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1.5
a.
Performance: instructions per second (IPS)

$$\text{CPU Time} = \frac{\text{Instruction Count} \times \text{CPI}}{Clock\ Rate}$$

$$\Rightarrow \text{IPS} = \frac{\text{Instruction Count}}{\text{CPU Time}} = \frac{Clock\ Rate}{CPI}$$

$$IPS_1 = \frac{3 \times 10^9}{1.5} = 2 \times 10^9$$

$$IPS_2 = \frac{2.5 \times 10^9}{1} = 2.5 \times 10^9$$

$$IPS_3 = \frac{4 \times 10^9}{2.2} = 1.8 \times 10^9$$

=> processor P2 has the highest performance. … Ans
b.
Clock Cycles = Instruction Count × CPI
Instruction Count = IPS × CPU Time
P1:
$\text{Instruction Count}_1 = 2 \times 10^9 \times 10 = 2 \times 10^{10}$ … Ans
$\text{Clock Cycles}_1 = 2 \times 10^{10} \times 1.5 = 3 \times 10^{10}$ … Ans
P2:
$\text{Instruction Count}_2 = 2.5 \times 10^9 \times 10 = 2.5 \times 10^{10}$ … Ans
$\text{Clock Cycles}_2 = 2.5 \times 10^{10} \times 1 = 2.5 \times 10^{10}$ … Ans
P3:
$\text{Instruction Count}_3 = 1.8 \times 10^9 \times 10 = 1.8 \times 10^{10}$ … Ans
$\text{Clock Cycles}_3 = \frac{4 \times 10^{10}}{2.2} \times 2.2 = 4 \times 10^{10}$ … Ans

c.

$$\text{CPU Time} = \frac{\text{Instruction Count} \times \text{CPI}}{Clock\ Rate}$$

$$\Rightarrow Clock\ Rate = \frac{\text{Instruction Count} \times \text{CPI}}{\text{CPU Time}}$$

∵ Instruction Count 不變

$$\therefore Clock\ Rate \propto \frac{\text{CPI}}{\text{CPU Time}} \Rightarrow \frac{1.2}{0.7} = \frac{12}{7}$$

$Clock\ Rate_1 = \frac{12}{7} \times 3 = 5.14\ (\text{GHz})\ \cdots$ Ans

$Clock\ Rate_2 = \frac{12}{7} \times 2.5 = 4.29\ (\text{GHz})\ \cdots$ Ans

$Clock\ Rate_3 = \frac{12}{7} \times 4 = 6.86\ (\text{GHz})\ \cdots$ Ans

1.6

$$\text{CPU Time} = \frac{\text{Clock Cycles}}{Clock\ Rate}$$

$$\text{Clock Cycles} = \sum_{i=1}^{n} \text{Instruction Count}_i \times CPI_i$$

P1:

$$\text{Clock Cycles}_1 = 0.1 \times 10^6 \times 1 + 0.2 \times 10^6 \times 2 + 0.5 \times 10^6 \times 3 + 0.2 \times 10^6 \times 3$$
$$= 2.6 \times 10^6$$

$$\text{CPU Time}_1 = \frac{2.6 \times 10^6}{2.5 \times 10^9} = 1.04 \times 10^{-3}\ (s)$$

P2:

$$\text{Clock Cycles}_2 = 0.1 \times 10^6 \times 2 + 0.2 \times 10^6 \times 2 + 0.5 \times 10^6 \times 2 + 0.2 \times 10^6 \times 2$$
$$= 2 \times 10^6$$

$$\text{CPU Time}_2 = \frac{2 \times 10^6}{3 \times 10^9} = 6.67 \times 10^{-4}\ (s)$$

=> P2 is faster. $\cdots$ Ans

a.

$$\text{CPI} = \frac{\text{Clock Cycles}}{\text{Instruction Count}}$$

$\text{CPI}_1 = \frac{2.6 \times 10^6}{10^6} = 2.6\ \cdots$ Ans

$\text{CPI}_2 = \frac{2 \times 10^6}{10^6} = 2\ \cdots$ Ans

b.

