Matching Time and Frequency Domain Representations

Overview: Students match sets of cards with time and frequency domain representations given prompts for how they are to be combined.

Setting: In class activity

Curricular elements: Gaming

Prerequisites:

- Understanding of the Properties of Linear, Time-Invariant Systems
- Understanding of Fourier Transform
- Basic Knowledge of Convolution

Topics/concepts covered:

- Linear, Time-Invariant Systems
- Fourier Transform
- Graphical/Analytical Convolution

Learning outcomes:
Students are refamiliarized with:

- Linear, Time-Invariant Systems
- Fourier Transform
- Filtering

Expected time to complete: Maximum of 30 minutes in class (could be extended).

Required hardware/materials: Printed cardstock cards with graphical time- and frequency-domain representations.

Required instructor interaction: Supervised, with occasional guidance.

Common mistakes/pitfalls:

Method of assessment: instructor- or peer-graded, based on final product (perhaps on time used for completion, as well).

Gamification/Tinkering Notes:
This activity combines the following Gamification Mechanics:

- Group Identification
  - Activity is completed in groups and judged, in part, by the collective performance of that group.
- Competition
  - Group members compete with eachother as well as collectively with the other groups.
- Feedback
  - Potential solutions are limited such that the correct solutions become clear when they are constructed.

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This work was supported by ONR grant N000141512442, *Contact: andy.klein@wwu.edu and richard.martin@afit.edu.*

Please complete the below exercises with a group of 3 to 4 students. Everything should be a review of EE 310 concepts.

In-Class Mini-Game: Matching Time and Frequency

1 Introduction

For this activity, groups will be supplied two sets of cards: 25 question cards (labeled 1 through 25) and 14 graph cards (labeled A through N). You will compete with your fellow group members by attempting to earn the most question cards by answering questions on the question cards by selecting the appropriate graph cards. Turns are taken drawing cards from the deck of question cards and selecting answers for evaluation by the rest of the group.

2 Gameplay

2.1 Setup

Set the deck of question cards face down, in a central location. The graph cards should be placed in a stack or spread out on the table face up. Select from the group the member that will go first in the rotation of turns, as well as a scribe that will record the answers for the activity on the provided answer sheet.

2.2 Turns

Turns should rotate about the table in the clockwise direction. Each player will complete the following steps in their turn:

Step 1: Draw a question card from the deck.

Step 2: Select from the graph cards, an appropriate answer to the question card drawn.

Step 3: Reveal the chosen card to the group for evaluation by placing the card in the "Final Choice" zone.

Step 4: All other group members must verbally confirm that they have no objection to the choice of answer. If there is any objection to the selection at this point, the objector may select an alternative graph card. If there is yet another objection, another card may be selected by that objector, and so on. The consensus of the group will decide the correct graph card and the question card is awarded to the player which selected the winning graph card. (If consensus cannot be reached, please alert the instructor for help.)

Step 5: The question card is then placed in front of the player to which it was awarded. The graph card is returned to it's place for potential reuse. This turn is now ended.

2.3 Finish

The above process is repeated until either the cards are run out or the time is up for the activity, at which point the points are tallied up from the cards won by each player in order to determine the winner(s).

Please list your answers for the activity next to the cooresponding question numbers.

In-Class Mini-Game: Matching Time and Frequency

Question 1: _____ **Question 2:** _____

Question 3: _____ **Question 4:** _____

Question 5: _____ **Question 6:** _____

Question 7: _____ **Question 8:** _____

Question 9: _____ **Question 10:** _____

Question 11: _____ **Question 12:** _____

Question 13: _____ **Question 14:** _____

Question 15: _____ **Question 16:** _____

Question 17: _____ **Question 18:** _____

Question 19: _____ **Question 20:** _____

Question 21: _____ **Question 22:** _____

Question 23: _____ **Question 24:** _____

Question 25: _____

In-Class Mini-Game: Matching Time and Frequency

QUESTIONS

(Question Card Deck Here, Face Down)	(Current Question Card Here, Face Up)

FINAL ANSWER ZONE

(Place Answer Card Here, Face Up)

