Feedback — Problem Set I

You submitted this homework on **Tue 26 Mar 2013 3:38 PM CDT -0500**. You got a score of **0.00** out of **16.00**. However, you will not get credit for it, since it was submitted past the deadline.

A pdf version of this problem set is available for you to print.
Note: all mathematical expressions have to be exact, even when involving constants. Such an expression is required when a function and/or a variable is required in the answer. For example, if the answer is $\sqrt{3}x$, you must type `sqrt(3)*x`, not `1.732*x` for the answer to be graded as correct.

Question 1

What is the period of the sinusoid $s(t) = A\sin(2\pi f_0 t)$? In your answer, write A as `A` and f_0 as `f0`.

You entered:

Preview Help

Your Answer		Score	Explanation
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Question Explanation

The period of a sinusoid is the reciprocal of its frequency, so the answer is `1/f0`.

Question 2

The **rms**(root-mean-square) value of a periodic signal $s(t)$ is defined to be

$$\text{rms}[s] = \sqrt{\frac{1}{T}\int_0^T s^2(t)dt}$$

where T is defined to be the signal's **period**: the smallest positive number such that $s(t) = s(t+T)$.

What is the rms value of the sinusoid $s(t) = A\sin(2\pi f_0 t)$? (Again, write A as `A` and f_0 as `f0`.)

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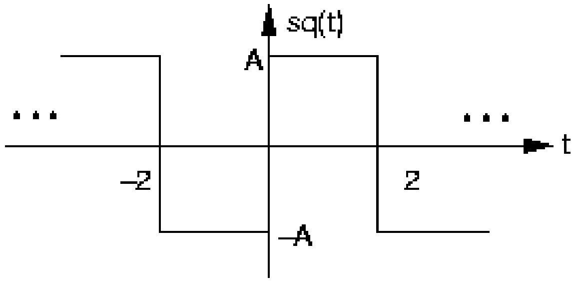
Question Explanation

A/sqrt(2).
Use the identity $\sin^2(\theta) = \frac{1}{2}\left(1-\cos(2\theta)\right)$. Integrating over a period leaves only the constant term.

Question 3

Consider the square wave, depicted below:



What is the rms value of a unit-amplitude square wave ($A = 1$)?

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Question Explanation

Since the squared-value of a square wave of amplitude A is constant equal to A^2, we arrive at an rms value equal to A.

Question 4

The word "modem" is short for "modulator-demodulator." Modems are used not only for connecting computers to telephone lines, but also for connecting digital (discrete-valued) sources to generic channels. In this problem, we explore a simple kind of modem, in which binary information is represented by the presence or absence of a sinusoid (presence representing a "1" and absence a "0"). Consequently, the modem's transmitted signal that represents a single bit has the form

$$x(t) = A\sin\left(2\pi f_0 t\right),\ 0 \leq t \leq T$$

Within each bit interval of duration T, the amplitude is either A or zero.

What is the smallest transmission interval that makes sense for the frequency f_0?

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Question Explanation

We want the transmission interval to correspond to an *integer* number of cycles (periods). The smallest transmission interval is therefore $1/f_0$.

Question 5

Assuming that ten cycles (periods) of the sinusoid comprise a single bit's transmission interval, what is the datarate in bits/s of this transmission scheme?

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Your Answer	Score	Explanation
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Question Explanation

It takes ten cycles (periods) for each bit: $\frac{10}{f_0}$. The rate at which bits are sent equals the reciprocal of the interval, making the answer $\frac{f_0}{10}$.

Question 6

Now suppose instead of using "on-off" signaling as just described, we allow one of several **different** values for the amplitude during any transmission interval. How many amplitude values are needed to send a b-bit sequence each transmission interval?

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Your Answer	Score	Explanation
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Question Explanation

On-off signaling uses two amplitude values, each of which corresponds to the value of a single bit. If you had $n = 4$ values, you could represent *two* bits: 00, 01, 10, 11. In general, b bits requires 2^b levels.

Question 7

While it may not seem to be more than a mathematical "strength" exercise, we must be able to find the real and imaginary parts and the magnitude and phase of any complex number, no matter its form. Turns out having this knowledge is essential to understanding how electrical engineering systems work!

Find the real part, imaginary part, magnitude, and angle (in radians) of the complex number: -1. (Separate your answers *in that order* with spaces, and type any irrational numbers as decimals rounded to the nearest hundredth, including multiples of π. If the phase is undefined, leave it blank.)

