

# ECS 455: Quiz 5 Solution

Semester/Year: 2/2010

Course Title: Mobile Communications

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## Instructions

1. Separate into groups of no more than three persons.
2. Closed book. Closed notes.
3. Only one submission is needed for each group. Late submission will not be accepted.
4. **Do not panic.**

Evaluate the following expressions by hand. Show your calculation.

1.  $[1 \ 2 \ -1] * [2 \ 1 \ -2]$

Flip  $\begin{matrix} 1 & 2 & -1 \\ -2 & 1 & 2 \end{matrix}$

shift  $\begin{matrix} & 1 & 2 & -1 \\ -2 & 1 & 2 & \\ & -2 & 1 & 2 \\ & & -2 & 1 & 2 \end{matrix}$

$\rightarrow 1 \times 2 = 2$   
 $\rightarrow 1 \times 1 + 2 \times 2 = 1 + 4 = 5$   
 $\rightarrow 1 \times (-2) + 2 \times 1 + (-1) \times 2 = -2 + 2 - 2 = -2$   
 $\rightarrow -2 \times 2 + (-1) \times 1 = -4 - 1 = -5$   
 $\rightarrow -2 \times 1 = -2$

**$= [2 \ 5 \ -2 \ -5 \ 2]$**

2.  $[1 \ 2 \ -1] \otimes [2 \ 1 \ -2]$

Flip  $\begin{matrix} 1 & 2 & -1 & 1 & 2 & -1 & 1 & 2 & -1 & \dots \\ -2 & 1 & 2 & & & & & & & \end{matrix}$

shift  $\begin{matrix} & -2 & 1 & 2 \\ & & -2 & 1 & 2 \\ & & & -2 & 1 & 2 \end{matrix}$

length = 3. So, we stop here.

$\rightarrow 2 \times (-2) + (-1) \times 1 + 1 \times 2 = -4 - 1 + 2 = -3$   
 $\rightarrow (-1)(-2) + 1 \times 1 + 2 \times 2 = 2 + 1 + 4 = 7$   
 $\rightarrow (1)(-2) + 2 \times 1 + (-1)(2) = -2 + 2 - 2 = -2$

**$= [-3 \ 7 \ -2]$**

3.  $[1 \ 2 \ -1 \ 0] \otimes [2 \ 1 \ -2 \ 0]$

Flip  $\begin{matrix} 1 & 2 & -1 & 0 & 1 & 2 & -1 & 0 & 1 & 2 & -1 & 0 \\ 0 & -2 & 1 & 2 & & & & & & & & \end{matrix}$

shift  $\begin{matrix} & 0 & -2 & 1 & 2 \\ & & 0 & -2 & 1 & 2 \\ & & & 0 & -2 & 1 & 2 \end{matrix}$

length = 4. So, we stop here.

$2 \times 0 + (-1)(-2) + 0 \times 1 + 1 \times 2 = 0 + 2 + 0 + 2 = 4$   
 $(-1)0 + 0(-2) + 1 \times 1 + 2 \times 2 = 0 + 0 + 1 + 4 = 5$   
 $0 \times 0 + 1(-2) + 2 \times 1 + (-1)2 = 0 - 2 + 2 - 2 = -2$   
 $1 \times 0 + 2(-2) + (-1)(1) + 0 \times 2 = 0 - 4 - 1 + 0 = -5$

**$= [4 \ 5 \ -2 \ -5]$**

4.  $[1 \ 2 \ -1 \ 0 \ 0] \otimes [2 \ 1 \ -2 \ 0 \ 0]$

Recall that the convolution of  $\underline{x}_1$  and  $\underline{x}_2$  whose length is  $N_1$  and  $N_2$  can be calculated from a circular convolution of  $\underline{x}_1$  and  $\underline{x}_2$  where the  $\underline{x}_1$  and  $\underline{x}_2$  are zero-padded to have length  $N_1 + N_2 - 1$ .

So  $\rightarrow = [1 \ 2 \ -1] * [2 \ 1 \ -2]$

Use the answer from Q1.  $\rightarrow = [2 \ 5 \ -2 \ -5 \ 2]$