Question 1

If H is the **time domain** representation of a signal, which card is most accurately matches its **frequency domain** representation?

$$\mathcal{F}\{H\} \; = \; ?$$

Question 2

If F is the **frequency domain** representation of a signal, which card most accurately matches its **time domain** representation?

$$\mathcal{F}^{-1}\{F\} \; = \; ?$$

Question 3

If J is the **time domain** representation of a signal, which card most accurately matches its **frequency domain** representation?

$$\mathcal{F}\{J\} \; = \; ?$$

Question 4

If C is the **frequency domain** representation of a signal, which card most accurately matches its **time domain** representation?

$$\mathcal{F}^{-1}\{C\} \; = \; ?$$

Question 5

If G is the **time domain** representation of a signal, which card most accurately matches its **frequency domain** representation?

$$\mathcal{F}\{J\} \; = \; ?$$

Question 6

If E is the **frequency domain** representation of a signal, which card most accurately matches its **time domain** representation?

$$\mathcal{F}^{-1}\{E\} \; = \; ?$$

Question 7

If L is the **time domain** representation of a signal, which card most accurately matches its **frequency domain** representation?

$$\mathcal{F}\{L\} \;=\; ?$$

Question 8

If N is the **frequency domain** representation of a signal, which card most accurately matches its **time domain** representation?

$$\mathcal{F}^{-1}\{N\} \;=\; ?$$

Question 9

If M is the **time domain** representation of a signal, which card is most accurately matches its **frequency domain** representation?

$$\mathcal{F}\{M\} \;=\; ?$$

Question 10

If K is the **frequency domain** representation of a signal, which card most accurately matches its **time domain** representation?

$$\mathcal{F}^{-1}\{K\} \;=\; ?$$

Question 11

If A is the **time domain** representation of a signal, which card most accurately matches its **frequency domain** representation?

$$\mathcal{F}\{A\} \;=\; ?$$

Question 12

If I is the **frequency domain** representation of a signal, which card most accurately matches its **time domain** representation?

$$\mathcal{F}^{-1}\{I\} \;=\; ?$$

Question 13

If B is the **time domain** representation of a signal, which card most accurately matches its **frequency domain** representation?

$$\mathcal{F}\{B\} \;=\; ?$$

Question 14

If D is the **frequency domain** representation of a signal, which card most accurately matches its **time domain** representation?

$$\mathcal{F}^{-1}\{D\} \;=\; ?$$

Question 15

Consider $J + G$ as a **time domain** signal. Which card most accurately matches its **frequency domain** representation?

$$\mathcal{F}\{C + G\} \;=\; ?$$

Question 16

Consider $J + G$ as a **time domain** signal. Which card most accurately matches the graph of that **time domain** signal?

$$\mathcal{F}\{J + G\} \;=\; ?$$

Question 17

Consider $E + C$ as a **frequency domain** signal. Which card most accurately matches its **time domain** representation?

$$\mathcal{F}^{-1}\{E + C\} \;=\; ?$$

Question 18

Consider $H + J$ as a **time domain** signal. Which card most accurately matches its **frequency domain** representation?

$$\mathcal{F}\{H + J\} \;=\; ?$$

Question 19

Consider $H + J$ as a **time domain** signal. Which card most accurately matches the graph of that **time domain** signal?

$$\mathcal{F}\{H + J\} \; = \; ?$$

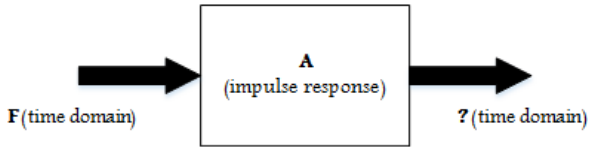
Question 20

Consider $F + C$ as a **frequency domain** signal. Which card most accurately matches its **time domain** representation?

$$\mathcal{F}^{-1}\{F + C\} \; = \; ?$$

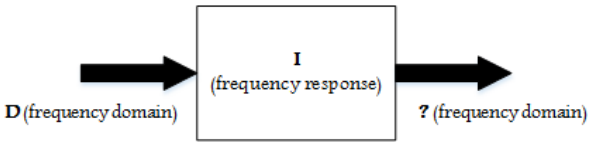
Question 21

If F is the **time domain** representation of the input to the system with **impulse response** described by A, which card matches most accurately the output of that system in the **time domain** (ignore any time delay or advancement)?



