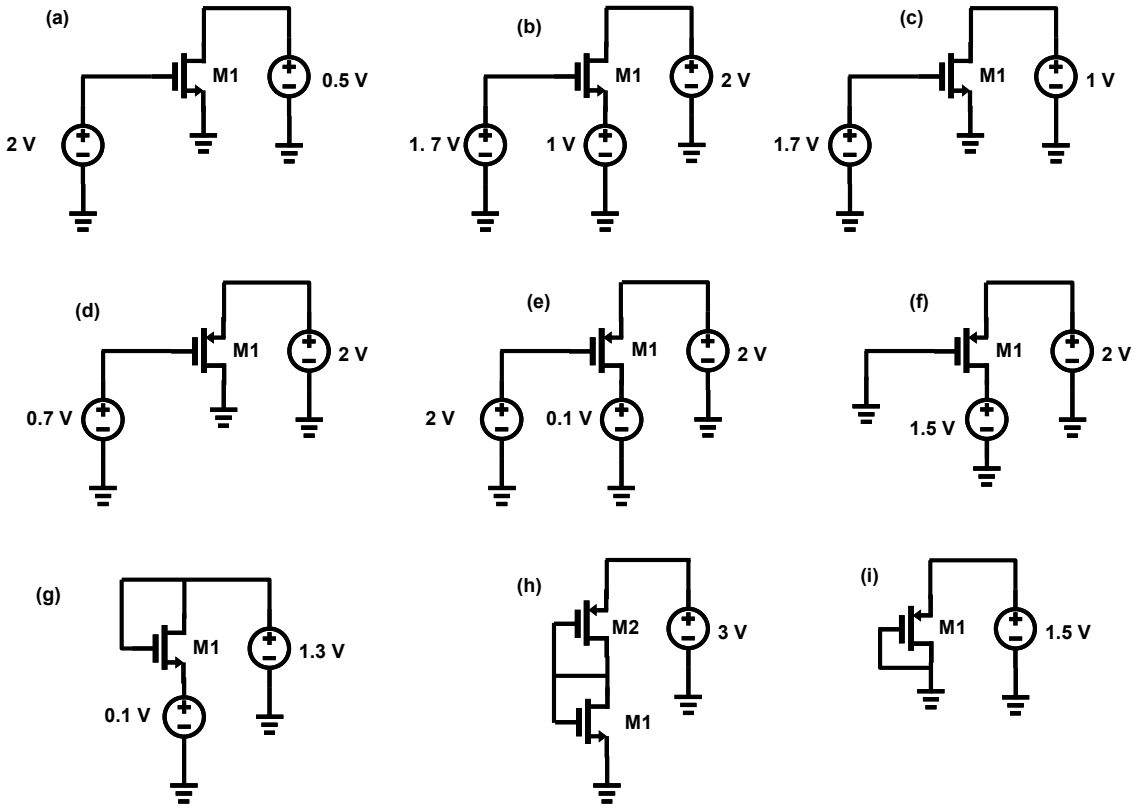
ECE 323
Homework 1

1) Determine the region of operation of M1 in each of the circuits below. Assume $V_{THN} = |V_{THP}| = 1$ V.



$V_{GS} < V_{TH} \rightarrow$ cutoff

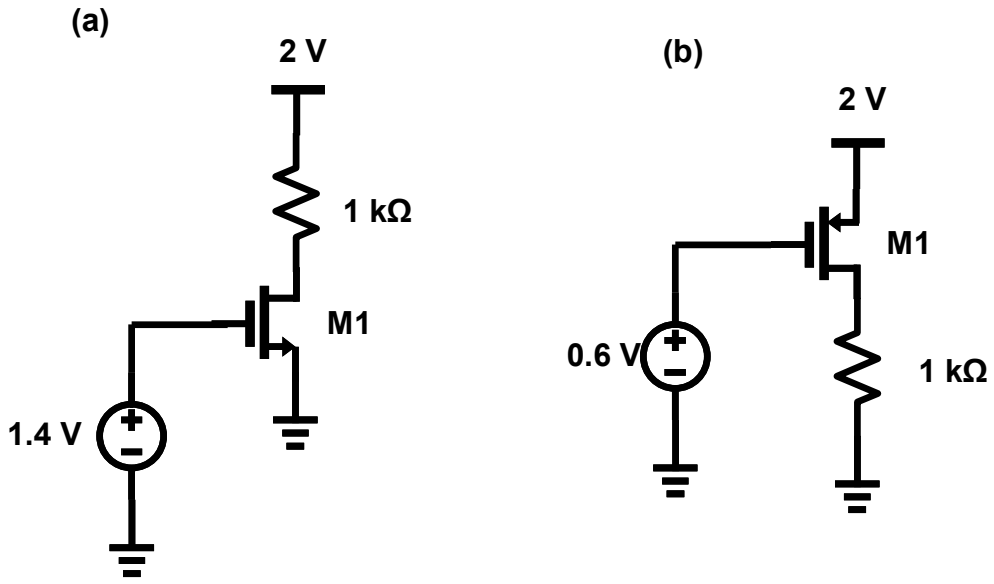
$0 < V_{GS} - V_{TH} < V_{DS} \rightarrow$ saturation

