CS & IT ENGINEERING

COMPUTER ORGANIZATION AND ARCHITECTURE

Instruction & Addressing Modes

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Recap of Previous Lecture

Topic Instruction Format

Topic Questions on Instructions

Topics to be Covered

Topic — Multiple Instruction Support

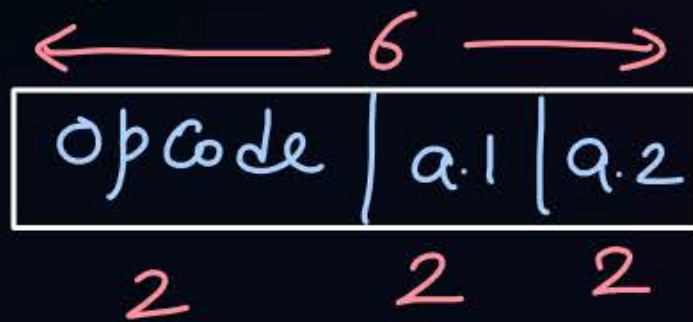**Topic** — Variable Size Instructions

#Q. Consider a computer which supports only 2-address and 1-address instructions. Each instruction is of 6-bits and each address is of 2-bits. If there are 3 2-address instructions supported by the system then maximum number of 1-address instructions supported by system is?
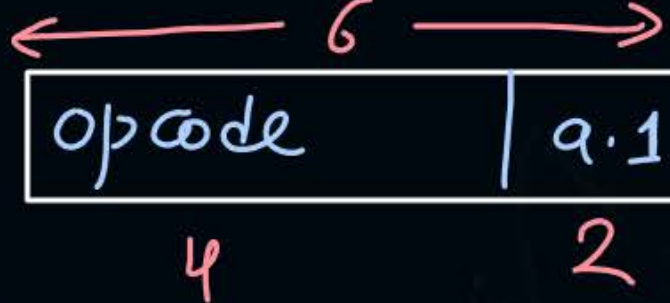
2-add.

$\longleftarrow 6 \longrightarrow$

Opcode	a.1	a.2

2   2   2

$$\text{max opcodes} = 2^2 = 4 \ (00, 01, 10, 11)$$

$$\text{used opcodes} = 3 \ (\text{assume} :- 00, 01, 10)$$

$$\underline{\text{unused opcodes} = 1 \ (\text{ex} :- 11)}$$

1-add.

$\longleftarrow 6 \longrightarrow$

Opcode	a.1

4   2

$\underset{\text{2 bits}}{\longleftrightarrow} \underset{\text{2 bits}}{\longleftrightarrow}$

$\Downarrow$

11 00
11 01   } max 1-add. inst^{ns} = 4
11 10
11 11

max 1-add. inst^{ns} = 4

An $inst^n$ goes to CPU for execution

$$010111$$

Interpretation

as $2-add.$ $inst^n$

01	01	11

as $1-add.$ $inst^n$

0101	11

inst^n	type
001100	2-add.
010101	2-add.
101010	2-add.
110110	1-add.

How to solve Questions :-

2-add.

opcode	a.1	a.2

6

2   2   2
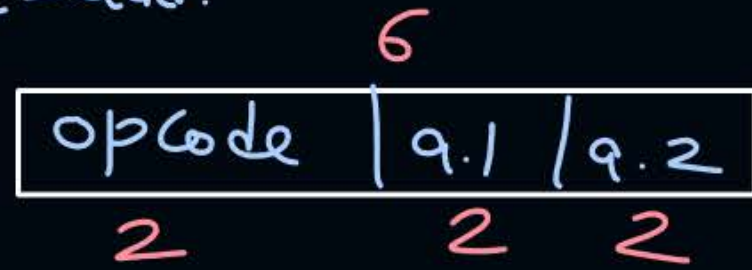
$\text{max opcodes} = 2^2 = 4$

$\text{used opcodes} = 3$

$\overline{\text{unused opcodes} = 1}$

1-add.