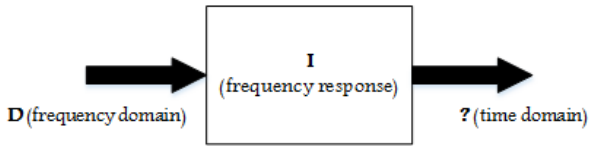
Question 22

If D is the **frequency domain** representation of the input to the system with **frequency response** described by I, which card matches most accurately the output of that system in the **frequency domain**?



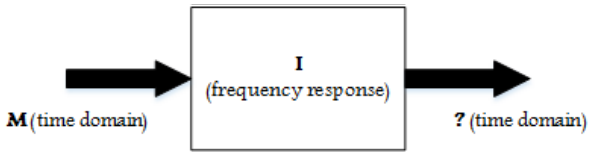
Question 23

If D is the **frequency domain** representation of the input to the system with **frequency response** described by I, which card matches most accurately the output of that system in the **time domain** (ignore any time delay or advancement)?



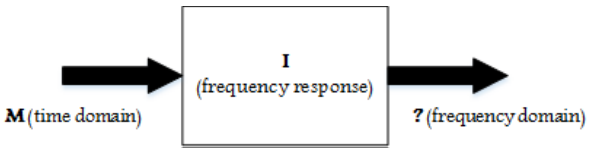
Question 24

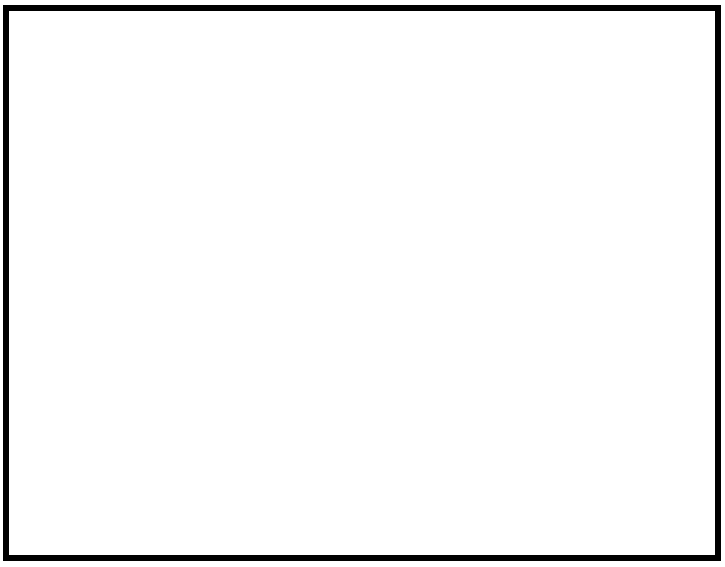
If M is the **time domain** representation of the input to the system with **frequency response** described by I, which card matches most accurately the output of that system in the **time domain** (ignore any time delay or advancement)?

