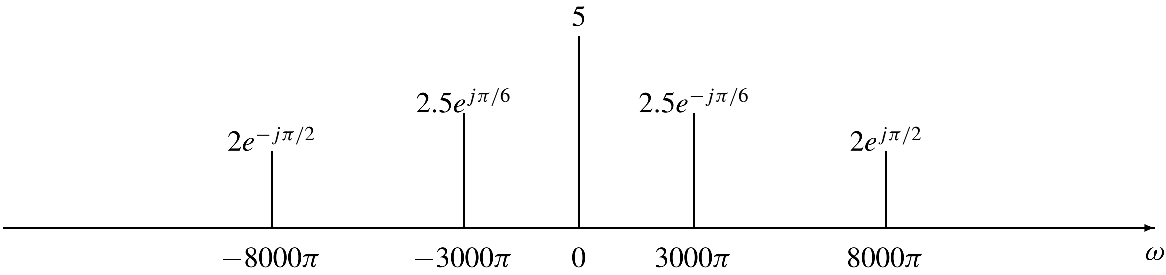
PROBLEM:

A real signal $x(t)$ has the following two-sided spectrum:



(a) Write an equation for $x(t)$ as a sum of cosines.

(b) Plot the spectrum of the signal $y(t) = 2x(t) - 3\cos(5000\pi(t - 0.002))$.

PROBLEM:

In AM radio, the transmitted signal (voice or music) is modulated by a sinusoid at the assigned broadcast frequency of the AM station. For example, WSB in Atlanta has a *carrier frequency* of 750 kHz. For example, if $x(t)$ is the voice/music signal, then the transmitted signal would be:

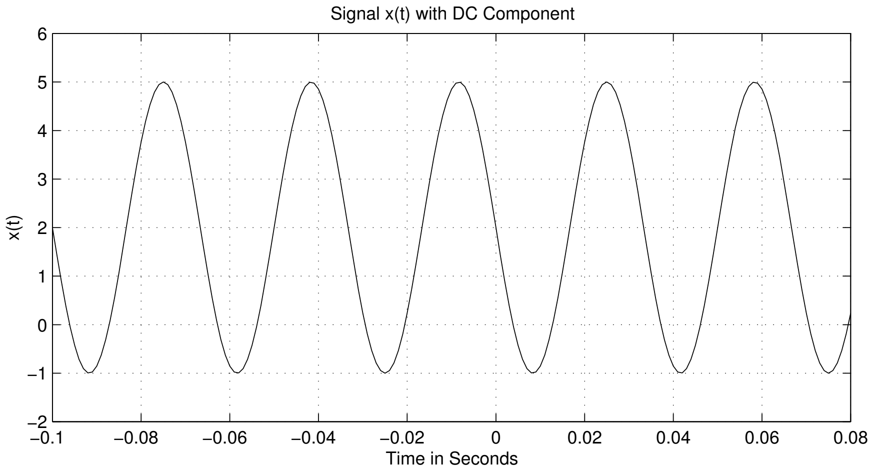
$$y(t) = \left[x(t) + A\right]\cos(2\pi(750 \times 10^3)t)$$

where A is a constant. (A is introduced to make the AM receiver design easier, in which case A must be chosen to be larger than the maximum value of $v(t)$.) Suppose that the signal that is to be transmitted is

$$x(t) = 3\cos(2000\pi t + \pi/4) + \cos(4000\pi t + \pi/2)$$

Draw the spectrum for $y(t)$ assuming a carrier at 750 kHz with $A = 2$. *Hint: Substitute for $x(t)$ and expand $y(t)$ into a sum of cosine terms of three different frequencies.*

PROBLEM:



The above signal $x(t)$ consists of a DC component plus a cosine signal. The terminology *DC component* means a component that is constant versus time.

(a) What is the frequency of the DC component? What is the frequency of the cosine component?

(b) Write an equation for the signal $x(t)$. You should be able to determine numerical values for all the amplitudes, frequencies, and phases in your equation by inspection of the above graph.

(c) Expand the equation obtained in the previous part into a sum of positive and negative frequency complex exponential signals.

(d) Plot the two-sided spectrum of the signal $x(t)$. Show the complex amplitudes for each positive and negative frequency contained in $x(t)$.

PROBLEM:

A linear-FM "chirp" signal is one that sweeps in frequency from $\omega_1 = 2\pi f_1$ to $\omega_2 = 2\pi f_2$ as time goes from $t = 0$ to $t = T_2$. We can define the *instantaneous frequency* of the chirp as the derivative of the phase of the sinusoid:

$$x(t) = A\cos(\alpha t^2 + \beta t + \phi) \tag{1}$$

where the cosine function operates on a time-varying argument

$$\psi(t) = \alpha t^2 + \beta t + \phi$$

The derivative of the argument $\psi(t)$ is the *instantaneous frequency* which is also the audible frequency heard from the chirp *if the chirping frequency does not change too rapidly.*

$$\omega_i(t) = \frac{d}{dt}\psi(t) \qquad \text{radians/sec} \tag{2}$$

There are examples on the CD-ROM in the Chapter 3 demos.

(a) For the linear-FM "chirp" in (1), determine formulas for the beginning instantaneous frequency (ω_1) and the ending instantaneous frequency (ω_2) in terms of α, β and T_2. For this problem, assume that the starting time of the "chirp" is $t = 0$.

