

HOMEWORK 2

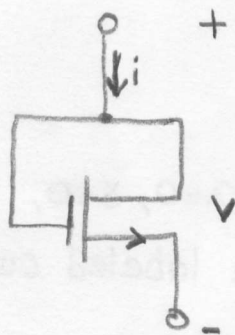
FIELD-EFFECT TRANSISTORS (FETs)

① Neglecting the channel-length-modulation effect show that for the depletion-type NMOS transistor of figure below the i - v relationship is given by;

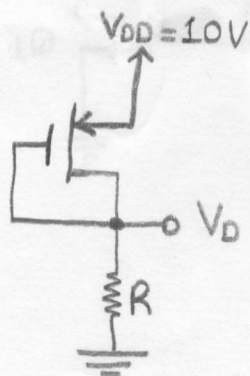
$$i = \frac{1}{2} k'_n \left(\frac{W}{L} \right) (v^2 - 2V_t v), \quad \text{for } v \geq V_t$$

$$i = -\frac{1}{2} k'_n \left(\frac{W}{L} \right) V_t^2, \quad \text{for } v \leq V_t$$

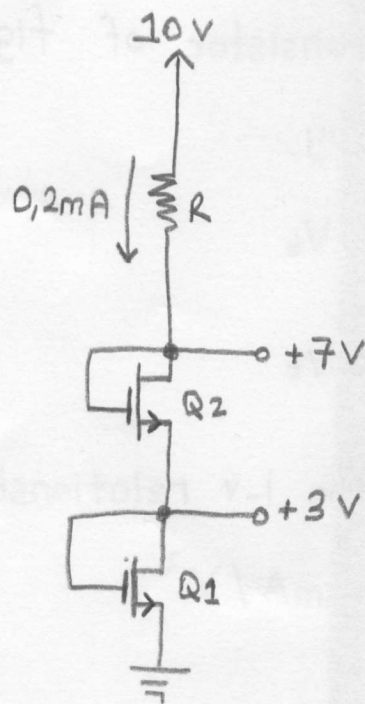
(Recall that V_t is negative.) Sketch the i - v relationship for the case $V_t = -2V$ and $k'_n \left(\frac{W}{L} \right) = 2 \text{ mA/V}^2$



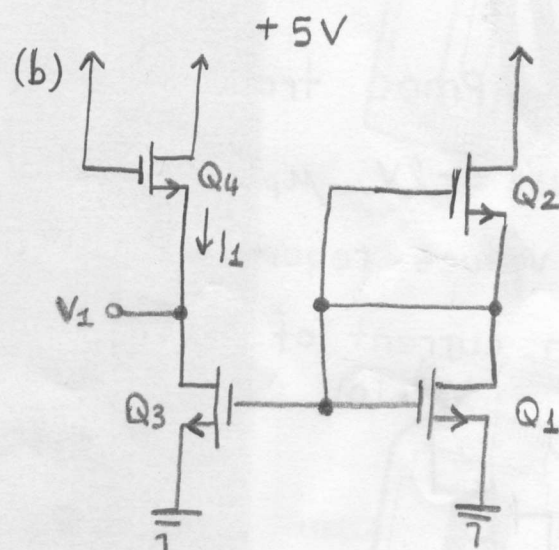
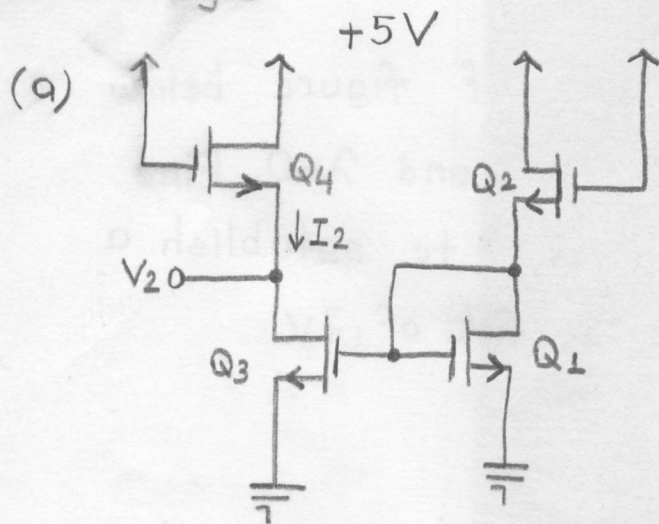
② The PMOS transistor in the circuit of figure below has $V_t = -2V$, $\mu_p C_{ox} = 8 \mu\text{A/V}^2$, $L = 10 \mu\text{m}$ and $\lambda = 0$. Find the values required for W and R in order to establish a drain current of 0.1 mA and a voltage V_D of $7V$.