opcode	a.1

6

4   2

2   2
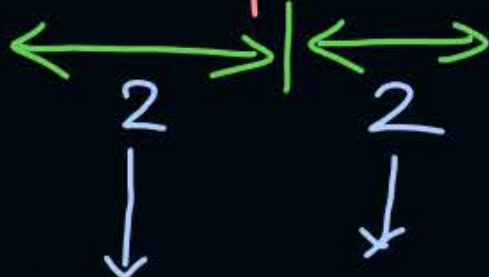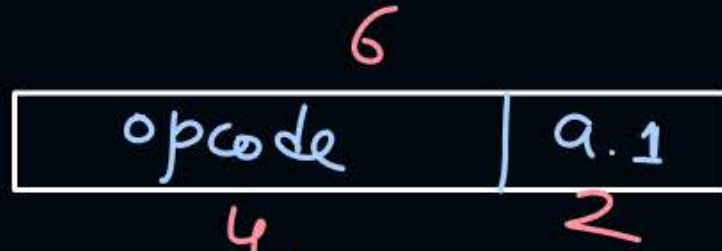
$1 * 2^2 = 4 \Longleftarrow \text{max 1-add. inst}^{ns}$

2-add. insts used	Unused opcode	Max 1-add. insths
4	$4-4=0$	$0 * 2^2 = 0$ ← only 2-add. type inst^n supported
3	$4-3=1$	$1 * 2^2 = 4$
2	$4-2=2$	$2 * 2^2 = 8$
1	$4-1=3$	$3 * 2^2 = 12$
0	$4-0=4$	$4 * 2^2 = 16$ ← only 1-add. type insths supported.

#Q. Consider a computer which supports only 2-address and 1-address instructions. Each instruction is of 6-bits and each address is of 2-bits. If there are 3 2-address instructions supported by the system then maximum number of 1-address instructions supported by system is?
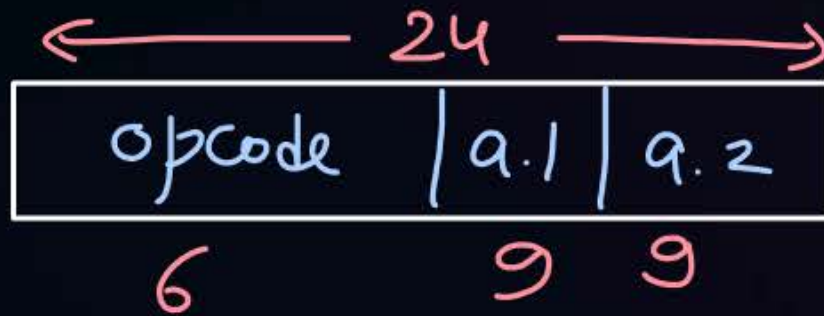
In above ~~instruction~~ Questⁿ what is the range of number of 1-address instructions supported?

Ans:- 1 to 4

Ans = 3584

#Q.   Consider a system with 24-bit instructions and 9-bit addresses. If there are (57) 2-address instructions then maximum how many 1-address instructions can be formulated in the system?
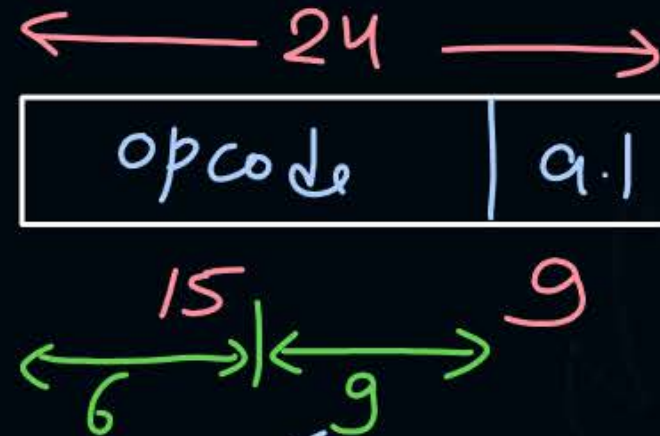
2-add.

$$\xleftarrow{\hspace{1cm}} 24 \xrightarrow{\hspace{1cm}}$$

opcode	a.1	a.2

6   9   9

1- add.