(b) For the "chirp" signal

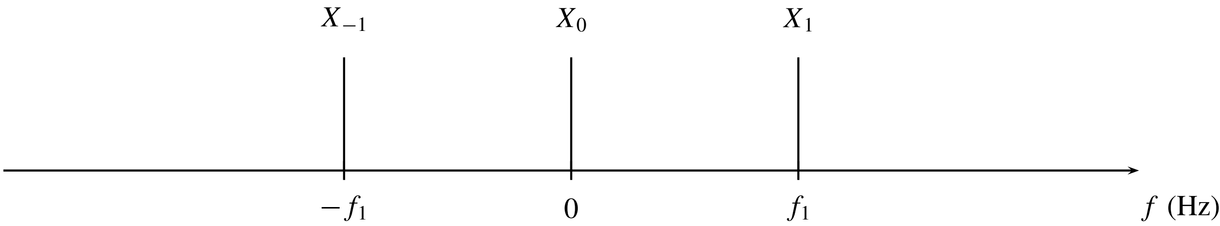
$$x(t) = \Re e\left\{e^{j2\pi(30t^2 - 30t)}\right\}$$

derive a formula for the *instantaneous* frequency versus time. Should your answer for the frequency be a positive number?

PROBLEM:

In each of the following parts, two different representations for a signal are given. Find the values of the parameters in the second representation so that the two representations are equivalent.

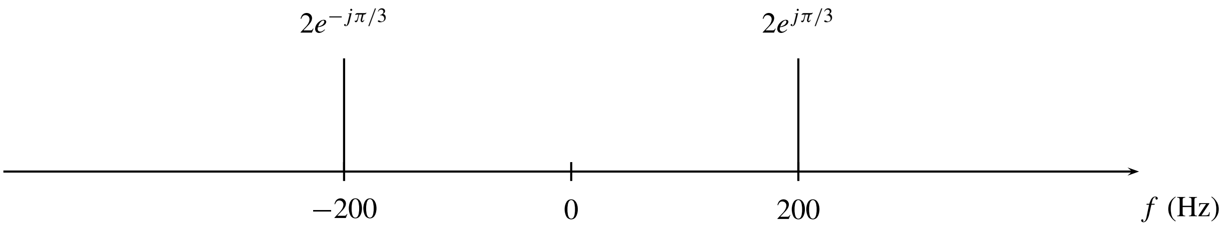
(a) A signal $x(t)$ is given by $x(t) = 3\cos(250\pi t - \pi/6)$, and its spectrum has the form



Determine the values for f_1, X_0, X_1, and X_{-1}. Note that the frequencies f are given in Hertz.

$f_1 =$ | $X_0 =$ | $X_1 =$ | $X_{-1} =$

(b) The spectrum of a signal $x(t)$ has the form



Therefore, the signal has the form

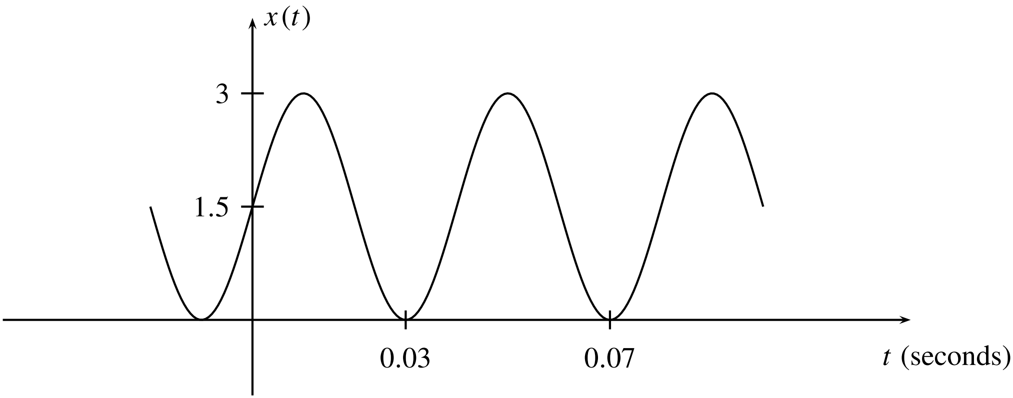
$$x(t) = A\cos(2\pi f_0(t - t_0))$$

Determine the values for A, f_0, and t_0,

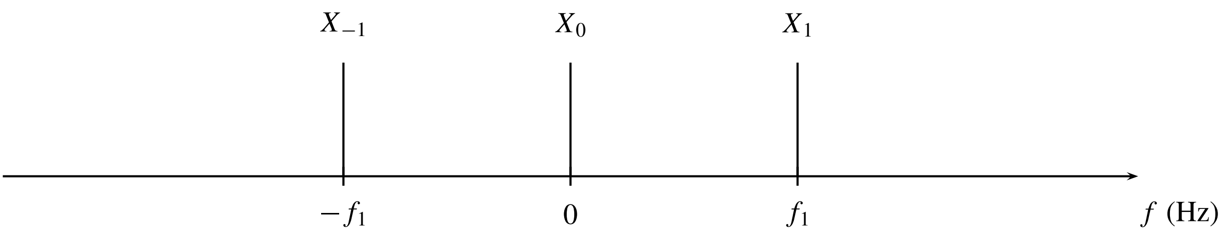
$A =$ | $f_0 =$ | $t_0 =$

PROBLEM:

A signal $x(t) = A\cos(2\pi f_1 t + \phi)$ is shown in the figure below,



The spectrum of $x(t)$ has the form

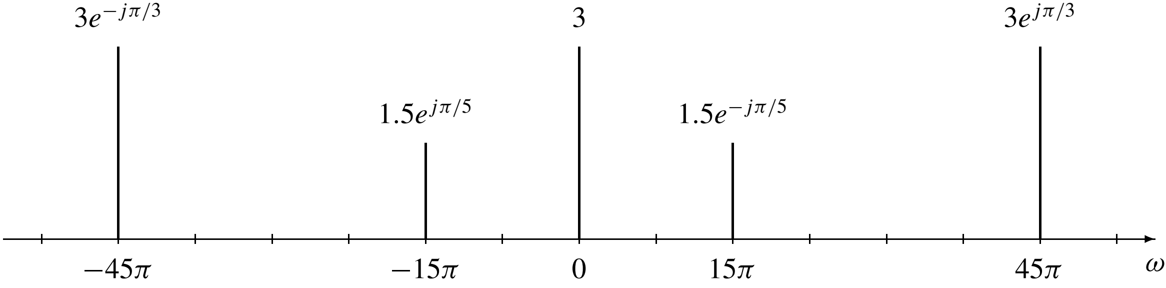


Determine the values for f_1, X_0, X_1, and X_{-1}. Note that the frequencies f are given in Hertz.

$f_1 =$	$X_0 =$	$X_1 =$	$X_{-1} =$

PROBLEM:

The spectrum of a signal $x(t)$ is shown in the following figure:



Note that the frequency axis is radian frequency (ω) *not* cyclic frequency (f).

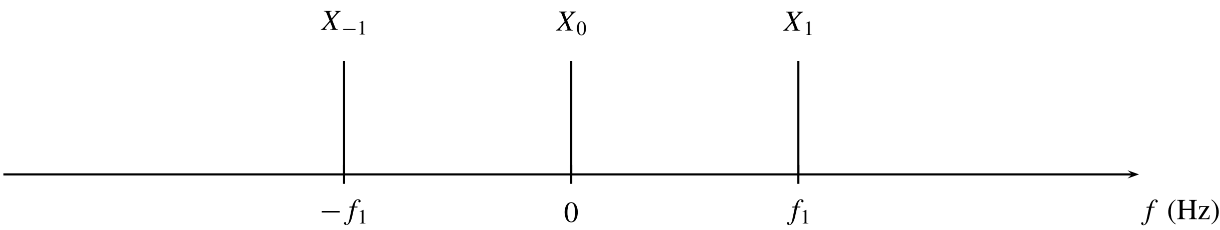
(a) Write an equation for $x(t)$ in terms of cosine functions.

(b) This signal is periodic. What is the fundamental frequency and the corresponding period of $x(t)$?

PROBLEM:

In each of the following parts, two different representations for a signal are given. Find the values of the parameters in the second representation so that the two representations are equivalent.

(a) A signal $x(t)$ is given by $x(t) = 2\cos(200\pi t + \pi/8)$, and its spectrum has the form



Determine the values for f_1, X_0, X_1, and X_{-1}. Note that the frequencies f are given in Hertz.

