GEORGIA INSTITUTE OF TECHNOLOGY
SCHOOL OF ELECTRICAL AND COMPUTER ENGINEERING

ECE 2026 — Summer 2024
Quiz #1

June 17, 2024

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

Important Notes:

- Do not unstaple the test.
- Closed book, except for one two-sided page (8.5" × 11") of hand-written notes.
- No calculators or other electronics (no smartphones/readers/watches/tablets/laptops/etc.)
- JUSTIFY your reasoning CLEARLY to receive partial credit.
- Express all angles as a fraction of π. For example, write 0.1π as opposed to 18° or 0.3142 radians.
- You must write your answer in the space provided on the exam paper itself.
  Only these answers will be graded. Write your answers in the provided answer boxes.
- Do not write on the backs of pages, only the fronts will be graded.

Problem	Value	Score Earned
1	25	
2	25	
3	25	
4	25	
Total		

PROB. Su24-Q1.1. Let $z_1 = 0.9e^{j2\pi/3}$ and $z_2 = 0.9e^{-j\pi/20}$.
Match each complex number listed below to its location in the complex plane.
Indicate answer by writing a letter (from labeled A through T) into each answer box:

(a) ☐ $z_1 = 0.9e^{j2\pi/3}$

(b) ☐ $z_2 = 0.9e^{-j\pi/20}$

(c) ☐ z_1^3

(d) ☐ z_2^3

(e) ☐ z_1^*

(f) ☐ z_2^*

(g) ☐ $(z_1 + z_1^*)/2$

(h) ☐ $(z_2 + z_2^*)/2$

(i) ☐ $z_1 z_2$

(j) ☐ $z_1 z_2^*$

(k) ☐ $(z_1 - z_1^*)/2$

(l) ☐ $(z_2 - z_2^*)/2$

(m) ☐ jz_1

(n) ☐ jz_2

(o) ☐ $-jz_1$

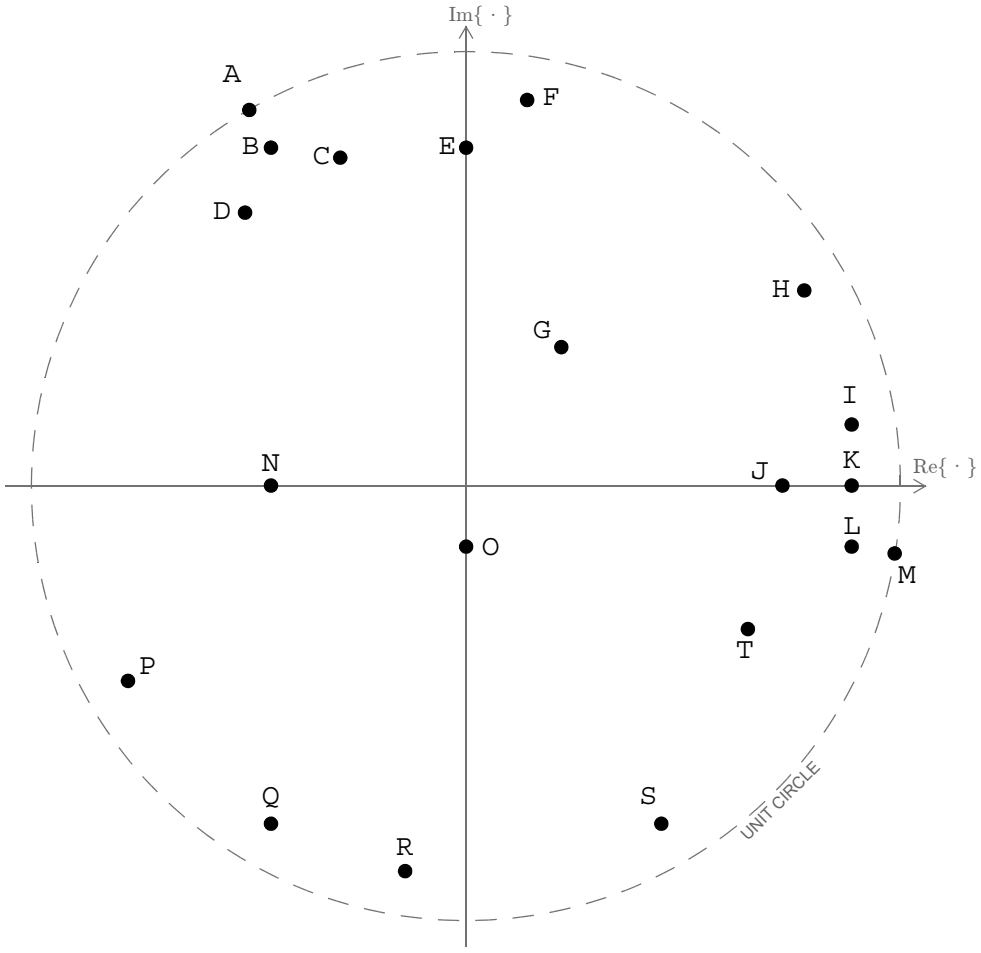
(p) ☐ $-jz_2$

(q) ☐ $j^2 z_1$

(r) ☐ $z_1/|z_1|$

(s) ☐ $z_2/|z_2|$

(t) ☐ $(z_1 + z_2)/2$



PROB. Su24-Q1.2.

If the following equation is valid for all time t:

$$4\cos(230\pi t + 0.2\pi) + B\cos(240\pi t)\cos(2\pi F t + \theta) = A\cos(2\pi f_0 t + \varphi),$$

and if the unspecified parameters are all positive, then it must be that:

$B =$ [ ] > 0, $F =$ [ ] Hz > 0, $\theta =$ [ ] $\in (-\pi, \pi]$,

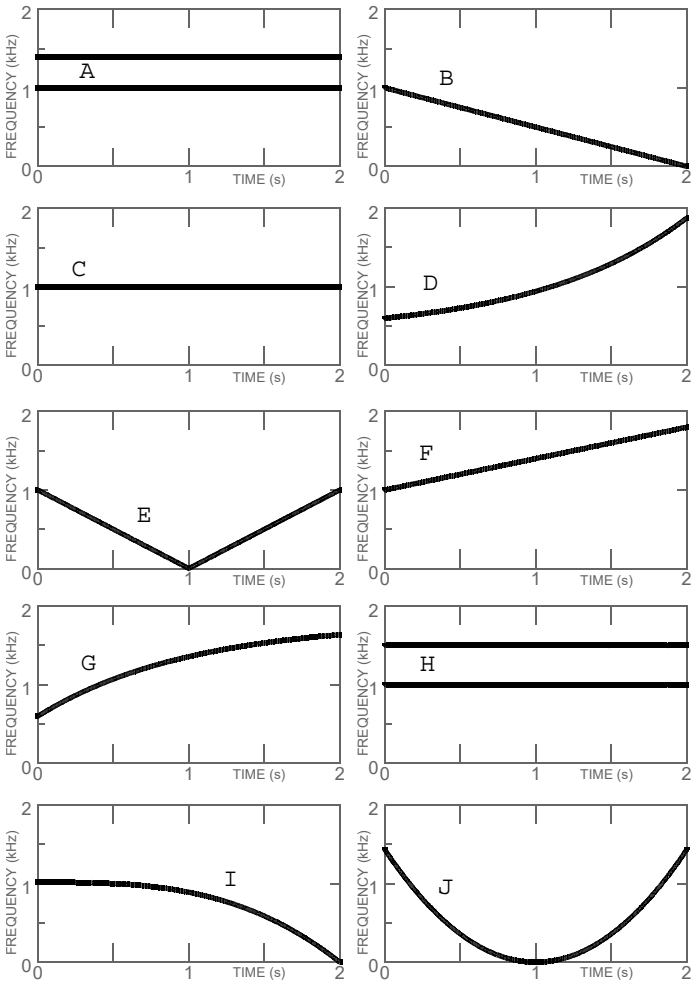
$A =$ [ ] > 0, $f_0 =$ [ ] Hz > 0, and $\varphi =$ [ ] $\in (-\pi, \pi]$.

PROB. Su24-Q1.3.

Shown on the right are ten spectrogram plots, labeled A through J.

Match each spectrogram plot to the corresponding signal listed at the bottom of the page.

Indicate answers by writing a letter (from A to J) into each answer box.