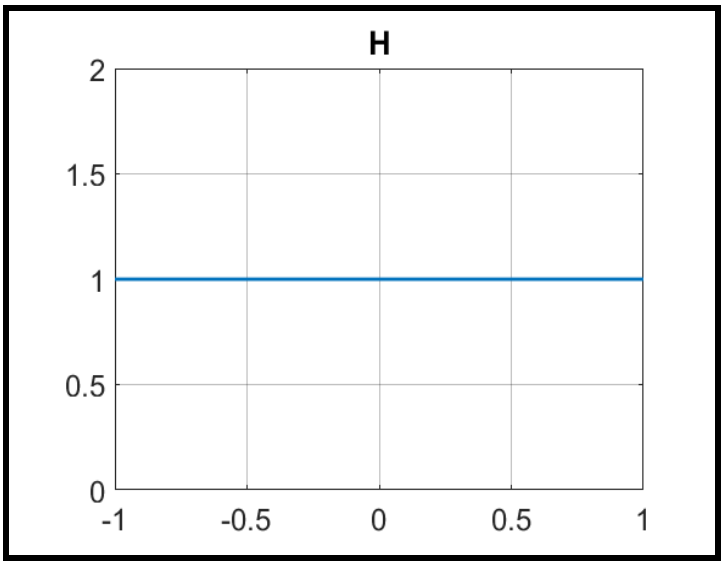


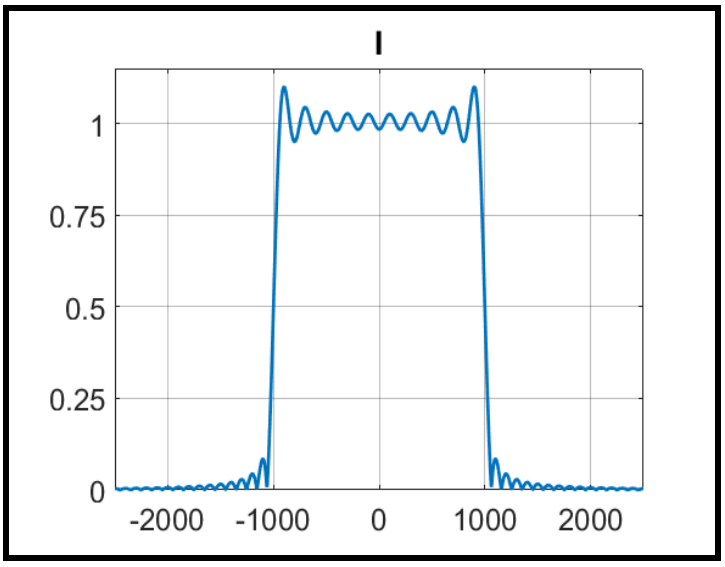
Question 25

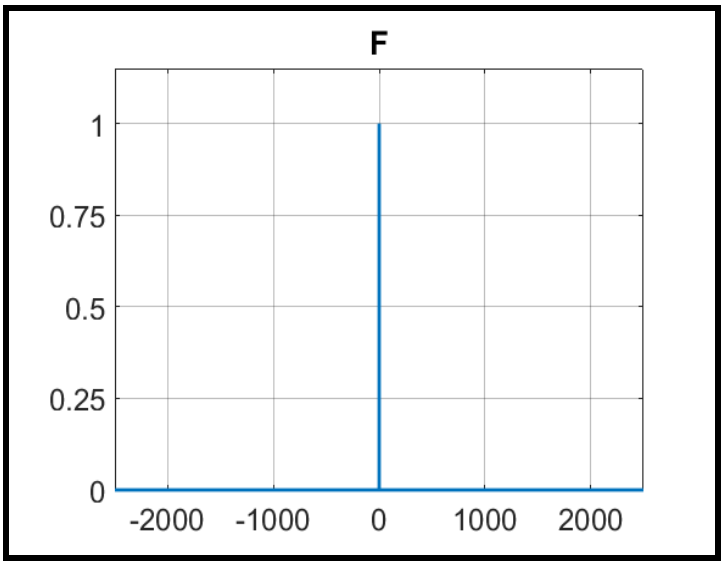
If M is the **time domain** representation of the input to the system with **frequency response** described by I, which card matches most accurately the output of that system in the **frequency domain**?

