Midterm

Started: Mar 7 at 3:06pm

Quiz Instructions

See Midterm Instructions: https://www.seas.upenn.edu/~ese150/spring2021/midterm_details.pdf

Answer Questions 1--4 Based upon the following sampled waveform:
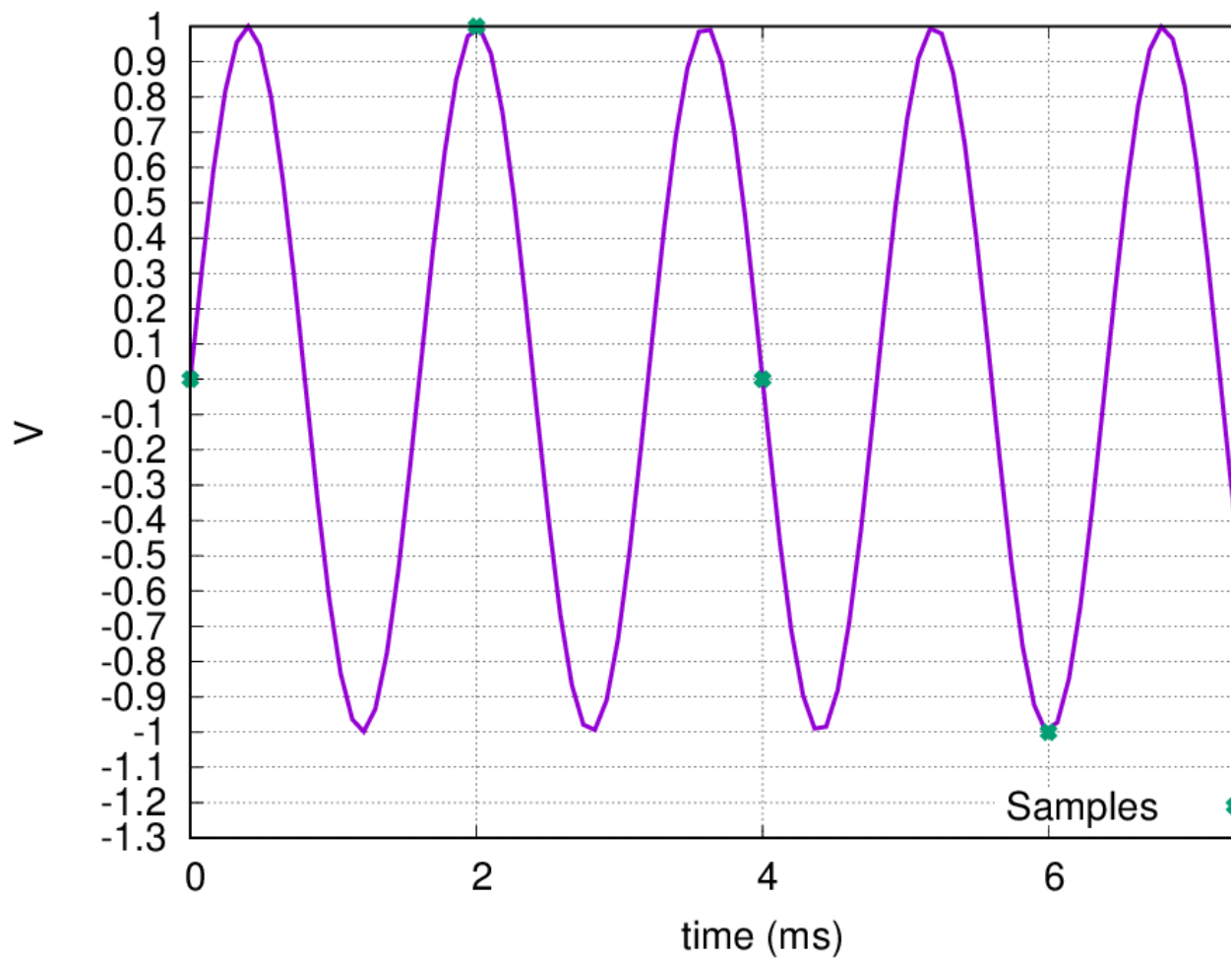
Question 1

2 pts

Frequency of waveform in Hz?