$$\xleftarrow{\hspace{1cm}} 24 \xrightarrow{\hspace{1cm}}$$

opcode	a.1

15   9

6   9

$$\text{max opcodes} = 2^6 = 64$$

$$\text{used opcodes} = 57$$
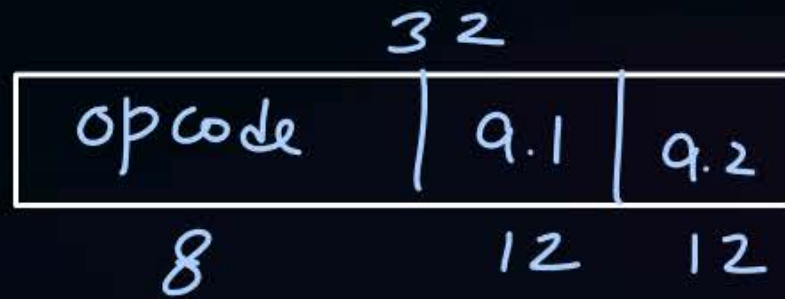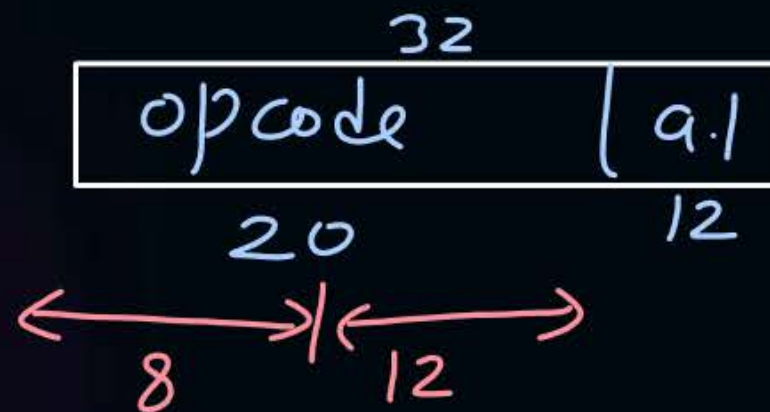
$$\underline{\text{unused opcodes} = 7}$$

$$7 * 2^9 = \underline{\underline{3584}} \quad \text{Ans}$$

#Q. Consider a system with 32-bit instructions and 12-bit addresses. If there are 254 2-address instructions then maximum how many 1-address instructions can be formulated in the system?

2-add.

$$opcode \quad | \quad a.1 \quad | \quad a.2$$

8   12   12

32

$\Downarrow$

$max = 2^8 = 256$

$used = 254$

$unused = 2$

1 - add.

$$opcode \quad | \quad a.1$$

20   12

32

8 | 12

$2 \ast 2^{12} = 2^{13} = 8192$ Ans.

#Q. Consider a system with 32-bit instructions and 12-bit addresses. If there are 254 2-address instructions and 8000 1-address instructions then maximum how many 0-address instructions can be formulated?
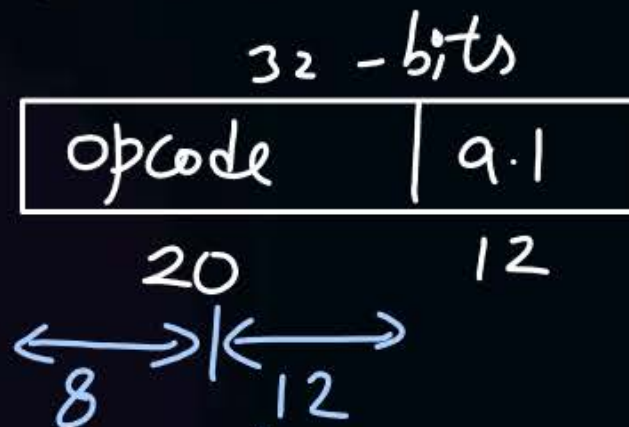
2 – add.

32 – bits

opcode	a.1	a.2

8   12   12

$max = 2^8 = 256$

$used = 254$

$unused = 2$

1 – add.

32 – bits

opcode	a.1

20   12

8   12
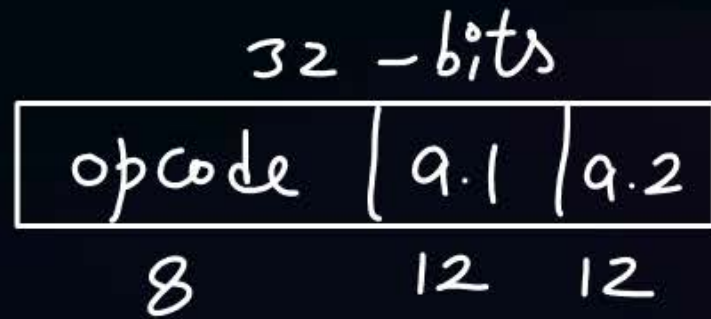
$max = 2 * 2^{12} = 8192$

$used = 8000$

$unused = 192$

0 – add.

