

Problem 1

(a) $C_L = 200 \text{ pF}$ $C_{ref} = 3 \text{ pF}$
 $C_u = 1 \text{ fF}$

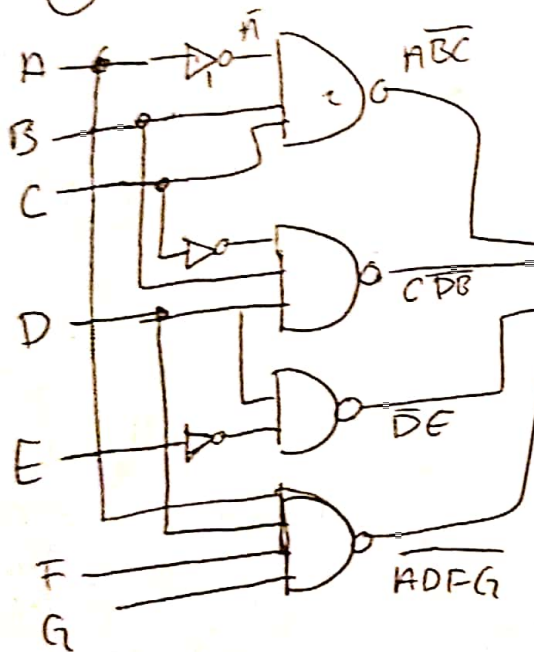
$$F = \frac{C_L}{C_{in}}$$

$$\# = \log_4 F$$

$$F = \frac{200 \text{ f}}{3 \text{ f}} = 66.67$$

$$\begin{aligned} \# &= \log_4 (66.67 \text{ f}) \\ &= 1.66 \log (66.67 \text{ f}) \\ &= 3.027 \Rightarrow \text{3 stages} \end{aligned}$$

(b)



$$\begin{aligned} &ABC + CDB + DE + ADFG \\ &= ABC + CDB + DE + ADFG \end{aligned}$$

(c) $\frac{M_n}{M_p} = 2$ $C_u = 1 \text{ fF}$

$p=1$ $p=3$ $p=4$
 $g=1$ $g=\frac{25}{3}$ $g=\frac{6}{3}=2$

$$\begin{aligned} t_p &= t_{p0} \left(1 + 3 + 4 + \left[1 \cdot \frac{5}{3} \right] + \left[\frac{5}{3} \cdot \frac{6}{5} \right] + \left[2 \cdot \frac{200 \text{ f}}{6} \right] \right) \\ &= 78.33 t_{p0} \end{aligned}$$

$$F = \frac{200}{3} \quad h = (1 \cdot 1 \cdot \frac{5}{3} \cdot 2) = 3.33$$

$$B = 1$$

$$h = \sqrt[3]{222} = 6.055$$

$$H = 222$$

$$C_{in} = \frac{C_{out} + 3 \cdot g_u}{h} = \frac{200 (2)}{6.055} = 66.06 \text{ fF}$$

$$h = Fg \quad f = \frac{out}{cin}$$

$$g = \frac{C_n}{3}$$

$$C_{in} = g(3) \quad C_{in} = 4/3 \cdot 3$$

$$C_{in} = \frac{5}{3} (3) = 5$$

$$C_{in} = 1(3) = 3$$

$$C_{in3} = 2(3) = 6$$

$$C_{in2} = \frac{C_{out2} \cdot g_2}{h} = \frac{66.06 \left(\frac{5}{3}\right)}{6.055} = 18.18 fF$$

$$C_{in1} =$$

$$B_{new} = \frac{18.18 + S}{18.18} =$$

$$S_3 = \frac{66.06}{8} = 11.01 \text{ OTs } \& \text{ nmos}$$

$$\Rightarrow \begin{cases} \text{pmos } \frac{w}{l} \text{ gate } 3 = 27.02 \\ \text{nmos } \frac{w}{l} \text{ gate } 3 = 11.01 \end{cases}$$

$$S_2 = \frac{18.18}{S} = 3.64$$

$$\Rightarrow \begin{cases} \text{pmos } \frac{w}{l} \text{ gate } 2 = 7.27 \\ \text{nmos } \frac{w}{l} \text{ gate } 2 = 7.27 \end{cases}$$

d)

