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EE-255 EXAM 2 March 5, 1998

Instructor (circle one) Ogborn Lundstrom

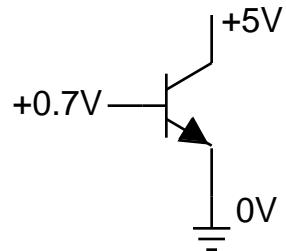
This exam consists of 20 multiple choice questions. Record all answers on this page, but you must turn in the entire exam. There will be no partial credit, but you must show your work.

Circle the one best answer for each question. Five points per question.

Do not open and begin until you are instructed to do so!

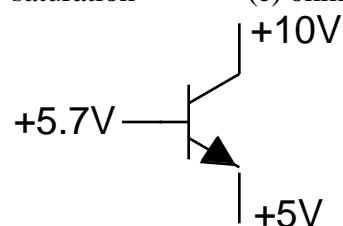
- | | | | | | |
|-----|---|---|---|---|---|
| 1) | a | b | c | d | e |
| 2) | a | b | c | d | e |
| 3) | a | b | c | d | e |
| 4) | a | b | c | d | e |
| 5) | a | b | c | d | e |
| 6) | a | b | c | d | e |
| 7) | a | b | c | d | e |
| 8) | a | b | c | d | e |
| 9) | a | b | c | d | e |
| 10) | a | b | c | d | e |
| 11) | a | b | c | d | e |
| 12) | a | b | c | d | e |
| 13) | a | b | c | d | e |
| 14) | a | b | c | d | e |
| 15) | a | b | c | d | e |
| 16) | a | b | c | d | e |
| 17) | a | b | c | d | e |
| 18) | a | b | c | d | e |
| 19) | a | b | c | d | e |
| 20) | a | b | c | d | e |

- 1) In what region is this transistor operating?
 (a) cutoff; (b) forward-active; (c) inverse-active; (d) saturation (e) ohmic



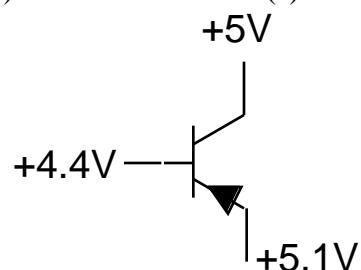
- 2) In what region is this transistor operating?

- (a) cutoff; (b) forward-active; (c) inverse-active; (d) saturation (e) ohmic



- 3) In what region is this transistor operating?

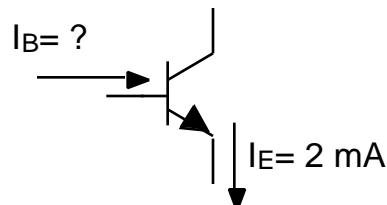
- (a) cutoff; (b) forward-active; (c) inverse-active; (d) saturation (e) ohmic



- 4) If the transistor below is operating in the forward-active region, what is the value of I_B ?

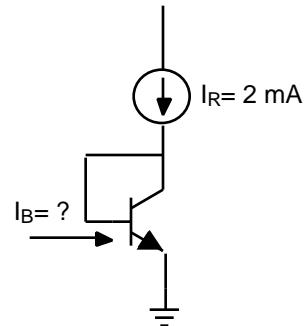
(Assume that $V_{BE(on)} = 0.7V$, $\beta = 10$, and $V_{CE(sat)} = 0.2V$)

- (a) 0.20 mA; (b) 0.18 mA; (c) 1.82 mA; (d) 2.00 mA; (e) 2.20 mA



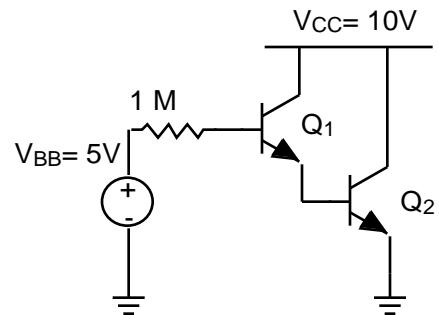
- 5) For the circuit shown below, what is the value of I_B ?
 (Assume that $V_{BE(on)} = 0.7V$, $\beta = 10$, and $V_{CE(sat)} = 0.2V$)