32 – bits

opcode

32

20   12
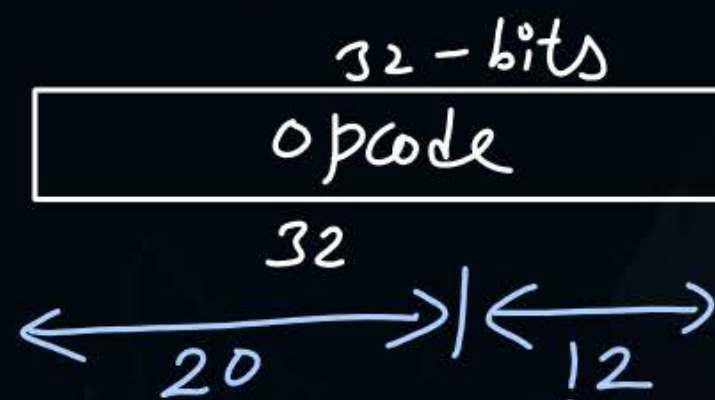
$= 192 * 2^{12} = 786432$ Ans.

#Q.   Consider a system which supports 3-address and 2-address instructions both. It has 30-bit instructions with 8-bit addresses. If there are 'x' 3-address instructions then maximum how many 2-address instructions can be formulated?
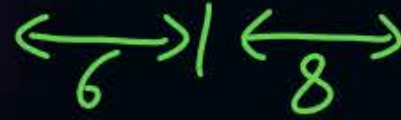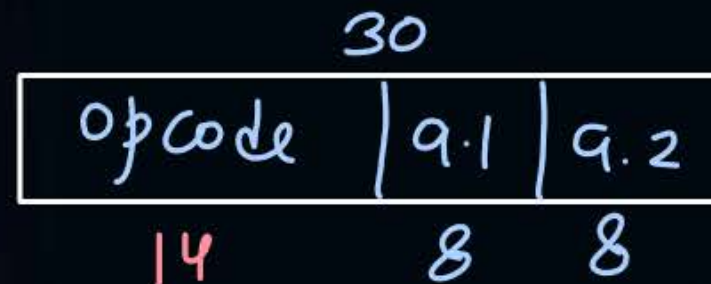
3-add.

30

opcode	a.1	a.2	a.3
6	8	8	8

$$max = 2^6 = 64$$

$$\underline{\begin{array}{l} used \quad = \quad x \end{array}}$$

$$unused = 64 - x$$

2-add.

30

opcode	a.1	a.2
14	8	8

$\xleftarrow{6} | \xrightarrow{8}$
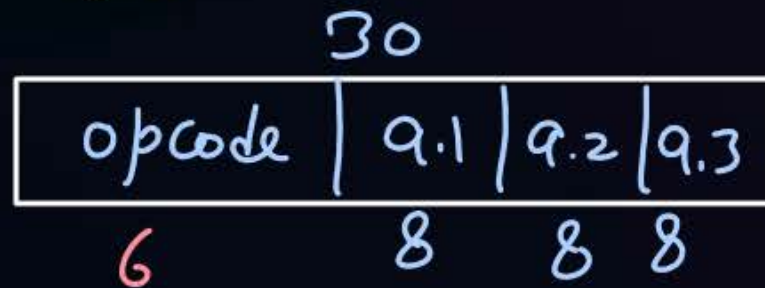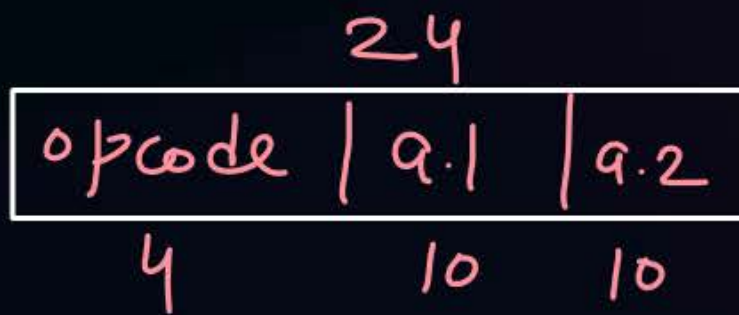
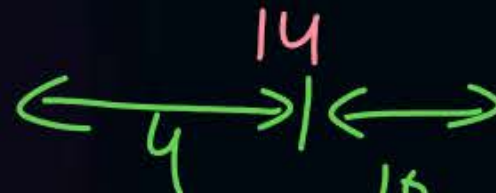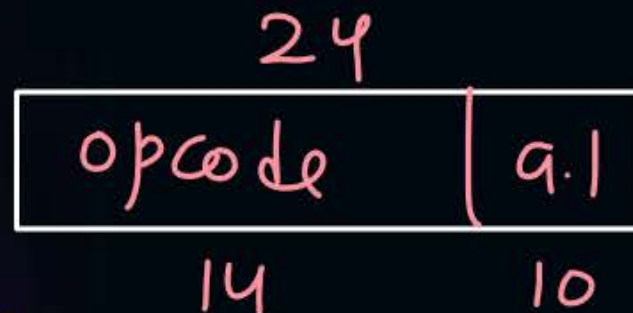$(64-x) * 2^8$