- ③ The NMOS transistors in the circuit below have $V_t = 2V$, $\mu_n C_{ox} = 20 \mu A/V^2$, $\lambda = 0$ and $L_1 = L_2 = 10 \mu m$. Find the required values of gate width for each of Q_1 and Q_2 , and the value of R , to obtain the voltage and current values indicated.



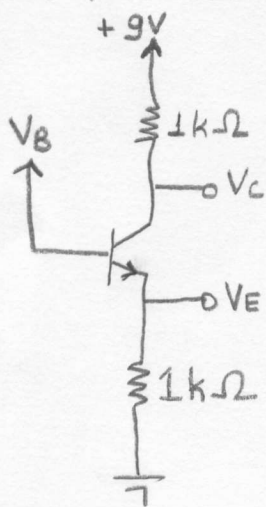
- ④ For the devices in the circuits below $|V_t| = 1V$, $\lambda = 0$, $\gamma = 0$, $\mu_n C_{ox} = 20 \mu A/V^2$, $L = 1 \mu m$ and $W = 20 \mu m$. Find the labeled currents and voltages.



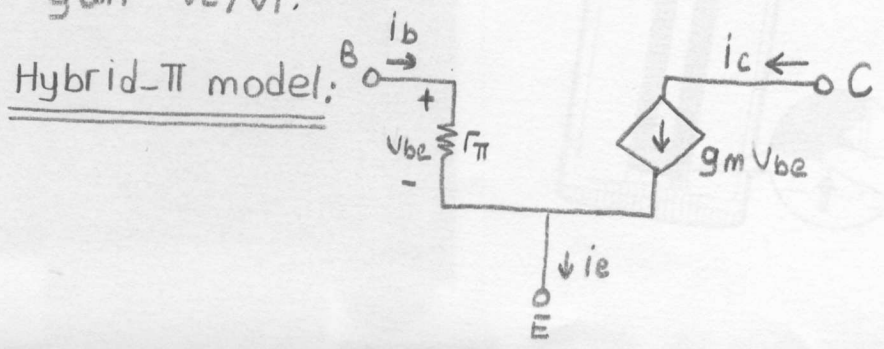
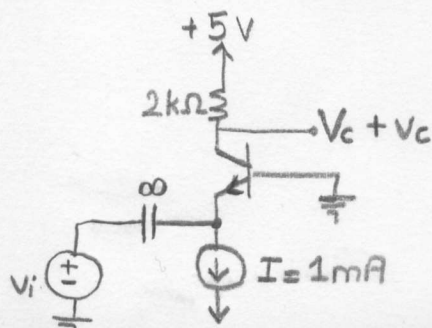
BIPOLAR JUNCTION TRANSISTORS (BJTs)

⑤ A pnp transistor has $V_{EB} = 0.8V$ at a collector current of $1A$. What do you expect V_{EB} to become at $I_C = 10mA$? at $I_C = 5A$?

⑥ Consider the circuit below with the base voltage V_B obtained using a voltage divider across the $9V$ supply. Assuming the transistor β to be very large (that is, ignoring the base current), design the voltage divider to obtain $V_B = 3V$. Design for a $0.2mA$ current in the voltage divider. Now if the BJT $\beta = 100$, analyze the circuit to determine the collector current and collector voltage.



⑦ The transistor amplifier below is biased with a current source I and has a very high β . Find the dc voltage at the collector, V_C . Also find the value of g_m . Replace the transistor with its simplified hybrid- π model. (Note that the dc current source I should be replaced with an open circuit.) Hence find the voltage gain v_c/v_i .



⑧ For the common-emitter amplifier shown below, let $V_{CC} = 9V$, $R_1 = 27k\Omega$, $R_2 = 15k\Omega$, $R_E = 1.2k\Omega$ and $R_C = 2.2k\Omega$. The transistor has $\beta = 100$ and $V_A = 100V$. Calculate the dc bias current I_E . If the amplifier operates between a source for which $R_S = 10k\Omega$ and a load of $2k\Omega$, replace the transistor with its hybrid- π model, and find the values of R_i , the voltage gain V_o/V_s and the current gain i_o/i_i .

