Problem Set I

The **due date** for this homework is **Mon 28 Jan 2013 11:59 PM CST**.

Note: all mathematical expressions have to be exact, even when involving constants. For example, if the answer is $\sqrt{3}x$, you must type `sqrt(3)*x`, not `1.732*x`.

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`.

Preview

Question 2

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

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

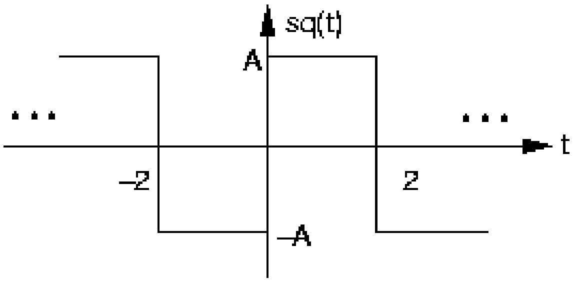
where T is defined to be the signal's **period**: the smallest positive number such that $s(t) = s(t+T)$.

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`.)

Preview

Question 3

Consider the square wave, depicted below:



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

Preview

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

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

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?

Preview

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?

Preview

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?

Preview

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.)

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.

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.)

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.)

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.

Preview

Question 12

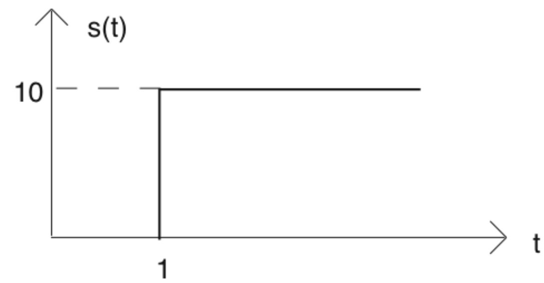
Find the phasor representation for $x(t) = \sqrt{2}\cos(2\pi 60t + \pi/4)$. That is, find a complex exponential such that $x(t)$ is the *real* part of that complex exponential.

Preview

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).

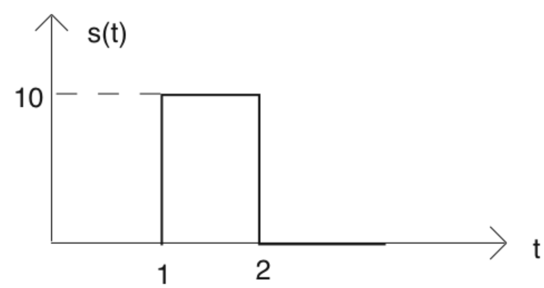


For grading purposes, use the 'sign' function to represent the step function, and 'abs' for the ramp, even though these functions are NOT equal to each other!

Preview

Question 14

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

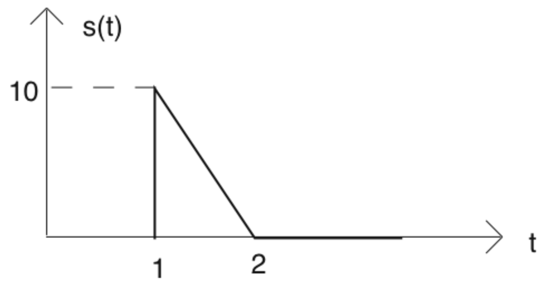


For grading purposes, use the 'sign' function to represent the step function, and 'abs' for the ramp, but note that these functions are NOT equal to each other!

Preview

Question 15

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

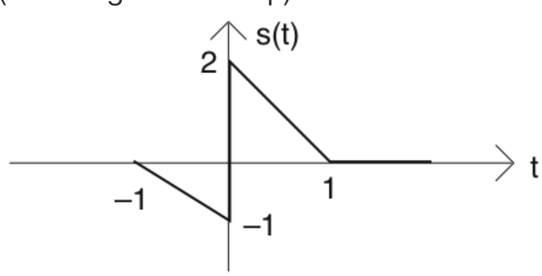


For grading purposes, use the 'sign' function to represent the step function, and 'abs' for the ramp, but note that these functions are NOT equal to each other!

Preview

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!

Preview

In accordance with the Honor Code, I certify that my answers here are my own work.

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