

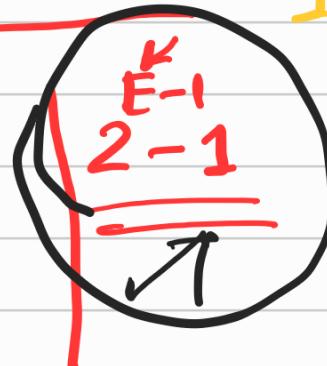
IEEE754 FP Repⁿ →

S	E	F
1	8	23

- 23.732

23 → 10111

0.732 → 0.10111



$$0.732 \times 2 = 1.464$$

$$0.464 \times 2 = 0.928$$

$$0.928 \times 2 = 1.856$$

$$0.856 \times 2 = 1.712$$

$$0.712 \times 2 = 1.424$$

$$\begin{aligned} -23.732 &\rightarrow 10111.10111 \\ &\rightarrow -1.011110111 \times 2^4 \end{aligned}$$

$$G \rightarrow 4 + \underline{127} = 131 = \frac{10000011}{E}$$

1 10000011 011110111...
C 1 B D —

- 0.732 → 1011111001111...

- 27.32

S	E	F
1	6	12

27 → 11011

0.32 → 0.01010

- 27.32 → 11011.01010

$$= -1.101101010 \times 2^4$$

$$2^{E-1} - 1 \rightarrow 2^{6-1} - 1 = 31$$

$$9 \rightarrow 31 + 4 \rightarrow 35 \rightarrow \underline{100011}$$

1100011101101010

A234B000 Hex
10100010001101001011
 Q → 01000100 → 68

$$E = 68 - 127 = -59$$

$$\begin{array}{r} -1'01101001011X2 \\ \hline = -0'0 \end{array}$$

$\circlearrowleft \quad \checkmark$ $-59 \quad -61 \quad -62 \quad -64$

$0'10110100\ 011$

$$= -2 + 2^{-61} + 2^{-62} + 2^{-64} + 2^{-67} + \dots$$

$$= -2 \cdot 44 \times 10^{-18}$$

CSE340-2, 4-12-24

- 27.732

27 → 11011

0.732 → 0.10111

- 27.732 → 11011.10111

→ - 1.101110111 × 2⁴ ← E

0.732 × 2 → 1.464

0.464 × 2 → 0.928

0.928 × 2 → 1.856

0.856 × 2 = 1.712

0.712 × 2 = 1.424

Q → 4 + 127 → 131 → 10000011

1 10000011 101110111.....

0.6732

$\rightarrow 0.1010110$

$$+ 1.0101 \times 2^{-1}$$

F E

$$Q = -1 + 127 = 126$$

$$= \underline{\underline{01111110}}$$

$$0.6732 \times 2 = 1.3464$$

$$0.3464 \times 2 = \underline{\underline{0.6928}}$$

$$0.6928 \times 2 = \underline{\underline{1.3856}}$$

$$0.3856 \times 2 = 0.7712$$

$$0.7712 \times 2 = 1.5424$$

$$0.5424 \times 2 = 1.0848$$

$$0.0848 \times 2 = \underline{\underline{0.1696}}$$

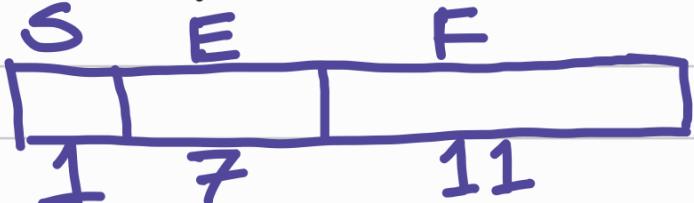
$$\begin{array}{r} 0.0111110101011\ldots \\ \hline 3 \quad F \quad 2 \end{array}$$

