These are examples of the types of problems that might show up on exam 3. This “homework set” is not meant to be turned in for grading. Use these problems as you see fit as you review in preparation for the exam.

XVI. For the diode circuit shown at right, calculate the 3 indicated diode currents.

\[ i_{D1} = \text{______________________; } i_{D2} = \text{______________________; } i_{D4} = \text{______________________} \]

Now a Zener diode has been added. The breakdown voltage for the Zener is 5 V (reverse current begins to flow when voltage across the Zener is \(-5\) V.)

\[ i_{D1} = \text{______________________; } i_{D2} = \text{______________________; } i_{D4} = \text{______________________} \]
XVII. In the circuit shown below, calculate the power being dissipated in resistor $R_E$, if $V_I = 1$ V.

$P_{RE} =$ __________________________

Now repeat with $V_I = 5$ V.

$P_{RE} =$ __________________________
XVIII. In the circuit shown below, calculate the power being dissipated in resistor $R_C$, if $V_i = 0.5$ V.

\[ P_{RC} = \text{______________________________} \]

Now repeat with $V_i = 1.5$ V.

\[ P_{RC} = \text{______________________________} \]
XIX. For the circuit shown below, find the value of $R_C$ so that the LED current will be 100 mA when $v_i = 5$ V.

Assume that the LED will have a forward drop of 1 V when it is turned on. (An LED is not a silicon diode, and so the forward drop is usually somewhat bigger than 0.7 V.) The BJT is a conventional silicon transistor with $\beta_F = 100$.

\[ R_C = \______________ \]

Then calculate the power dissipated in $R_C$, the LED and the BJT and the total power being delivered by the $V_{CC}$ supply.

\[ P_{RC} = \______________; P_{BJT} = \______________; P_{LED} = \______________ \]

\[ P_{VCC} = \______________ \]
XX. Calculate the voltage transfer function for the circuit shown below. Let the input range from \(-6V\) to \(+6V\). The BJT has \(\beta_F = 100\). Write down the equations that describe the transfer function. Then make a good sketch of the transfer function. (Use the axes provided below.)

Both the equations and the sketch are needed in order to adequately answer this question.

Notes: 1. As we have seen with these things, there will be 3 distinct regions of operation for the BJT that show up in the transfer characteristic. For two of those regions, calculating the output voltage is a trivial exercise. 2. This is NOT an inverter circuit, and the transfer characteristic cannot be expected to follow an normal inverter curve.
XXI. Calculate For the circuit shown at right, calculate $v_o$ when $v_i = 0.5$ V. Then derive the equation for $v_o$ when the transistor is operating in saturation. Use your equation to calculate $v_o$ for $v_i = 2$ V.
(Note that $v_{GS} = v_i - i_D R_S = v_i - v_o$.)

For the NMOS, $K = 0.5$ mA/V$^2$ and $V_T = 1$ V.

$v_i = 0.5$ V: $v_o =$

$v_o =$

$v_i = 2.0$ V: $v_o =$
XXII. For the circuit shown below, calculate $v_o$ if $v_i = 2.5$ V. Then repeat for $v_i = 5$ V.

For the NMOS, $K = 0.5$ mA/V$^2$ and $V_T = 1$ V.

$V_{DD} = 6$ V

$v_i = 2.5$ V: $v_o =$ __________________________

$v_i = 5$ V: $v_o =$ __________________________
XXIII. For the circuit shown at right, calculate $i_L$ for $v_i = 0.5$ V. Then repeat for $v_i = 3$ V and $v_i = 6$ V.

The BJT has $\beta_F = 100$.

$v_i = 0.5$ V: $i_L = \frac{v_i}{R_B} = \frac{0.5}{75 \, \text{k}\Omega}$

$v_i = 3.0$ V: $i_L = \frac{v_i}{R_B} = \frac{3}{75 \, \text{k}\Omega}$

$v_i = 6.0$ V: $i_L = \frac{v_i}{R_B} = \frac{6}{75 \, \text{k}\Omega}$
XXIV. For the circuit shown at right, calculate $i_C, v_{CE}, i_D,$ and $v_{DS}$ if $v_i = 3$ V. Then repeat for $v_i = 10$ V.