$$Ans = (64-x)\, 2^8$$

$$Ans = 12$$

#Q. Consider a system which supports 2-address and 1-address instructions both. It has 24-bit instructions with 10-bit addresses. If there are 4096 1-address instructions then maximum how many 2-address instructions can be formulated?

24

opcode	a.1	a.2
4	10	10

$$max = 2^4 = 16$$

$$used = x$$

$$unused = 16 - x$$

24

opcode	a.1
14	10

4 → | ← 10

$$(16 - x) * 2^{10} = 4096$$

$$(16 - x) = \frac{4096}{1024}$$

$$16 - x = 4$$

$$\boxed{x = 12}$$

$\rightarrow$ Reg. field = 6 bits

#Q. Consider a system with 16-bits instructions and (64) CPU registers. The System supported 2 types of instructions: Type-A and Type-B.
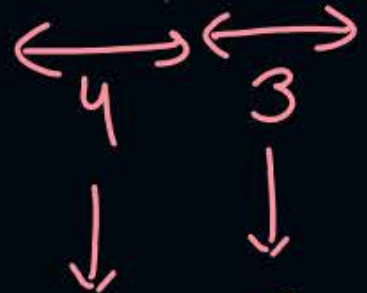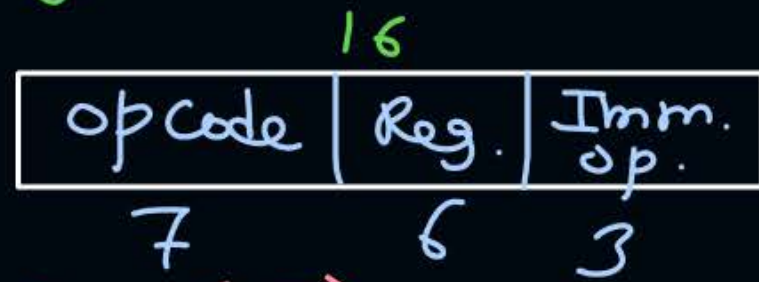
Type-A instructions have an opcode, one register operand and one immediate operand of 3-bits

Type-B instructions have an opcode, and 2 register operands.

If there are 10 Type-B instructions supported by the system then maximum how many Type-A Instructions supported by the system?

