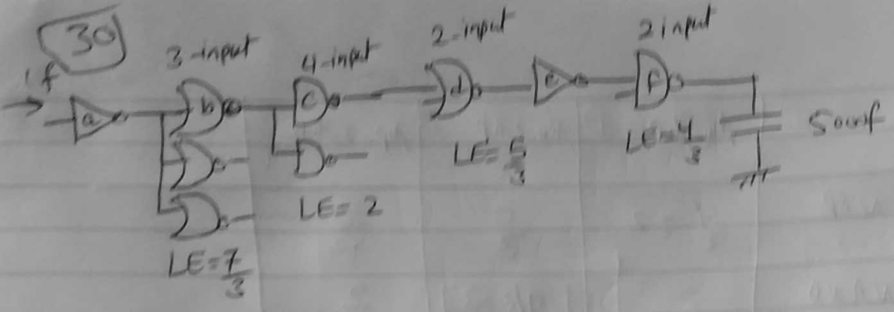
30



$F = \frac{5000}{1} = 5000$

$\prod LE = \frac{7}{3} \times 2 \times \frac{5}{3} \times \frac{4}{3} \times 1 \times 1 = \frac{280}{27} = 10.37$

$\prod B = 3 \times 2 = 6$

a- $P.E = \prod LE \cdot \prod B \times F = \frac{280}{27} \times 6 \times 5000 = 311,111.111$

b- $EF/s = \sqrt[6]{311,111.11} = 8.23163$

c- Stage f: $8.23163 = \frac{4}{3} \times \frac{5000}{f} \Rightarrow f = 809.294\,f$ 2

2×5 " e: $8.23163 = 1 \cdot \frac{809.294}{e} \Rightarrow e = 98.315\,f$ 2

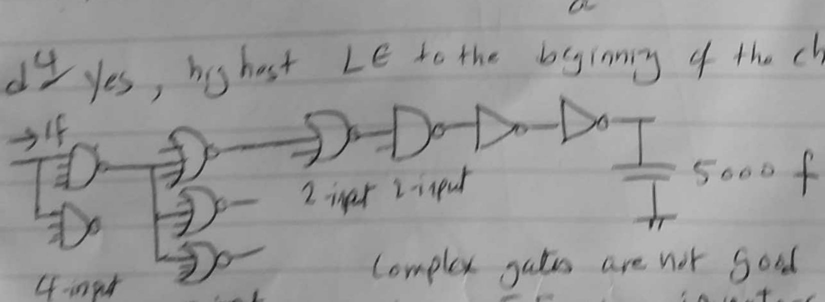
" d: $8.23163 = \frac{5}{3} \times \frac{98.315}{d} \Rightarrow d = 19.891\,f$ 2

" C: $8.23163 = 2 \times \frac{19.891}{c} \Rightarrow b = 4.833\,f$ 2 ?

" b: $8.23163 = \frac{7}{3} \times 2 \times \frac{4.833}{b} \Rightarrow 2.74\,f$ 2

" a: $8.23163 = 1 \times 3 \times \frac{2.74}{a} \Rightarrow a = .998$ ✓

d- yes, highest LE to the beginning of the chain



Complex gates are not good drivers, they need larger EF than inverters.

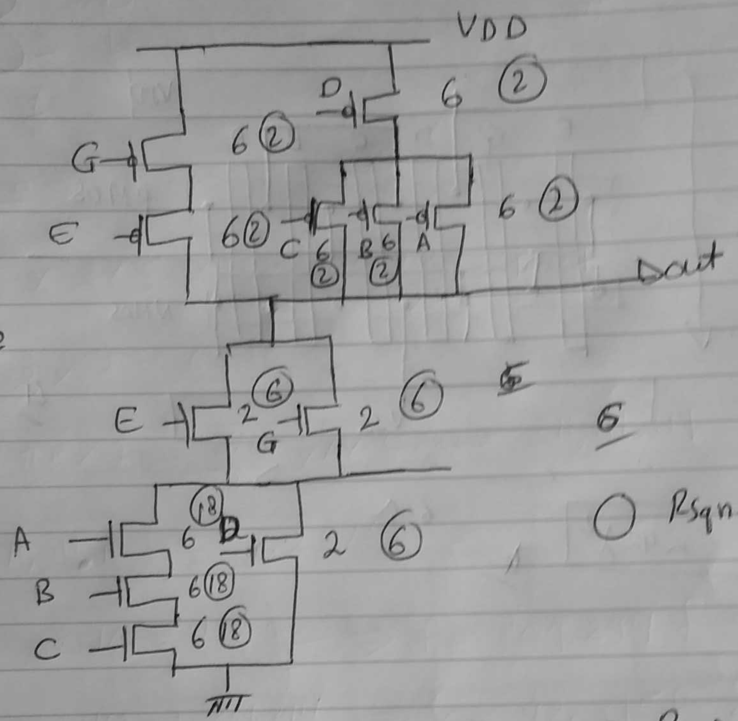
e)