E-1
2-1
 $= 21023$

$$Q_{64} \rightarrow -1 + 1023 = 1022 -$$

0111111110

0011111110 010111111



11.317

$$11.317 \rightarrow 1011.01010001$$

$$\rightarrow 1.01101010001 \times 2^3$$

$$2^{7-1} = 63$$

$$Q: 3 + 63 = 66$$

$= 10000010$

010000100011010100001

A24BC000 Hex
101000100100 101111000 — 0

9

$$g = 01000100 \rightarrow 68$$

$$E = 68 - 127 \rightarrow -59$$

$$- 1.10010111 \times 2^{-59}$$

$$= -0.0\overline{58} -59.60 \quad -63 \quad -15.666\overline{67}$$

$$= \frac{1}{\pi} \left(2^{-59} + 2^{-60} - 2^{-63} + 2^{-65} - 2^{-66} + 2^{-67} \right)$$

$$= -2.758 \times 10^{-18}$$

$$= -2.758 \times 10^{-18}$$

Ex

BAZC000007

101110100001011000 — 0
9 F ✓

$9 \rightarrow 01110100 \rightarrow 116$

$$E \rightarrow Q - 127 \rightarrow -11$$

$$-1.01011 \times 2^{-11}$$

$$= -0.\overline{0}\overline{10101011} \quad \text{(-13-15-16)}$$

$$= -\left(2^{-11} + 2^{-13} + 2^{\frac{1}{2} \cdot 15} + 2^{-16} \right)$$

$$= -6.56 \times 10^{-4}$$

$$0.010001 \times 2^3$$

$$\begin{array}{r} 2'132 \\ \rightarrow 10'00001 \rightarrow \underline{1'00000}\frac{1}{2} \end{array}$$

Ex $X \rightarrow 9.732$

$$\rightarrow 1001.10\cancel{0}11$$

$$\rightarrow 1.00110011 \times 2^3$$

$$Y = 11.313$$

$$\rightarrow 1011.01010$$

$$\rightarrow 1.01101010 \times 2^2$$

$$X+Y=?$$

$$X+Y \rightarrow 1.00110111$$

$$\rightarrow 1.01101010$$

$$\overline{10.1010000} \times 2^3$$

$$= 10101.00001$$

$$= 21 + 2^{-5}$$

$$= \underline{\underline{21.03125}}$$

$$X+Y$$

$$= 9.732 +$$

$$11.313$$

$$= \underline{\underline{21.045}}$$

$$X+Y = 23.53125$$

$$X+Y = 23.541$$

Ex

$$X \rightarrow 7.925$$

$$Y = 15.616$$

$$X+Y=?$$

Ex

$$X = 7A2B0000_{\text{Hex}}; Y = 3DA20000_{\text{Hex}}$$

$$X = 0\underline{\underline{11110100}}\underline{\underline{010101}} \dots$$

$$Q = 11110100 = 244$$

$$E = Q - 127 = 117$$

$$X = 1.0101011 \times 2^{117}$$

$$Y = 0\underline{\underline{01110110}}\underline{\underline{100010}} \dots$$

$$Q = 0111011 = 123$$

$$E = Q - 127 = -4$$

$$Y = 1.010001 \times 2^{-4}$$

$$= 0.0 \underline{\underline{— 01010001}} \times 2^{-17}$$

$$\underline{\underline{120}}$$

$$X+Y \approx X$$

$$\text{Ex: } x = 3.313$$

$$= 1.101010 \times 2^1$$

$$Y = 4.123$$

$$= 1.0000011 \times 2^2$$

$$\begin{array}{r} 1.0000011 \\ 1.101010 \\ \hline 00000000 \end{array}$$

$$\begin{array}{r} 100000011 \\ 100000000 \\ 100000000 \\ 100000000 \\ 100000000 \\ 100000000 \\ \hline 10011000111110 \end{array}$$

$$x * y = ?$$

$$= 1.1011000111110 \times 2^3$$

$$= 11011000111110$$

$$= 13 + 2^{-1} + 2^{-5} + 2^{-6} + 2^{-7} + 2^{-8} \dots$$

$$= \underline{\underline{13.5605}}$$

$$\approx 13.6$$

$$x * y = \underline{\underline{13.659}}$$

$$= \underline{\underline{13.6}}$$

$$\text{Ex } x = 7.312$$

$$Y = 6.713$$

$$x * y = ?$$

$$x = 1.1101001 \times 2^2$$

$$Y = 1.101011 \times 2^2$$

1.1101001
1.101011

CSE 340-2; 09.12.24

Ex AC2B0000 Hex

10101100001010110 — 0
S 9 F

$$Q = 01011000 = 88$$

$$E = Q - 127 = -39 - 39$$
$$= 1.0101011 \times 2^{-39}$$

$$= -(0.0 \overline{10101011})_{-39-41-43-45-46}$$

$$= -(2^{-39} + 2^{-41} + 2^{-43} + 2^{-45} + 2^{-46})$$

$$\approx -2.43 \times 10^{-12}$$

Ex 75AB2000 $\approx 4.34 \times 10^{32}$ (17)?