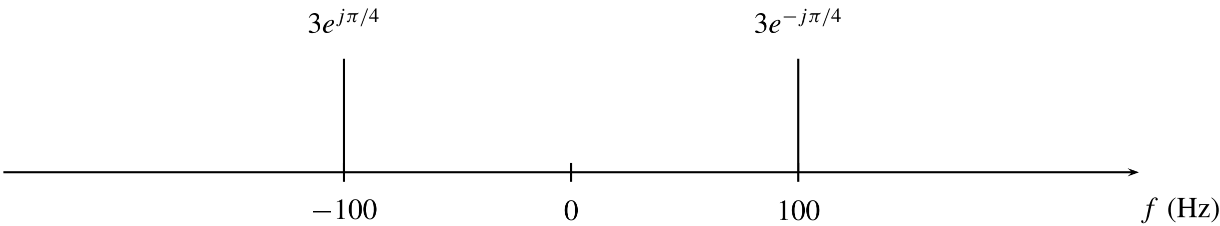
$f_1 =$

$X_0 =$

$X_1 =$

$X_{-1} =$

(b) The spectrum of a signal $x(t)$ has the form



Therefore, the signal has the form

$$x(t) = A\cos(2\pi f_0(t - t_0))$$

Determine the values for A, f_0, and t_0,

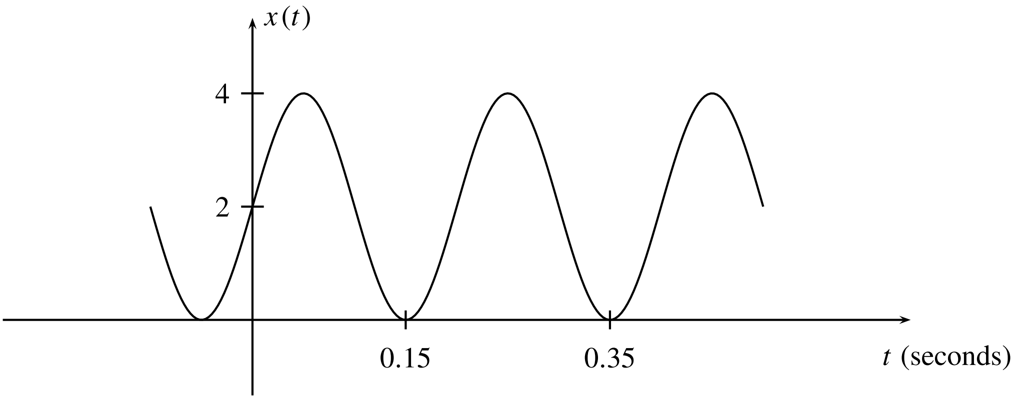
$A =$

$f_0 =$

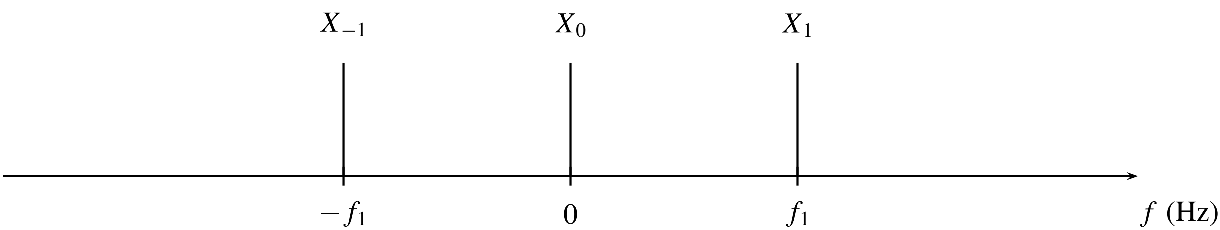
$t_0 =$

PROBLEM:

A signal $x(t) = A\cos(2\pi f_1 t + \phi)$ is shown in the figure below,



The spectrum of $x(t)$ has the form

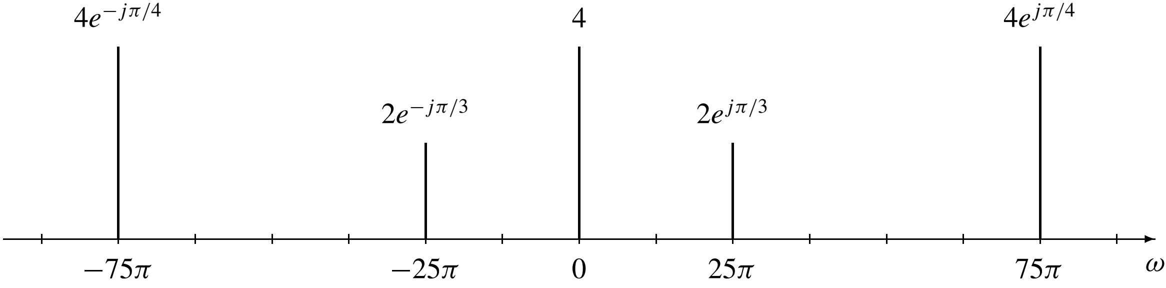


Determine the values for f_1, X_0, X_1, and X_{-1}. Note that the frequencies f are given in Hertz.

$f_1 =$	$X_0 =$	$X_1 =$	$X_{-1} =$

PROBLEM:

The spectrum of a signal $x(t)$ is shown in the following figure:



Note that the frequency axis is radian frequency (ω) *not* cyclic frequency (f).

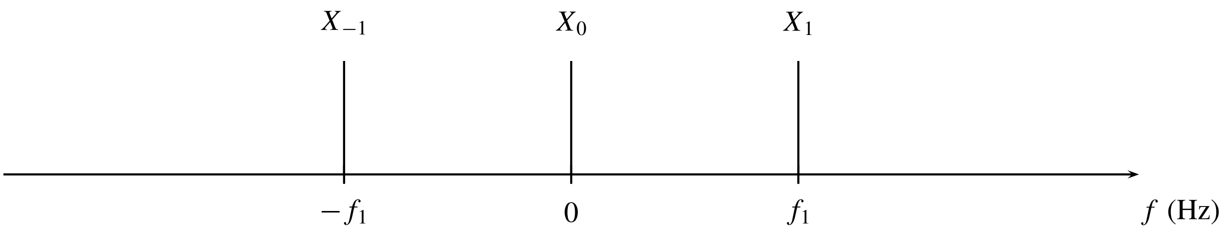
(a) Write an equation for $x(t)$ in terms of cosine functions.

(b) This signal is periodic. What is the fundamental frequency and the corresponding period of $x(t)$?

PROBLEM:

In each of the following parts, two different representations for a signal are given. Find the values of the parameters in the second representation so that the two representations are equivalent.

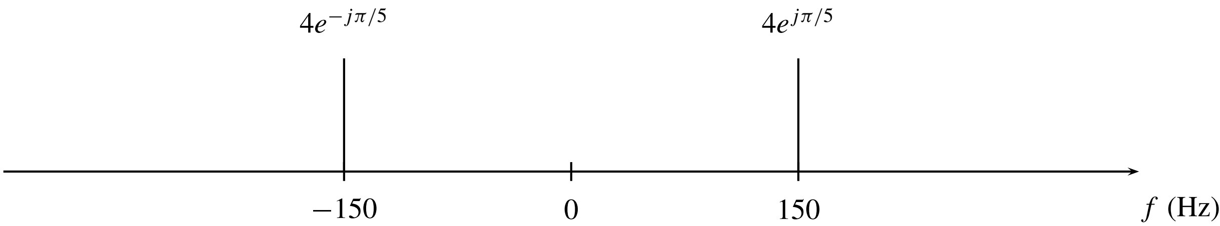
(a) A signal $x(t)$ is given by $x(t) = 4\cos(300\pi t - \pi/3)$, and its spectrum has the form



Determine the values for f_1, X_0, X_1, and X_{-1}. Note that the frequencies f are given in Hertz.