Question 2

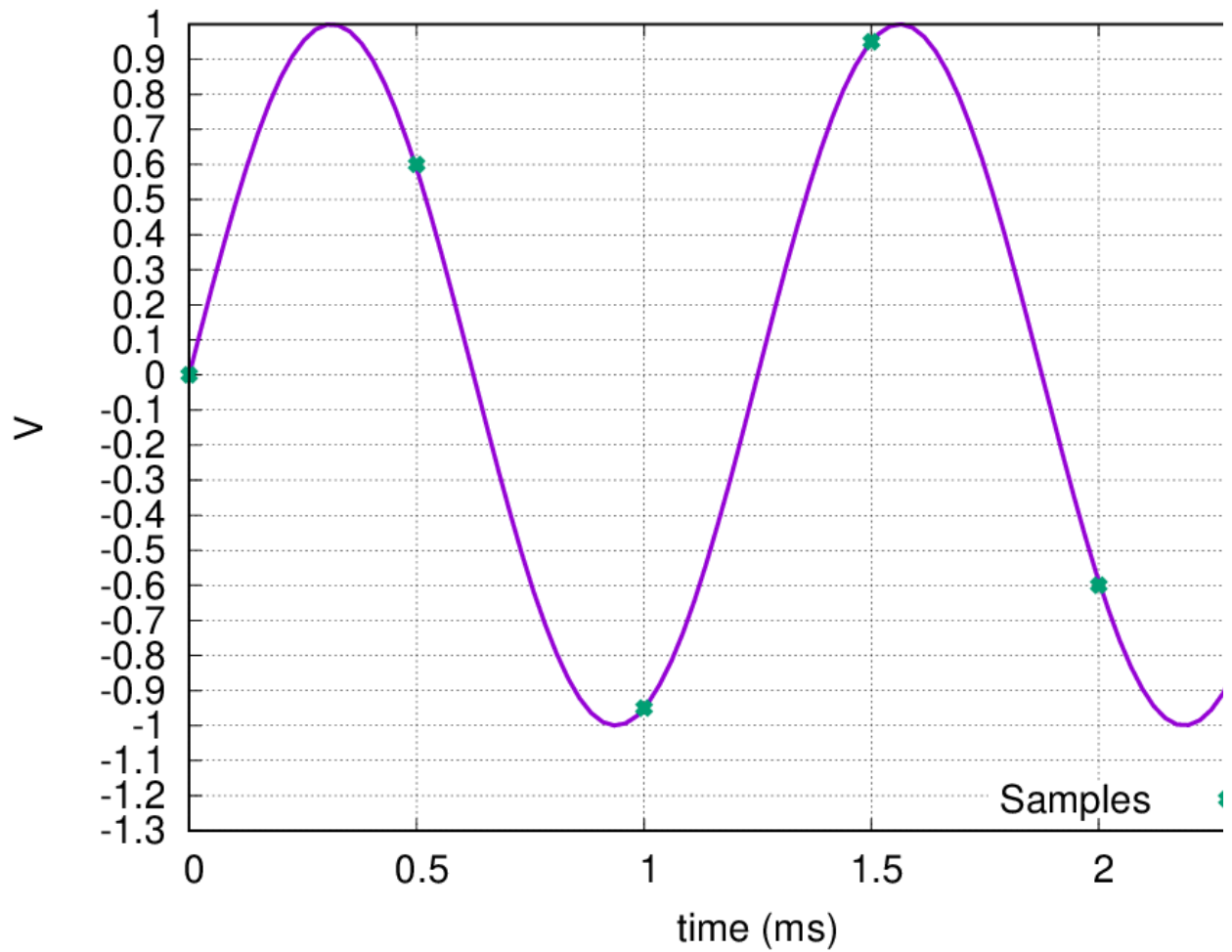**2 pts**

Sample rate in Hz?

Question 3

2 pts

The waveform is correctly sampled.

○ True

○ False

Question 4

2 pts

Inferred frequency from samples in Hz?

Answer questions 5--8 based on the following sampled waveform:

Question 5

2 pts

Frequency of waveform in Hz?