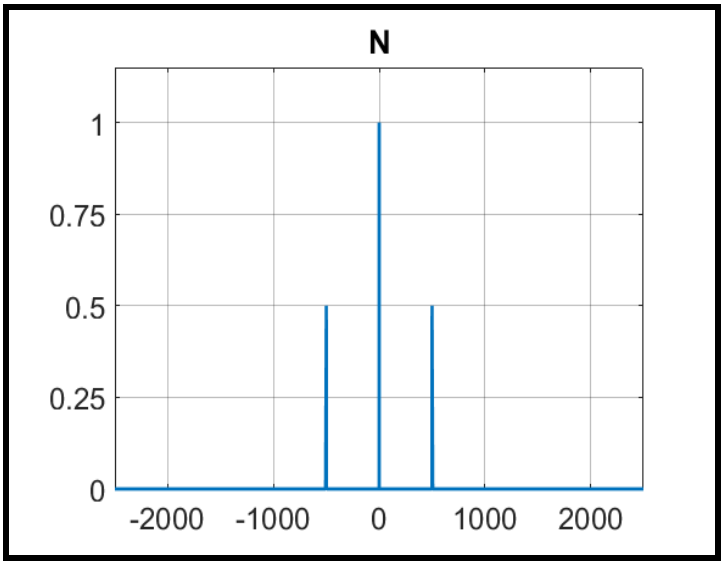


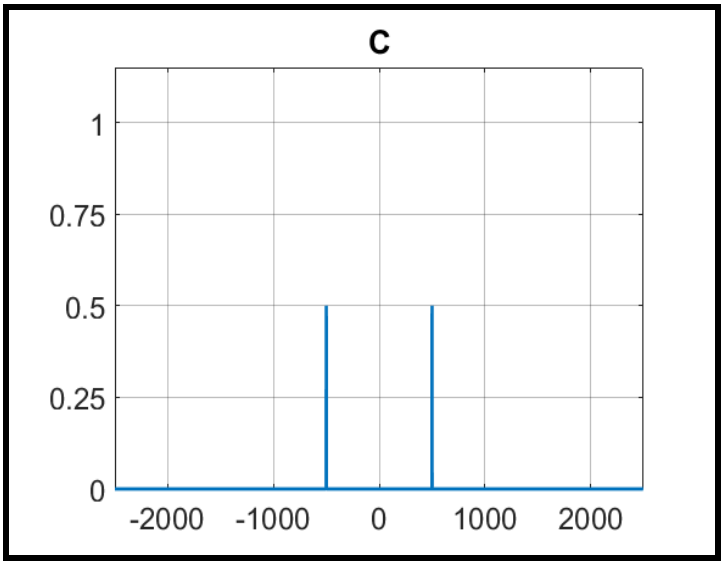


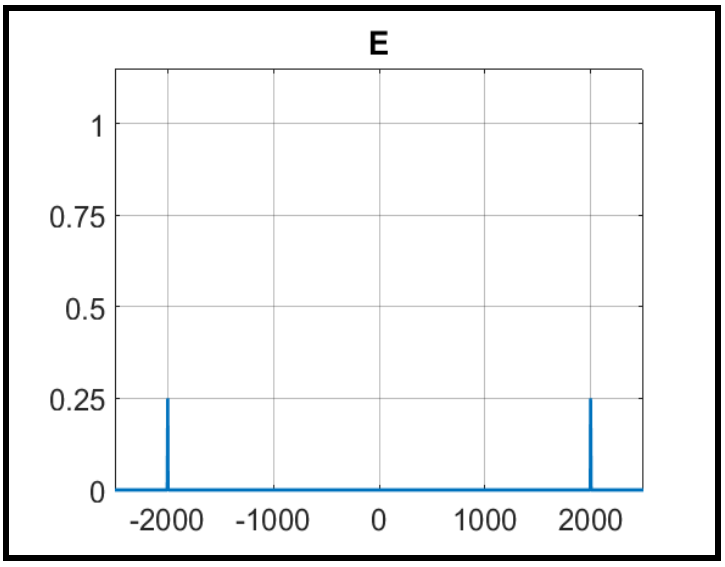

H
2
1.5
1
0.5
0
-1
-0.5
0
0.5
1

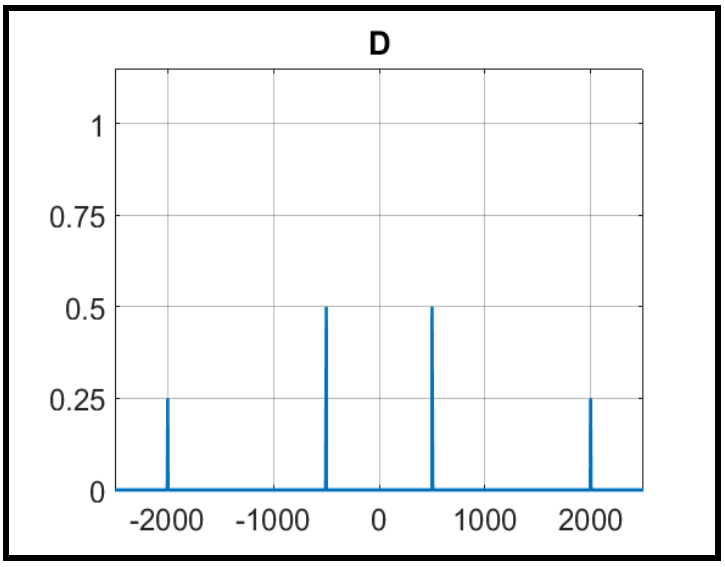

I
1
0.75
0.5
0.25
0
-2000
-1000
0
1000
2000


F
1
0.75
0.5
0.25
0
-2000
-1000
0
1000
2000


N
1
0.75
0.5
0.25
0
-2000
-1000
0
1000
2000


C
1
0.75
0.5