$\text{Clock Cycles}_1 = 2.6 \times 10^6\ \cdots$ Ans

$\text{Clock Cycles}_2 = 2 \times 10^6\ \cdots$ Ans

1.7

a.

$$\text{CPU Time} = \text{Instruction Count} \times \text{CPI} \times \text{Clock Cycle Time}$$

$$\Rightarrow \text{CPI} = \frac{\text{CPU Time}}{\text{Instruction Count} \times \text{Clock Cycle Time}}$$

$$\text{CPI}_A = \frac{1.1}{10^9 \times 10^{-9}} = 1.1 \ \cdots \ \text{Ans}$$

$$\text{CPI}_B = \frac{1.5}{1.2 \times 10^9 \times 10^{-9}} = 1.25 \ \cdots \ \text{Ans}$$

b.

$$\text{CPU Time} = \text{Instruction Count} \times \text{CPI} \times \text{Clock Cycle Time}$$

$$\Rightarrow \text{Clock Cycle Time} = \frac{\text{CPU Time}}{\text{Instruction Count} \times \text{CPI}}$$

∵ CPU Time 相同

$$\therefore \text{Clock Cycle Time} \propto \frac{1}{\text{Instruction Count} \times \text{CPI}}$$

$$\Rightarrow \frac{\text{Clock Cycle Time}_A}{\text{Clock Cycle Time}_B} = \frac{\text{Instruction Count}_B \times \text{CPI}_B}{\text{Instruction Count}_A \times \text{CPI}_A} = \frac{1.2 \times 10^9 \times 1.25}{10^9 \times 1.1} = 1.36$$

$$\Rightarrow \text{Clock Cycle Time}_A \ \textit{is}\ 36\%\ \textit{slower than}\ \text{Clock Cycle Time}_B. \ \cdots \ \text{Ans}$$

c.

$$\text{CPU Time} = \text{Instruction Count} \times \text{CPI} \times \text{Clock Cycle Time}$$

$$\Rightarrow \text{CPU Time}_{new} = 6 \times 10^8 \times 1.1 \times 10^{-9} = 0.66 \text{ (s)}$$

compiler A:

$$\frac{Performance_{new}}{Performance_A} = \frac{\text{CPU Time}_A}{\text{CPU Time}_{new}} = \frac{1.1}{0.66} = 1.67 \ \cdots \ \text{Ans}$$

compiler B:

$$\frac{Performance_{new}}{Performance_B} = \frac{\text{CPU Time}_B}{\text{CPU Time}_{new}} = \frac{1.5}{0.66} = 2.27 \ \cdots \ \text{Ans}$$

1.11

1.11.1

$$\text{CPU Time} = \text{Instruction Count} \times \text{CPI} \times \text{Clock Cycle Time}$$

$$\Rightarrow \text{CPI} = \frac{\text{CPU Time}}{\text{Instruction Count} \times \text{Clock Cycle Time}} = \frac{750}{2.389 \times 10^{12} \times 0.333 \times 10^{-9}} = 0.94 \ \cdots \ \text{Ans}$$

1.11.2

$$\text{SPECratio} = \frac{reference\ time}{execution\ time} = \frac{9650}{750} = 12.87 \ \cdots \ \text{Ans}$$

1.11.3

$$\text{CPU Time} = \text{Instruction Count} \times \text{CPI} \times \text{Clock Cycle Time}$$

∵ CPI 跟 Clock Cycle Time 不變

$$\therefore \text{CPU Time} \propto \text{Instruction Count}$$

=> CPU Time increases by 10%. ⋯ Ans

1.11.4

CPU Time = Instruction Count × CPI × Clock Cycle Time

∵ Clock Cycle Time 不變

∴ CPU Time ∝ Instruction Count × CPI => $1.1 \times 1.05 = 1.155$

=> CPU Time increases by 15.5%. ⋯ Ans

1.11.5

$$\text{SPECratio} = \frac{reference\ time}{execution\ time}$$

∵ reference time 相同

$$\therefore \text{SPECratio} \propto \frac{1}{execution\ time} \Rightarrow \frac{1}{1.155} = 0.866$$

$$\Rightarrow \text{SPECratio}_{new} = 0.866 \times \text{SPECratio}_{old} \cdots \text{Ans}$$

1.11.6

$$\text{CPU Time} = \frac{\text{Instruction Count} \times \text{CPI}}{Clock\ Rate}$$

$$\Rightarrow \text{CPI} = \frac{\text{CPU Time} \times Clock\ Rate}{\text{Instruction Count}} = \frac{700 \times 4 \times 10^9}{0.85 \times 2.389 \times 10^{12}} = 1.38 \cdots \text{Ans}$$