$f_1 =$	$X_0 =$	$X_1 =$	$X_{-1} =$

(b) The spectrum of a signal $x(t)$ has the form



Therefore, the signal has the form

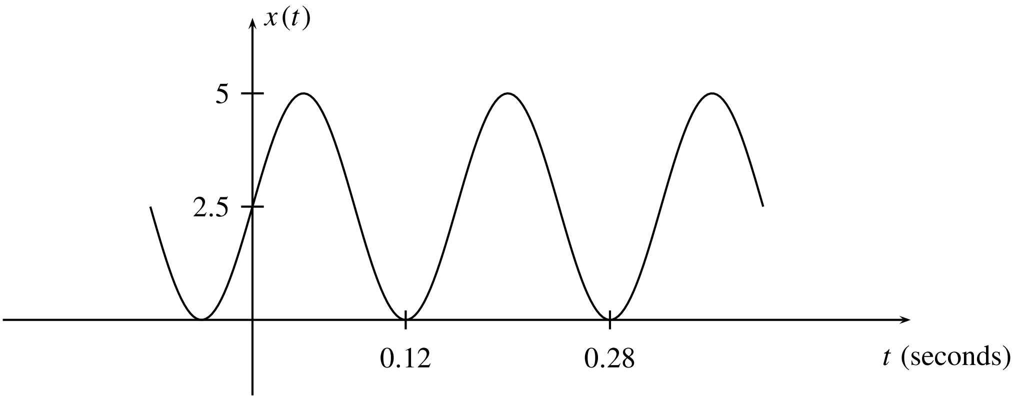
$$x(t) = A\cos(2\pi f_0(t - t_0))$$

Determine the values for A, f_0, and t_0,

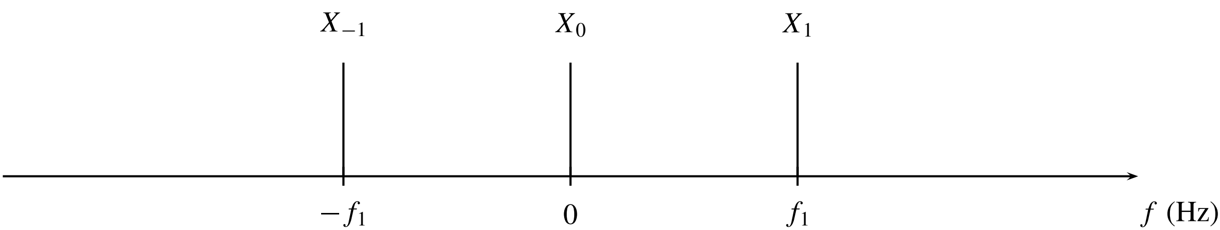
$A =$	$f_0 =$	$t_0 =$

PROBLEM:

A signal $x(t) = A\cos(2\pi f_1 t + \phi)$ is shown in the figure below,



The spectrum of $x(t)$ has the form

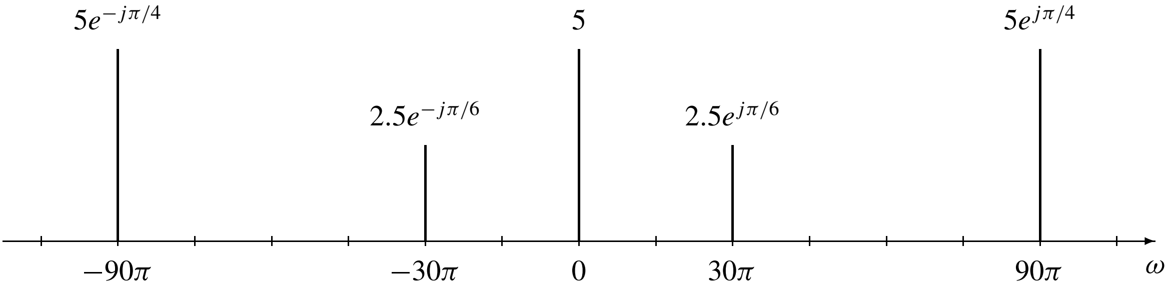


Determine the values for f_1, X_0, X_1, and X_{-1}. Note that the frequencies f are given in Hertz.

$f_1 =$	$X_0 =$	$X_1 =$	$X_{-1} =$

PROBLEM:

The spectrum of a signal $x(t)$ is shown in the following figure:



Note that the frequency axis is radian frequency (ω) *not* cyclic frequency (f).

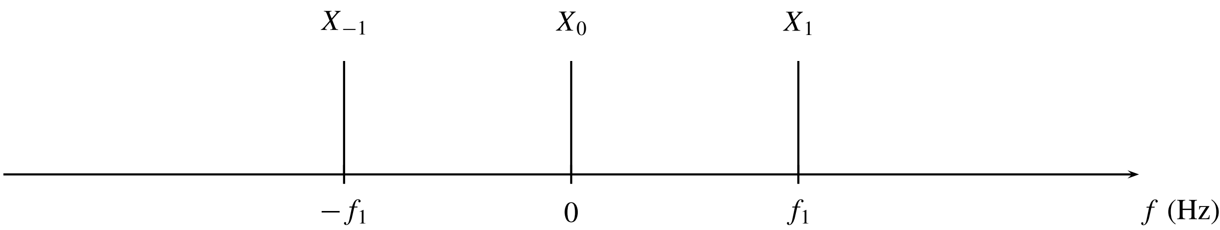
(a) Write an equation for $x(t)$ in terms of cosine functions.

(b) This signal is periodic. What is the fundamental frequency and the corresponding period of $x(t)$?

PROBLEM:

In each of the following parts, two different representations for a signal are given. Find the values of the parameters in the second representation so that the two representations are equivalent.