$0 < V_{GS} - V_{TH} > V_{DS} \rightarrow$ triode

(a) triode (b) cutoff (c) sat. (d) sat. (e) cutoff

(f) triode (g) sat. (h) sat. (i) sat.

2) What value of W/L places M1 at the brink of saturation? $V_{THN} = |V_{THP}| = 1$ V, $u_nC_{ox} = 100$ uA/V^2 $u_pC_{ox} = 50$ uA/V^2



Brink of saturation → $V_{DS} = V_{GS} - V_{TH}$

Either triode or sat. equation works.

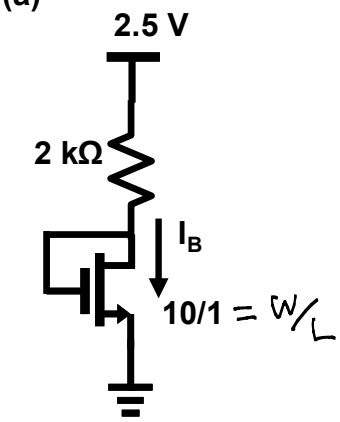
(a) $I_D = \frac{1}{2}\mu_n C_{ox}\frac{W}{L}(V_{GS}-V_{TH})^2 = 1.6\,mA \rightarrow \left(\frac{W}{L}\right)_{M1} = 200$

(b) $\mu_p C_{ox} = \frac{1}{2}\mu_n C_{ox}$

Similar conditions of sat. & $I_D \rightarrow \left(\frac{W}{L}\right)_{M1} = 400$

3) Determine I_B in the following circuits. Use parameters from problem 2.

(a)



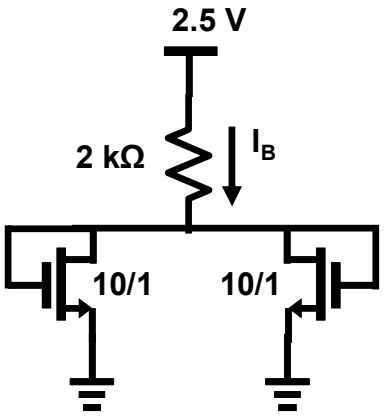
Sat. region

$I_B = \frac{1}{2}\mu_n C_{ox}\frac{W}{L}(V_B - V_{TH})^2$

$\rightarrow V_B = 1.82\,V$

$I_B = 338.5\,\mu A$

(b)



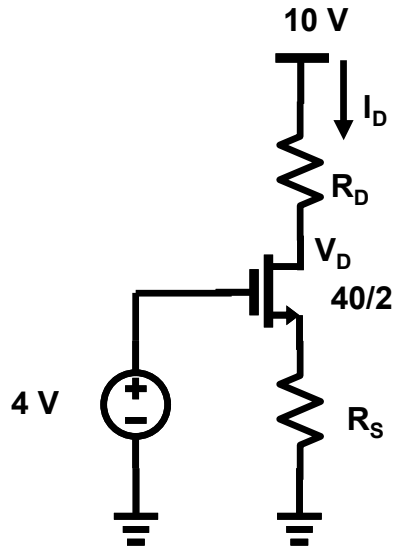
Sat.

$\frac{10}{1}\ \frac{10}{1} = \frac{20}{1} = \frac{W}{L}$

$V_B = 1.65\,V$

$I_B = 425\,\mu A$

4) Design the circuits below such that I_D =2mA and V_D = 5V. V_{THN} = 1 V, u_nC_{ox} = 100 uA/V^2.