$x_1(t) = \cos(2000\pi t) + \cos(3000\pi t)$

$x_2(t) = 16\cos(400\pi t)\cos(2400\pi t)$

$x_3(t) = \sin(2\pi(1000t + 200t^2))$

$x_4(t) = \sin(1000\pi(t-1)^2)$

$x_5(t) = \cos(500\pi(t-2)^2)$

$x_6(t) = \cos(2\pi(-400t - 200e^t))$

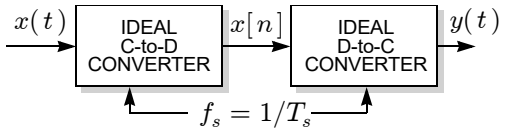
$x_7(t) = \cos(2\pi(1800t + 1200e^{-t}))$

$x_8(t) = 3000\cos(3000(t-1)^3)$

$x_9(t) = \pi^2\cos(200t(32 - t^3))$

$x_{10}(t) = \sin(2000\pi t) + \cos(2000\pi t + 0.3\pi)$

PROB. Su24-Q1.4. Consider the sampling/reconstruction system with input $x(t)$ and $y(t)$ shown here, and assume that the spectrum of the input signal $x(t)$ is as shown below:



(a) The input $x(t)$ is periodic with fundamental frequency $f_0 =$ ☐ Hz.

(b) To ensure that $y(t) = x(t)$, the sampling rate must satisfy $f_s >$ ☐ samples/second.

(c) When $f_s = 330$ Hz, the output $y(t)$ is periodic with fundamental frequency $f_0 =$ ☐ Hz.

(d) When $f_s = 71$ Hz, the output $y(t)$ is periodic with fundamental frequency $f_0 =$ ☐ Hz.

(e) Find f_s so that the output can be written as $y(t) = A\cos(240\pi t + \varphi)$, and specify resulting A and φ:

$f_s =$ ☐ samples/s > 0, $A =$ ☐ > 0, $\varphi =$ ☐ $\in(-\pi, \pi]$.

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GEORGIA INSTITUTE OF TECHNOLOGY
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ECE 2026 — Summer 2024
Quiz #1

June 17, 2024

VERSION A

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

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Problem	Value	Score Earned
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Total		

PROB. Su24-Q1.1. Let $z_1 = 0.9e^{j2\pi/3}$ and $z_2 = 0.9e^{-j\pi/20}$.
Match each complex number listed below to its location in the complex plane.
Indicate answer by writing a letter (from labeled A through T) into each answer box:

(a) B $z_1 = 0.9e^{j2\pi/3}$

(b) L $z_2 = 0.9e^{-j\pi/20}$

(c) J z_1^3

(d) T z_2^3

(e) Q z_1^*

(f) I z_2^*

(g) N $(z_1 + z_1^*)/2$

(h) K $(z_2 + z_2^*)/2$

(i) C $z_1 z_2$

(j) D $z_1 z_2^*$

(k) E $(z_1 - z_1^*)/2$

(l) O $(z_2 - z_2^*)/2$

(m) P jz_1

(n) F jz_2

(o) H $-jz_1$

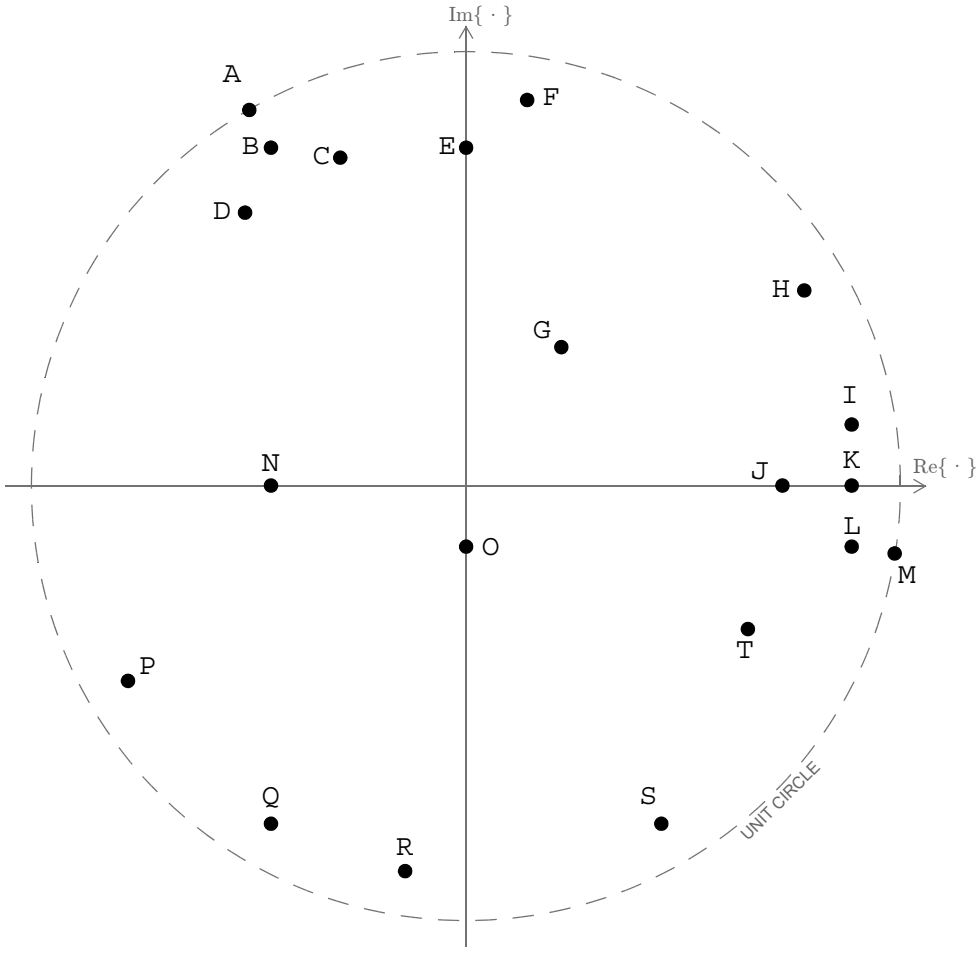
(p) R $-jz_2$

(q) S $j^2 z_1$

(r) A $z_1/|z_1|$

(s) M $z_2/|z_2|$

(t) G $(z_1 + z_2)/2$



PROB. Su24-Q1.2.

If the following equation is valid for all time t:

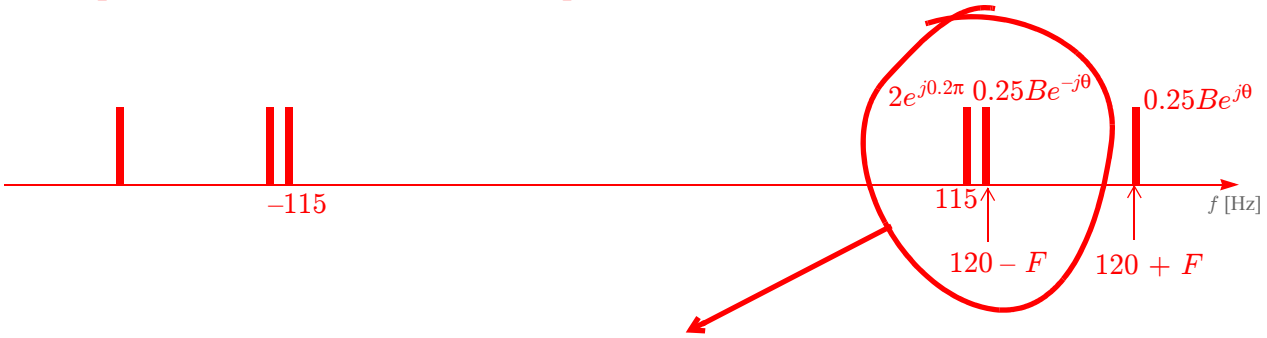
$$4\cos(230\pi t + 0.2\pi) + B\cos(240\pi t)\cos(2\pi F t + \theta) = A\cos(2\pi f_0 t + \varphi),$$

and if the unspecified parameters are all positive, then it must be that:

$B =$ 8 > 0, $F =$ 5 Hz > 0, $\theta =$ 0.8π $\in(-\pi, \pi]$,

$A =$ 4 > 0, $f_0 =$ 125 Hz > 0, and $\varphi =$ 0.8π $\in(-\pi, \pi]$.

Spectrum for left-hand side of equation looks like this:



$\Rightarrow$ *Cancellation* when $F = 5$ Hz and $B = 8$ and $\theta = 0.8\pi$, yielding only a sinusoid at $f_0 = 125$ Hz:

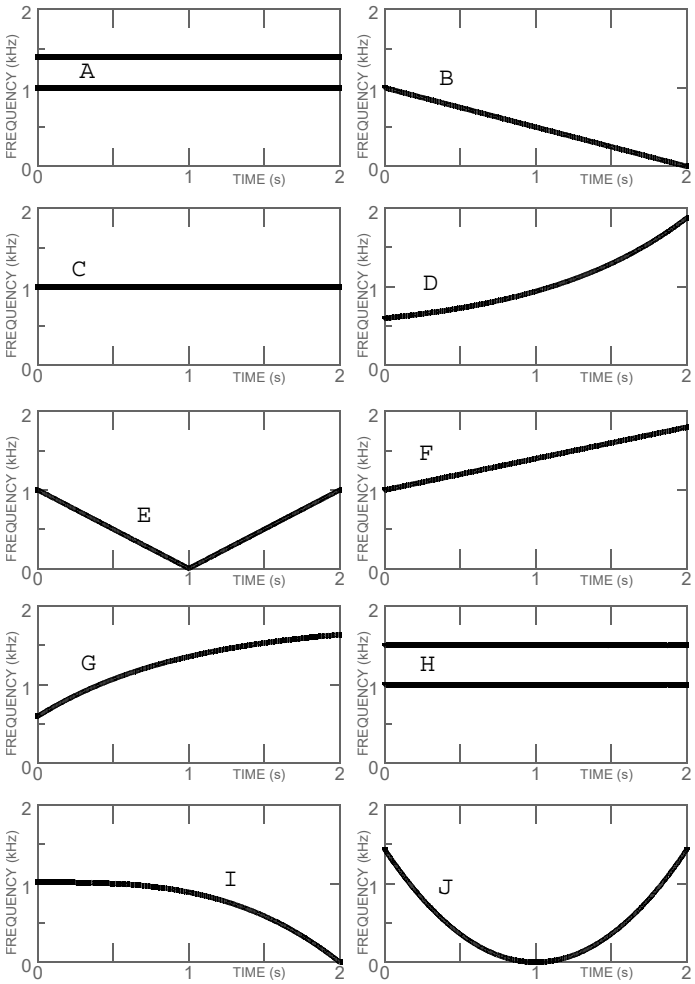
$\Rightarrow A = 0.5B = 4$ and $\varphi = \theta = 0.8\pi$

PROB. Su24-Q1.3.

Shown on the right are ten spectrogram plots, labeled A through J.

Match each spectrogram plot to the corresponding signal listed at the bottom of the page.

Indicate answers by writing a letter (from A to J) into each answer box.



H $x_1(t) = \cos(2000\pi t) + \cos(3000\pi t)$

A $x_2(t) = 16\cos(400\pi t)\cos(2400\pi t)$

F $x_3(t) = \sin(2\pi(1000t + 200t^2))$

E $x_4(t) = \sin(1000\pi(t-1)^2)$

B $x_5(t) = \cos(500\pi(t-2)^2)$

D $x_6(t) = \cos(2\pi(-400t - 200e^t))$

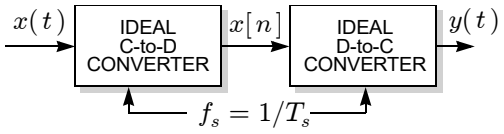
G $x_7(t) = \cos(2\pi(1800t + 1200e^{-t}))$

J $x_8(t) = 3000\cos(3000(t-1)^3)$

I $x_9(t) = \pi^2\cos(200t(32 - t^3))$

C $x_{10}(t) = \sin(2000\pi t) + \cos(2000\pi t + 0.3\pi)$

PROB. Su24-Q1.4. Consider the sampling/reconstruction system with input $x(t)$ and $y(t)$ shown here, and assume that the spectrum of the input signal $x(t)$ is as shown below:



(a) The input $x(t)$ is periodic with fundamental frequency $f_0 =$ [60] Hz.

$$f_0 = \gcd(120,\ 180)$$

(b) To ensure that $y(t) = x(t)$, the sampling rate must satisfy $f_s >$ [360] samples/second.

(c) When $f_s = 330$ Hz, the output $y(t)$ is periodic with fundamental frequency $f_0 =$ [30] Hz.

$$f_0 = \gcd(120,\ 180 - 30)$$

(d) When $f_s = 71$ Hz, the output $y(t)$ is periodic with fundamental frequency $f_0 =$ [11] Hz.

$$\begin{aligned} f_0 &= \gcd(|120 - \ell_1 71|,\ |180 - \ell_2 71|) \\ &= \gcd(|120 - (2)71|,\ |180 - (3)71|) \\ &= \gcd(22,\ 33) \end{aligned}$$

(e) Find f_s so that the output can be written as $y(t) = A\cos(240\pi t + \varphi)$, and specify resulting A and φ:

There are two solutions, either is acceptable:

$f_s =$ [300 samples/s] > 0, $A =$ [$2\sqrt{2}$] > 0, $\varphi =$ [-0.25π] $\in(-\pi, \pi]$.

$f_s =$ [360 samples/s] > 0, $A =$ [2] > 0, $\varphi =$ [0] $\in(-\pi, \pi]$.