GEORGIA INSTITUTE OF TECHNOLOGY
SCHOOL OF ELECTRICAL AND COMPUTER ENGINEERING

ECE 2026 — Summer 2013
Quiz #1

June 10, 2013

NAME: ______________ ________________ GT username: ________________
(FIRST) (LAST) (e.g., gtxyz123)

Circle your recitation section (otherwise you lose 3 points!):

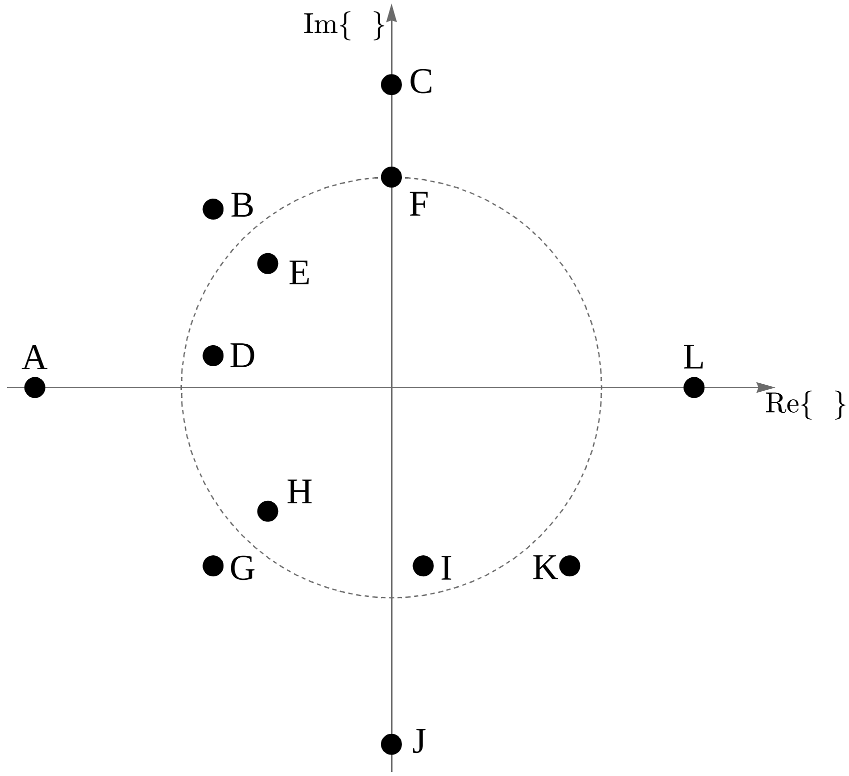
	Mon	Tue
10 – 11:45am		L02 (Moore)
12 – 1:45pm		L03 (Moore)
4 – 5:45pm	L01 (Barry)	

Important Notes:

- DO NOT unstaple the test.
- One two-sided page (8.5” $\times$ 11”) of hand-written notes permitted.
- JUSTIFY your reasoning CLEARLY to receive partial credit.
- You must write your answer in the space provided on the exam paper itself.
  Only these answers will be graded. Circle your answers, or write them in the boxes provided.
  If more space is needed for scratch work, use the backs of the previous pages.

