Problem 1.

$1\times10^9 \times 15 = 1.5\times10^{10}$ cycles

$1.5\times10^{10} \times 1.2 = 1.8\times10^{10}$ cycles

$\frac{1.8\times10^{10}}{10\,s} = 1.8\times10^9 = 1.8$ GHz

Problem 2.

a

	CPI	# of instruction on one processor
Arithmetic	1	3×10^9
Load/Store	10	2×10^9
Branch	5	2.56×10^8

1 processor

clock cycle: $3\times10^9 + 2\times10^{10} + 1.28\times10^9 = 2.428\times10^{10}$ cycles

Execution time for 1 processor $t = \frac{2.428\times10^{10}}{2\times10^9} = 12.14\,s$

2 processors

clock cycle: $\frac{3\times10^9 + 2\times10^{10}}{0.8\times2} + 1.28\times10^9 = 1.3655\times10^{10}$ cycles

$t = \frac{1.3655\times10^{10}}{2\times10^9} = 7.8275\,s$

speedup $= \frac{12.14}{7.8275} = 1.55$

4 processors

clock cycle: $\frac{3\times10^9 + 2\times10^{10}}{0.8\times4} + 1.28\times10^9 = 8.47\times10^9$

$t = \frac{8.47\times10^9}{2\times10^9} = 4.2355$

speed up $= \frac{12.14}{4.235} = 2.87$

8 processors

clock cycle: $\frac{3\times10^9 + 2\times10^{10}}{0.8\times8} + 1.28\times10^9 = 4.87\times10^9$

$t = \frac{4.87 \times 10^9}{2 \times 10^9} = 2.435$

speedup = 4.99

b. if CPI of arithmetic instruction was doubled

1 processor

clock cycle : $2 \times 3 \times 10^9 + 2 \times 10^{10} + 1.28 \times 10^9 = 2.728 \times 10^{10}$ cycles

$t = \frac{2.728 \times 10^{10}}{2 \times 10^9} = 13.64\,s$

2 processors

$$t = \frac{\frac{6 \times 10^9 + 2 \times 10^{10}}{0.8 \times 2} + 1.28 \times 10^9}{2 \times 10^9} = 8.765\,s$$

4 processors

$$t = \frac{\frac{6 \times 10^9 + 2 \times 10^{10}}{0.8 \times 4} + 1.28 \times 10^9}{2 \times 10^9} = 4.7025\,s$$

8 processors

$$t = \frac{\frac{6 \times 10^9 + 2 \times 10^{10}}{0.8 \times 8} + 1.28 \times 10^9}{2 \times 10^9} = 2.67\,s$$

1.5s, 0.94s, 0.46s, 0.235s increase in execution time

c. $3 \times 10^9 + a \cdot 2 \times 10^{10} + 1.28 \times 10^9 = \frac{3 \times 10^9 + 2 \times 10^{10} + 1.28 \times 10^9}{0.8 \times 4}$

$a = 0.21$ reduced to 21%.

3 a. P_1 : $t = \frac{0.9 \times 5 \times 10^9}{4 \times 10^9} = 1.125s$

P_2 : $t = \frac{0.75 \times 1 \times 10^9}{3 \times 10^9} = 0.25s$

not true

b. $\frac{1 \times 10^9 \times 0.9}{4 \times 10^9} = \frac{a \times 0.75}{3 \times 10^9}$

$a = 9 \times 10^8$

c. P_1 : $\frac{4 \times 10^9}{0.9} = 4.44 \times 10^9$ Instructions

P_2 : $\frac{3 \times 10^9}{0.75} = 4 \times 10^9$ Instruction

but P_2 has better performace so not true

d. P_1 MFIOPS $= \frac{0.4 \times 5 \times 10^9}{1.125 \times 10^6} = 1.78 \times 10^3$

P_2 MFIOPS $= \frac{0.4 \times 10^9}{0.25 \times 10^6} = 1.6 \times 10^3$

4. 11001010000 0010 000000 0000 0000

1101000000 00000 001111 0000 0000

11111000010 0000001 00 0000 1001

10110100 11111111 11111111101 1001

1101001101 00000 00001 1001 1001

1000101110000 1001 000000 0000 0000

00001 11111111111111111111100

5.

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B.LT  4
ADDI  X2, X2, #1
  B   0
ADDI  X31, X31, 0
CBZ   X0, 5
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