011101011010101100100 — 0
S 9 F

$$Q = 11101011 = 235$$

$$E = Q - 127 = 108$$

$$1.0101011001 \times 2^{108}$$

$$= 2^{108} + 2^{106} + 2^{104} + 2^{102} + 2^{101} + 2^{98}$$

$$= 4.34 \times 10^{32}$$

Ex $x = 3.754$

$$\begin{aligned}
 &= 11 \cdot 11000 \leftarrow \\
 &= 1 \cdot 111 \times 2^1 \underline{1} \\
 &= 0 \cdot 01111 \times 2^3
 \end{aligned}$$

$$Y = 9.612$$

$$\begin{array}{r} = 1001 \cdot 10011 \leftarrow \\ = 1 \cdot 00110011 \times \end{array}$$

$$x+y=?$$

1.00110011

0.011110000

$$\begin{array}{r} \underline{10101011 \times 2^3} \\ 10101011000 \end{array}$$

$$= 1101.01011$$

$$= 13 + 2^{-2} + 2^{-4} + 2^{-5}$$

$$= \underline{\underline{13}} \cdot \underline{\underline{34}} \underline{\underline{375}} / \underline{\underline{13}} \cdot \underline{\underline{366}}$$

Ex

$$x = 11.312$$

$$Y = 0.619$$

$$X+Y=?$$

H W

Ex $x = 3^\circ 713$ $y = 4^\circ 321$ $x * y = ?$

$$= 11^{\circ}10'10''$$

$$= 100'01010$$

$$= 1 \cdot 11011x2^1$$

$$= 1.000101x2^2$$

$$\cancel{x * y = 160473}$$

1° 0000101

1° 1 1 0 1 1

1000101

100010

1 0 0 0 0 0 0
1 0 0 0 1 0 1

1000101

$$\begin{array}{r} \underline{1\ 0\ 0\ 0\ 1\ 0\ 1} \\ 1\cdot 1\ 1\ 1\ 1\ 1\ 1\ 0\ 0\ 1\ 1\ 1 \end{array} \times 2^3$$

$$\begin{aligned}
 & 1111.11100111 \\
 & = 15 + 2^{-1} + 2^{-2} + 2^{-3} + 2^{-6} + 2^{-7} + 2^{-8} \\
 & = 15.90234
 \end{aligned}$$

CSE340-1: 11112124

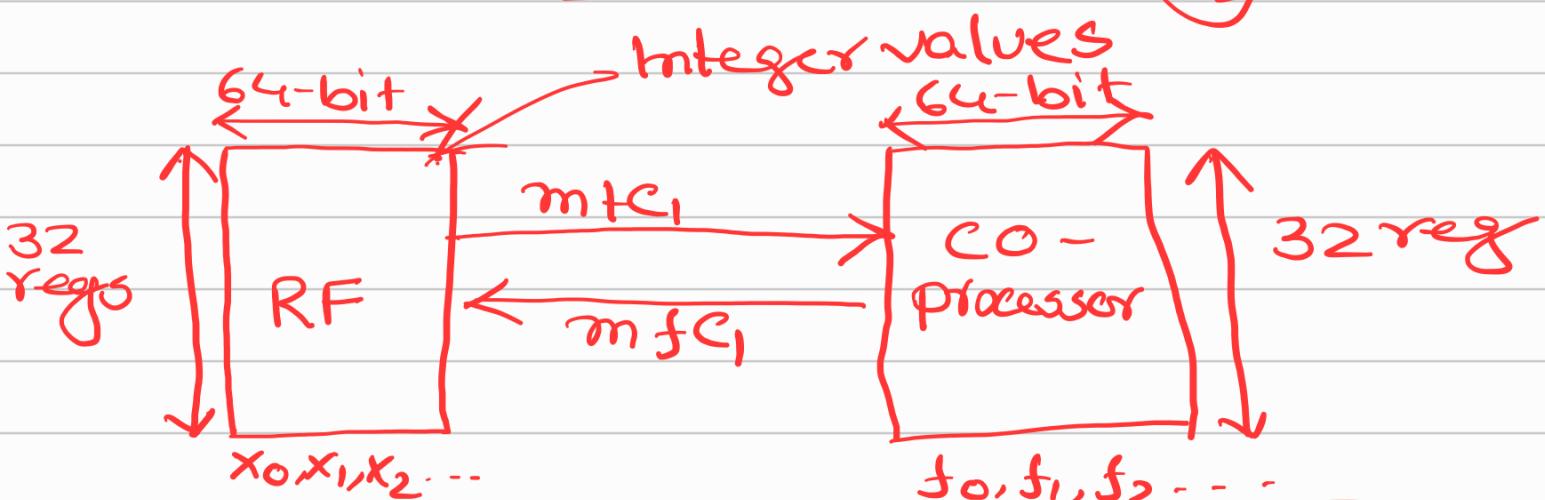
$$\begin{aligned}
 X &= 0.7132 & Y &= 0.135 & X * Y = ? \\
 &= 0.\underline{101101} & &= 0.0010\underline{001} \\
 &= 1.01101 \times 2^{-1} & &= \underline{1.0} \times 2^{-3}
 \end{aligned}$$