$$Ans = 48$$

Type A

16

opcode	Reg.	Imm. op.
7	6	3

4 → 3

$$6 * 2^3 = \underline{\underline{48}} \quad \text{Ans.}$$

Type B

16

opcode	Reg. 1	Reg 2
4	6	6

$$max = 2^4 = 16$$
$$used = 10$$
$$\overline{unused = 6}$$

Instruction length

Fixed ⟵ ⟶ variable

↓ ↓

opcode length variable

opcode length fixed

(expanding opcode)
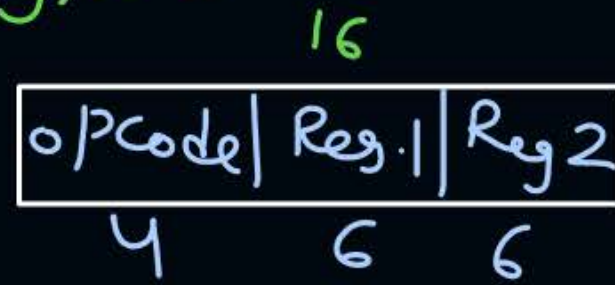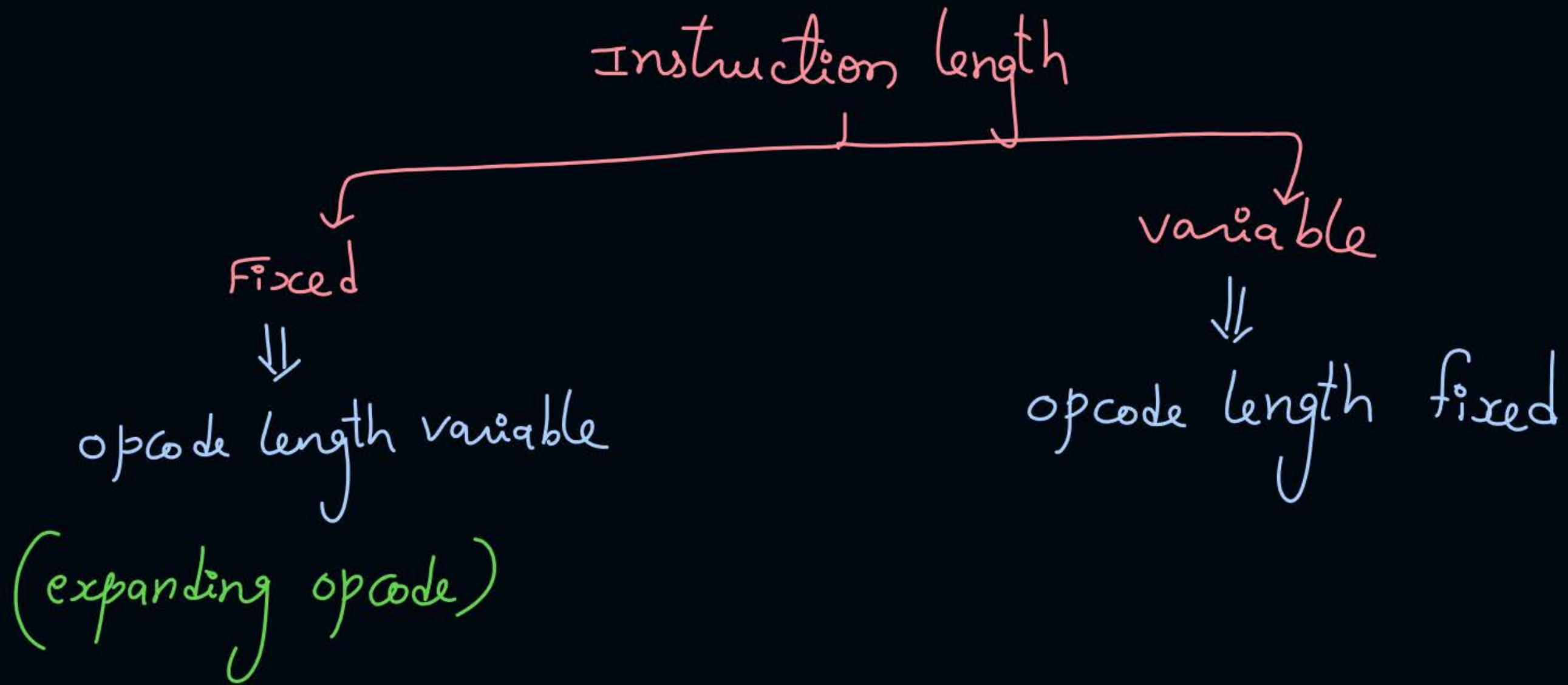
Max = 40 bits
Min = 17 bits

#Q. Consider there are 3 types of instructions in system: (Variable length inst^{ns})

1. Register Operand instructions: One opcode and 2 registers
2. Memory Operand instructions: One opcode, 1 register and 1 memory address
3. Immediate Operand Instructions: One opcode, 1 register and 1 immediate operand