0.25
0
-2000
-1000
0
1000
2000


E
1
0.75
0.5
0.25
0
-2000
-1000
0
1000
2000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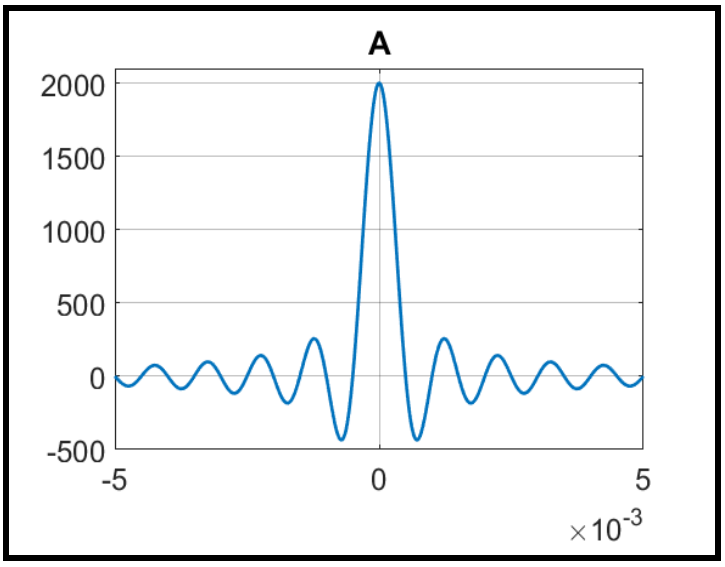
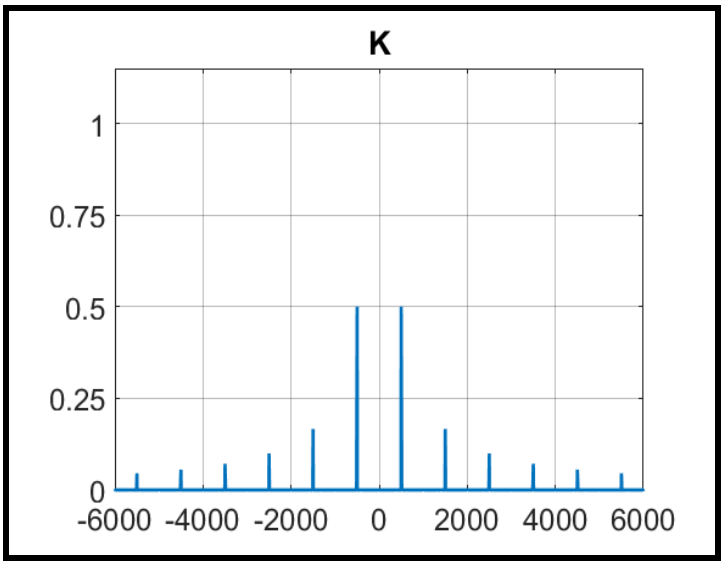
0.75
0.5
0.25
0
-2000
-1000
0
1000
2000


A
2000
1500
1000
500
0
-500
-5
0
5
×10^-3


K
1
0.75
0.5
0.25
0
-6000
-4000
-2000
0
2000
4000
6000