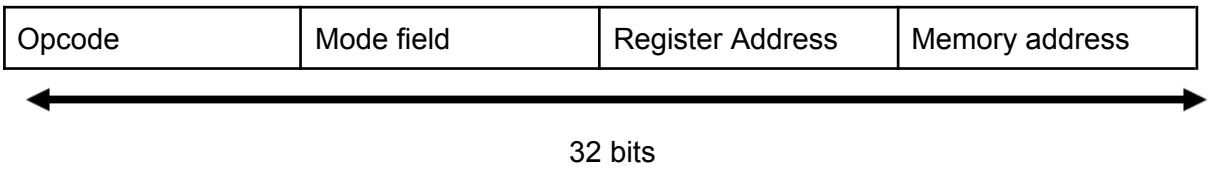
1. The memory unit of a computer has 256K words of 32 bits each. The computer has an instruction format with 4 fields: an opcode field; a mode field to specify 1 of 7 addressing modes; a register address field to specify one of 60 registers; and a memory address field. Assume an instruction is 32 bits long. Answer the following:
a. How large must the mode field be?
b. How large must the register field be?
c. How large must the memory address field be?
d. How large is the opcode field?

Ans Memory -256k words of 32 bits instruction format -4 fields



a. 1-7 addressing mode
$2^3 = 8$
Therefore, the mode field must be large 3bits.

b. 60 registers
$2^2 \geq 60$
$2^6 = 64$
Therefore, the memory address field must be large 6 bits

c. 256k words
256×10^3
$= 256 \times 2^{10}$
$= 2^8 \times 2^{10}$
$= 2^{18}$
Therefore, the memory address field must be large 18 bits

d. Opcode + mode(field) + register(address)+memory(address) = 32 bits
Opcode + 3 + 6+18 = 32
Opcode + 27 = 32
Opcode = 5 bits

2. Write code to implement the expression: A= (B + C) * (D + E) on 3-, 2-, 1- and 0-address machines. In accordance with programming language practice, computing the expression should not change the values of its operands.

A = (B + C) * (D + E)

3 Address Machine

```
ADD     R1, B, C
ADD     R2, D, E
MULT    A, R1, R2
```

2 Address Machine

```
LOAD    R1, B
ADD     R1, C
LOAD    R2, D
ADD     R2, E
MULT    R1, R2
STORE   A, R1
```

1 Address Machine

```
LOAD    B
ADD     C
STORE   TEMP
LOAD    D
ADD     E
MULT    TEMP
STORE   A
```

0 Address Machine

```
PUSH    B
PUSH    C
ADD
PUSH    D
PUSH    E
ADD
MULT
POP     A
```

3. 11. Convert the following expressions from infix to reverse Polish (postfix) notation.
a) (8–6)/2
b) (5×(4+3)×2–6)

a) Ans 8 6 -2/
b) Ans 543 + × 2 × 6 -

4. The first two bytes of a 2M x 16 main memory have the following hex values:
Byte 0 is FE
Byte 1 is 01

0	1
FE	01

If these bytes hold a 16-bit two's complement integer, what is its actual decimal value if:
a. memory is big endian?
b. memory is little endian?

a) Big endian

F	E	O	L
1111	1110	0000	0001
0000	0001	1111	1110→ 1's Complement
+			1
	1	1111	1111
	2^8	$2^8 2^6 2^5 2^4$	$2^3 2^2 2^1 2^0$

$2^8+2^7+2^6+2^5+2^4+2^3+2^2+2^1+2^0 = -511$

b) Little endian

0	1	F	E
0000	0001	1111	1110
	2^8	$2^7 2^6 2^5 2^4$	$2^3 2^2 2^1$

$2^8 +2^7+2^6+2^5+2^4+2^3+2^2 = 510$

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