(a) 0.20 mA; (b) 0.18 mA; (c) 1.82 mA; (d) 2.00 mA; (e) 2.20 mA



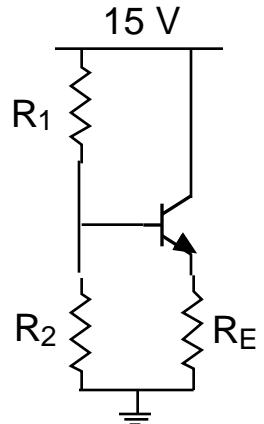
- 6) What is I_{C2} for the circuit shown below?
 (Assume that $V_{BE(on)} = 0.7V$, $\beta = 50$, and $V_{CE(sat)} = 0.2V$)

(a) 0.2 mA (b) 1.0 mA (c) 9.2 mA (d) 10.8 mA (e) 50 mA



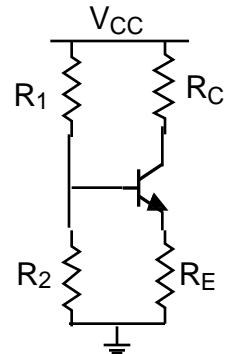
- 7) For the bias circuit shown below, specify R_E so that $I_C = 2 \text{ mA}$ and $V_{CE} = 5\text{V}$ in the forward-active region of operation.
 (Assume that $V_{BE(on)} = 0.7V$, $\beta = 50$, and $V_{CE(sat)} = 0.2V$.)

(a) 1 K (b) 2 K (c) 3 K (d) 4 K (e) 5 K



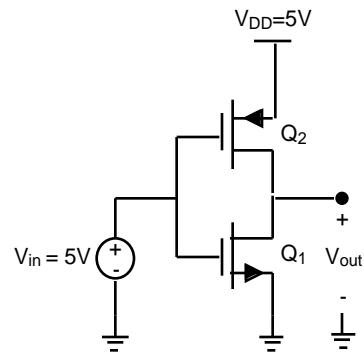
- 8) Assume that we wish to analyze the circuit below with a load line. We first plot the transistor characteristics I_C vs. V_{CE} . What is the equation of the load line that should be plotted on the same axes? Assume that β is very large.

- (a) $V_{CC} - I_C R_C = 0$ (b) $V_{CC} - I_C R_E = 0$ (c) $V_{CC} - I_C(R_C + R_E) = 0$
 (d) $V_{CC} - I_C(R_C + R_E) - V_{CE} = 0$ (e) $V_{CC} - V_{CE} = 0$



- 9) For the circuit shown below, which one of the following is true? (Assume that $V_T = 1V$ for Q_1 and $V_T = -1V$ for Q_2 .)

- (a) Q_1 is cutoff, Q_2 is cutoff (b) Q_1 is cutoff, Q_2 is on (c) Q_1 is on, Q_2 is cutoff
 (d) Q_1 is on, Q_2 is on (e) not enough information given

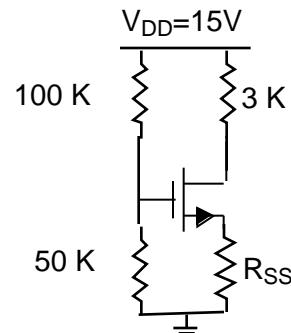


- 10) For the circuit shown in Fig. 9, assume that V_{in} is changed to 2V and that V_{out} is measured to be 4V. Which one of the following is true?

- | | |
|--------------------------------------|----------------------------------|
| (a) Q_1 is in the ohmic region | Q_2 is in the ohmic region |
| (b) Q_1 is in the saturated region | Q_2 is in the ohmic region |
| (c) Q_1 is in the ohmic region | Q_2 is in the saturated region |
| (d) Q_1 is in the saturated region | Q_2 is in the saturated region |
| (e) Q_1 is cutoff | Q_2 is in the ohmic region |

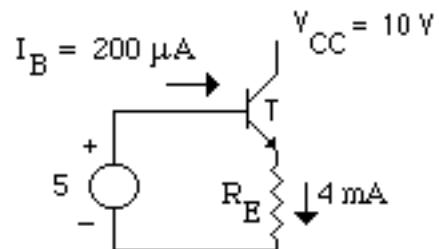
- 11) Select R_{SS} in the circuit below to produce $I_D = 2$ mA. Assume that $k_n = 2$ mA/V² and that $V_{Th} = 1$ V.