(a) A signal $x(t)$ is given by $x(t) = 5\cos(350\pi t - \pi/7)$, and its spectrum has the form



Determine the values for f_1, X_0, X_1, and X_{-1}. Note that the frequencies f are given in Hertz.

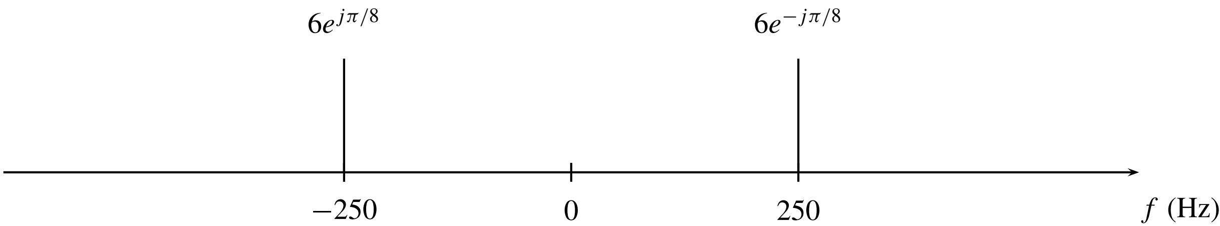
$f_1 =$

$X_0 =$

$X_1 =$

$X_{-1} =$

(b) The spectrum of a signal $x(t)$ has the form



Therefore, the signal has the form

$$x(t) = A\cos(2\pi f_0(t - t_0))$$

Determine the values for A, f_0, and t_0,

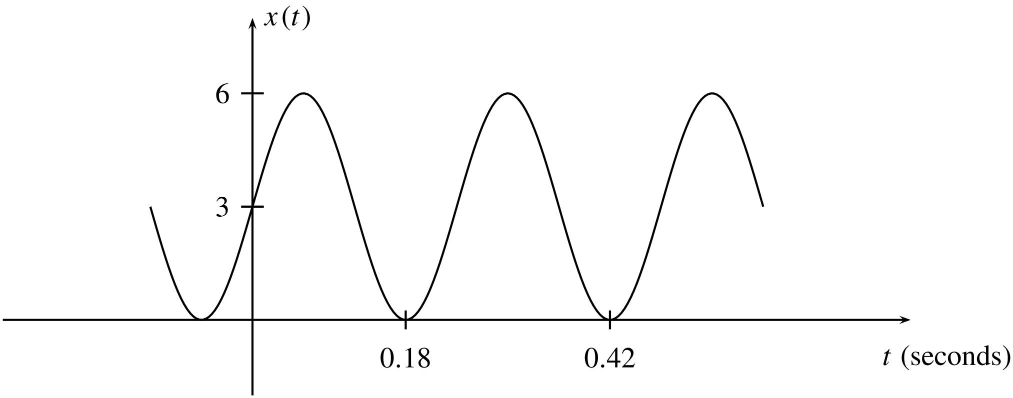
$A =$

$f_0 =$

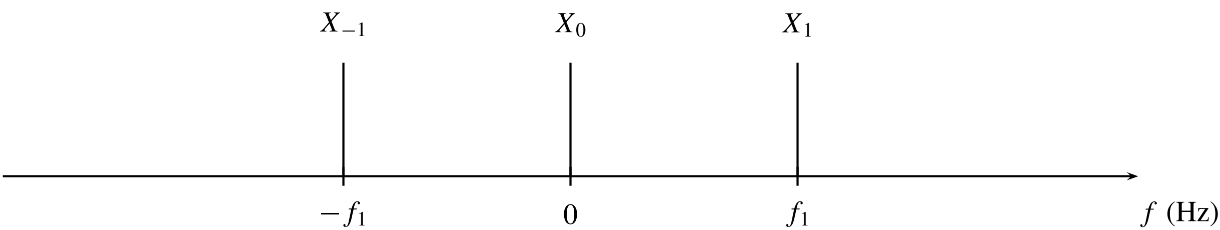
$t_0 =$

PROBLEM:

A signal $x(t) = A\cos(2\pi f_1 t + \phi)$ is shown in the figure below,



The spectrum of $x(t)$ has the form

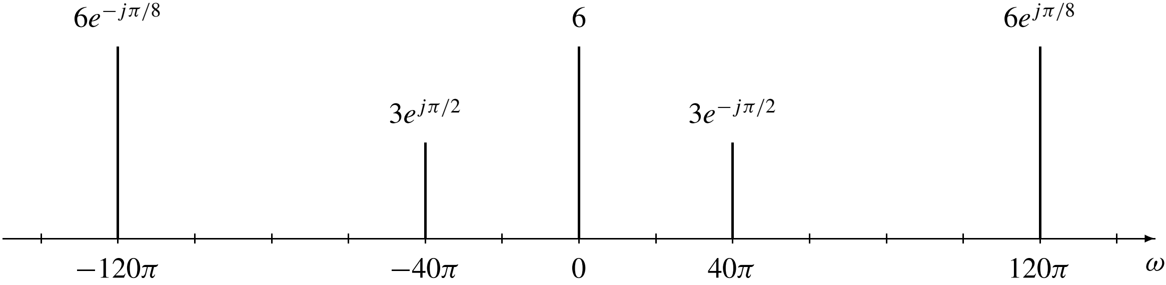


Determine the values for f_1, X_0, X_1, and X_{-1}. Note that the frequencies f are given in Hertz.

$f_1 =$	$X_0 =$	$X_1 =$	$X_{-1} =$

PROBLEM:

The spectrum of a signal $x(t)$ is shown in the following figure:



Note that the frequency axis is radian frequency (ω) *not* cyclic frequency (f).

