HW1 solution

1.2 a. Phoenix:

$$\text{Dies per wafer} = \left(\pi \times (45/2)^2\right)/2 - (\pi \times 45)/\text{sqrt}(2 \times 2) = 795 - 70.7 = 724.5 = 724$$

$$\text{Yield} = 1/(1 + (0.04 \times 2))^{14} = 0.340$$

$$\text{Profit} = 724 \times 0.34 \times 30 = \$7384.80$$

b. Red Dragon:

$$\text{Dies per wafer} = \left(\pi \times (45/2)^2\right)/2 - (\pi \times 45)/\text{sqrt}(2 \times 1.2) = 1325 - 91.25 = 1234$$

$$\text{Yield} = 1/(1 + (0.04 \times 1.2))^{14} = 0.519$$

$$\text{Profit} = 1234 \times 0.519 \times 15 = \$9601.71$$

c. Phoenix chips: 25,000/724 = 34.5 wafers needed
Red Dragon chips: 50,000/1234 = 40.5 wafers needed

1.4 a. Energy: 1/8. Power: Unchanged.

b. Energy: $\text{Energy}_{new}/\text{Energy}_{old} = (\text{Voltage} \times 1/8)^2/\text{Voltage}^2 = 0.0156$
Power: $\text{Power}_{new}/\text{Power}_{old} = 0.0156 \times (\text{Frequency} \times 1/8)/\text{Frequency} = 0.00195$

c. Energy: $\text{Energy}_{new}/\text{Energy}_{old} = (\text{Voltage} \times 0.5)^2/\text{Voltage}^2 = 0.25$
Power: $\text{Power}_{new}/\text{Power}_{old} = 0.25 \times (\text{Frequency} \times 1/8)/\text{Frequency} = 0.0313$

d. 1 core = 25% of the original power, running for 25% of the time.

$$0.25 \times 0.25 + (0.25 \times 0.2) \times 0.75 = 0.0625 + 0.0375 = 0.1$$

1.5 a. Amdahl's law: 1/(0.8/4 + 0.2) = 1/(0.2 + 0.2) = 1/0.4 = 2.5

b. 4 cores, each at 1/(2.5) the frequency and voltage
Energy: $\text{Energy}_{quad}/\text{Energy}_{single} = 4 \times (\text{Voltage} \times 1/(2.5))^2/\text{Voltage}^2 = 0.64$
Power: $\text{Power}_{new}/\text{Power}_{old} = 0.64 \times (\text{Frequency} \times 1/(2.5))/\text{Frequency} = 0.256$

c. 2 cores + 2 ASICs vs. 4 cores

$$(2 + (0.2 \times 2))/4 = (2.4)/4 = 0.6$$

1.9

a. 60%
b. 0.4+0.6*0.2=0.52, which reduces the energy to 58% of the original energy
c. 0.8*0.8+0.6=0.384
d. 0.4+0.3*2=0.46, which reduces the energy to 46% of the original energy

1.13 a. old execution time $= 0.5$ new $+ 0.5 \times 10$ new $= 5.5$ new

b. In the original code, the unenhanced part is equal in time to the enhanced part (sped up by 10), therefore:
$(1 - x) = x/10$
$10 - 10x = x$
$10 = 11x$
$10/11 = x = 0.91$

1.14 a. $1/(0.8 + 0.20/2) = 1.11$

b. $1/(0.7 + 0.20/2 + 0.10 \times 3/2) = 1.05$

c. fp ops: $0.1/0.95 = 10.5\%$, cache: $0.15/0.95 = 15.8\%$

1.15 a. $1/(0.5 + 0.5/22) = 1.91$

b. $1/(0.1 + 0.90/22) = 7.10$

c. $41\% \times 22 = 9$. A runs on 9 cores. Speedup of A on 9 cores: $1/(0.5 + 0.5/9) = 1.8$ Overall speedup if 9 cores have 1.8 speedup, others none: $1/(0.6 + 0.4/1.8) = 1.22$

d. Calculate values for all processors like in c. Obtain: 1.8, 3, 1.82, 2.5, respectively.

e. $1/(0.41/1.8 + 0.27/3 + 0.18/1.82 + 0.14/2.5) = 2.12$

1.16 a. $1/(0.2 + 0.8/N)$

b. $1/(0.2 + 8 \times 0.005 + 0.8/8) = 2.94$

c. $1/(0.2 + 3 \times 0.005 + 0.8/8) = 3.17$

d. $1/(.2 + \log N \times 0.005 + 0.8/N)$

e. $d/dN\ (1/((1 - P) + \log N \times 0.005 + P/N) = 0)$