hw 08

Estimate input capacitance of base inverter 12/6.

gate area $= 12 \cdot 2 + 6 \cdot 2 = 36\ \lambda^2$

$$= 36\ \lambda^2 \cdot \left(\frac{0.3\mu m}{\lambda}\right)^2 = 3.24\ \mu m^2$$

$$C_{in} = \left(\frac{C_{gate}}{area}\right)(area)$$

$$= \left(2400 \frac{aF}{\mu m^2}\right)\left(3.24 \mu m^2\right) = \boxed{7.8\ fF}$$

↑ estimate only, round to 2 digits

$C_{load} = 50\ pF$

Electrical effort $H = \frac{C_{load}}{C_{in}} = \frac{50 pF}{7.8 fF} = 6410$

inverter chain path effort:

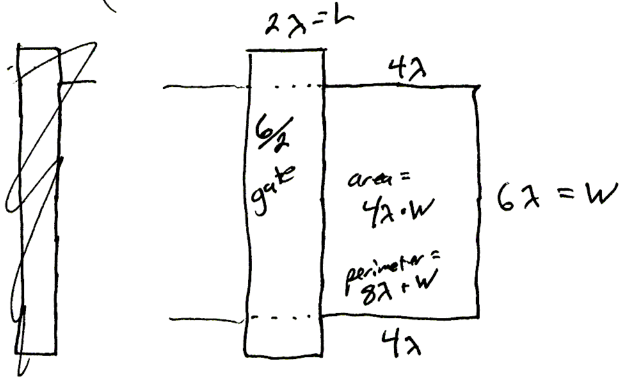
$$F = GBH$$
$$= (1)(1)(6410)$$

According to "inverter-chain-derivation.pdf", to find the optimum, we really need a value for $\gamma = \frac{C_{diffusion}}{C_{gate}}$

C_{gate} is easy. ↑ done.

$$C_{gate} = \left(\frac{C_{gate}}{area}\right)(\overset{L}{2\lambda}) \cdot W = 1.44\ fF/\cancel{width}(\mu m)$$

C depletion: (one side)



$$C_{depletion} = \left(\frac{C_{depletion}}{area}\right)(4\lambda)\cdot W + \left(\frac{C_{depletion}}{perimeter}\right)(8\lambda + W)$$

$$C_{depletion}(N) = \left(0.42\,\frac{fF}{\mu m^2}\right)\underbrace{(4\cdot 0.3\,\mu m)}_{0.504\,fF}\cdot W + \left(0.35\,\frac{fF}{\mu m}\right)(8\cdot 0.3\,\mu m) + 0.35\,\frac{fF}{\mu m}\cdot W$$

$$= 0.84\,fF + 0.854\,\frac{fF}{\mu m}\cdot W$$

$$C_{depletion}(P) = \left(0.71\,\frac{fF}{\mu m^2}\right)(4\cdot 0.3)\,W + \left(0.24\,\frac{fF}{\mu m}\right)(8\cdot 0.3) + 0.24\cdot W$$

$$= 0.576\,fF + 1.092\,\frac{fF}{\mu m}\cdot W$$

For a 12λ wide PMOS:

$C_{depletion}$ = 4.51 fF

C_{gate} = 5.18 fF

$\gamma = 0.87$

For a 6λ wide NMOS:

$C_{depletion}$ = 2.38 fF

C_{gate} = 2.59 fF

$\gamma = 0.92$

Complete gate

$C_{depletion}$ = 6.89

$C_{gate_{in}}$ = 7.77

$\gamma = 0.89$

this γ ~~gpn~~ $= 0.89$ gives an f_{opt} of about 3.5

book rounds to : 4.

Use $f_{opt} = 3.5$ for these calculations.

Optimum
Number of stages :

$$N_{opt} = \log_{f_{opt}}(F) = \log_{3.5}(6410)$$

$$= \frac{\ln(6410)}{\ln(3.5)} = 6.997$$

Choose $\boxed{7 \text{ stages}}$

Stage effort

$$\hat{f} = F^{1/7} = (6410)^{1/7} = 3.498 \rightarrow 3.5$$

(not suprising!)