[   ]

Question 6

2 pts

Sample rate in Hz?

[   ]

Question 7

2 pts

The waveform is correctly sampled.

○ True

○ False

Question 8

2 pts

Imferred frequency from samples in Hz?

[   ]

For the next few questions, consider the 27 symbol quote:

m	a	k	e		t	h	e	
c	o	m	m	o	n		c	a
s	e		s	h	o	r	t	.

This uses 13 unique symbols.

Question 9   **2 pts**

If we assign the same number of bits to each of the 13 symbols, how many bits will we need to encode the 27 symbol quote?

[   ]

Question 10   **4 pts**

According to Shannon Entropy, what is the lower bound on the number of bits needed to represent the collection of 27 symbols for the entire quote?

Question 11   6 pts

Select an encoding for each symbol to minimize the length of the encoded quote.

You may use each encoding only once (equivalently, you should assign all symbols, and will only be able to assign one symbol to each encoding).

The following table may be useful in planning your assignment before using the canvas-dropdown-matching below to record your solution. You may want to print and fill in the table.

symbol	encoding		symbol	encoding
a			c	
e			h	
k			m	
n			o	
r			s	
t			. (period)	
(space)				

000	[Choose] ▲▼
100	[Choose] ▲▼
101	[Choose] ▲▼
110	[Choose] ▲▼
111	[Choose] ▲▼
0010	[Choose] ▲▼
0011	[Choose] ▲▼
0101	[Choose] ▲▼
0110	[Choose] ▲▼
01000	[Choose] ▲▼
01001	[Choose] ▲▼
01110	[Choose] ▲▼
01111	[Choose] ▲▼

