Homework Assignment 1 Solution

Exercise 1.5

a. (5 points)

Instructions/sec = f/CPI, where f stands for clock rate

Performance of P1 (instructions/sec) = $3 \times 10^9/1.5 = 2 \times 10^9$
Performance of P2 (instructions/sec) = $2.5 \times 10^9/1.0 = 2.5 \times 10^9$
Performance of P3 (instructions/sec) = $4 \times 10^9/2.2 = 1.8 \times 10^9$

P2 has the highest performance.

b. (10 points)

clock cycles = time × clock rate,
then IC = clock cycles/CPI

clock cycles (P1) = $10 \times 3 \times 10^9 = 30 \times 10^9$s
clock cycles (P2) = $10 \times 2.5 \times 10^9 = 25 \times 10^9$s
clock cycles (P3) = $10 \times 4 \times 10^9 = 40 \times 10^9$s

IC (P1) = $30 \times 10^9/1.5 = 20 \times 10^9$
IC (P2) = $25 \times 10^9/1 = 25 \times 10^9$
IC (P3) = $40 \times 10^9/2.2 = 18.18 \times 10^9$

c. (5 points)

f = *IC* × CPI/time,
where
timenew = timeold × 0.7= 7s
CPInew = CPIold × 1.2,
then
CPI(P1) = 1.8,
CPI(P2) = 1.2,
CPI(P3) = 2.64

f(P1) = $20 \times 10^9 \times 1.8 / 7 = 5.14$ GHz
f(P2) = $25 \times 10^9 \times 1.2 / 7 = 4.28$ GHz
f(P3) = $18.18 \times 10^9 \times 2.6 / 7 = 6.85$ GHz

Exercise 1.6

(6 points)

Class A: 10^5 instr.
Class B: 2×10^5 instr.
Class C: 5×10^5 instr.
Class D: 2×10^5 instr.

CPU Time = IC × CPI/clock rate

Total time P1 = $(10^5 + 2 \times 10^5 \times 2 + 5 \times 10^5 \times 3 + 2 \times 10^5 \times 3) / (2.5 \times 10^9) = 10.4 \times 10^{-4}$ s
Total time P2 = $(10^5 \times 2 \times 2 + 10^5 \times 2 + 5 \times 10^5 \times 2 + 2 \times 10^5 \times 2) / (3 \times 10^9) = 6.66 \times 10^{-4}$ s

P2 is faster

a. (6 points)

CPI(P1) = $(1 \times 1/10 + 2 \times 2/10 + 3 \times 5/10 + 3 \times 2/10) = 2.6$
or
CPI(P1) = CPU time × f/IC = $10.4 \times 10^{-4} \times 2.5 \times 10^9 / 10^6 = 2.6$
CPI(P2) = $6.66 \times 10^{-4} \times 3 \times 10^9 / 10^6 = 2.0$

b. (8 points)
clock cycles = $\sum IC_i \times CPI_i$

clock cycles(P1) = $10^5 + 2 \times 10^5 \times 2 + 5 \times 10^5 \times 3 + 2 \times 10^5 \times 3 = 26 \times 10^5$
clock cycles(P2) = $10^5 \times 2 \times 2 + 10^5 \times 2 + 5 \times 10^5 \times 2 + 2 \times 10^5 \times 2 = 20 \times 10^5$

Exercise 1.7

a. (5 points)
CPI = Texec × f / IC., where f stands for the clock rate

Compiler A CPI = 1.1
Compiler B CPI = 1.25

b. (5 points)
fB/fA = (IC(B) × CPI(B)) / (IC(A) × CPI(A)) = 1.37

c. (5 points)

T/Tnew = (IC × CPI) / (IC_{new} × CPI_{new})

TA/Tnew = 1.67
TB/Tnew = 2.27

Exercise 1.12

1.12.1 (7 points)

CPU Time = IC × CPI/clock rate

T(P1) = $5 \times 10^6 \times 0.9/(4 \times 10^9) = 1.125 \times 10^{-3}$s
T(P2) = $10^6 \times 0.75/(3 \times 10^9) = 0.25 \times 10^{-3}$s

Clock rate (P1) > clock rate (P2), but performance (P1) < performance (P2)

1.12.2 (6 points)

T = IC × CPI/clock rate

T(P1) = 0.225s

T(P2) = IC(P2) × 0.75/(3×10^9)
Then IC(P2) = ($0.225 \times 3 \times 10^9$) /0.75 = 9×10^8

same CPU time but P1 runs more instructions

1.12.3 (7 points)
MIPS = Clock Rate × 10^{-6}/CPI
MIPS(P1) = $4 \times 10^9 \times 10^{-6}/0.9 = 4.44 \times 10^3$
MIPS(P2) = $3 \times 10^9 \times 10^{-6}/0.75 = 4.0 \times 10^3$

MIPS(P1) > MIPS(P2), however performance(P1) < performance(P2)

Exercise 1.13

1.13.1 (5 points)
Tfp = 70 × 0.8 = 56s.
Tnew = 56 + 85 + 55 + 40 = 236s.

Reduction = $(T_{old} - T_{new})/T_{old}$
Reduction : 5.6%

1.13.2 (5 points)
Tnew = 250 × 0.8 = 200s,
Tfp + Tl/s + Tbranch = 195s,
Tint =5s.
Reduction time INT: 90.9%

1.13.3 (5 points)
Tnew = 250 × 0.8 = 200 s,
Tfp + Tint + Tl/s = 210s > 200s
NO, not possible