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Your Answer		Score	Explanation
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Question Explanation

-1 is real, so it's real part is -1 and its imaginary part is 0. the magnitude is 1 and its angle is π or $-\pi$. Consequently, $-1 = e^{j\pi}$.

Question 8

Find the real part, imaginary part, magnitude, and angle of the complex number $\frac{1+j\sqrt{3}}{2}$. (Separate your answers *in that order* with spaces, and type all the answers as numerics: write all the irrational numbers as decimals rounded to the nearest hundredth, including multiples of π. If the phase is undefined, leave it blank.)

Note: for questions with multiple answers separated by spaces, the grader only accepts numeric answers, you will not be able to get full score using mathematical expressions. For example, `1/5` is an mathematical expression, and you should enter it as 0.2 in this question.

You entered:

Your Answer		Score	Explanation
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Question Explanation

Since this number is written in Cartesian form, the real and imaginary parts are obvious: $\frac{1}{2}$ and $\frac{\sqrt{3}}{2}$. The magnitude equals $\sqrt{\left(\frac{1}{2}\right)^2+\left(\frac{\sqrt{3}}{2}\right)^2}=\sqrt{\frac{1}{4}+\frac{3}{4}}=1$. The angle is $\tan^{-1}\left(\frac{\frac{\sqrt{3}}{2}}{\frac{1}{2}}\right)=\tan^{-1}\sqrt{3}=\frac{\pi}{3}$.

Question 9

Find the real part, imaginary part, magnitude, and angle of the complex number $1+j+e^{j\frac{\pi}{2}}$. (Separate your answers *in that order* with spaces, and type any irrational numbers as decimals rounded to the nearest hundredth, including multiples of π. If the phase is undefined, leave it blank.)

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Your Answer		Score	Explanation
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Question Explanation

Since $e^{j\frac{\pi}{2}}=j$, the number can be simplified to $1+2j$. Consequently, the real part is 1 and the imaginary part is 2. The magnitude is $\sqrt{1^2+2^2}=\sqrt{5}$ and the angle is $\tan^{-1} 2=1.107$.

Question 10

Find the real part, imaginary part, magnitude, and angle of the complex number $e^{j\frac{\pi}{3}} + e^{j\pi} + e^{-j\frac{\pi}{3}}$. (Separate your answers *in that order* with spaces, and type any irrational numbers as decimals rounded to the nearest hundredth, including multiples of π. If the phase is undefined, leave it blank.)

You entered:

Your Answer	Score	Explanation
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Question Explanation

$e^{j\frac{\pi}{3}}$, in Cartesian form, is $\cos\frac{\pi}{3} + j\sin\frac{\pi}{3} = \frac{1}{2} + j\frac{\sqrt{3}}{2}$. Furthermore, $e^{j\frac{\pi}{3}} + e^{-j\frac{\pi}{3}} = 2\text{Re}\left[\frac{1}{2} + j\frac{\sqrt{3}}{2}\right] = 1$. Since $e^{j\pi} = -1$, the sum is zero! So, real and imaginary parts are both zero, the magnitude is zero, and the phase is undefined.

Question 11

Complex numbers and phasors play a very important role in electrical engineering. Solving systems for complex exponentials is much easier than for sinusoids, and linear systems analysis is particularly easy.

In the following questions, write π as `pi` and j as `j`.

Find the phasor representation for $x(t) = 3\sin(24t)$. That is, find a complex exponential such that $x(t)$ is the *real* part of that complex exponential.

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Your Answer	Score	Explanation

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Question Explanation

By Euler's formula, $e^{j\theta} = \cos\theta + j\sin\theta$. Therefore, $je^{j\theta} = j\cos\theta - \sin\theta$. Consequently, we can write $3\sin(24t) = \text{Re}\left[-3je^{j24t}\right]$ and as $\text{Re}\left[3e^{j\left(24t-\frac{\pi}{2}\right)}\right]$; both are correct.

Question 12

Find the phasor representation for $x(t) = \sqrt{2}\cos(2\pi 60t + \pi/4)$. That is, find a complex exponential such that $x(t)$ is the *real* part of that complex exponential.

