Problem 1:

Area of one transistor \( = 10 \, nm \times 10 \, nm \times 10 = 1000 \, nm^2 \)

Diameter of wafer \( = 3.048 \times 10^8 \, nm \)

Area of wafer \( = \left( \frac{3.048 \times 10^8}{2} \right)^2 \times \pi = 7.297 \times 10^{16} \, nm \)

Number of dies \( = \frac{7.298 \times 10^{16} \, nm^2}{2000 \times 1000 \, nm^2} = 3.649 \times 10^{10} \, \text{die/wafer} \)

Problem 2:

The cost per die \( = \frac{\$3500}{3.649 \times 10^{10}} = \frac{\$9.592 \times 10^{-8}}{\text{die}} \)

Problem 3

Assuming that a circular ink drop diameter is 100 um:

\[ \text{Area} = \left( \frac{100 \times 10^{-6}}{2} \right)^2 \times \pi = 7.854 \times 10^9 \, nm^2 \]

Number of transistors \( = \frac{7.854 \times 10^9 \, nm^2}{100 \, nm^2} = 7.854 \times 10^6 \)

Problem 4:

Some can be turned off when not needed. Lower frequency means less power consumed by parasitics.

Problem 5:

Feature size of 10 nm process \( = 10 \, nm \)

Diameter of a silicon atom \( = 210 \, pm = 0.210 \, nm \)

\( \frac{10 \, nm}{0.210 \, nm} = 47.62 \, \text{times larger}. \)

Diameter of SiO\(_2\) about \( 310 \, pm = 0.310 \, nm \)

\( \frac{10 \, nm}{0.310 \, nm} = 32.26 \, \text{times larger}. \)
Diameter of a human hair = 100 um = 100,000 nm

\[
\frac{10 \text{ nm}}{100,000 \text{ nm}} = \frac{1}{1000}
\]

the diameter of a human hair.

Problem 6

Intel: $59.38 Billion

Saudi Aramco: $311 Billion

Nestle $92.55 Billion

Problem 7:

a) Feature size = 14nm

b) Die area = 82 mm²

c) Transistor area = \( \frac{82 \text{ mm}^2}{1,400,000,000} = 58.572 \times 10^3 \text{ nm}^2 \)

d) Active Area = 14 nm \times 14 nm = 196 \text{ nm}^2

\[
\frac{\text{Active Area}}{\text{Average Area}} = \frac{196 \text{ nm}}{58.572 \text{ nm}^2} = 0.003345 = 0.335\%\text{ of the average area is active area}
\]

This can also be read as the average area is 298.8 times the active area.

Problem 8:

a) For Core Intel i7 3930k P = 123.69W

Current at 1.2V = \( I = \frac{P}{V} = \frac{123.69W}{1.2V} = 103A \)

b) For gold wire \( \rho = 1.16\Omega/\text{inch} \)

\[ R = \rho \times L = 1.16\Omega \times \frac{1}{2} = 0.58\Omega \]

\[ V = I \times R = 59.78V \]

\[ P = I^2 \times R = 103^2 \times 0.58 = 6153 W \]

d) Fusing Current = 0.6~0.7 A

Actual Current = 0.06~0.07 A

Number of wires = \( \frac{103}{0.06} ~\frac{103}{0.07} = 1471~1717 \text{ gold wired} \)
Problem 9:

<table>
<thead>
<tr>
<th>Type</th>
<th>Storage Density (Bit/cm²)</th>
<th>Cost of Storage ($/bit)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CD</td>
<td>$10^7$</td>
<td>$10^{-11}$</td>
</tr>
<tr>
<td>DVD</td>
<td>$10^8$</td>
<td>$10^{-12}$</td>
</tr>
<tr>
<td>Blue Ray</td>
<td>$10^9$</td>
<td>$10^{-12}$</td>
</tr>
<tr>
<td>Hard Disk</td>
<td>$10^{10}$</td>
<td>$10^{-12}$</td>
</tr>
<tr>
<td>SRAM</td>
<td>$10^7$</td>
<td>$10^{-6}$</td>
</tr>
<tr>
<td>DRAM</td>
<td>$10^9$</td>
<td>$10^{-9}$</td>
</tr>
<tr>
<td>FLASH</td>
<td>$10^{10}$</td>
<td>$10^{-10}$</td>
</tr>
</tbody>
</table>

Ratio $= \frac{10^{-6}}{10^{-12}} = 10^6$

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 = \( \frac{500 \times 1 \times 1495358000}{60000} \) = 1.25 \( \times \) 10^6 engineers

Problem 15:

Area of Skylane Chip = 82 mm^2

a) Number of Skylane Chips/wafer = \( \frac{(450 \text{ mm})^2}{82 \text{ mm}^2} \) * \( \frac{\pi}{2} \) = 1939

b) Cost = \( \frac{2500}{1940 \times 0.9} \) = $1.43/\text{chip}

Problem 16:

```
h /home/jaaymond/ee330/verilog/EE330Homework/
Ln#          |
-------------|
  1 | `timescale 1ns/1ps
  2 | module HW1_2NOR(iA, iB, out);
  3 |   input iA, iB;
  4 |   output out;
  5 |   wire out;
  6 |   assign out = ~(iA | iB);
  7 | endmodule

h /home/jaaymond/ee330/verilog/EE330Homework/
Ln#          |
-------------|
  1 | `timescale 1ns/1ps
  2 | module HW1_2AND(iA, iB, iC, out);
  3 |   input iA, iB, iC;
  4 |   output out;
  5 |   wire out;
  6 |   assign out = iA*iB*iC;
  7 | endmodule
```
```verilog
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
```