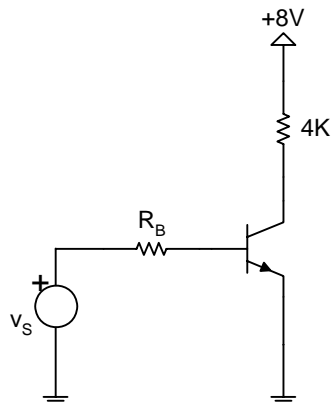
a) Design the bias circuit in the figure below (find the values of R_B and R_C) to get a collector current of $10 \mu\text{A}$ and a collector voltage of 0.9 V . Assume that $\beta = 60$.



b) If β of the BJT happens to be 120, find the new Q point (I_C , V_{CE}). Use the values of R_B and R_C that you found in part (a).

32.

For the BJT amplifier shown below, the source v_s establishes a DC base current of $10 \mu\text{A}$. In addition, the source causes a sinusoidal signal current component i_b of $10 \mu\text{A}$ *peak-to-peak* to appear in the base, and a sinusoidal signal voltage component v_{be} of 20 mV *peak-to-peak* to appear between base and emitter.



From the graphical characteristics of the BJT shown below, use the load line to find the Q point (I_C , V_{CE}). What is the value of β for the BJT, at the Q point?

Given the signal component i_b , determine, graphically, the signal components in i_c and v_{CE} . Mark all your points on the graph.

Determine the following quantities: voltage gain v_{ce}/v_{be} , current gain i_c/i_b , and i_c/v_{be} . What does this last quantity (i_c/v_{be}) represent? Give an estimate of the value of the Early voltage V_A for this BJT, around the Q point.

BJT Characteristics

