1.

a)

Control:0
Regwrite:1
Aloop:0000
ALUsrc:0
Memwrite:0
MemRead:0
MemtoReg:0
Zero:0
Branch:0

b)

instruct memory, ALU, MUX, Registers

c)

Data memory, branch

2.

	R-type	I-type	ldur	stur	cbz	b
Data memory	×	×	✓	✓	×	×
Instruction memory	✓	✓	✓	✓	✓	✓
sign extend	×	✓	✓	✓	✓	✓

a)

The fraction of all instructions use data memory is 35%.

b)

The fraction of all instructions use instruction memory is 100%.

c)

The fraction of all instructions use data memory is 76%.

d)

It will wait for the next instruction.

3.

a)

All instructions will fail to operate.

b)

add, sub, ldur and cbz will fail to operate.

c)

add, sub, ldur and stur will fail to operate.

4.

a)

The output will be $0x0000000000000014$ and $0x0000000000001400$.

b)

The value is 0010.

c)

It will be PC+4.

d)

00011 and 00010.

e)

The input of two add units are $PCaddress + 4$ and $currentaddress + PCaddress$.

f)

00011 and 00010.

5.

a)

It needs to add an execute operation. It will receive the value of $op(data1, data2)$ to ALU result.

b)

Regwrite:1

Aloop:0010

ALUsrc:1

Memwrite:0

MemRead:0

MemtoReg: no information

Zero: no

Branch:0

6.

a)

P1: 3GHz/1.5 = $2 * 10^9$ instructions per second.

P2: 2.5GHz/1.0 = $2.5 * 10^9$ instrctions per second.

P3: 4GHz/2.2 = $1.82 * 10^9$ instrctions per second.
P2 has the highest performance.

b)

	Cycles	Number of instructions
P1	$3 * 10^10$	$2 * 10^10$
P2	$2.5 * 10^10$	$2.5 * 10^10$
P3	$4 * 10^10$	$1.82 * 10^10$

7.

For class A, we have $1 * 10^5$ instructions.
For class B, we have $2 * 10^5$ instructions.
For class C, we have $5 * 10^5$ instructions.
For class D, we have $2 * 10^5$ instructions.

$$\begin{aligned} Time(P1) &= \frac{1 * 10^5 + 2 * 10^5 * 2 + 5 * 10^5 * 3 + 2 * 10^5 * 3}{2.5 * 10^9} \\ &= 1.04 * 10^{-3} \end{aligned}$$

$$\begin{aligned} Time(P2) &= \frac{1 * 10^5 * 2 + 2 * 10^5 * 2 + 5 * 10^5 * 2 + 2 * 10^5 * 2}{3 * 10^9} \\ &= 6.66 * 10^{-4} \end{aligned}$$

Because $Time(P1) > Time(P2)$, So P2 is faster.

a)

$$\begin{aligned} Global(P1) &= \frac{Time(P1) * 2.5 * 10^9}{1 * 10^6} \\ &= 2.6 \end{aligned}$$

$$\begin{aligned} Global(P2) &= \frac{Time(P2) * 3 * 10^9}{1 * 10^6} \\ &= 2 \end{aligned}$$

b)

$$\begin{aligned} Cycles(P1) &= Global(P1) * 1 * 10^6 \\ &= 2.6 * 10^6 \end{aligned}$$

$$\begin{aligned} Cycles(P2) &= Global(P2) * 1 * 10^6 \\ &= 2 * 10^6 \end{aligned}$$