Problem	Value	Score Earned
1	20	
2	20	
3	20	
4	20	
5	20	
No/Wrong Rec	–3	
Total		

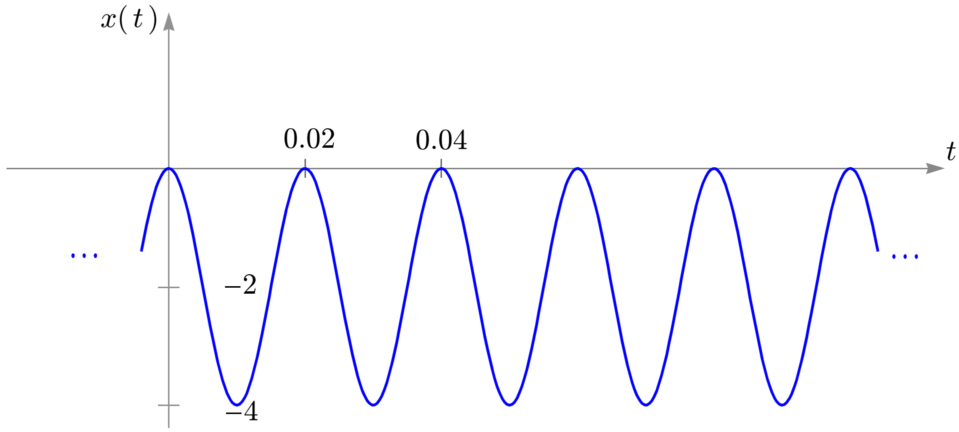
PROB. Su13-Q1.1. The figure below shows the locations of twelve points in the complex plane, along with the unit circle:



Match each point above to one of the functions of an unspecified complex number z shown in the table below, by arranging the letters {A, B, ... M} in the second column of the table below:

(1)	z	
(2)	$1/z$	
(3)	z^*	
(4)	$1/z^*$	
(5)	$z + z^*$	
(6)	$z - z^*$	
(7)	zz^*	
(9)	z/z^*	
(9)	z^2	
(10)	jz	
(11)	$z + j$	
(12)	$z + 1$	

PROB. Su13-Q1.2. The signal $x(t) = B + A\cos(2\pi f_0 t + \theta)$ achieves a peak value of zero at time $t = 0.02$ and again at time $t = 0.04$, as shown below:



(a) Specify numeric values for the following parameters:

$B =$ ☐

$A =$ ☐

$f_0 =$ ☐ Hz

$\theta =$ ☐ $\in (-\pi, \pi]$.

(b) Consider the following MATLAB code:

```
tt = 0:0.001:dur; % dur is the duration in seconds
xx = real((1-j)*exp(j*16*pi*tt)) + real((2-j)*exp(j*16*pi*tt));
```

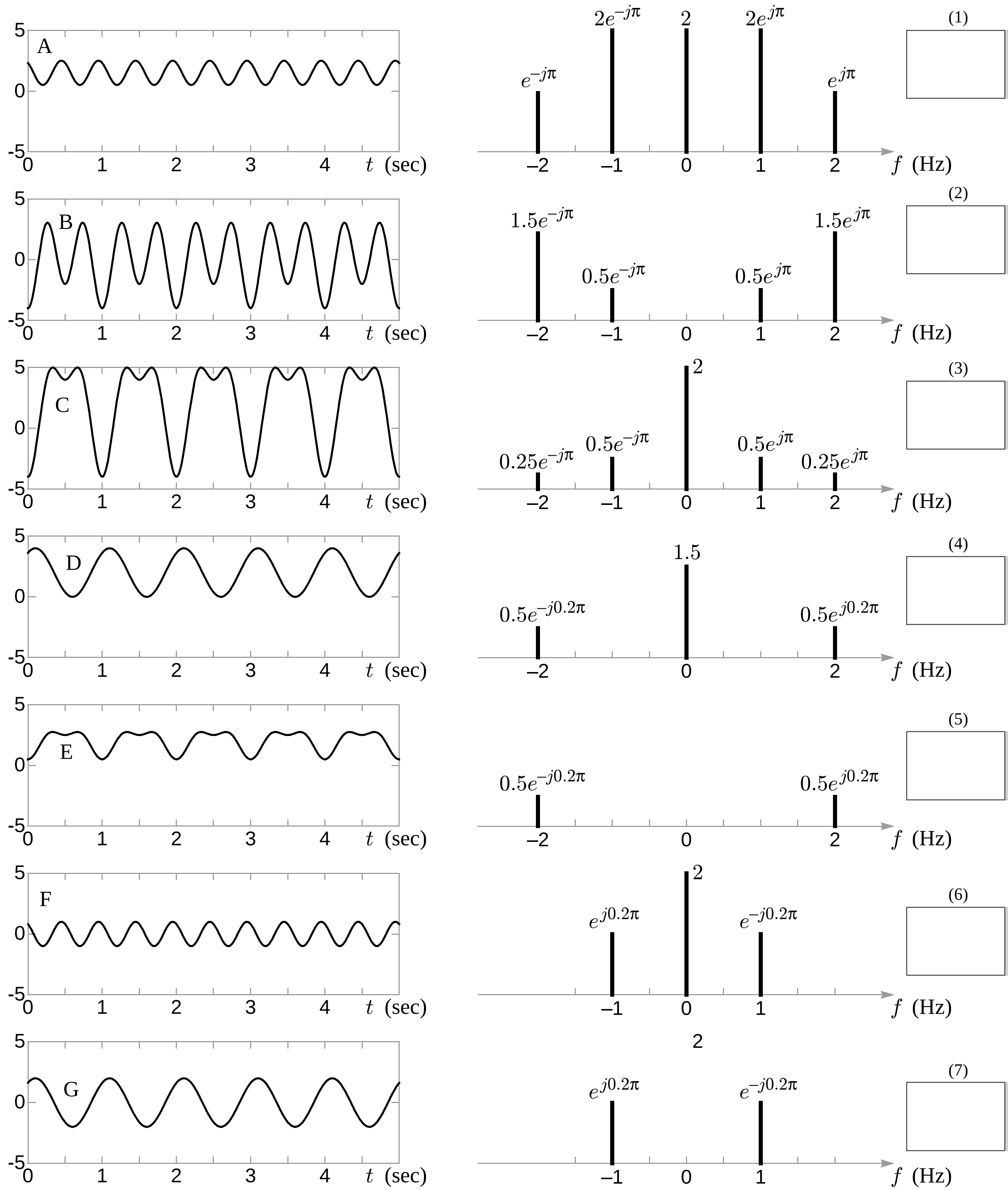
The variable xx represents a sinusoidal signal $x(t) = A\cos(\omega t + \theta)$ in standard form, where:

$\omega =$ ☐ ≥ 0 rad/s

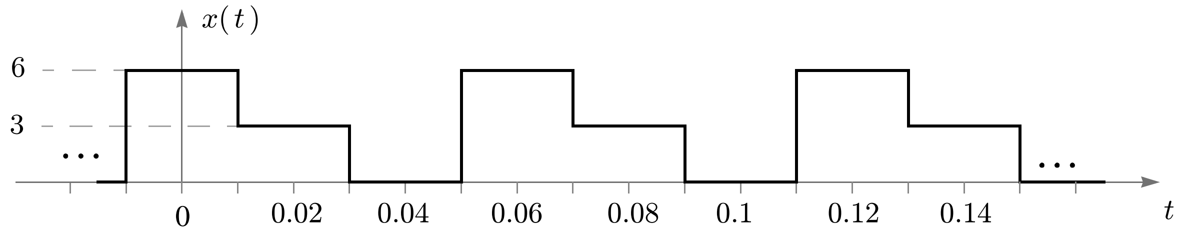
$A =$ ☐ ≥ 0

$\theta =$ ☐ $\in (-\pi, \pi]$.

PROB. Su13-Q1.3. Several signals are plotted below along with their corresponding spectra. However, they are in a scrambled order. For each of the signals below, identify its corresponding spectrum by writing a letter {A, B, ... G} into each answer box:



PROB. Su13-Q1.4. Consider the periodic signal $x(t)$ shown below:



(a) The fundamental period of $x(t)$ is $T_0 = \boxed{}$ seconds.

(b) The fundamental frequency is $f_0 = \boxed{}$ Hz.

