Notes:

Problems 6 and 15 were removed and will not be graded.

Reasonable answers to research questions (that are not on this solution manual) will be accepted as correct answers.

Approximations (and rounding differences) within the same order of magnitude will be accepted as correct answers.

For questions where you need to research numbers and use them to solve, any number that is reasonably close to the ones in this solution manual will be accepted.

Problem 1:

Area of one transistor = $7\ nm * 7\ nm * 10 = 490\ nm^2$

Size of die = 490 nm^2 x 2000 transistors = 980,000 nm^2

Area of wafer $= (\frac{3.048*10^8}{2})^2 * \pi = 7.297 * 10^{16}\ nm$

Number of dies = $\frac{7.298*10^{16}\ nm^2}{980000\ nm^2} = 7.447 * 10^{10}\ \frac{dies}{wafer}$

Problem 2:

The $\frac{cost}{die} = \frac{\$3500}{7.447*10^{10}} = \frac{\$4.700*10^{-8}}{die}$

Problem 3:

Assuming that a circular ink drop diameter is 100 um:

$Area = (\frac{100*10^{-6}}{2})^2 * \pi = 7.854 * 10^9\ nm^2$

Number of transistors = $\frac{7.854*10^9\ nm\char`^2}{490\ nm^2} = 1.603 * 10^7$

Problem 4:

Some can be turned off when not needed, reducing heat/power consumption. Also, lower frequency means less power consumed by parasitic.

Problem 5:

Feature size of 7 nm process = 7 nm

Diameter of a silicon atom = 210 pm = 0.210 nm

$\frac{7\ nm}{.210\ nm} =$ 33.33 times larger.

Diameter of SiO_2 about 310 pm = .310 nm

$\frac{7\ nm}{.310\ nm} =$ 22.58 times larger.

Diameter of a human hair = 100 um = 100,000 nm

$\frac{7\ nm}{100{,}000\ nm} =$ 0.00007 times the diameter of a human hair.

Problem 7:

10 nm

Problem 8:

a) For Core Intel i7 3930k P = 95W
   Current at 1.2V = $I = \frac{P}{V} = \frac{95W}{1.2V} = 79.16A$ *(3 points)*
b) For gold wire ρ = 1.16Ω/inch
   $R = \rho * L = 1.16\Omega * \frac{1}{2} = 0.58\Omega$
   $V = I * R = 45.91V$ *(3 points)*
c) Power Dissipated = $P = I^2 * R = 79.16^2 * 0.58 = 3634.5\ W$ *(3 points)*
d) Fusing Current = 0.6~0.7 A
   Actual Current = 0.06~0.07 A
   Number of wires = $\frac{79.16}{.06} \sim \frac{79.16}{.07} =$ 1130~1319 gold wired *(3 points)*

Problem 9-10:

Type	Storage Density (Bit/cm^2)	Cost of Storage ($/bit)	
CD	10^7	10^{-11}	
DVD	10^8	10^{-12}	Lowest
Blue Ray	10^9	10^{-12}	Lowest
Hard Disk	10^{10}	10^{-12}	Lowest
SRAM	10^7	10^{-6}	Highest
DRAM	10^9	10^{-9}	
FLASH	10^{10}	10^{-10}	

$$\text{Ratio} = \frac{10^{-6}}{10^{-12}} = 10^6$$ *(3 points)*

Problem 11:

Techcrunch and HIS Markit report approximately 6.1 billion smartphones will be in use by 2020.

Problem 12:

From Gartner.com

Android	81.7%
iOS	17.9%
Windows	0.3%
BlackBerry	0.0%
Other	0.1%

Problem 13:

From Gartner.com

Worldwide Smartphone sales in 2016 – 1,495,358,000
Worldwide Smartphone users in 2016 – 2,100,000,000
About 70% of smartphone users bought a new phone in 2016. This creates a large market potential each year and implies the useful life of a smartphone is about 1 – 2 years.

Problem 14:

Number of full time engineers = $\frac{\$500*.1*1495358000}{\$60000} = 1.25*10^{6}$ engineers

Problem 16:

2-input NOR code:

/home/jaaymond/ee330/verilog/EE330Hom

```
`timescale 1ns/1ps

module HW1_2NOR(iA, iB, out);
  input iA, iB;
  output out;
  wire out;

  assign out = ~(iA | iB);
endmodule
```

3-input AND code:

/home/jaaymond/ee330/verilog/EE330Homework/

```
`timescale 1ns/1ps

module HW1_3AND(iA, iB, iC, out);
  input iA, iB, iC;
  output out;
  wire out;

  assign out = iA*iB*iC;
endmodule
```

Test Bench:

/home/jaaymond/ee330/verilog/EE330Homework/HW1_tb.v (/HW1_tb) - Defau

```
`timescale 1ns/1ps
module HW1_tb();
  reg a, b, c;
  wire oAnd, oNor;
  HW1_3AND myAnd( .iA(a), .iB(b), .iC(c), .out(oAnd) );
  HW1_2NOR myNor( .iA(a), .iB(b), .out(oNor) );

  initial
  begin
    a = 1'b0; b = 1'b0; c = 1'b0;
    #20;
    a = 1'b0; b = 1'b0; c = 1'b1;
    #20;
    a = 1'b0; b = 1'b1; c = 1'b0;
    #20;
    a = 1'b0; b = 1'b1; c = 1'b1;
    #20;
    a = 1'b1; b = 1'b0; c = 1'b0;
    #20;
    a = 1'b1; b = 1'b0; c = 1'b1;
    #20;
    a = 1'b1; b = 1'b1; c = 1'b0;
    #20;
    a = 1'b1; b = 1'b1; c = 1'b1;

  end

endmodule
```

Waveform: