Set-A

[3]

1a) $X = 3.021$

$= 11.00000010$ (Binary)

$0.021 \times 2 = 0.042 \approx 0$
$0.042 \times 2 = 0.084 \approx 0$
$0.084 \times 2 = 0.168 \approx 0$
$0.168 \times 2 = 0.336 \approx 0$
$0.336 \times 2 = 0.672 \approx 0$
$0.672 \times 2 = 1.344 \approx 1$
$0.344 \times 2 = 0.688 \approx 0$

Binary Normalized $= 1.10000010 \times 2^1$

$Y = 0.71$

Binary $= 0.10110110$

$0.71 \times 2 = 1.42 \approx 1$
$0.42 \times 2 = 0.84 \approx 0$
$0.84 \times 2 = 1.68 \approx 1$
$0.68 \times 2 = 1.36 \approx 1$
$0.36 \times 2 = 0.72 \approx 0$
$0.72 \times 2 = 1.44 \approx 1$
$0.44 \times 2 = 0.88 \approx 0$

Binary Normalized $= 1.011010 \times 2^{-1}$

$X \times Y = (1.10000010 \times 1.011010) \times 2^0$

$$
\begin{array}{r}
1.10000010 \\
\times\ 1.011010 \\
\hline
0\ 0000000\ 0 \\
1\ 1\ 0000010\times \\
0\ 0\ 0\ 000000\times\times \\
1\ 1\ 0\ 0\ 00010\times\times\times \\
0\ 0\ 0\ 0\ 0\ 0000\times\times\times\times \\
1\ 1\ 0\ 0\ 0\ 0\ 0\ 10\times\times\times\times\times \\
\hline
1\ 0.0\ 0\ 0\ 1\ 1\ 1\ 1\ 0\ 1\ 1\ 0\ 1\ 0\ 0 \\
\quad\quad\quad\quad -4\ -5\ -6\ -7\ -9\ -10\ -12
\end{array}
$$

$= 2.120361328$ (Decimal)

b) -91.312 [3]

$0.312 \times 2 = 0.624 \approx 0$
$0.624 \times 2 = 1.248 \approx 1$
$0.248 \times 2 = 0.496 \approx 0$
$0.496 \times 2 = 0.992 \approx 0$
$0.992 \times 2 = 1.982 \approx 1$
$0.982 \times 2 = 1.968 \approx 1$
$0.968 \times 2 = 1.936 \approx 1$
$0.936 \times 2 = 1.872 \approx 1$
$0.872 \times 2 = 1.744 \approx 1$
$0.744 \times 2 = 1.488 \approx 1$
~~$0.488 \times 2 = 0.976$~~

Binary = 1011011.0100111111

Normalized Binary =

$1.0110110100111111 \times 2^6$

Exponent = 6

5-bits bias = $2^{5-1} - 1 = 15$

Biased exponent = $6 + 15 = 21 = 10101$

Sign bit = 1

1	10101	01101010011111

1AB69F

c) $X = 7CAC2000_{Hex}$ $Y = 28CD000_{Hex}$ [3]

X (Binary) = 0 1111100 1010 1100 0010 0000 0000 0000

Biased Exponent = 11111001

Biased Exponent (Decimal) = 249

Bias = 127

Exponent = 249 − 127 = 122

X (Binary Normalized) = ~~1.1100001×2^{122}~~

$= 1.01011000010000000000000 \times 2^{122}$

Y = 00101000 1100 1101 0000 00000000

Biased Exponent = 01010001 ≈ Decimal = 81

Bias = 127

Exponent = 81 − 127 = −46

Y (Binary Normalized) = $1.10011010000000000000 \times 2^{-46}$

$= 0.[167\ 0s..]\ 10011010000000000000 \times 2^{122}$

$\therefore X+Y = 1.0101100011[157\ 0's]1010110000100000000000000 \times 2^{122}$

· Decimal $= (1.689453125)_{10}$

d) i) Pseudo instructions [1.5]

ii) False (PC) [1.5]

2a) Addressing Scheme:

b) i) [2.5]

```
lw $t0, 8($s0)      // A[2]
lw $t1, 28($s4)
sll $t1, $t1, 2
add $t1, $t1, $s0
lw $t1, 0($t1)      // A[F[7]]
bne $t0, $t1, Exit
lw $t1, 12($s0)     // A[3]
sll $t2, $t1, 3     // t2 = 8* A[3]
add $t1, $t2, $t1   // t1 = 9* A[3]
sll $t2, $t0, 4     // t2 = 16* A[2]
add $t2, $t2, $t0
add $t2, $t2, $t0   // t2 = 18* A[2]
sub $t1, $t1, $t2
```

~~Sub $t1,$~~

addi $t1, $t1, -10

Sw $t1, 20($s4)

Exit:

2bii) add $s1, $zero, $zero

Loop: slt $t0, $s1, $s2

beq $t0, $zero, Exit

sll $t1, $s1, 2

add $t1, $t1, $s0 // t1 = MA of A[i]

lw $t2, 0($t1) // t2 = A[i]

sll $t2, $t2, 2

add $t2, $t2, $s0

lw $t3, 0($t2) // t3 = A[A[i]]

~~sll $t3, $t3, 1~~

sll $t2, $t3, 4

sub $t2, $t2, $t3

sub $t2, $t2, $t3

sw $t2, 0($t1)

addi $s1, $s1, 1

Exit: j Loop

c) i) bne $5, $6, 512 | PC+4 = 44000044

512 = 0000001000000000 (16bit)

Sign Extension =

```
  0000000000000000 0000001000000000
+ 0100010000000000 0000000100010100
-----------------------------------
  0100010000000000 0000001100010100
    4    4    0    0    0    C    5    4
```

ii) 512 (26bit) = 0...01000000000 (16bit)

```
  01000000000000 0000001000000000
    4    0    0    0    0    8    0    0
```

3a) ⊞ Single cycle Datapath:

lw: 60ps + 30ps + 50ps + 60ps + 30ps = 230ps

sw: 60ps + 30ps + 50ps + 60ps* = 200ps

∴ lw = 230 ps ∴ sw = ~~200ps~~ 230ps

⊞ Pipeline:

Longest delay = 60 ps

∴ lw = 60ps × 5 = 300 ps ∴ sw = 60ps × 5 = 300ps

b) Bne $10, $11, 1004

c) i) add $s1, $s2, $s0

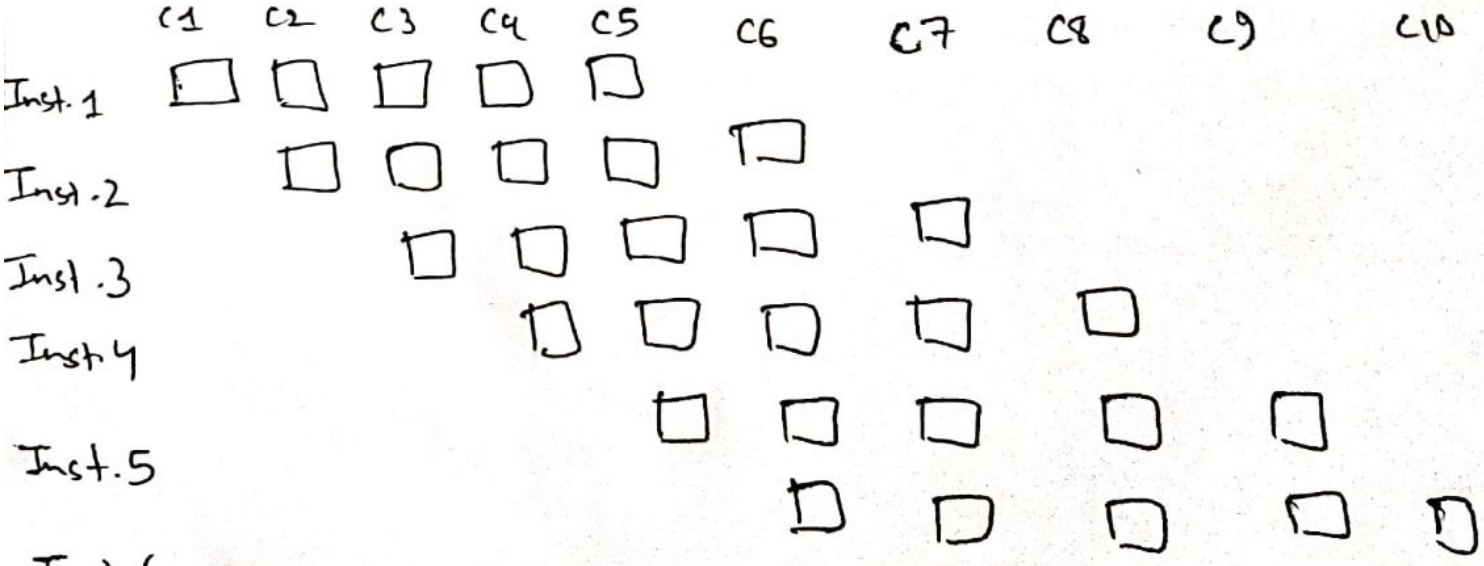
sub $s3, $s1, $s2

addi $t0, $s1, 5

Solve: Stalls, Forwarding

ii) Opcode → Decode Stage

3di) Total Time = (60ps × 10) = 600ps | CPI = $\frac{10}{6}$ = 1.67



ii) 4 Hazards

(iii)

lw $10, 40($11)

add $5, $10, $7

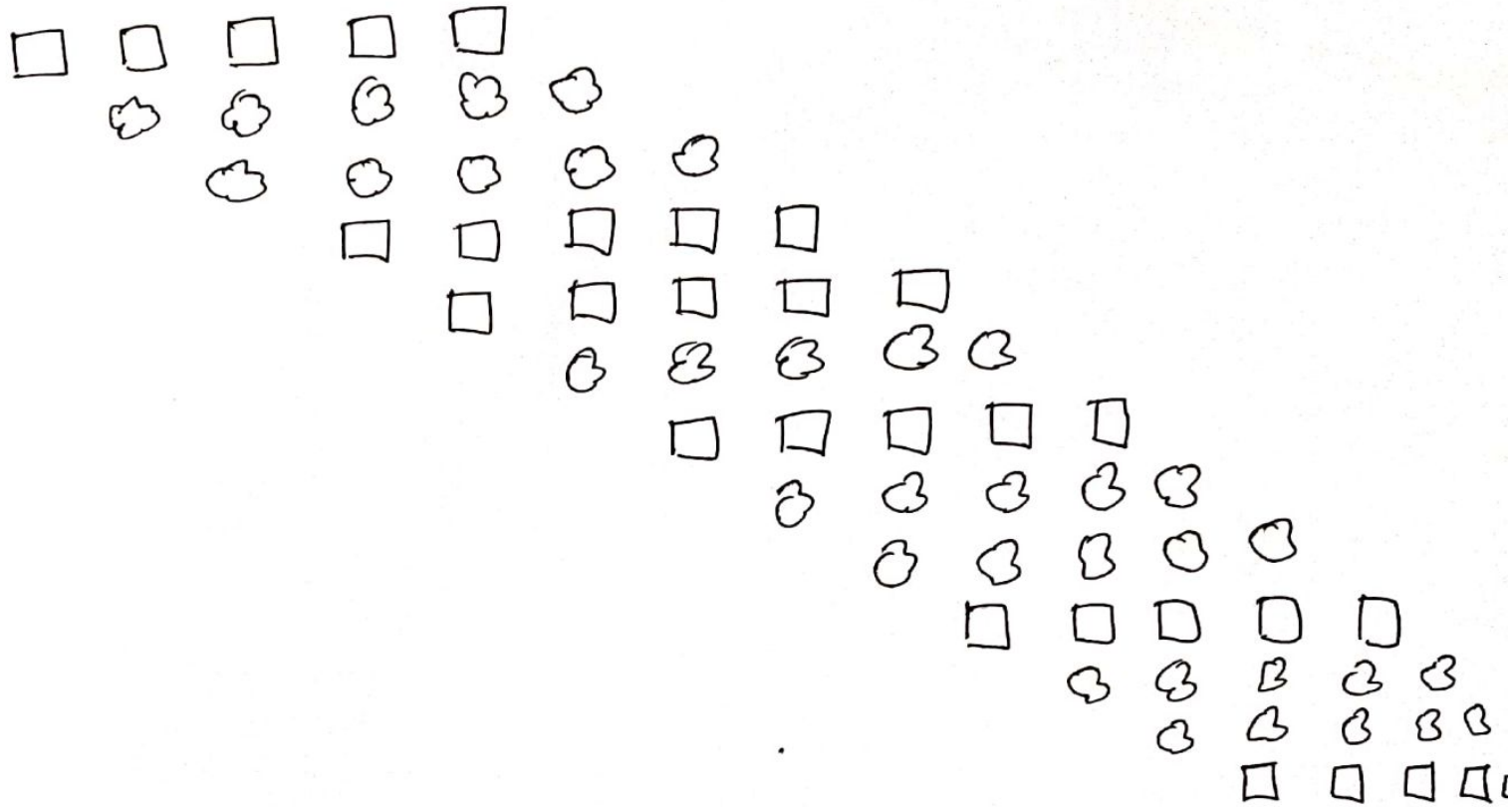
sub $3, $7, $4

~~sll $5, $5, 3~~

sll $5, $5, 3

lw $13, 48($5)

lw $13, 32($13)



Total Time = 60ps × 17 = 1020ps

$CPI = \frac{17}{6} = 2.83$