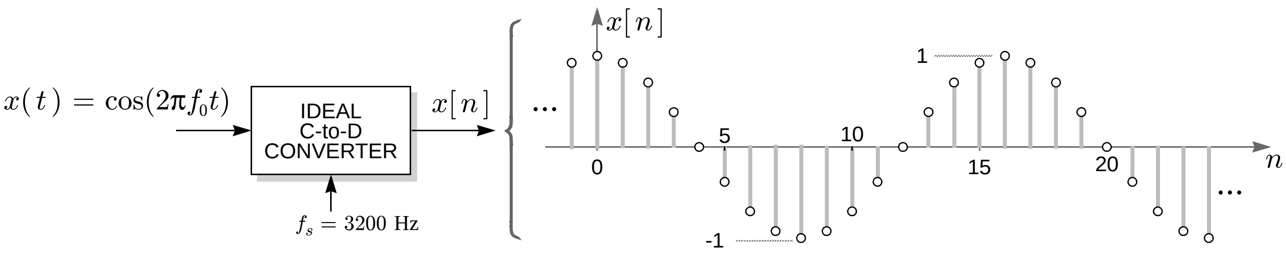
(c) In the Fourier series representation $x(t) = \sum_{k=-\infty}^{\infty} a_k e^{jk2\pi t/T_0}$, the DC component is $a_0 = \boxed{}$.

(d) The spectrum for $x(t)$ will have a line at 90 Hz.

(Check one.) YES ☐ NO ☐ NOT ENOUGH INFORMATION ☐

Explain.

PROB. Su13-Q1.5. Suppose a sinusoidal signal $x(t) = \cos(2\pi f_0 t)$ with frequency f_0 is sampled with a sampling rate of $f_s = 3200$ samples/sec, and suppose that the resulting discrete-time sequence is as sketched below:



There are many possible values for the frequency f_0. Name any two.

$f_0 =$ ☐ Hz , or $f_0 =$ ☐ Hz.

The remainder of this problem concerns the following piece of MATLAB code:

```
fsamp = 8000;
dt = 1/fsamp;
dur = 0.05;
A3 = ________
phi3 = ______
tt = 0 : dt : dur;
x1 =    cos(200*pi*tt          );
x2 =    cos(200*pi*tt + 0.25*pi);
x3 = A3*cos(200*pi*tt + phi3   );
x  = x1 + x2 + x3;
```

(a) The length of the vector `x1` is `length(x1)` = ☐ .

(b) The sum `x = x1 + x2 + x3` represents the sum of three sinusoids.
In order for this sum to *zero*, the variables `A3` and `phi3` need to be:

`A3` = ☐ ≥ 0, `phi3` = ☐ $\in (-\pi, \pi]$.

GEORGIA INSTITUTE OF TECHNOLOGY
SCHOOL OF ELECTRICAL AND COMPUTER ENGINEERING

ECE 2026 — Summer 2013
Quiz #1

June 10, 2013

VERSION A

NAME: ______________ ______________ GT username: ______________
(FIRST) (LAST) (e.g., gtxyz123)

