Question 2

(a) Average instruction execution time for type A instruction :

Fetch instruction time + execute time = 100 + 10 = 110 cycles

Average instruction execution time for type B instruction :

Fetch instruction time + fetch operand time + execute time = 100 + 100 + 100 = 300 cycles

→ Average instruction execution time : $\frac{110 \times 80 + 300 \times 20}{100} = 148$ cycles

(b) Cycle time = $\frac{1}{f} = \frac{1}{10^6} = 1000\,ns = 1\,\mu s$ (microsec)

→ Average instruction execution time : $148 \times 1 = 148\,\mu s$

(c) Average instruction execution time in second : 148×10^{-6} s

→ Instruction execution rate = $\frac{1}{148 \times 10^{-6}} = 6756$ (round down from 6756.756) (ips)

(d) Cycle time = $\frac{1}{f} = \frac{1}{20 \times 10^6} = 50\,ns$

→ Average instruction execution time : $148 \times 50 = 7400\,ns = 7.4 \times 10^{-6}$ s

→ Instruction execution rate : $\frac{1}{7.4 \times 10^{-6}} = 135135$ (ips)

(e) Program completion time = $M \times t_i = 5{,}000{,}000 \times 7.4 \times 10^{-6}$

$= 37$ (s)

Question 3

(a) Longest ALU operations = 12 ns

→ $T \geq 4 + 12 = 16$ ns

→ $f = \frac{1}{T} = \frac{1}{16 \times 10^{-9}} = 62.5$ MHz

Every instruction take 3 cycles to complete

→ $BW = \frac{1}{3T} = \frac{1}{16 \times 3 \times 10^{-9}} \approx 20.833$ MIPS

(b) The loading time and ALU time remain the same

→ f is the same = 62.5 MHz

Since now there is new instruction issued every cycles.

→ $BW = f = 62.5$ MIPS

↓

Since this is number of cycles per sec

(c) Program completion time = M × instruction completion time

Part a : $M \times 3T = 0.048$ s

Part b : $M \times T = 0.016$ s