$$\begin{array}{r}
 1.01101 \\
 \times 1.0 \\
 \hline
 000000 \\
 101101 \\
 \hline
 1.01101 \times 2^{-4}
 \end{array}$$

$$\begin{aligned}
 &= 0.000101101 \\
 &= 2^{-4} + 2^{-6} + 2^{-7} + 2^{-9} \\
 &= 0.\underline{0}8789
 \end{aligned}$$

$$X * Y = 0.\underline{0}96282$$

5/77



(Add)

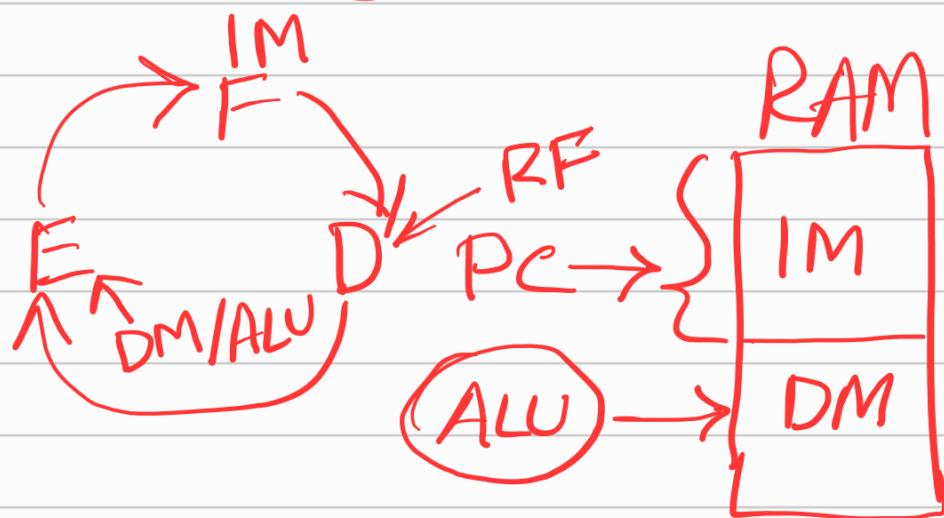
(5) * (7.92)

Add. d

Sub. d

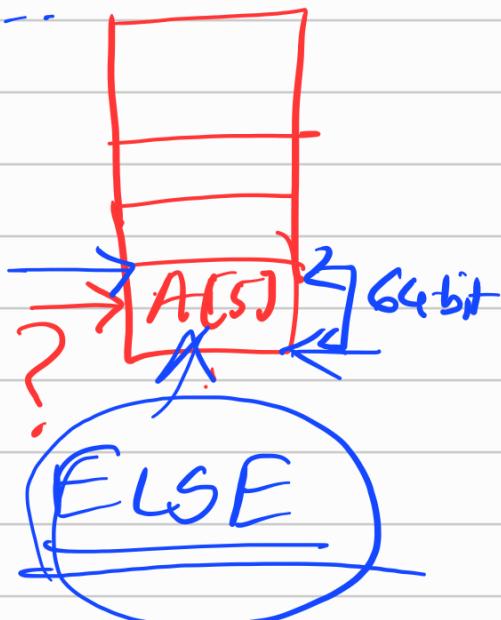
Mem, Ar, Cont

PC → points to the next memory address



~~ID X₅, 40(X₆)~~ AC]

