1.5

(a). CPU time = IC · CPI · Clock Cycle Time

P1: $1 \cdot 1.5 / 3 = 0.5$

P2: $1 \cdot 1 / 2.5 = 0.4$

P3: $1 \cdot 2.2 / 4 = 0.55$

Answer: P2 has the highest performance #

(b)

P1: $10 = IC \cdot 1.5 / (3 \cdot 10^9)$

$\Rightarrow IC = 2 \cdot 10^{10}$ #

numbers of cycle = $IC \cdot CPI = 3 \cdot 10^{10}$ #

P2: $10 = IC \cdot 1 / (2.5 \cdot 10^9) =$

$\Rightarrow IC = 2.5 \cdot 10^{10}$ #

numbers of cycle = $IC \cdot CPI = 2.5 \cdot 10^{10}$ #

P3: $10 = IC \cdot 2.2 / (4 \cdot 10^9)$

$\Rightarrow IC = \frac{2}{1.1} \cdot 10^{10}$ #

numbers of cycle = $IC \cdot CPI = 4 \cdot 10^{10}$ #

(c)

execution time = IC · CPI / clock rate

$\Rightarrow 0.7 = 1 \cdot 1.2 / X$

$\Rightarrow X = \frac{12}{7}$

clock rate should be $\frac{12}{7}$ times bigger #

$\Rightarrow$ clock rate that processors should have: P1 = 5.14 GHz

P2 = 4.29 GHz

P3 = 6.86 GHz #

1.6

CPU time of P1: $(0.1+0.4+1.5+0.6)\cdot 10^6 / 2.5\cdot 10^9$

$= \frac{26}{25}$ ms

CPU time of P2 $= (0.2+0.4+1+0.4)\cdot 10^6 / 3\cdot 10^9$

$= \frac{2}{3}$ ms

$\Rightarrow$ P2 is faster #

(a)

Global CPI of P1 $= \frac{26}{25} \times 10^{-3} \times 2.5 \times 10^9 / 10^6 = 2.6$ #

Global CPI of P2 $= \frac{2}{3} \times 10^{-3} \times 3 \times 10^9 / 10^6 = 2$ #

(b)

P1: CPU time $\times$ clock rate = clock cycles

$\Rightarrow$ clock cycles $= \frac{26}{25} \times 10^{-3} \times 2.5 \times 10^9 = 2.6 \times 10^6$ #

P2:

$\frac{2}{3} \times 10^{-3} \times 3 \times 10^9 = 2 \times 10^6$ #

1.7

(a)

$$\text{average CPI} = \frac{1.1}{1\cdot10^9\cdot1\cdot10^{-9}}\cdot\frac{1}{2.2} + \frac{1.5}{1.2\cdot10^9\cdot10^{-9}}\cdot\frac{1.2}{2.2}$$

$$= \frac{1}{2} + \frac{15}{22} = \frac{26}{22} = \frac{13}{11} \approx 1.18 \#$$

(b)

$$\frac{1}{1\cdot1.1} \Big/ \frac{1}{1.2\cdot1.25} = \frac{15}{11} \approx 1.36 \#$$

(c)

$$\frac{1\times10^9\times1.1}{6\times10^8\times1.1} = \frac{5}{3}$$ (versus A)

↑ speed up

$$\frac{1.2\times10^9\times\frac{5}{4}}{6\times10^8\times1.1} = \frac{25}{11}$$ (versus B)

↑ speedup

1.11.

(1)

$$\frac{750}{2.389\cdot10^{12}\cdot0.333\cdot10^{-9}} = \frac{750}{2389\cdot0.333} \approx 0.94 \#$$

(2) $\frac{9650}{750} = \frac{193}{15} \approx 12.87 \#$

(3) $1.1\cdot1\cdot1 = 1.1$, CPU time increase 10% #

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(4) $1.1 \cdot 1.05 \cdot 1 = 1.155$, CPU time increase 15.5% #

(5)

for 1.11.3, SPEC ratio $= \frac{193}{15} \times \frac{1}{1.1} = \frac{193}{16.5} = \frac{1930}{165} = \frac{386}{33} \doteq 11.7$ #

for 1.11.4, SPEC ratio $= \frac{193}{15} \times \frac{1}{1.155} = \frac{1720}{693} \doteq 11.14$ #

(reduce 9%)

(reduce 13%)

(6)

$$700 = 2.389 \times 10^{12} \times 0.85 \times CPI / 4 \times 10^{9}$$

$$\Rightarrow CPI = \frac{2.8 \times 10^{12}}{2.389 \times 0.85 \times 10^{12}} \doteq 1.38 \#$$

(7) $\frac{1.38}{0.94} = 1.47$; $\frac{4}{3} = 1.5$, they are similar #

(8) $1 - \frac{700}{750} \doteq 0.07$, reduced 7% #

(9) $960 \cdot 10^{-9} \cdot 0.9 = IC \cdot 1.61 / 4 \cdot 10^{9}$

$\Rightarrow IC = 960 \cdot 4 \cdot 0.9 / 1.61 = 2147$ #

(10) $960 \cdot 10^{-9} \cdot 0.9 = 2147 \cdot 1.61 /$ clock rate

$\Rightarrow$ clock rate = 4 GHz #

(11) $960 \cdot 10^{-9} \cdot 0.8 = 2147 \cdot 1.61 \cdot 0.85 /$ clock rate

$\Rightarrow$ clock rate = 3.83 GHz #

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1.14

(1) $\frac{1}{2} = \frac{x \cdot 50 + 110 + 80 \cdot 4 + 16 \cdot 2}{50 + 110 + 80 \cdot 4 + 16 \cdot 2}$

$\Rightarrow 100x + 924 = 512$

$\Rightarrow$ it's impossible #

(2) $\frac{1}{2} = \frac{50 + 110 + 80 \cdot x + 16 \cdot 2}{50 + 110 + 320 + 32}$

$\Rightarrow 160x + 384 = 512$

$\Rightarrow x = 0.8$

CPI of LIS instructions must reduce 80% to 0.8 #

(3) $\frac{50 \cdot 0.6 + 110 \cdot 0.6 + 80 \cdot 2.8 + 16 \cdot 1.4}{50 + 110 + 80 \cdot 4 + 16 \cdot 2}$

$= \frac{342.4}{512} = 0.67$, execution time reduce 33% #