

Problem 1:

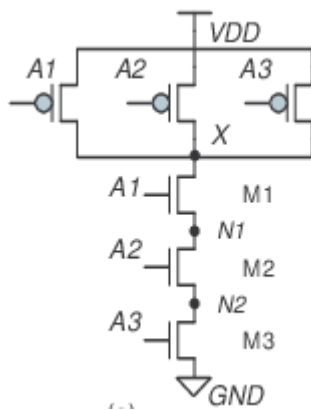
In figure 1.4 we can find the count of transistors in the processor increases by about ~10 times per seven years. In 2002 the count was about 0.1 Billion, so we can predict the count in 2020 to be about

$$0.1 \text{ billion} * 10^{(18/7)} = 37.28 \text{ billion.}$$

The answers to this problem will vary considerably as it is an extrapolation question

Problem 2:

The transistor level schematic for a CMOS 3-input NAND gate can be made like this (other ways are possible)



A1, A2, and A3 are inputs

X is the output

$$X = \overline{A1A2A3}$$

Problem 3:

$$\text{Area of die} = A_{die} = (5\text{mm})^2 = 25 \text{ mm}^2 = 0.25 \text{ cm}^2$$

$$\text{Area of wafer} = A_{wafer} = \left(\frac{300}{2}\right)^2 * \pi = 70685 \text{ mm}^2 = 706.85 \text{ cm}^2$$

$$\text{Hard yield of die } Y_H = e^{-A_{die} * d} = e^{-0.25 * 1.4} = e^{-0.35} = 0.705$$

$$\text{The total yield } Y = Y_H * Y_S = 0.705 * 1 = 0.705$$

$$\text{The cost per good die } C_{good} = \frac{C_{wafer}}{A_{wafer}/A_{die}} * \frac{1}{Y} = \frac{\$3200}{\frac{70685}{25}} * \frac{1}{0.705} = \$1.605$$

Problem 4:

$$Y = \frac{x-u}{g} = \frac{3mv-0mv}{1.5mv} = \frac{3}{2} = 1.5$$

$$P_{Soft_Amp} = \int_{-1.5}^{1.5} f(x) dx = 2F_N(1.5) - 1 = 0.866$$

There are multiple ways to perform this step

$$\text{Two Op Amps per chip } P_{Soft_chip} = 0.866^2 = 0.750$$

Problem 5:

Since the input offset voltage follow Gaussian distribution we have the soft yield θ :

$$Y_s = P_{soft} = 2F_N(y) - 1 = 0.98 \Rightarrow F_N(y) = 0.990$$

There are multiple ways to perform this step.

$$y = 2.33 = \frac{x-u}{g} = \frac{1.5mv-0}{\left(\frac{20mV\mu m}{\sqrt{A}}\right)} \Rightarrow A = 965.14 \mu m^2$$

Problem 6:

$$\text{The area of a die in new process} = A_{die} = \left(\frac{7}{65}\right)^2 * 0.5cm^2 = 5.7988 * 10^{-3}cm^2$$

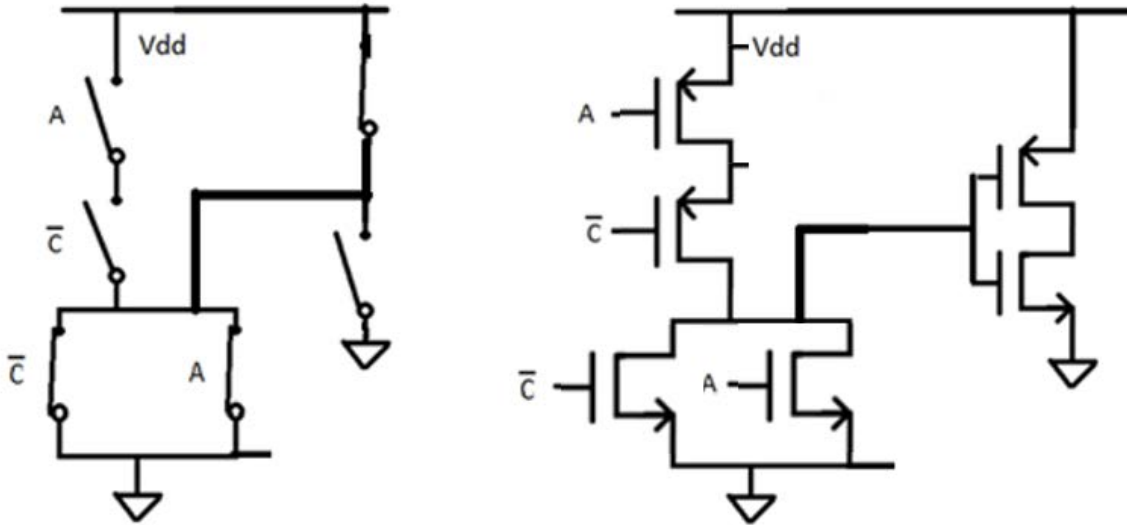
$$\text{The hard yield} = Y_H = e^{-A_{die}*d} = e^{-0.00696} = 0.9931$$