~~40 + 0x1234000~~



bne X₃, X₅,

ELSE

$X_3 - X_5 = 0, \neq 0$
Adder / ALU

Add X_3, X_5, X_6

AND \bar{X}_5, X_6, X_7

(Add)

Addi $X_3, \underline{X_5}, 100$

I2 $X_5, \underline{40(X_6)}$

Mem

PC+4

PC+4 + Branch

CSE 340-2; 11/12/24

$$X = 0.9123 \quad Y = 0.5432 \quad X * Y = ?$$

$$= 0.111010$$

$$= 1.11010 \times 2^{-1}$$

$$= 0.100010 \quad -1$$

$$= 1.00010 \times 2^{-1}$$

$$\begin{array}{r} 1.11010 \\ 1.00010 \\ \hline \end{array}$$

$$\begin{array}{r} 000000 \\ 111010 \\ 000000 \\ 000000 \\ 000000 \\ 111010 \\ \hline \end{array}$$

$$\begin{array}{r} 000000 \\ 111010 \\ 000000 \\ 000000 \\ 000000 \\ 111010 \\ \hline \end{array}$$

$$\begin{array}{r} 000000 \\ 111010 \\ 000000 \\ 000000 \\ 000000 \\ 111010 \\ \hline \end{array}$$

$$\begin{array}{r} 000000 \\ 111010 \\ 000000 \\ 000000 \\ 000000 \\ 111010 \\ \hline \end{array}$$

$$\begin{array}{r} 000000 \\ 111010 \\ 000000 \\ 000000 \\ 000000 \\ 111010 \\ \hline \end{array}$$

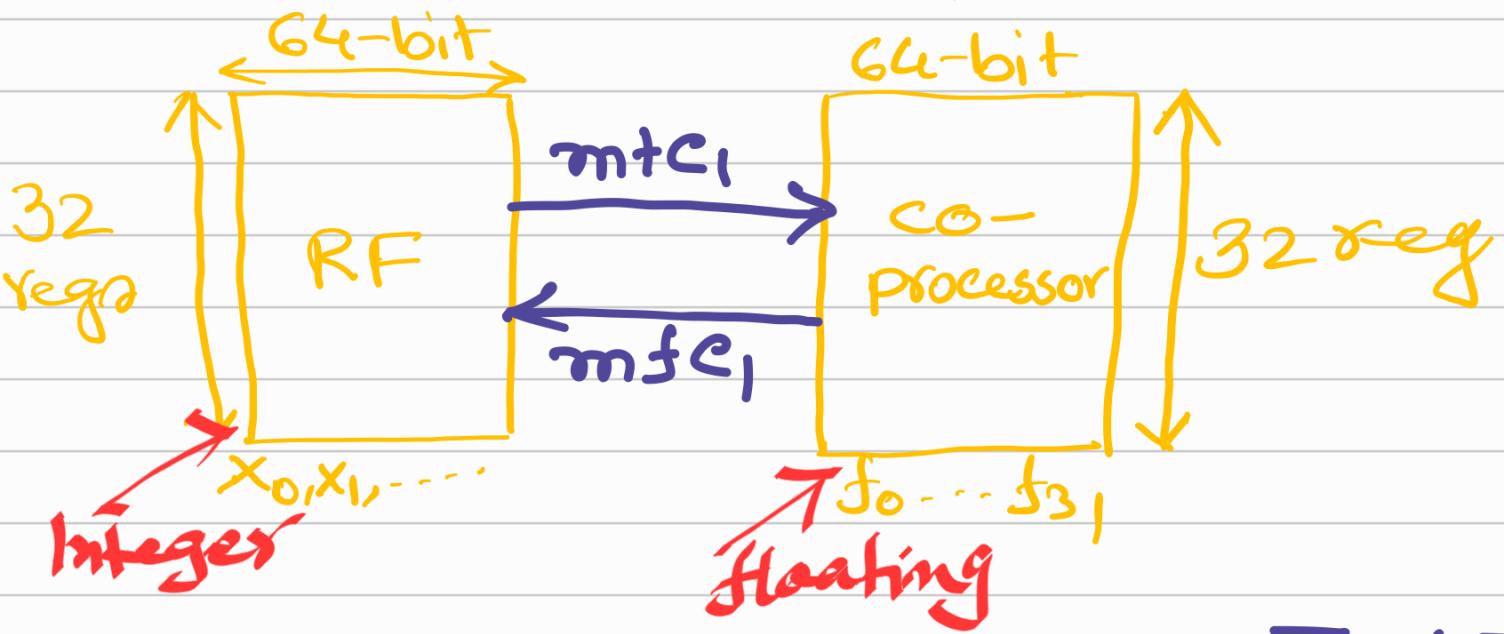
$$\begin{array}{r} 000000 \\ 111010 \\ 000000 \\ 000000 \\ 000000 \\ 111010 \\ \hline \end{array}$$