For the BJT, $\beta_F = 100$.

For the NMOS, $K = 0.5$ mA/V$^2$ and $V_T = 1$ V.

$v_i = 3$ V: $i_C =$ ___________________________; $v_{CE} =$ ______________________________

$i_D =$ ___________________________; $v_{DS} =$ ______________________________

$v_i = 10$ V: $i_C =$ ___________________________; $v_{CE} =$ ______________________________

$i_D =$ ___________________________; $v_{DS} =$ ______________________________
XXV. For the circuit shown at right, calculate \( i_C \), \( v_{CE} \), \( i_D \), and \( v_{DS} \) if \( v_i = 2 \) V. Then repeat for \( v_i = 3.5 \) V, and then once more for \( v_i = 7.0 \) V.

For the BJT, \( \beta_F = 100 \). For the NMOS, \( K = 0.5 \) mA/V\(^2\) and \( V_T = 1 \) V.

\[
\begin{align*}
 v_i = 2.0 \text{ V}: & \quad i_C = \_ \_ \_ \_ \_ \_ \_ \_ \_ \_ \_ \; ; \; v_{CE} = \_ \_ \_ \_ \_ \_ \_ \_ \_ \_ \_ \\
 i_D = \_ \_ \_ \_ \_ \_ \_ \_ \_ \_ \_ \; ; \; v_{DS} = \_ \_ \_ \_ \_ \_ \_ \_ \_ \_ \_ \\
 v_i = 3.5 \text{ V}: & \quad i_C = \_ \_ \_ \_ \_ \_ \_ \_ \_ \_ \_ \; ; \; v_{CE} = \_ \_ \_ \_ \_ \_ \_ \_ \_ \_ \_ \\
 i_D = \_ \_ \_ \_ \_ \_ \_ \_ \_ \_ \_ \; ; \; v_{DS} = \_ \_ \_ \_ \_ \_ \_ \_ \_ \_ \_ \\
 v_i = 7.0 \text{ V}: & \quad i_C = \_ \_ \_ \_ \_ \_ \_ \_ \_ \_ \_ \; ; \; v_{CE} = \_ \_ \_ \_ \_ \_ \_ \_ \_ \_ \_ \\
 i_D = \_ \_ \_ \_ \_ \_ \_ \_ \_ \_ \_ \; ; \; v_{DS} = \_ \_ \_ \_ \_ \_ \_ \_ \_ \_ \_ 
\end{align*}
\]
XXVI. For the circuit shown at right, calculate $i_C$ and $v_{CE}$. For the transistor $\beta_F = 100$.

\[ i_C = \text{______________________________}. \]

\[ v_{CE} = \text{______________________________}. \]

Now repeat for $V_{BB} = 7.5$ V.

\[ i_C = \text{______________________________}. \]

\[ v_{CE} = \text{______________________________}. \]
XXVII. For the circuit shown at right, calculate $i_D$ and $v_{DS}$.

For the NMOS $V_T = 1$ V, and $K = 0.5$ mA/V$^2$.

\[ i_D = \text{______________________________}. \]

\[ v_{DS} = \text{______________________________}. \]

What is the maximum value that the gate supply $V_G$ can have while keeping the NMOS operating in saturation?

\[ V_G \text{(max)} = \text{______________________________} \]
XXVIII. Find $v_o$ in terms of $v_o$ (and $R$ and the BJT parameters) for the circuit shown below. The npn BJT has collector-current scale factor, $I_S$ and forward current gain, $\beta_F$.

Note: Assume the transistor is in forward active operation and then use the exact expression for the BJT, not the simplifying approximation.

$$v_o = \text{Expression}$$
XXIX. For the circuit at right, find the value of $K$ for the NMOS that would be needed in order to have $v_{DS} = 5$ V. The threshold voltage for the NMOS is $V_T = 1$ V.

$K = \underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{\underline{