$$\text{The yield } Y = Y_H * Y_s = 0.9931$$

$$C_{good} = \frac{C_{wafer}}{(A_{wafer}/A_{die})} * \frac{1}{Y} = \frac{\$10000}{\frac{1590.4}{0.005799}} * \frac{1}{0.9931} = \$0.0367$$

Problem 7:

This switch level model assumes $A = 1$ and $\bar{C} = 1$.



An inverter should be used to convert C to $\sim C$ (not shown)

Problem 8:

When both inputs are 0V the output is VDD = 3V

When one input is 0V and the other is 3V the output is VDD = 3V

When both inputs are 3V the output is VSS = 0V

Problem 9:

Here is one solution to this problem:

```

1  module NOR2 (i_A, i_B, o_F);
2      input i_A, i_B;
3      output o_F;
4
5      assign o_F = ~(i_A||i_B);
6
7  endmodule

module OR2 (i_A, i_B, o_F);
    input i_A, i_B;
    output o_F;
    wire A_nor_B;

    NOR2 nor0(i_A(i_A), i_B(i_B), o_F(A_nor_B));
    NOR2 nor1(i_A(A_nor_B), i_B(A_nor_B), o_F(o_F));

endmodule

1  module AND2 (i_A, i_B, o_F);
2      input i_A, i_B;
3      output o_F;
4      wire A_not, B_not;
5
6      NOR2 nor0(i_A(i_A), i_B(i_A), o_F(A_not));
7      NOR2 nor1(i_A(i_B), i_B(i_B), o_F(B_not));
8      NOR2 nor2(i_A(A_not), i_B(B_not), o_F(o_F));
9
10 endmodule

```

```

1 module HW2_Problem_TB();
2     reg r_A, r_B, r_C;
3     wire w_F;
4
5     initial
6     begin
7         r_A = 1'b0;
8         r_B = 1'b0;
9         r_C = 1'b0;
10    end
11
12    always
13        #10 r_A = ~r_A;
14    always
15        #20 r_B = ~r_B;
16    always
17        #40 r_C = ~r_C;
18
19    HW2_Problem name(.i_A(r_A), .i_B(r_B), .i_C(r_C), .o_F(w_F));
20
21 endmodule

```

```

1 module HW2_Problem (i_A, i_B, i_C, o_F);
2     input i_A, i_B, i_C;
3     output o_F;
4     wire A_not, C_not;
5     wire nA_B, nA_B_C, B_nC, A_B_nC;
6
7     NOR2 nor0(i_A(i_A), i_B(i_B), o_F(A_not));
8     NOR2 nor1(i_A(i_C), i_B(i_C), o_F(C_not));
9     AND2 and0(i_A(A_not), i_B(i_B), o_F(nA_B));
10    AND2 and1(i_A(nA_B), i_B(i_C), o_F(nA_B_C));
11    AND2 and2(i_A(i_B), i_B(C_not), o_F(B_nC));
12    AND2 and3(i_A(i_A), i_B(B_nC), o_F(A_B_nC));
13    OR2 or0(i_A(nA_B_C), i_B(A_B_nC), o_F(o_F));
14
15 endmodule

```