$$1.1111011010 \times 2^{-2}$$

$$= 0.0111101101$$

$$= 2^{-2} + 2^{-3} + 2^{-4} + 2^{-5} + 2^{-7} + 2^{-8} + 2^{-10}$$

$$= 0.4814$$



$$5.0 +$$

$$5 + 6.73$$

0.011
 $1 \cdot 1 \times 2^{-2}$

32-bit

E

IEEE 754 Format:

S	E	17	732	F
---	---	----	-----	---

Binary Representation:

$$\begin{array}{|c|c|c|c|c|c|} \hline & 1 & 10000011 & 000110111 & \dots & \\ \hline \end{array}$$

Exponent (E) = 10001 (8)

Mantissa (F) = 000110111

Sign (S) = 1

$-17 = -10001$

$-17.732 = -10001.10111$

$= -1 \frac{000110111 \times 2^8}{F}$

$\boxed{E-1} = 127$

$0.732 \times 2 = 1.464$

$0.464 \times 2 = 0.928$

$0.928 \times 2 = 1.856$

$0.856 \times 2 = 1.712$

$0.712 \times 2 = 1.424$

Biased notation, $Q \rightarrow 127 + 4 = 131 = \underline{10000011}$

$-21.375 \rightarrow \underline{1100000110101011\dots}$

$0.3672 \rightarrow \underline{0111101011}$

$= 0.01011$

$= 1 \cdot \underline{011} \times 2^{-2}$

$Q = -2 + 127 = 125$

$= \underline{0111101}$

$00111101011\dots$

$0.3672 \times 2 = 0.7344$

$0.7344 \times 2 = 1.4688$

$0.4688 \times 2 = 0.9376$

$0.9376 \times 2 = 1.8752$

$0.8752 \times 2 = 1.7504$

A Z B 5 0 0 0 0

$\begin{array}{r} 1010001010110101 \\ \hline Q \end{array}$

$Q = 01000101 = \underline{69}$

$E = 69 - 127 = -58$

$1 \cdot \underline{0110101} \times 2^{-58}$

$$= 2^{-58} + 2^{-60} + 2^{-61} + 2^{-63} + 2^{-65}$$

$$\approx \boxed{4.906 \times 10^{-18}}$$

BA2CB000
 22DEA 000
 ,
 ,
 ,

-13.715

$-13 \rightarrow -1101$

$0.715 \rightarrow 0.10110$

$-13.715 = -1101.10110$

$$= -1\underset{\text{E}}{\underline{101}} 10110 \times 2^3$$

$$Q = 3 + 31 = 34 = \underline{100010}$$

$$\begin{array}{r} 6-1 \\ 2-1 \\ \hline 31 \end{array}$$

S	E	F
1	100010	10110110...

1 6 11

$$\left| \begin{array}{l}
 0.715 \times 2 = \underline{\underline{1.430}} \\
 0.430 \times 2 = \underline{\underline{0.860}} \\
 0.860 \times 2 = \underline{\underline{1.720}} \\
 0.720 \times 2 = \underline{\underline{1.440}} \\
 0.440 \times 2 = \underline{\underline{0.880}} \\
 \vdots
 \end{array} \right.$$