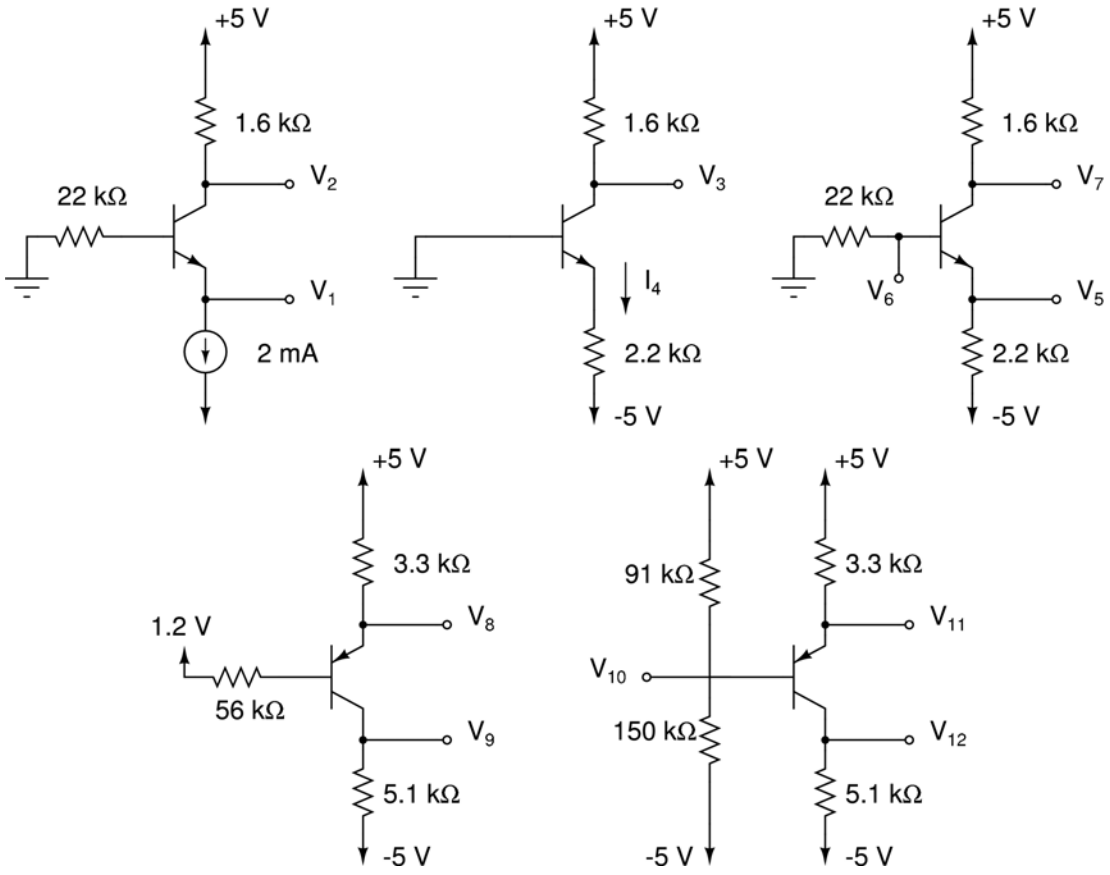
$V_D = 5V$ means in saturation.

$I_D = \frac{10 - V_D}{R_D}$ $\qquad 4V = V_{GS} + I_D \cdot R_S = V_{GS} + V_S$

Solving for I_D, V_S

$R_D = 2.5K\Omega$ $\qquad V_S \cong 1.6V$ $\qquad R_S \cong 800\,\Omega$

5) For the circuits in Fig 5, find values for the labeled node voltages and branch currents. Assume β to be very high and $|V_{BE}| = 0.7$ V



β is very high = no base current.

$I_B = 0$, $I_C = I_E$

$V_1 = -0.7$ V
$V_2 = 1.8$ V

$V_3 = 1.88$ V
$I_4 = 1.95$ mA

$V_5 = -0.7$ V
$V_6 = 0$ V

$V_7 = 1.88$ V
$V_8 = 1.9$ V

$V_9 = -0.2$ V
$V_{10} = 1.224$ V

$V_{11} = 1.924$ V
$V_{12} = -0.24$ V