2.

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HW4-EE 307

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t_R = rise time between 10% & 90% of swing

$V_{out} = V_{max}[1 - e^{(\frac{-t}{RC})}]$

$V_{out} = V_{max} \times [1 - e^{(\frac{-t}{RC})}] \frac{V_{max}}{9}$

$\frac{-t}{9} = e^{(\frac{-t}{RC})}$

$-\ln(9) = \frac{-t}{RC}$

$\boxed{t_R = RC\ln(9) = 2.2RC}$

b)

$V_{out} = V_{max}(e^{\frac{-t}{RC}}) = \frac{V_{max}}{9}$

$e^{(\frac{-t}{RC})} = \frac{1}{9}$

$\frac{-t}{RC} = -\ln 9$

$\boxed{t_F = \ln 9 \, RC}$
$\boxed{t_F = 2.2RC}$

c) $\frac{V_{dd}}{2} = V_{dd} \, e^{\frac{-t}{RC}}$

$t_{PHL} = RC\ln 2 \qquad t_{PLH} = RC\ln 2$

$t_P = \frac{1}{2}(t_{PHL} + t_{PLH})$

$\boxed{t_P = RC\ln(2)}$

3. a) $R_{ave} = \dfrac{\left(\dfrac{V_{DD}}{I_{DS,VDD}}\right) + \left(\dfrac{\frac{1}{2}V_{DD}}{I_{DSVDD}}\right)}{2} \approx \dfrac{\left(\dfrac{3}{0.015}\right) + \left(\dfrac{1.5}{0.0125}\right)}{2} = \boxed{160\Omega}$

b) $R_{ave} = \dfrac{\left(\dfrac{V_{DD} \cdot \frac{3}{4}}{I_{DSVDD\frac{3}{4}}}\right)}{2} = \dfrac{\left(\dfrac{0.75 \cdot 3}{14A \times 10^{-3}}\right)}{2} = \boxed{81\Omega}$

c) Active region for calculating Ron b/c that's when the circuit is on and transistor can be seen as resistor.

d) Using center point approximation

$\frac{k'}{2} \frac{W}{L} = \frac{1}{1000} \frac{A}{V^2}$, $V_{TN} = 0.6$ $V_{DD} = 5V$

$I_{DS} = \frac{1}{1000} \frac{A}{V^2} (5 - 0.6)^2 = 0.01936$

$\frac{5}{0.01936} = \boxed{193.678 \, \Omega}$

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e) $\left(\frac{W}{L}\right) \Rightarrow \left(\frac{40\,\mu m}{2\,\mu m}\right)(6.2) = 124\,\Omega$

f) $(260.7)\left(\frac{5\,\mu m}{L}\right) = 10K$

$$\boxed{L = 76.77\,\mu m}$$

4. $V_m = \frac{6V}{2} = 3V$ ← $\frac{V_{max} - V_{min}}{2}$

a)

b) $G = 2 - K'(V_m - V_t)\frac{1}{2\lambda V_{DS}}$

$= 2 \cdot 200\frac{\mu A}{V^2}(3 - 0.5)\frac{1}{2(0.07)(0.00752)} = 9.445$

$I_D = \frac{K}{2}(V_{GS} - V_m)^2(1 + \lambda V_{DS})$

$100\,\mu(3 - V_m)^2(1 + 10.0773) = 0.756m$

c) $V_{IL} \Rightarrow y = mx + b$

$V_{out}(V_m) = 9(1 + 9.4451) = 31.33 = b$

$V_{max} = 6 = -9.945\,V_{in} + 3(31.33) = V_{max} = 2.68$

$V_{min} = 0 = -9.945\,V_{in} + 3(31.33)$ $= 3.3176$

d) $V_{IL} = 2.68$

$V_{IH} = 3.3176$

e) $N_{ML} = 2.68 - 0 = 2.68V$

f) $N_{MH} = 6 - 3.3176 = 2.68$

5.

a) Truth Table 2:1 MUX

Sel	A	B	Q
0	0	0	0
0	0	1	1
0	1	0	0
0	1	1	1
1	0	0	0
1	0	1	0
1	1	0	1
1	1	1	1

	AB			
Sel\	00	01	11	10
0	0	1	1	0
1	0	0	1	1

$Q = \overline{Sel}\,B + Sel\,A$

b)

c) 2:1 MUX
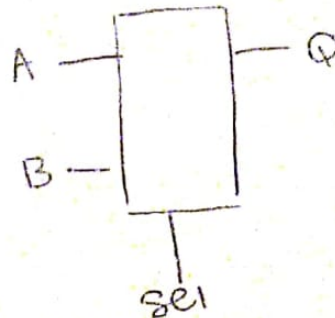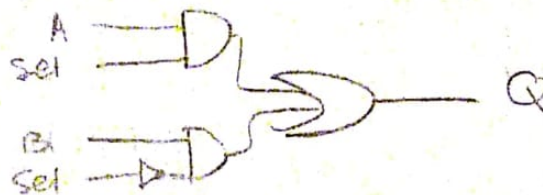
Mult - Adder - Mux
   A when Sel = 1
   B when Sel = 0
⚹ ⟹ When Sel = 1 ⟹ mult = 3×14 = 42   101010
         Sel = 0 ⟹ adder = 3+14 = 17   10001