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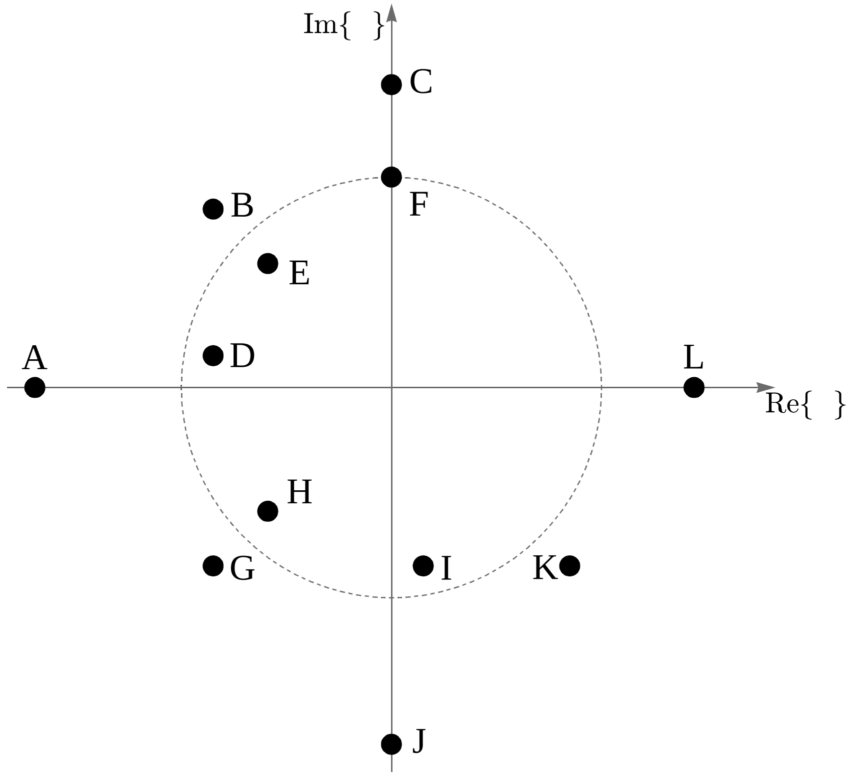
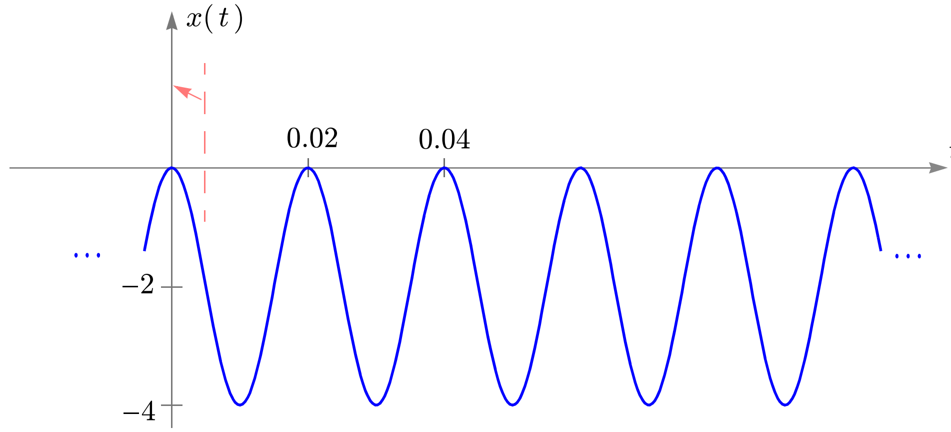
PROB. Su13-Q1.1. **The figure below shows the locations of twelve points in the complex plane, along with the unit circle:**



Match each point above to one of the functions of an unspecified complex number z shown in the table below, by arranging letters $\{$A, B, ... M$\}$ in the second column of the table below:

(1)	z	G
(2)	$1/z$	E
(3)	z^*	B
(4)	$1/z^*$	H
(5)	$z + z^*$	A
(6)	$z - z^*$	J
(7)	zz^*	L
(9)	z/z^*	F
(9)	z^2	C
(10)	jz	K
(11)	$z + j$	D
(12)	$z + 1$	I

PROB. Su13-Q1.2. **The signal $x(t) = B + A\cos(2\pi f_0 t + \theta)$ achieves a peak value of zero at time $t = 0.02$ and again at time $t = 0.04$, as shown below:**



(a) **Specify numeric values for the following parameters:**

$B =$ -2

$A =$ 2

$f_0 =$ 50 **Hz**

$\theta =$ 0 $\in (-\pi, \pi]$.

(b) **Consider the following MATLAB code:**

```
tt = 0:0.001:dur; % dur is the duration in seconds
xx = real((1-j)*exp(j*16*pi*tt)) + real((2-j)*exp(j*16*pi*tt));
```

The variable `xx` represents a sinusoidal signal $x(t) = A\cos(\omega t + \theta)$ in standard form, where:

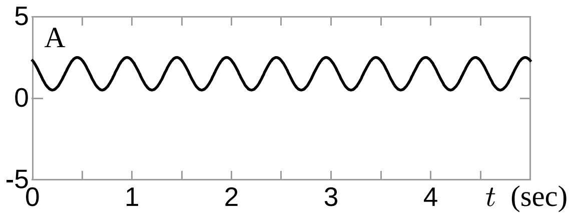
$(1 - j) + (2 - j) = 3 - 2j \approx 3.6e^{-j0.19\pi}$