	[illegible]	[illegible]	[illegible]
2-input NOR	$\frac{4}{2} = 2$	$\frac{6}{3}$	$\frac{7}{3}$
2-input NAND	$\frac{5}{2}$	[illegible]	2
3-input NOR	$\frac{3}{2}$	$\frac{4}{3}$	$\frac{5}{3}$
3-input NAND	$\frac{3}{2}$	$\frac{5}{3}$	$\frac{4}{3}$
ΠLE	$\frac{30}{7}$ ([illegible])	[illegible] ([illegible])	[illegible] ([illegible])

Best Choice

30

Q2) $F = \overline{(A.B.C + D).(E + G)}$



◯ $R_{sq\,n} = 3 R_{sq\,p}$

$R_{sq\,p} = 3 R_{sq\,n}$

$LE_A = \frac{6+6}{4} = 3$ ✓

$LE_B = \frac{6+6}{4} = 3$ ✓

$LE_G = \frac{2+6}{4} = 2$ ✓

$R_{sq\,n} = 3 R_{sq\,p}$

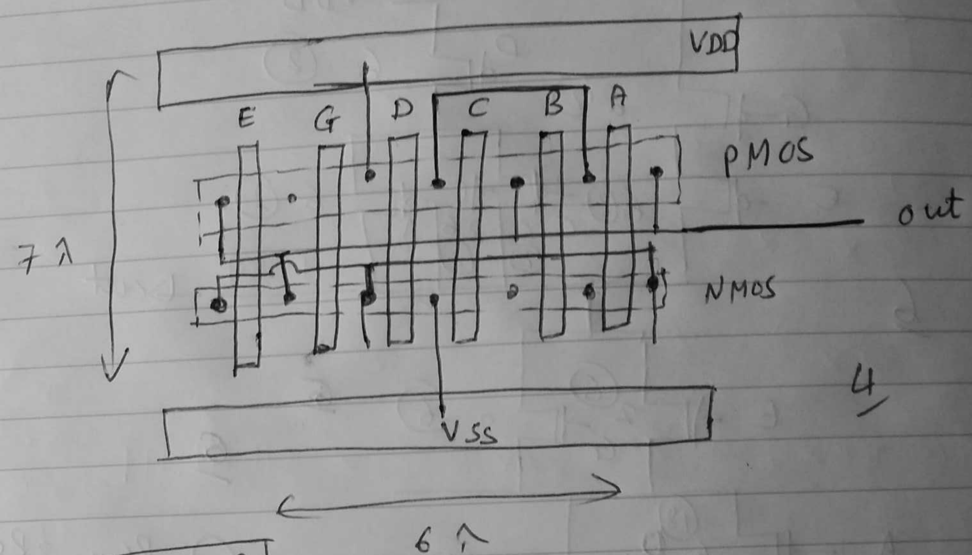
$LE_A = (18+2)/4 = 5$ ✓

$LE_B = (18+2)/4 = 5$ ✓

$LE_G = (6+2)/4 = 2$ ✓

Euler path: {E G D C B A} ✓

Euler bath {E G D C B A}

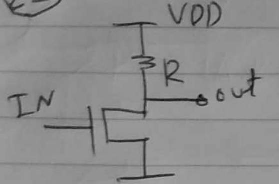


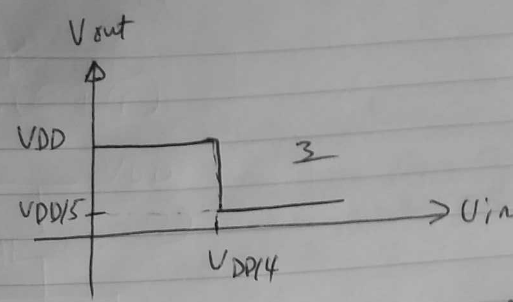
4

area $\sim 42\lambda^2$

Q3) 25

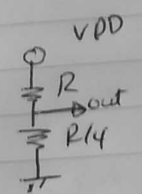
(a)





