Q1.

the devices are in triode region to be considered as resistors.

\[ R_{on(a)} = \frac{1}{M_n C_o x \left( \frac{W}{L} \right) (V_{gs} - V_{th})} + \frac{1}{M_n C_o x \left( \frac{W}{L} \right) (V_{gs} - V_{th})} \]

\[ = \frac{2}{M_n C_o x \left( \frac{W}{L} \right) (V_{gs} - V_{th})} \]

\[ R_{on(b)} = \frac{1}{M_n C_o x \left( \frac{W}{L} \right)_b (V_{gs} - V_{th})} \]

So \( \frac{W}{L}_a = 2 \left( \frac{W}{L} \right)_b \)

For example \( \frac{W}{L}_a = \frac{W}{L}_b \), \( L_a = \frac{1}{2} L_b \)

Q16. Based on the equation of \( I \) vs \( V_{gs} \) (\( V_{gs} \))

\[ I = M_n C_o x \left[ \left( V_{gs} - V_{th} \right) V_{gs} - \frac{1}{2} V_{gs}^2 \right] \]

we know the \( I/V_{gs} \) curve would be like a parabola.
And it has the peak when \( V_{gs} - V_{th} = V_{gs} \). So, the curve will look like the one shown on Figure 6.17. But, for real devices, the curve will not bend down after the peak.
Q 19. (a) \[ V_{GS} = 0V \]

it is \underline{off}.

(b) \[ V_{GS} = 1V > 0.4V \]
\[ V_{GD} = -0.5 < V_{th} \]

it's in \underline{SAT} region.

(c) \[ V_{GS} = 1V > V_{th} \]
\[ V_{DS} = 0V \]

it's \underline{off}.

(d) \[ V_{GD} = 1.5V > V_{th} \]
\[ V_{DS} = 0.5V \]
\[ V_{GS} = 1V > V_{th} \]

The device \underline{S & D switched} and in \underline{Triode Region}.

(e) \[ V_{GS} = 1.5V > V_{th} \]
\[ V_{GD} = 1V > V_{th} \]

it's in \underline{Triode region}.
(f) \[ V_{GS} = 0 \]
\[ V_{GD} > 0 \]
It's **off**

(g) \[ V_{GS} = 0.5V > V_{th} \]
\[ V_{GD} = 0 < V_{th} \]
It's in **SAT** Region

(h) \[ V_{GS} = 1V > V_{th} \]
\[ V_{GD} = 0 \]
It's in **SAT** Region

(i) \[ V_{GS} = 0.5V > V_{th} \]
\[ V_{GD} = -0.5 < V_{th} \]
It's in **SAT** Region
Q 20

(a) 
\[ V_{DS} = 1V, \quad (D\&S \text{ switched}) \]
\[ V_{GD} = 0V \]
\[ \text{it's off} \]

(b) 
\[ V_{GS} = 0V \]
\[ \text{it's off} \]

(c) 
\[ V_{GS} = 0.8V \]
\[ V_{GD} = 0V \]
\[ \text{it's off} \]

(d) 
\[ V_{GD} = 0.5V, \quad (D\&S \text{ switched}) \]
\[ V_{GD} = 0.8V > V_{th} \]
\[ V_{GS} = 0.3V < V_{th} \]

So, D\&S switched and it's in SAT region.
Q. 25

To guarantee it's on the edge of SAT region:

\[ V_{GD} = V_{th} \]

So \[ V_b = V_{DD} - I_D R_D \]

\[ V_{GD} = V_{DD} - (V_{DD} - I_D R_D) = I_D R_D \]

So \[ I_D R_D = V_{th} \]

So \[ \frac{1}{2} M_n \text{Cox} \left( \frac{W}{L} \right) (V_{DD} - V_{th})^2 \cdot R_D = V_{th} \]

Q. 28

(a)

when \( V_x < \frac{1}{4} V + V_{th} = 1.4V \) the device is in SAT region:

\[ I_x = \frac{1}{2} M_n \text{Cox} \frac{W}{L} (V_x - 1.4V)^2 \]

when \( V_x \geq 1.4V \) the device is in Triode region:

\[ I_x = M_n \text{Cox} \frac{W}{L} \left[ (V_x - V_{th}) \cdot 1 - \frac{1}{2} \cdot 1^2 \right] \]
When $V_G < V_G - V_{th} = 0.6V$, device is in Triode region

$$I_X = \frac{1}{2} M_0 C_0 \frac{W}{L} [(1-0.4) V_T - \frac{1}{2} V_T^2]$$

When $V_G > V_G - V_{th} = 0.6V$, device is in SAT region

$$I_X = \frac{1}{2} M_0 C_0 \frac{W}{L} (1-0.4)^2$$

Since $V_G = V_D$, when device turns on, it is always in SAT region.

When $V_G < V_{th}$, the device is turns off

$$I_X = 0$$

When $V_G \geq V_{th}$, the device is in SAT region

$$I_X = \frac{1}{2} M_0 C_0 \frac{W}{L} (V_L - V_{th})^2$$
Again, the $V_{DD} = 1.8$, the device will be SAT when it turns on.

When $V_C \leq 1.8 - V_{th} = 1.4V$, the device is in SAT region.

$$I_X = -\frac{1}{2}Mn Cox \frac{W}{L} (1.8 - V_C - V_{th})^2$$

When $V_C > 1.4V$, the device is off.

$$I_X = 0$$