- (a) $R_{SS} = 0.5$ K (b) $R_{SS} = 1.0$ K (c) $R_{SS} = 1.5$ K
(d) $R_{SS} = 2.0$ K (e) $R_{SS} = 2.5$ K



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- 12) Assume $V_{BE} = 0.7$ volts. In the circuit below, the collector emitter voltage, $V_{CE} =$

- (a) 3.7 V (b) 4.3 V (c) 5.3 V (d) 5.7 V (e) 10 V



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- 13) In Problem 12, the value of R_E is about:

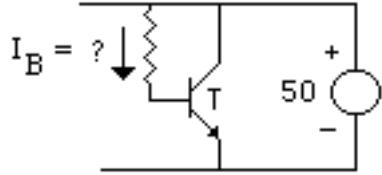
- (a) 0.93 k (b) 1.08 k (c) 1.32 k (d) 1.43 k (e) 2.50 k

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- 14) In Problem 12, the value of the transistor is:

- (a) 10 (b) 19 (c) 20 (d) 21 (e) 40

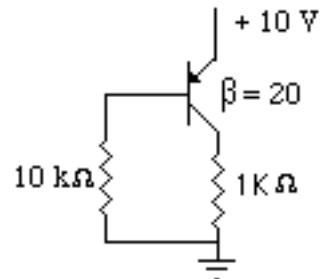
- 15) The collector current in the circuit below was measured and found to be 2 mA. The thermal resistance $\text{dev-case} = 10 \text{ }^{\circ}\text{C/W}$, $\text{case-snk} = 5 \text{ }^{\circ}\text{C/W}$ and $\text{snk-amb} = 20 \text{ }^{\circ}\text{C/W}$. If the device temperature is $120 \text{ }^{\circ}\text{C}$, the ambient temperature is:

(a) $116.5 \text{ }^{\circ}\text{C}$ (b) $123.5 \text{ }^{\circ}\text{C}$ (c) $135.0 \text{ }^{\circ}\text{C}$ (d) $137.5 \text{ }^{\circ}\text{C}$ (e) $200.0 \text{ }^{\circ}\text{C}$



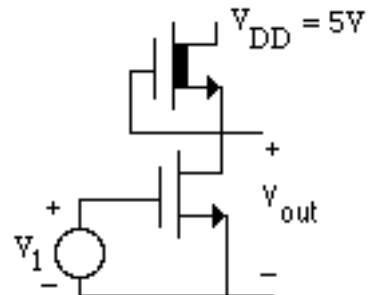
- 16) The best estimate for I_C is about: (Assume $V_{BE(\text{on})} = 0.7\text{V}$, $\beta = 20$, and $V_{CE(\text{sat})} = 0.3\text{V}$).

(a) 1.0 mA (b) 2.0 mA (c) 5.0 mA (d) 9.7 mA (e) 19 mA



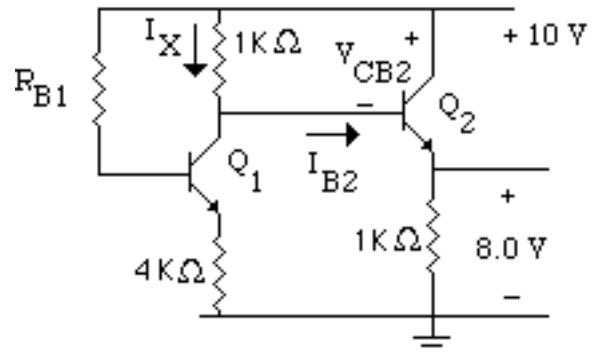
- 17) The top transistor has $V_{Th} = -2\text{V}$, $k_n = 10 \mu\text{A/V}^2$. The bottom transistor has $V_{Th} = 1 \text{ V}$, $k_n = 50 \mu\text{A/V}^2$. For this circuit, $V_{out} = 0.7 \text{ volts}$. The total power delivered to the circuit is:

(a) 0.0 W (b) $100 \mu\text{W}$ (c) $200 \mu\text{W}$ (d) $500 \mu\text{W}$ (e) more than 1 W



- 18) Both transistors in the circuit below have $\beta = 100$. The collector to base voltage, V_{CB2} for Q_2 is about:

(a) 1.3 v (b) 1.7 V (c) 2.0 V (d) 3.7 V (e) 4.3 V



- 19) In Problem 18, the value of I_{B2} is about:

(a) 1.0 μ A (b) 4.3 μ A (c) 8.0 μ A (d) 24 μ A (e) 79 μ A

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- 20) In Problem 18, the value of I_X is about:

(a) 0.0 mA (b) 1.3 mA (c) 2.0 mA (d) 2.7 mA (e) 3.3 mA

EE-255 Formula Sheet: Exam 2

Data:

$$At \ 25 \ ^\circ C \ (R.T.) \quad V_T = kT/q = 0.026 \text{ volts}$$

$$k = 1.3806 \times 10^{-23} \text{ J / K} = 8.618 \times 10^{-5} \text{ eV / K} \quad q = 1.6022 \times 10^{-19} \text{ C} \quad 0^\circ C = 273.16K$$

Formulas: $e^x = 1 + x + x^2/2 + \dots$

Diodes:

$$I_D = I_S (e^{V_D/I_n V_T} - 1) \quad V_D = V_o + I_D r_f \quad C_j = C_{j0} (1 + V_R/V_{bi})^{-1/2}$$

$$r_d = \left. \frac{dV_D}{di_D} \right|_Q = \frac{V_T}{I_{DQ}} \quad (\text{forward bias}) \quad v_D = V_D + v_d$$

Rectifiers:

$$V_r = V_M \frac{T_p}{RC} \quad R = R_s \frac{L}{W}$$

Monolithic Resistors:
n-channel MOSFETs:

$$I_D = k_n [2(V_{GS} - V_{Th})V_{DS} - V_{DS}^2] \quad (\text{ohmic/triode})$$

$$I_D = k_n [V_{GS} - V_{Th}]^2 \quad (\text{saturation})$$

$$V_{GS} > V_{Th} \quad (\text{NOT cut-off})$$

$$V_{DS} > V_{GS} - V_{Th} \quad (\text{saturation})$$

p-channel MOSFETs:

$$I_D = k_p [2(V_{GS} - V_{Th})V_{DS} - V_{DS}^2] \quad (\text{ohmic/triode})$$

$$I_D = k_p [V_{GS} - V_{Th}]^2 \quad (\text{saturation})$$

$$V_{GS} < V_{Th} \quad (\text{NOT cut-off})$$

$$V_{DS} < V_{GS} - V_{Th} \quad (\text{saturation})$$

$$I_D = k_p [2(V_{SG} + V_{Th})V_{SD} - V_{SD}^2] \quad (\text{ohmic/triode})$$

$$I_D = k_p [V_{SG} + V_{Th}]^2 \quad (\text{saturation})$$

$$V_{SG} > -V_{Th} \quad (\text{NOT cut-off})$$

$$V_{SD} > V_{SG} + V_{Th} \quad (\text{saturation})$$

MOSFETs:

$$r_o = \frac{1}{I_D} = \frac{V_A}{I_D} \quad V_{Th} = V_{Th0} + \left[\sqrt{2 \cdot f + V_{SB}} - \sqrt{2 \cdot f} \right]$$

Bipolar Transistors:

$$I_C = I_B \quad I_S e^{\frac{V_{BE}}{V_T}} \quad 1 + \frac{V_{CE}}{V_A} \quad (\text{active}) \quad = \frac{1}{1 -} \quad = \frac{1}{1 +}$$

$$I_C = \frac{[V_{Th} - V_{BE}(\text{on})]}{R_{Th} + (+1)R_E}$$

Thermal Effects:

$$T_{dev} - T_{amb} = P_D \quad P_D = I_B V_{BE} + I_C V_{CE} \quad P_D = I_D V_{DS}$$