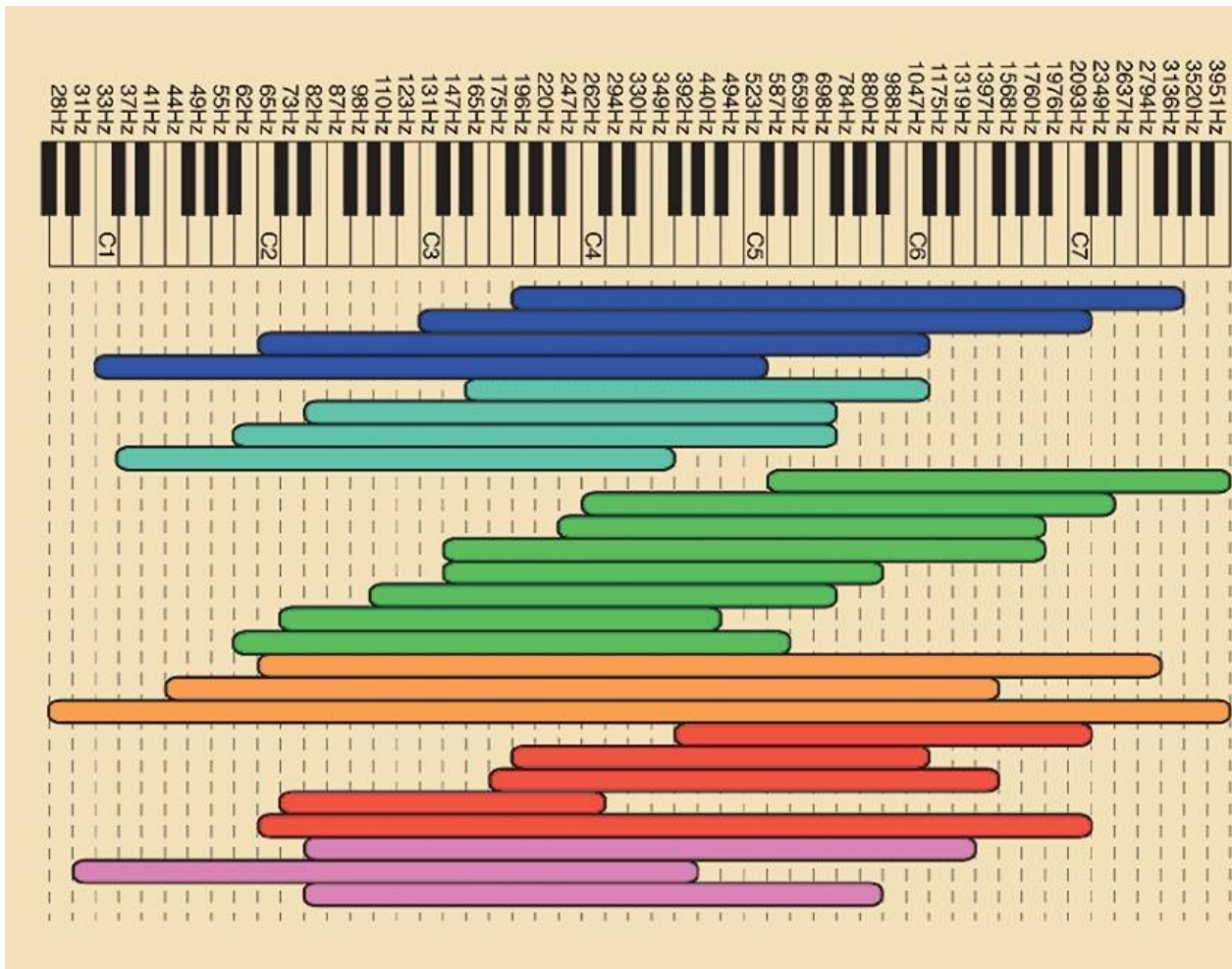## Question 12

2 pts

For your selected encoding, how many bits are required to represent the quote?

For the next set of questions, consider the musical instrument range and piano scale:

Question 13
1 pts

What is the minimum sample rate in Hz for accurately capturing a Tuba solo?

[ ]

Question 14   1 pts

What is the minimum sample rate in Hz for capturing a piccolo solo?

[ ]

Question 15   2 pts

If you only need to represent notes on the scale (corresponding to notes for which there are piano keys), how many bits do you need to represent the frequency of single notes in a Tuba-Piccolo duet?

[ ]

Question 16   6 pts

Assuming the Tuba and Piccolo each play one note at a time that lasts at least 100ms in a Tuba-Piccolo duet.

Assume you can represent the loudness of each note with 8 bits.

How much smaller can a recording of the notes play in the duet be compared to 16b PCM time-sample recording taken at a 44KHz sample rate?