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Preview Help

Your Answer	Score	Explanation
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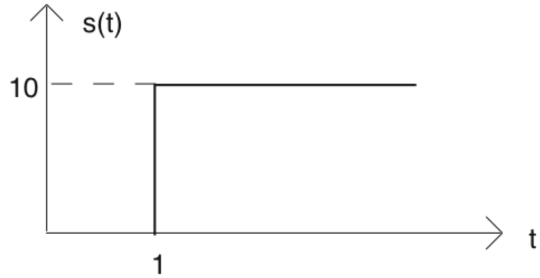
Question Explanation

Because of Euler's formula, we know that $\text{Re}\left[\sqrt{2}e^{j(2\pi 60t+\pi/4)}\right] = \sqrt{2}\cos(2\pi 60t + \pi/4)$.

Question 13

The *structure* of a signal can often be discovered by expressing it in as a superposition (a linear weighted combination) of simpler signals. Let's discern the following signals' underlying structure.

Express the following signal as a linear combination of delayed and weighted step functions and ramps (the integral of a step).



For grading purposes, use the 'sign' function to represent the step function, and 'abs' for the ramp, even though these functions are NOT equal to each other!

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Your Answer		Score	Explanation
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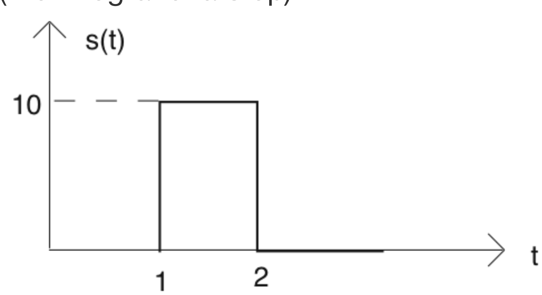
Question Explanation

$10\mathrm{u}(t-1)$, a delay unit-step having an amplitude of one.

Question 14

Express the following signal as a linear combination of delayed and weighted step functions and ramps (the integral of a step).



For grading purposes, use the 'sign' function to represent the step function, and 'abs' for the ramp, but note that these functions are NOT equal to each other!

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Your Answer	Score	Explanation
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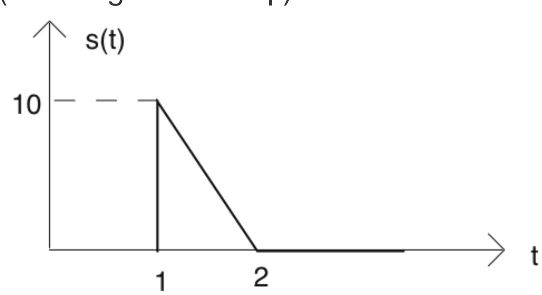
Question Explanation

Now we have a superposition of delayed and scaled unit step signals.
$s(t) = 10\mathrm{u}(t-1) - 10\mathrm{u}(t-2)$. At every moment the signal has a discontinuity, a unit-step of some amplitude occurs at that time.

Question 15

Express the following signal as a linear combination of delayed and weighted step functions and ramps (the integral of a step).



For grading purposes, use the 'sign' function to represent the step function, and 'abs' for the ramp, but note that these functions are NOT equal to each other!

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Your Answer	Score	Explanation
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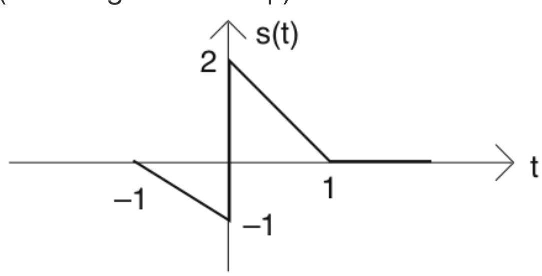
Question Explanation

When a ramp occurs, there is a change of slope. Visual inspection shows one discontinuity (at $t = 1$) and two slope changes (at $t = 1$ and $t = 2$). Therefore, $s(t) = 10\mathrm{u}(t-1) - 10\mathrm{r}(t-1) + 10\mathrm{r}(t-2)$, with $\mathrm{r}(t)$ representing the ramp function.

Question 16

Express the following signal as a linear combination of delayed and weighted step functions and ramps (the integral of a step).



For grading purposes, use the 'sign' function to represent the step function, and 'abs' for the ramp, but note that these functions are NOT equal to each other!

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Preview Help

Your Answer	Score	Explanation
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Question Explanation

Slope changes at $t = -1$, $t = 0$ and $t = 1$. One discontinuity at $t = 0$. So, we have $s(t) = -\mathrm{r}(t+1) + 3\mathrm{u}(t) - \mathrm{r}(t) + 2\mathrm{r}(t-1)$.