1.11.7

$$\frac{Clock\ Rate_{new}}{Clock\ Rate_{old}} = \frac{4}{3} = 1.33$$

$$\frac{CPI_{new}}{CPI_{old}} = \frac{1.38}{0.94} = 1.47$$

They are dissimilar.

$$\because \text{CPU Time} = \frac{\text{Instruction Count} \times \text{CPI}}{Clock\ Rate}$$

$$\Rightarrow \frac{Clock\ Rate}{CPI} = \frac{\text{Instruction Count}}{\text{CPU Time}}$$

但 Instruction Count 跟 CPU Time 減少的比例不一致。 ⋯ Ans

1.11.8

$$\frac{\text{CPU Time}_{new}}{\text{CPU Time}_{old}} = \frac{700}{750} = 0.933$$

=> CPU Time increases by 6.7%. ⋯ Ans

1.11.9

$$\text{CPU Time} = \frac{\text{Instruction Count} \times \text{CPI}}{Clock\ Rate}$$

$$\Rightarrow \text{Instruction Count} = \frac{\text{CPU Time} \times Clock\ Rate}{\text{CPI}} = \frac{0.9 \times 960 \times 10^{-9} \times 4 \times 10^9}{1.61} = 2147 \cdots \text{Ans}$$

1.11.10

$$\text{CPU Time} = \frac{\text{Instruction Count} \times \text{CPI}}{Clock\ Rate}$$

$$\Rightarrow Clock\ Rate = \frac{\text{Instruction Count} \times \text{CPI}}{\text{CPU Time}}$$

∵ Instruction Count 跟 CPI 不變

$$\therefore Clock\ Rate \propto \frac{1}{\text{CPU Time}} \Rightarrow \frac{1}{0.9} = 1.11$$

$$\Rightarrow Clock\ Rate_{new} = 1.11 \times 3 = 3.33\ (GHz)\ \cdots \text{Ans}$$

1.11.11

$$\text{CPU Time} = \frac{\text{Instruction Count} \times \text{CPI}}{Clock\ Rate}$$

$$\Rightarrow Clock\ Rate = \frac{\text{Instruction Count} \times \text{CPI}}{\text{CPU Time}}$$

∵ Instruction Count 不變

$$\therefore Clock\ Rate \propto \frac{\text{CPI}}{\text{CPU Time}} \Rightarrow \frac{0.85}{0.8} = 1.0625$$

$$\Rightarrow Clock\ Rate_{new} = 1.0625 \times 3 = 3.1875\ (GHz)\ \cdots \text{Ans}$$

1.14

1.14.1

$$\text{CPU Time} = \frac{\text{Clock Cycles}}{Clock\ Rate} = \frac{\sum_{i=1}^{n} \text{Instruction Count}_i \times CPI_i}{Clock\ Rate}$$

$$= \frac{50 \times 10^6 \times 1 + 110 \times 10^6 \times 1 + 80 \times 10^6 \times 4 + 16 \times 10^6 \times 2}{2 \times 10^9}$$

$$= 0.256\ (s)$$

$$\text{CPU Time}_{new}$$

$$= \frac{50 \times 10^6 \times CPI_{FP\_new} + 110 \times 10^6 \times 1 + 80 \times 10^6 \times 4 + 16 \times 10^6 \times 2}{2 \times 10^9}$$

$$= \frac{0.256}{2} = 0.128\ (s)$$

$$\Rightarrow CPI_{FP\_new} = -4.12 < 0 \Rightarrow \text{impossible.}\ \cdots \text{Ans}$$

1.14.2

$$\text{CPU Time}_{new}$$

$$= \frac{50 \times 10^6 \times 1 + 110 \times 10^6 \times 1 + 80 \times 10^6 \times CPI_{L/S\_new} + 16 \times 10^6 \times 2}{2 \times 10^9}$$

$$= \frac{0.256}{2} = 0.128\ (s)$$

$=> CPI_{L/S\_new} = 0.8$ ⋯ Ans

1. 14. 3

CPU Time_{new}

$$= \frac{50 \times 10^6 \times 1 \times 0.6 + 110 \times 10^6 \times 1 \times 0.6 + 80 \times 10^6 \times 4 \times 0.7 + 16 \times 10^6 \times 2 \times 0.7}{2 \times 10^9}$$

$= 0.1712\ (s)$ ⋯ Ans