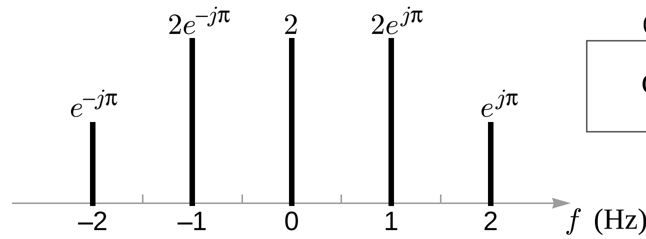
$\omega =$ 16π ≥ 0 **rad/s**

$A =$ $\sqrt{13} \approx 3.6$ ≥ 0

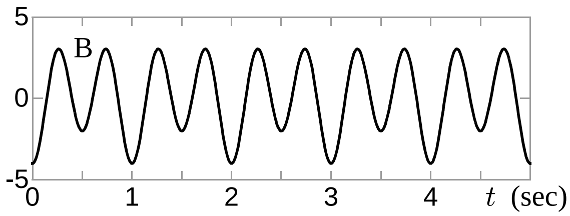
$\theta =$ -0.19π $\in (-\pi, \pi]$.

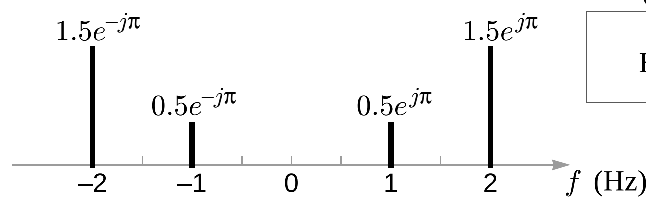
PROB. Su13-Q1.3. **Several signals are plotted below along with their corresponding spectra. However, they are in a scrambled order. For each of the signals below, identify its corresponding spectrum by writing {A, B, ... G} into each answer box:**