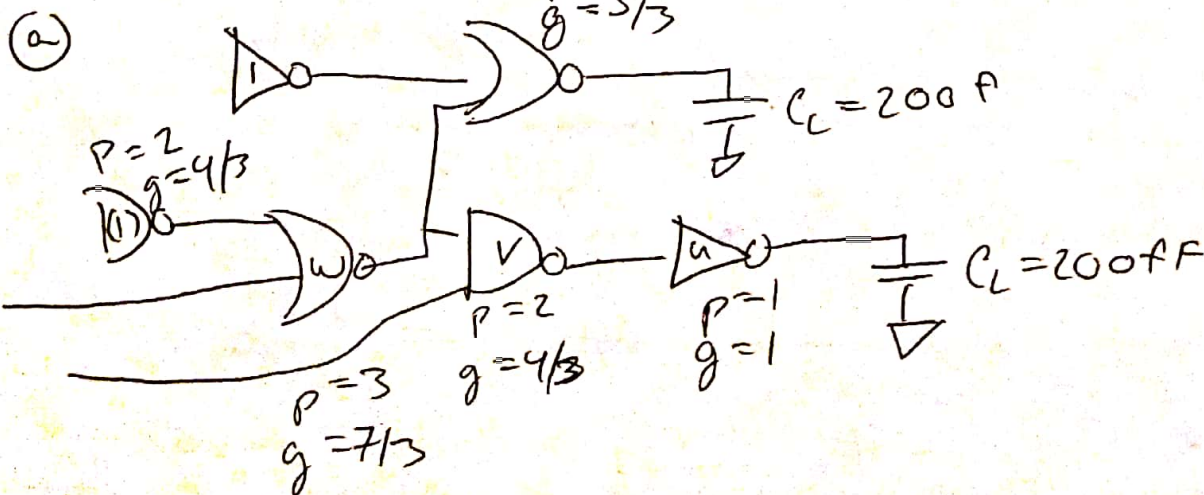
$$t_p = t_{p0} \left[1 + 3 + 4 \left(1 \cdot \frac{5}{3} \right) + \left(\frac{5}{3} \cdot \frac{6}{5} \right) + \left(2 \cdot \frac{200}{6} \right) \right]$$

$$= 78.33 t_{p0}$$

e)

$$ABCDEFG = 10000000 \Rightarrow 00000000$$

Problem 2



$$t_{PX} = t_{PO} [2 + 3 + 2 + 1 + \left[\frac{4}{3} \cdot \frac{7}{9} \right] + \left[\frac{7}{3} \cdot \frac{9}{7} \right] + \left[\frac{4}{3} \cdot \frac{3}{4} \right] + \left[1 \times \frac{200}{3} \right]] = \boxed{81 t_{PO}}$$

$$t_{PZ} = t_{PO} [2 + 3 + 2 + \frac{7}{3} + \frac{9}{3} + \left[\frac{5}{3} \times \frac{200}{3} \right]] = \boxed{79 t_{PO}}$$

$$(b) F = \frac{200}{4} = 50 \quad G_X = \frac{4}{3} \cdot \frac{7}{3} \cdot \frac{4}{3} \cdot 1 = 4.15$$

$$B = \frac{9}{4} = 2.25 \quad H = FGB = 467 \quad h = \sqrt[4]{4.67} = 4.7$$

$$C_{inU} = \frac{(a+u)g}{h} = \frac{200(1)}{4.7} = 42.5 f$$

$$C_{inW} = \frac{(12.1+5) \frac{7}{3}}{4.7} = 6 f$$

$$C_{inV} = \frac{C_{inU}g}{h} = \frac{42.5(\frac{4}{3})}{4.7} = 12.1$$

$$C_{inW} = 7 f$$

$$B' = \frac{12.1+5}{12.1} = 1.41$$

$$h' = \sqrt[4]{236.55} = 4.1$$

$$C_{inU} = \frac{200 \cdot 1}{4.1} = 48.8 f \quad C_{inV} = \frac{48.8 \cdot \frac{4}{3}}{4.1} = 15.9 f \quad C_{inW} = \frac{\frac{7}{3}(15.9+5)}{4.1} = 11.9 f$$

$$B'' = \frac{15.9+5}{15.9} = 1.3 \quad h = \sqrt[4]{269.75} = 4.1 \text{ no } 10\%$$

$$C_{inU} = \frac{200}{4}$$

$$S_U = \frac{48.8}{3 f} = 16.3$$

$$S_V = \frac{15.9}{4} = 4$$

$$S_W = \frac{11.9}{7} = 1.7$$

| gate U | gate V | gate W |
|-------------|----------|------------|
| nmos = 16.3 | nmos = 8 | nmos = 1.7 |
| pmos = 32.6 | pmos = 8 | pmos = 6.8 |

$$(c) t_{PX} = t_{PO} [8 + (4 \times 4.1)] = \boxed{24.4 t_{PO}}$$

$$t_{PZ} = t_{PO} \left[7 + \left(\frac{4}{3} \times \frac{11.9}{4} \right) + \left(\frac{7}{3} \cdot \frac{20.9}{11.9} \right) + \left(\frac{5}{3} \cdot \frac{200}{5} \right) \right] = \boxed{81.8 t_{PO}}$$