Edit   View   Insert   Format   Tools   Table

12pt ∨   Paragraph ∨ | **B**   *I*   U̲   A ∨   ✎ ∨   T² ∨ | ⋮

p

⌨   ⓘ | 0 words | </>   ↗   ⋮

Consider the following signal made from two sine waves:
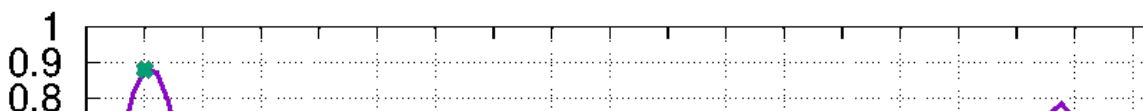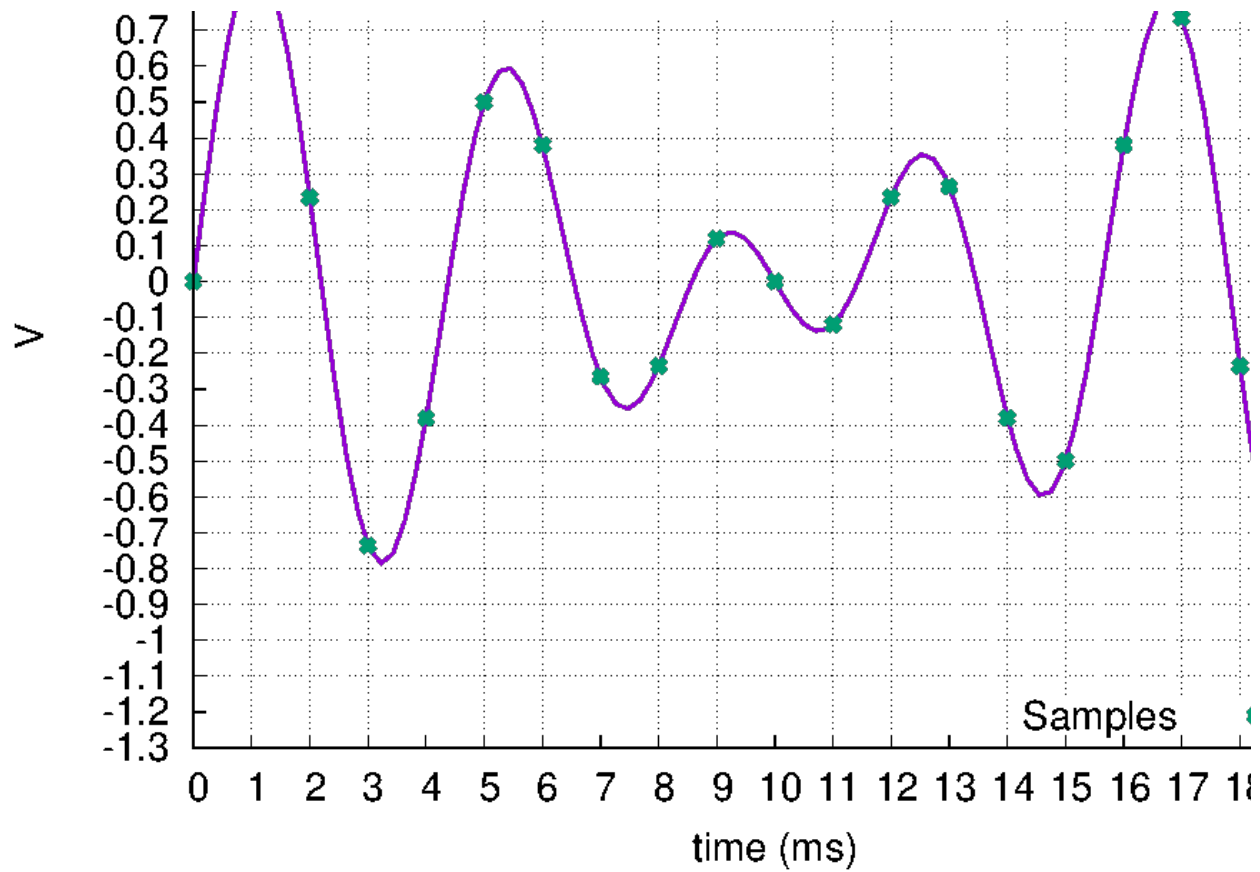
This signal is f(t) = $A \cdot \sin(2\pi \cdot 250 \cdot t) + B \cdot \sin(2\pi \cdot C \cdot t)$.

In the next three questions, we ask you to determine A, B, and C.

Given:

i	1	2	3	4	5	6	7	8	9
f(i*0.001)	0.88	0.23	-0.73	-0.38	0.5	0.38	-0.26	-0.23	0.12
$\sin(2\pi \cdot 250 \cdot i \cdot 0.001)$	1	0	-1	0	1	0	-1	0	1

both are 0 at i=0, i=10, and i=20

Question 17   6 pts

What is A?

[   ]

Question 18   6 pts

What is C in Hz?

[   ]

Question 19   6 pts

What is B?

[   ]

Question 20   10 pts

Consider critical band 2 from 100--200 Hz.

Assume humans can only distinguish frequencies as different in this range if they differ by > 3Hz.

Assume humans can only notice amplitude difference as small as 1 dB.

How many bits do you need to represent sounds in this band for humans?

State assumptions and show work.

For the next few questions, consider the following scenario.

You are a spy sitting in a cafe.

At the table on the right there is a conversation of interest that you hear at 30dB at your table.

After a time, a loud group comes in and sits at a table on the left that you hear at 50dB at your table.

Question 21   **2 pts**

How does this new group at your left impact your ability to hear the interesting conversation on your right?

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12pt ∨   Paragraph ∨ | **B** *I* U A ∨ ✏ ∨ T² ∨ | ⋮

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Question 22   3 pts

Would it help to record the audio at your table to an MP3? Why or why not?

p   ⌨   ⓣ | 0 words | </>   ↗   ⋮

Question 23   3 pts

Would it help to record the audio at your table in PCM? Why or why not?

