$\boxed{\text{HW3}}$

1. $91_{10} + C6_{16}$

- $91_{10}\%2 = \underline{1}$ $91_{10}/2 = 45$ $45_{10}\%2 = \underline{1}$ $45_{10}/2 = 22$ $22_{10}\%2 = \underline{0}$ b1011011 (unsigned, 7 bits, integer) U7

  $22_{10}/2 = 11$ $11_{10}\%2 = \underline{1}$ $11_{10}/2 = 5$ $5_{10}\%2 = \underline{1}$ $5_{10}/2 = 2$ $2_{10}\%2 = \underline{0}$

  $2/2 = 1$ $1_{10}\%2 = \underline{1}$ $1_{10}/2 = 0$

- $C6_{16} = b\underbrace{1100}_{C_{16}}\underbrace{0110}_{6_{16}}$ (unsigned, 8 bits, integer) U8

$$
\begin{array}{r}
b\;1011011 \\
+\,b\;11000110 \\
\hline
b100100001
\end{array}
$$

$\boxed{b100100001}$ (unsigned, 9 bits, integer) U9

$b100100001 = 256_{10} + 32_{10} + 1_{10} = \boxed{289_{10}}$

2. $11_8 - 11_{10}$

$11_8 = b\underbrace{001}_{1_8}\underbrace{001}_{1_8}$ (unsigned, 6 bits, integer) U6

$11_{10}\%2 = \underline{1}$ $11_{10}/2 = 5$ $5_{10}\%2 = \underline{1}$ $5_{10}/2 = 2$ $2_{10}\%2 = \underline{0}$ $2_{10}/2 = 1$

$1_{10}\%2 = \underline{1}$ $1_{10}/2 = 0$

b1011 (unsigned, 4 bits, integer) U4

b001001 − b1011 = b001001 + b0100 + 1 = b001001 + b0101

$$
\begin{array}{r}
b001001 \\
+\,b\;\;0101 \\
\hline
b001110
\end{array}
$$

b001110 = b1110

$b1110 = \boxed{-2_{10}}$ (signed, 4 bits, integer) I4

3. $12.3125_{10} + 0110_{I2Q2}$ U4Q4 I2Q2

b1100.0101 + b01.10 (unsigned 8 bits fixed point ; signed 4 bits fixed point)

$$
\begin{array}{r}
b\;1100.0101 \\
+\,b\;\;\;\;01.10\;\; \\
\hline
b\;1101.1101
\end{array}
$$

(unsigned 8 bits fixed point) U8

$b\;1101.1101 = \boxed{13.8125_{10}}$

4. $5.75_{10} - 7.125_{10}$

= b101.11 (unsigned, 5 bits, fixed point U3Q2) − b111.001 (Unsigned, 6 bits, fixed point U3Q3)

= b101.11 + b000.111 I3Q3

$$
\begin{array}{r}
b\;101.11\;\, \\
+\,b\;000.111 \\
\hline
b\;110.101
\end{array}
$$

(signed 6 bits fixed point)

$b110.101 = -b001.011 = \boxed{-1.375_{10}}$

5. $9_{10} \cdot 3_{10}$

$9_{10} \% 2 = \underline{1}$ $\quad 9_{10}/2 = 4$ $\quad 4_{10} \% 2 = \underline{0}$ $\quad 4/2 = 2$ $\quad 2_{10} \% 2 = \underline{0}$ $\quad 2_{10}/2 = 1$ $\qquad$ b $\overline{\underline{1001}}$

$1_{10} \% 2 = \underline{1}$ $\quad 1_{10}/2 = 0$ $\qquad$ U4 (unsigned 4 bits integer)

$3_{10} \% 2 = \underline{1}$ $\quad 3/2 = 1$ $\quad 1 \% 2 = 1$ $\quad 1/2 = \underline{0}$ $\qquad$ b $\underline{11}$

b1001 $\qquad$ U2 (unsigned 2 bits integer)

```
   b1001
 x b  11
 --------
    1001
   1001
 --------
 b11011
```

b11011 $= 16_{10} + 8_{10} + 2_{10} + 1_{10} = \boxed{27_{10}}$

(unsigned 5 bits integer) U5

6. $(-5)_{10} \cdot (-6)_{16} = 5_{10} \cdot 6_{16}$

$5_{10} =$ b0101 $\qquad$ b 0101 (unsigned 4 bits integer) U4

$6_{16} =$ b0110 $\qquad$ x b 0110 (unsigned 4 bits integer) U4

```
     0000
    0101
   0101
  0000
 ---------
 b0011110
```

b0011110 $= 2_{10} + 4_{10} + 8_{10} + 16_{10} = \boxed{30_{10}}$

(unsigned 7 bits integer) U7

7. $9.5_{10} \cdot 2.625_{10}$

$9.5_{10} =$ b1001.1 (unsigned 5 bits fixed point U4Q1)

$2.625_{10} =$ b10.101 (unsigned 5 bits fixed point U2Q3)

```
 b        1001.1000
 x b      0010.1010
 ------------------
          1.0011000
        100.11000
      10011.000
 ------------------
 b11000.1111000
```

b11000.1111000 $= 16_{10} + 8_{10} + 2_{10}^{-1} + 2_{10}^{-2} + 2_{10}^{-3} + 2_{10}^{-4} = \boxed{24.9375_{10}}$

(unsigned 12 bits fixed point U5Q7)

Method 1.

8. $(-1.25)_{10} \cdot 3.5_{10} = -(3.5_{10} \cdot 1.25_{10})$

$3.5_{10} = b11.1$ (unsigned 3 bits fixed point U2Q1)

$1.25_{10} = b1.01$ (unsigned 3 bits fixed point I1Q2)

$$\begin{array}{lr} b & 11.10 \\ \times\ b & 01.01 \\ \hline & 1110 \\ & 11.10 \\ \hline & b100.0110 \end{array}$$

$-b100.0110 = -(4_{10} + 2_{10}^{-2} + 2_{10}^{-3}) = -4.375_{10}$

(unsigned 7 bits fixed point U3Q4)

Method 2.

$3.5_{10} = b11.10$ (unsigned 4 bits fixed point U2Q2)

$1.25_{10} = b01.01$ $\quad -1.25_{10} = 10.11$ (signed 4 bits fixed point I2Q2)

$$\begin{array}{lr} b & 10.11 \\ \times\ b & 11.10 \\ \hline & 00\,00 \\ & 111.011 \\ & 110.11 \\ & 101.1 \\ \hline & b1011.1010 \end{array}$$

(signed 8 bits fixed point I4Q4)

$b1011.1010 \rightarrow -b0100.0110 = -(4_{10} + 2_{10}^{-2} + 2_{10}^{-3}) = \boxed{-4.375_{10}}$

Challenge

1. $-5.6875_{10} \rightarrow$ Single-precision floating point format

0 101.1011 $\qquad 0.6875 * 2 = 1.375 \quad 1$

0 1.011011×2^2 $\qquad 0.375 * 2 = 0.75 \quad 0$

0 01101100000000000000000 $\qquad 0.75 * 2 = 1.5 \quad 1$

$\boxed{\begin{array}{l} 0\ 10000001\ 01101100000000000000000 \\ = (-1)^0 * (1.01101100000000000000000) * 2^{(10000001_2 - 127_{10})} \end{array}}$ $\qquad 0.5 * 2 = 1 \quad 1$

$2_{10} + 127_{10} = 129_{10} \rightarrow 10000001$

(unsigned 32 bits floating point)