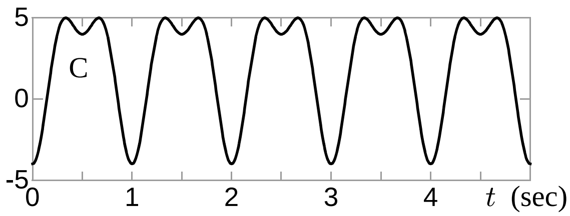


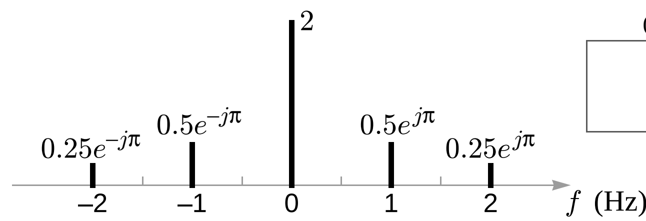
(1) C



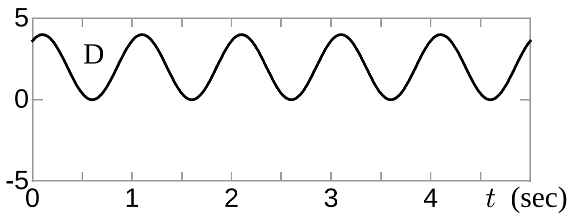


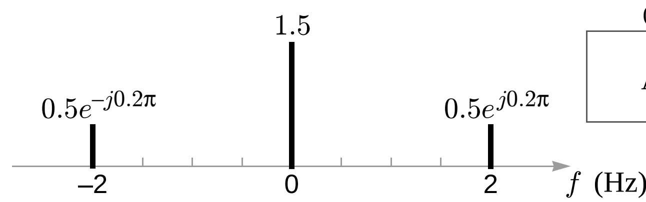
(2) B



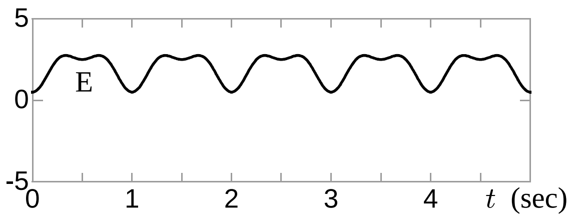


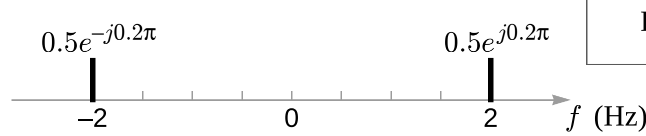
(3) E



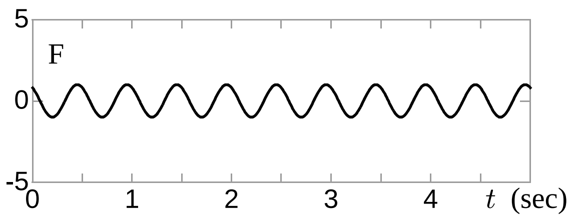


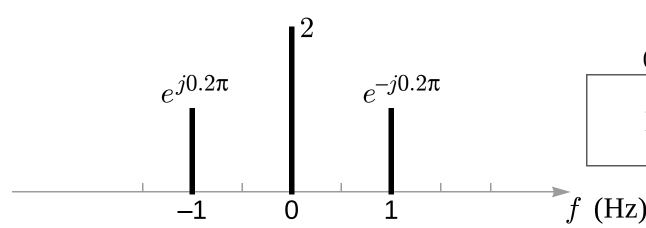
(4) A



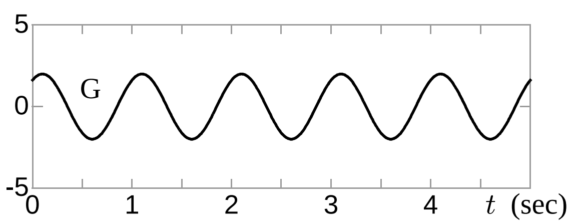


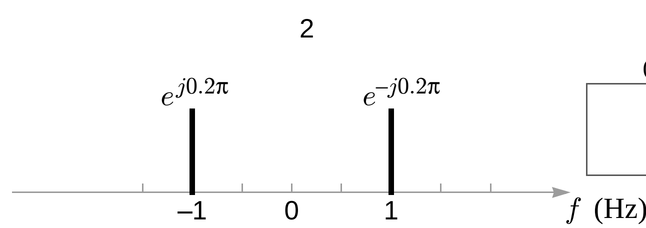
(5) F





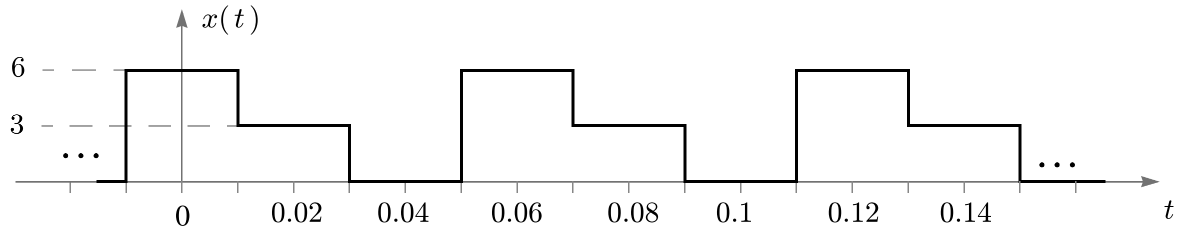
(6) D





(7) G

PROB. Su13-Q1.4. **Consider the periodic signal $x(t)$ shown below:**



(a) **The fundamental period of $x(t)$ is $T_0 =$** $\boxed{0.06}$ **seconds.**

(b) **The fundamental frequency is $f_0 =$** $\boxed{16.67}$ **Hz.**

$$f_0 = 1/T_0$$

(c) **In the Fourier series representation $x(t) = \sum_{k=-\infty}^{\infty} a_k e^{jk2\pi t/T_0}$, the DC component is $a_0 =$** $\boxed{3}$.