Edit   View   Insert   Format   Tools   Table

12pt ∨   Paragraph ∨ | **B**   *I*   U̲   A ∨   ✎ ∨   T² ∨ | ⋮

p   ⌨   ⓘ | 0 words | </>   ↗   ⋮

Question 24   **8 pts**

Sketch how you could program audio processing (perhaps for your phone) to recover more of the interesting conversation on the right than you were able to hear unaided?

Reference for next set of questions:

Animal	Range	Octaves
Tuna	50 Hz-1.1 kHz	(4.5 8va)
Chicken	125 Hz-2 kHz	(4.0 8va)
Goldfish	20 Hz-3 kHz	(7.2 8va)
Bullfrog	100 Hz-3 kHz	(4.9 8va)
Catfish	50 Hz-4 kHz	(6.3 8va)
Tree frog	50 Hz-4 kHz	(6.3 8va)
Canary	250 Hz-8 kHz	(5.0 8va)
Cockatiel	250 Hz-8 kHz	(5.0 8va)
Parakeet	200 Hz-8.5 kHz	(5.4 8va)
Elephant	17 Hz-10.5 kHz	(9.3 8va)
Owl	200 Hz-12 kHz	(5.9 8va)
Human	31 Hz-19 kHz	(9.3 8va)
Chinchilla	52 Hz-33 kHz	(9.3 8va)
Horse	55 Hz-33.5 kHz	(9.3 8va)
Cow	23 Hz-35 kHz	(10.6 8va)
Raccoon	100 Hz-40 kHz	(8.6 8va)
Sheep	125 Hz-42.5 kHz	(8.4 8va)
Dog	64 Hz-44 kHz	(9.4 8va)
Ferret	16 Hz-44 kHz	(11.4 8va)
Hedgehog	250 Hz-45 kHz	(7.5 8va)
Guinea pig	47 Hz-49 kHz	(10.0 8va)
Rabbit	96 Hz-49 kHz	(9.0 8va)
Sea lion	200 Hz-50 kHz	(8.0 8va)
Gerbil	56 Hz-60 kHz	(10.1 8va)
Opossum	500 Hz-64 kHz	(7.0 8va)
Albino rat	390 Hz-72 kHz	(7.5 8va)
Hooded rat	530 Hz-75 kHz	(7.1 8va)
Cat	55 Hz-77 kHz	(10.5 8va)
Mouse	900 Hz-79 kHz	(6.4 8va)
Little brown bat	10.3 kHz-115 kHz	(3.5 8va)
Beluga whale	1 kHz-123 kHz	(6.9 8va)
Bottlenose dolphin	150 Hz-150 kHz	(10.0 8va)
Porpoise	75 Hz-150 kHz	(11.0 8va)

10 Hz   100 Hz   1 kHz   10 kHz   100 k

C0 C1 C2 C3 C4 C5 C6 C7 C8 C9 C10 C11 C12 C1

Question 25

3 pts

A chicken, a man, and an little brown bat walk into a ~~bar~~ zoom session....

Assume each can "speak" in the same range as their hearing. Here speak means produce sounds that can be assigned some meaning.

Which animals can communicate with each other directly?

☐ chicken and human

☐ chicken and little brown bat

☐ human and little brown bat

Question 26   12 pts

Consider designing a zoo-session (zoom optimized for communication among animals).

How could this zoo session allow any animals (like the chicken, human, and little brown bat) to communicate with each other?

Assume each animal is at its own, personal zoo-client terminal.

Sketch the basic processing your zoo-client could perform to allow the animals to communicate.

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Question 27   **0 pts**

Use this space for any derivation details where you want to show your work for potential partial credit for questions that don't have such space.

Edit   View   Insert   Format   Tools   Table

12pt ∨   Paragraph ∨   **B**   *I*   U̲   A ∨   ✏ ∨   T² ∨   ⋮

p   ⌨   ⓣ | 0 words | </>   ↗   ⠿

Question 28   1 pts

I complied with the University of Pennsylvania Code of Academic Integrity in completing this exam.

https://catalog.upenn.edu/pennbook/code-of-academic-integrity/

○ True

○ False