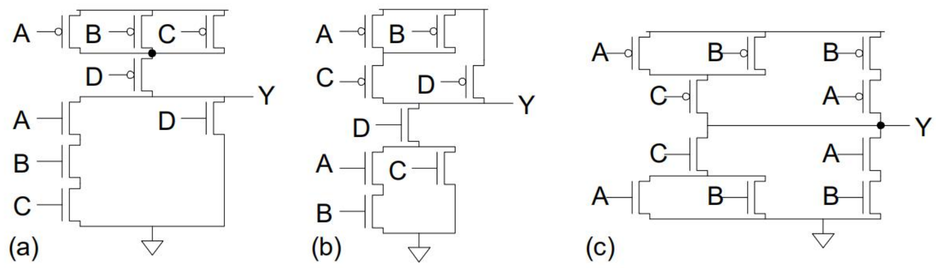
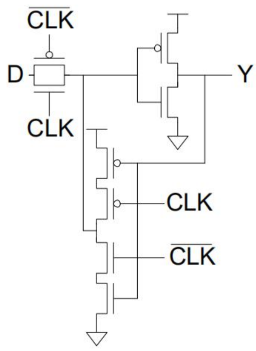
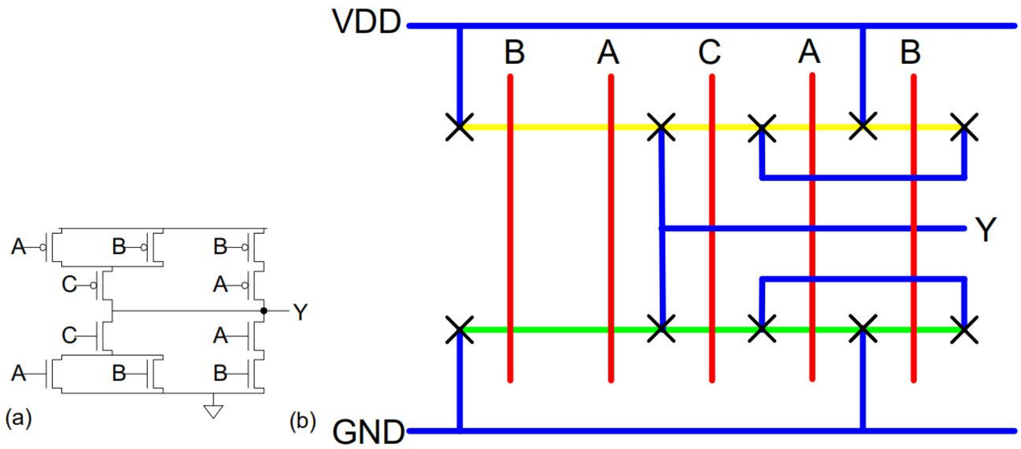
1.6



1.15 This latch is nearly identical save that the inverter and transmission gate feedback has been replaced by a tristate feedaback gate.



1.18



2.2 In (a), the transistor sees V_{gs} = V_{DD} and $V_{ds} = V_{DS}$. The current is

$$I_{DS1} = \frac{\beta}{2}\left(V_{DD} - V_t - \frac{V_{DS}}{2}\right)V_{DS}$$

In (b), the bottom transistor sees $V_{gs} = V_{DD}$ and $V_{ds} = V_1$. The top transistor sees $V_{gs} = V_{DD} - V_1$ and $V_{ds} = V_{DS} - V_1$. The currents are

$$I_{DS2} = \beta\left(V_{DD} - V_t - \frac{V_1}{2}\right)V_1 = \beta\left(\left(V_{DD} - V_1\right) - V_t - \frac{\left(V_{DS} - V_1\right)}{2}\right)\left(V_{DS} - V_1\right)$$

Solving for V_1, we find

$$V_1 = \left(V_{DD} - V_t\right) - \sqrt{\left(V_{DD} - V_t\right)^2 - \left(V_{DD} - V_t - \frac{V_{DS}}{2}\right)V_{DS}}$$

Substituting V_1 indo the I_{DS2} equation and simplifying gives $I_{DS1} = I_{DS2}$.

2.10 (a) $(1.2 - 0.3)^2 / (1.2 - 0.4)^2 = 1.26$ (26%)

(b) $$\frac{e^{\frac{-0.3}{1.4 \bullet 0.026}}}{e^{\frac{-0.4}{1.4 \bullet 0.026}}} = 15.6$$

(c) $v_T = kT/q = 34$ mV; $\frac{e^{\frac{-0.3}{1.4 \bullet 0.034}}}{e^{\frac{-0.4}{1.4 \bullet 0.034}}} = 8.2$; note, however, that the total leakage will normally be higher for both threshold voltages at high temperature.

2.16 Set the currents through the transistors equal and solve the nasty quadratic for V_{out}.

In region B, the nMOS is saturated and pMOS is linear:

$$\frac{\beta}{2}\left(V_{\text{in}}-V_t\right)^2=\beta\left(\left(V_{\text{in}}-V_{DD}\right)-\frac{\left(V_{\text{out}}-V_{DD}\right)}{2}+V_t\right)\left(V_{\text{out}}-V_{DD}\right)$$

$$V_{\text{out}}=\left(V_{\text{in}}+V_t\right)+\sqrt{\left(V_{\text{in}}+V_t\right)^2-\left(V_{\text{in}}-V_t\right)^2+V_{DD}\left(V_{DD}-2V_{\text{in}}-2V_t\right)}$$

In region D, the nMOS is linear and the pMOS is saturated:

$$\frac{\beta}{2}\left(V_{\text{in}}-V_{DD}+V_t\right)^2=\beta\left(V_{\text{in}}-V_t-\frac{V_{\text{out}}}{2}\right)\left(V_{\text{out}}\right)$$

$$V_{\text{out}}=\left(V_{\text{in}}-V_t\right)-\sqrt{\left(V_{\text{in}}-V_t\right)^2-\left(V_{DD}-V_{\text{in}}-V_t\right)^2}$$

2.20 (a) 0; (b) $2|V_{tp}|$; (c) $|V_{tp}|$; (d) V_{DD} - V_{tn}