By inspection, or by integration: $a_0 = (1/T_0)(\text{area under one period}) = (1/0.06)(0.18) = 3$

(d) **The spectrum for $x(t)$ will have a line at 90 Hz.**

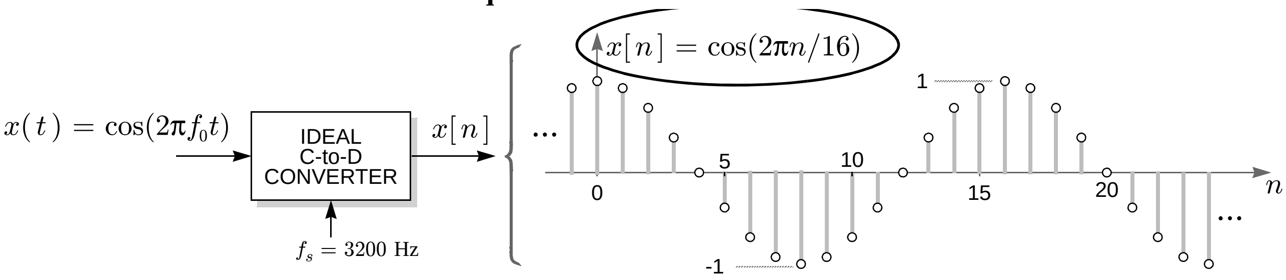
(Check one.)

YES ☐ NO ☒ NOT ENOUGH INFORMATION ☐

Explain.

90 Hz is not an integer multiple of f_0.

PROB. Su13-Q1.5. **Suppose a sinusoidal signal $x(t) = \cos(2\pi f_0 t)$ with frequency f_0 is sampled with a sampling rate of $f_s = 3200$ samples/sec, and suppose that the resulting discrete-time sequence is as sketched below:**



There are many possible values for the frequency f_0. Name any two.

$f_0 = \boxed{200}$ **Hz ,** **or** $f_0 = \boxed{200 + 3200\ell}$ **Hz.** for any integer ℓ

From the stem plot we can write $x[n] = \cos(2\pi n/16)$. Since this is a sinusoid whose digital frequency is less than π, we can convert to continuous time via the substitution $n = tf_s$

$$\Rightarrow x(t) = \cos(2\pi(f_s/16)t) \Rightarrow f_0 = f_s/16 = 200 \text{ Hz}.$$

Other solutions can be found by adding ℓf_s for *any* integer ℓ.

The remainder of this problem concerns the following piece of MATLAB code:

```
fsamp = 8000;
dt = 1/fsamp;
dur = 0.05;
A3 = ________
phi3 = ______
tt = 0 : dt : dur;
x1 =    cos(200*pi*tt           );
x2 =    cos(200*pi*tt + 0.25*pi);
x3 = A3*cos(200*pi*tt + phi3    );
x  = x1 + x2 + x3;
```

(a) **The length of the vector `x1` is `length(x1)` $=$** $\boxed{401}$.

$$\text{length} = \text{dur}/\text{dt} + 1 = (0.05)(8000) + 1 = 401$$

(b) **The sum `x = x1 + x2 + x3` represents the sum of three sinusoids. In order for this sum to *zero*, the variables `A3` and `phi3` need to be:**

`A3` $= \boxed{1.848} \geq 0,$ `phi3` $= \boxed{-0.875\pi} \in (-\pi, \pi].$

$$1 + e^{j0.25\pi} + A_3 e^{j\varphi_3} = 0 \qquad \Rightarrow \quad A_3 e^{j\varphi_3} = -(1 + e^{j0.25\pi}) \approx 1.848 e^{-j0.875\pi}$$