$R = 4 R_{NMOS}$

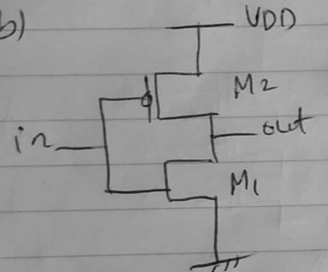
$V_{TN} = \frac{VDD}{4}$

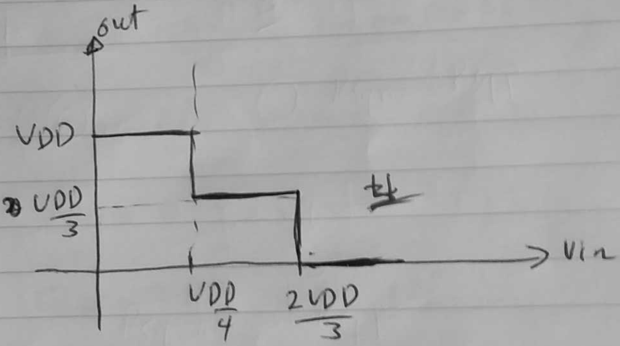


$0 < Vin \le \frac{VDD}{4} \rightarrow out = VDD$ 3

$Vin > \frac{VDD}{4} \rightarrow out = \frac{R/4}{R + R/4} VDD = \frac{VDD}{5}$ 3

(b)





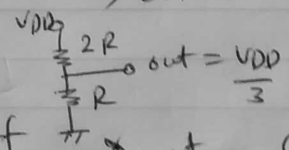
$V_{TN} = \frac{VDD}{4}$

$|V_{TP}| = \frac{VDD}{3}$

$R_{PMOS} = 2R_{NMOS}$

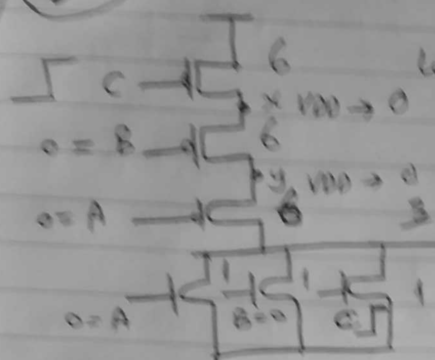
$Vin \le \frac{VDD}{4}$; M_1 is off ; M_2 is ON $\Rightarrow$ out = VDD 4

$\frac{VDD}{4} < Vin < \frac{2VDD}{3}$; M_1 is ON ; M_2 is ON $\Rightarrow$ out = VDD/3 4



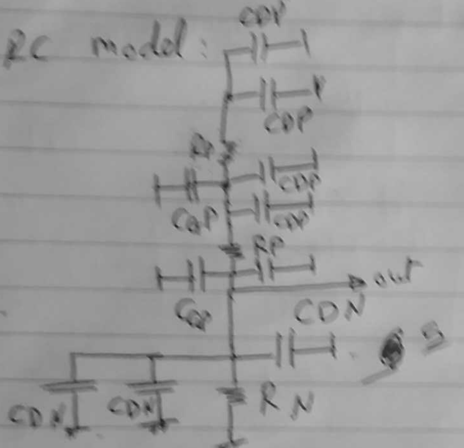
$Vin \ge \frac{2VDD}{3}$; M_1 is ON ; M_2 is off $\Rightarrow$ out = 0 4

Q4) (38)



Worst case delay when $A = B = 0$ & C goes from $0 \to 1$ single NMOS has to drive all the stack 5

RC model:



$R_P = 30\frac{k\Omega}{\square} \times \frac{100nm}{6\mu} = .5k\Omega$ 1

$R_N = 15\frac{k\Omega}{\square} \times \frac{100nm}{1\mu} = 1.5k\Omega$ 1

$C_{DP} = 2\frac{fF}{\mu m} \times 6\mu = 12f$ 1

$C_{DN} = 2\frac{fF}{\mu} \times 1\mu = 2f$ 1

$C_{GP} = 2\frac{fF}{\mu} \times 6 = 12f$ 1

$t_p = \ln(2) \cdot R_N (3C_{DN} + 5C_{DP} + 2C_{GP})$

$= \ln(2) \times 1.5k\Omega (3 \times 2 + 5 \times 12 + 2 \times 12)$ 5

$= \ln 2 \times 1.5k\Omega \times 90f = 93.57\ pf.$