Number of registers = (64) ⟶ Reg. field = 6 bits

Number of bits in immediate operand = 10-bits
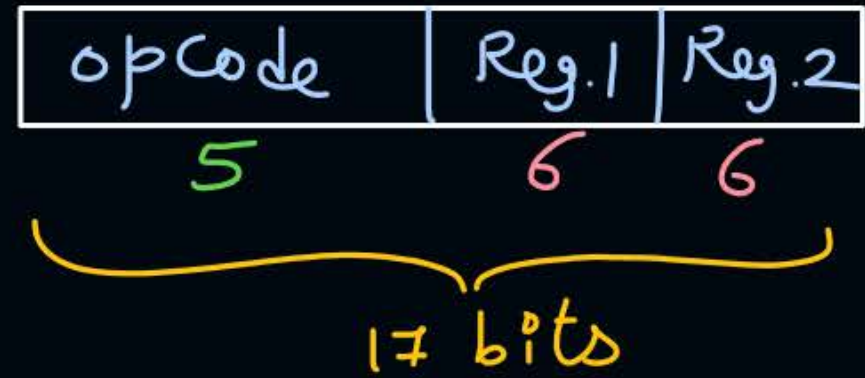
Memory size = 512Mbytes (byte addressable)

Total Instructions:

1. Reg Operand type: 10
2. Memory Operand type : 12   ⟶ Total = 10 + 12 + 4 = 26
3. immediate Operand type : 4

Maximum and Minimum instruction length are?

1. Reg. operand

opcode	Reg.1	Reg.2
5	6	6

$\underbrace{\qquad\qquad}$ 17 bits

2. Mem. operand

opcode	Reg.	mem. add.
5	6	29

$\underbrace{\qquad\qquad}$ 40 bits

3. Imm. operand

opcode	Reg.	Imm. operand
5	6	10

$\underbrace{\qquad\qquad}$ 21 bits

no. of cells in mem. $= \dfrac{512 \, MB}{1B} = 512M = 2^{9} \cdot 2^{20} = 2^{29}$

$\Downarrow$

mem. add. $= 29$ bits

no. of inst^{ns} $= 26 \Rightarrow$ opcode $= 5$ bits

Ans = 14

(PW)

Reg. field = 6-bits

#Q. A processor has (64) registers and uses 16-bit instruction format. It has two types of instructions: I-type and R-type. Each I-type instruction contains an opcode, a register name, and a 4-bit immediate value. Each R-type instruction contains an opcode and two register names. If there are 8 distinct I-type opcodes, then the maximum number of distinct R-type opcodes is _____?

I-type

16

opcode	Reg.	I.V.

6   6   4

$\xrightarrow{6}$ $\xleftarrow{2}$

4   2

$\Downarrow$

$(16-x) * 2^2 = 8$

$16 - x = 2 \Rightarrow \boxed{x = 14}$

R-type

16

opcode	Reg.1	Reg.2

4   6   6
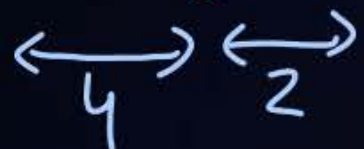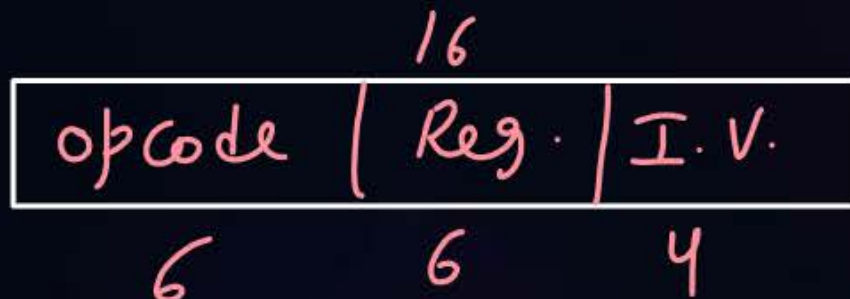
$max = 2^4 = 16$

$used = x$

$\overline{unused = 16 - x}$

#Q.   A processor has 16 integer registers (R0, R1, ... , R15) and 64 floating point registers (F0, F1, ... , F63). It uses a 2-byte instruction format. There are four categories of instructions: Type-1, Type-2, Type-3, and Type 4. Type-1 category consists of four instructions, each with 3 integer register operands (3Rs). Type-2 category consists of eight instructions, each with 2 floating point register operands (2Fs). Type-3 category consists of fourteen instructions, each with one integer register operand and one floating point register operand (1R+1F). Type-4 category consists of N instructions, each with a floating-point register operand (1F).

The maximum value of N is _____ ?

Topic Multiple Instruction Support

Topic Variable Size Instructions