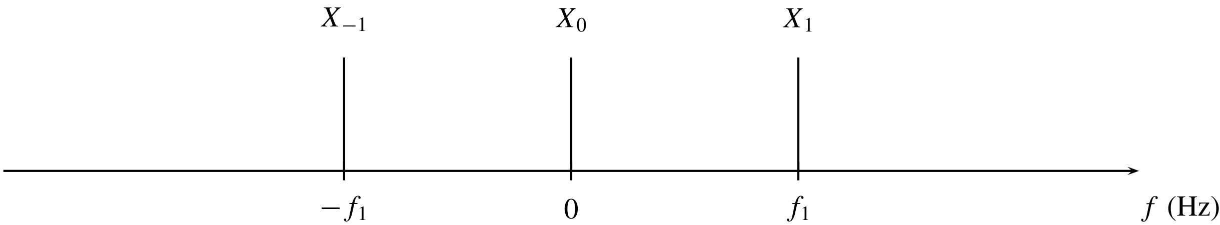
(a) Write an equation for $x(t)$ in terms of cosine functions.

(b) This signal is periodic. What is the fundamental frequency and the corresponding period of $x(t)$?

PROBLEM:

In each of the following parts, two different representations for a signal are given. Find the values of the parameters in the second representation so that the two representations are equivalent.

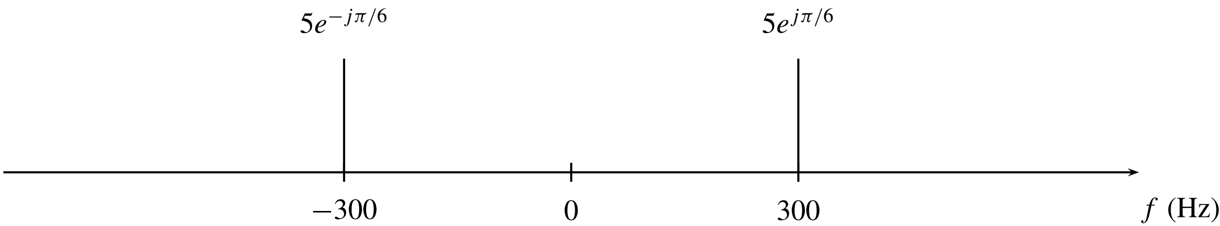
(a) A signal $x(t)$ is given by $x(t) = 3\cos(400\pi t + 3\pi/16)$, and its spectrum has the form



Determine the values for f_1, X_0, X_1, and X_{-1}. Note that the frequencies f are given in Hertz.

$f_1 =$	$X_0 =$	$X_1 =$	$X_{-1} =$

(b) The spectrum of a signal $x(t)$ has the form



Therefore, the signal has the form

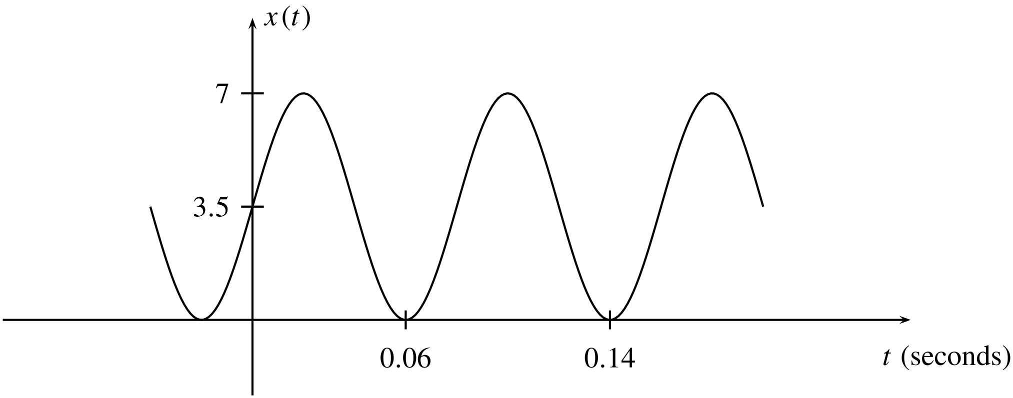
$$x(t) = A\cos(2\pi f_0(t - t_0))$$

Determine the values for A, f_0, and t_0,

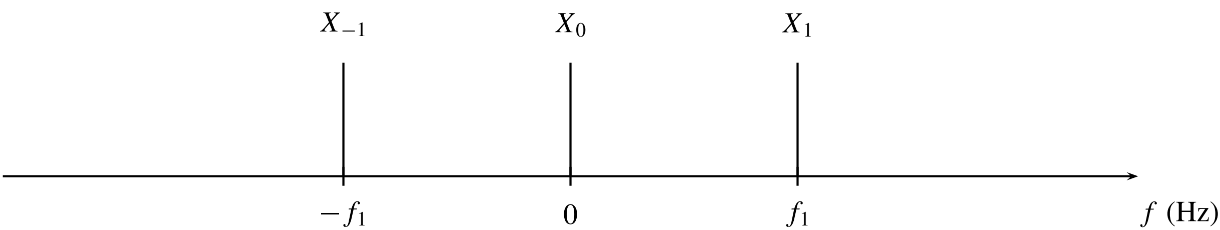
$A =$	$f_0 =$	$t_0 =$

PROBLEM:

A signal $x(t) = A\cos(2\pi f_1 t + \phi)$ is shown in the figure below,



The spectrum of $x(t)$ has the form

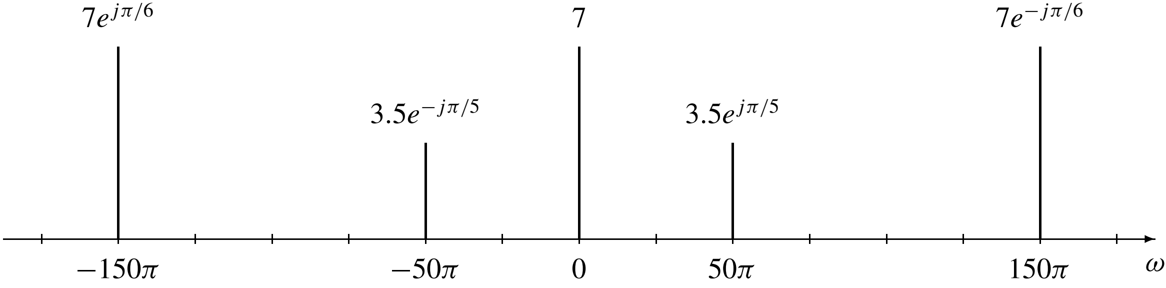


Determine the values for f_1, X_0, X_1, and X_{-1}. Note that the frequencies f are given in Hertz.

$f_1 =$	$X_0 =$	$X_1 =$	$X_{-1} =$

PROBLEM:

The spectrum of a signal $x(t)$ is shown in the following figure:



Note that the frequency axis is radian frequency (ω) *not* cyclic frequency (f).

(a) Write an equation for $x(t)$ in terms of cosine functions.

(b) This signal is periodic. What is the fundamental frequency and the corresponding period of $x(t)$?

PROBLEM:

A periodic signal, $x(t)$, is given by

$$x(t) = 1 + 3\cos(300\pi t) + 2\sin(500\pi t - \pi/4)$$

(a) What is the period of $x(t)$?

(b) Find the Fourier series coefficients of $x(t)$.

PROBLEM:

A periodic signal, $x(t)$, is given by

$$x(t) = 2 + \cos(150\pi t - \pi/6) + 2\sin(450\pi t)$$

(a) What is the period of $x(t)$?

(b) Find the Fourier series coefficients of $x(t)$.

PROBLEM:

A periodic signal, $x(t)$, is given by

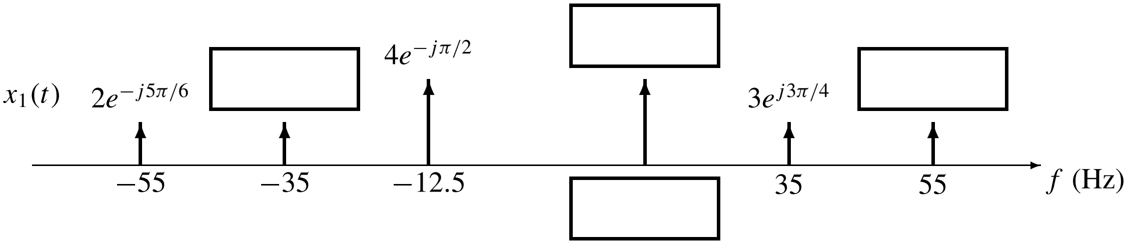
$$x(t) = 3 + \sin(200\pi t) + 3\cos(600\pi t + \pi/3)$$

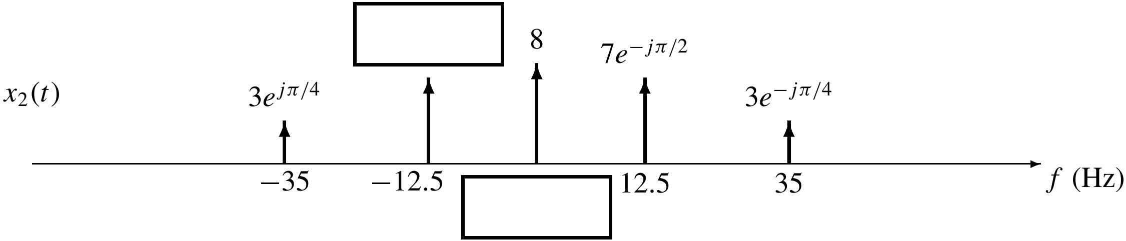
(a) What is the period of $x(t)$?

(b) Find the Fourier series coefficients of $x(t)$.

PROBLEM:

(a) The incomplete spectra for two *real* signals $x_1(t)$ and $x_2(t)$ are shown in the following figures. Fill in the empty boxes for the missing components.





(b) Write an equation for $x_2(t)$ in terms of cosine functions.

PROBLEM:

The signal $x(t)$ is formed from the signal $v(t)$ by AM modulation. Assume that

$$v(t) = 3 + 3\cos(5t + \pi/3)$$

and that

$$x(t) = v(t)\cos(20t).$$

(a) Draw the spectrum for $v(t)$.

(b) Draw the spectrum for $x(t)$.

PROBLEM:

Simplify the following complex-valued expressions. In each case reduce the answers to a **simple** numerical form. Let

$$V = -\frac{1}{\sqrt{3}} - j.$$

(a) Express jV in polar form. In addition plot jV as a vector.

(b) Express the inverse of V in rectangular form. In addition plot $\frac{1}{V}$ as a vector.

(c) If $Z = \frac{|V|}{V^*}$, express Z in polar form. In addition plot Z as a vector.

(d) Express $\Re e\{j^3 V e^{j15t}\}$ in the standard "cosine" form.