

$$16 \times 2 = 32 < 100$$
$$32 \times 2 = 64 < 100$$
$$64 \times 2 = 128 - 100 = 28$$
$$28 \times 2 = 56 < 100$$
$$12 \times 2 = 24 < 100$$
$$24 \times 2 = 48 < 100$$
$$48 \times 2 = 96 < 100$$
$$96 \times 2 = 192 - 100 = 92$$
$$92 \times 2 = 184 - 100 = 84$$
$$84 \times 2 = 168 - 100 = 68$$
$$68 \times 2 = 136 - 100 = 36$$
$$36 \times 2 = 72 < 100$$
$$72 \times 2 = 144 - 100 = 44$$
$$44 \times 2 = 88 < 100$$

← shift 3 bits to the left

Repeat the process for 20.69, we have

 $6 + 127$ 

|    |         |         |                  |
|----|---------|---------|------------------|
| 0  | 133     | 111000  | 1011000010100011 |
| 31 | 30 ← 23 | 22 ← 16 | 15 ← 0           |

shift 1 bit to the left

17.58

After the shifts, we have

|    |      |         |                  |
|----|------|---------|------------------|
| 0  | 131  | 0001100 | 1010001111010000 |
| 31 | 30 ← | 23 ←    | 22 ← 16 ← 15 ← 0 |

120.69

|    |      |         |                  |
|----|------|---------|------------------|
| 0  | 133  | 1110001 | 0110000101000110 |
| 31 | 30 ← | 23 ←    | 22 ← 16 ← 15 ← 0 |

### Addition

First, compare the Exponent if both are same.

If not same, shift the smaller number to match with the larger number

$$131 < 133$$

(17.58) (120.69)

Shift the mantissa to match with 133.

For number 17.58 need to shift right 2 to match with the exponent 133.

From → 0.100011001010001111010000

To → 0.01000110010100011110100

Now we can perform the addition of the 2 numbers

$$\begin{array}{r}
 0.01000110010100011110100 \\
 + 0.11100010110000101000110 \\
 \hline
 \end{array}$$

10.00101001000101000111010

← shift left 1 bit

1.00010100100010100011101

update the new exponent from adding  
17 and 120, we have  $2^7$  and  $7 + 127 = 134$

|    |         |                         |
|----|---------|-------------------------|
| 0  | 134     | 00010100100010100011101 |
| 31 | 30 ← 23 | 22 ← 0                  |

### Subtraction

Assume  $17.58 - 120.69$

First compare the two numbers

17.58 is smaller then the sign bit is 1, else 0.

Next, ensure both numbers have the same exponent. We have converted in the last step for 17.58 to have the same as 120.69

So, in order to subtract, take the larger number and deduct with the smaller one.

$$\begin{array}{r}
 1.11100010110000101000110 \\
 - 1.01000110010100011110100 \\
 \hline
 0.10011100011100001010010
 \end{array}$$

Update the new exponent from subtracting  
120 and 17, we have  $2^6$  and  $6 + 127 = 133$

|    |         |                         |
|----|---------|-------------------------|
| 1  | 133     | 10011100011100001010010 |
| 31 | 30 ← 23 | 22 ← 0                  |

## Multiplication

No need to shift to match up the exponents for both numbers.

If sign bits of both numbers are the same, then the sign bit is 0, otherwise 1. It is the same in this case.

$$\begin{array}{r} 1.0001100101000111010000 \\ \times 1.11100010110000101000110 \\ \hline \end{array}$$

After adding, we have

$$10.0001001001101110100111010101101001101011000$$

↳ shift left 1 bit

Since,

$$\begin{array}{l} 17.58 \text{ has a max } 2^4 \\ 120.69 \text{ has a max } 2^6 \end{array} > (4+6+1) + 127 = 138$$

is the exponent

|    |         |                        |   |
|----|---------|------------------------|---|
| 0  | 138     | 0000100100110110100111 | 1 |
| 31 | 30 ← 23 | 22 ←                   | 0 |