Indian Institute of Technology Bombay

Dept of Electrical Engineering

Handout Mid-Sem I | EE 210 Signals and Systems

xx marks | Sep 11, 2017

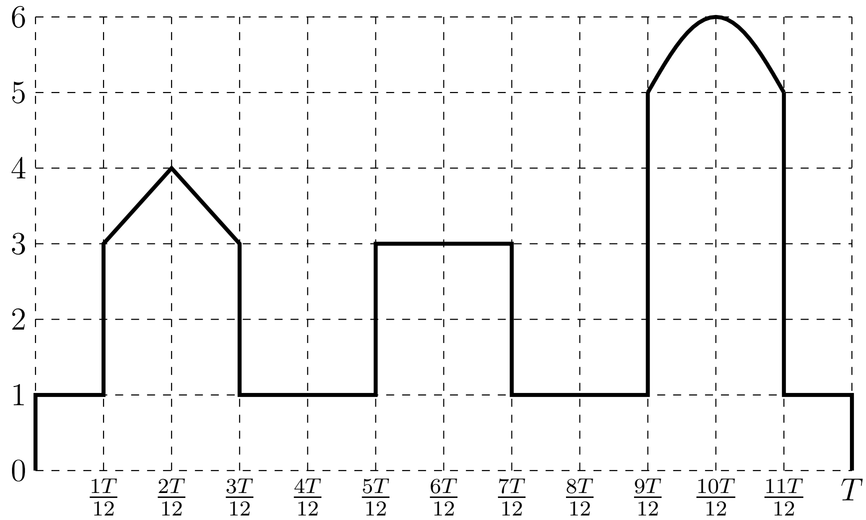
Question 1) For a discrete-time signal $\bar{x}$, let L_x denote the number of non-zero entries in the signal. Given $\bar{w} = [888888888888]$ (a vector/sequence of twelve 8s), find a set of discrete-time signals $\bar{u}$ and $\bar{v}$ with $L_u \geq 3$ and $L_v \geq 3$ such that $\bar{w} = \bar{u} * \bar{v}$, where $*$ stands for convolution.

[10 marks]

Question 2) Let $x(t)$ be a line drawn from origin to the point (a, b) in the positive quadrant. Take $x(t)$ to be zero outside this interval. Find the Fourier Transform of $x(t)$.

[5 marks]

Question 3) Consider the function $x(t)$ shown by the thick-line in the figure below, defined for the interval $t \in (0, T)$. Specifically, the function is $5 + \cos(\frac{6\pi}{T}(t - \frac{10T}{12}))$ for the interval $t \in [\frac{9T}{12}, \frac{11T}{12}]$. The function values are evident from the Figure for the remaining portion. Let a_m denote the Fourier series coefficients for the T−periodic repetition of $x(t)$.



(a) Identify the fundamental frequency.

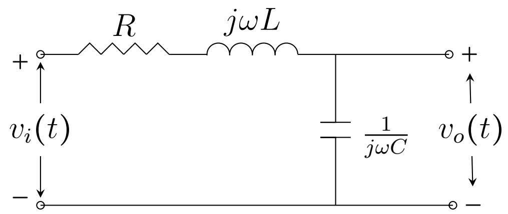
[3 marks]

(b) Explicitly evaluate the coefficients a_m, $-3 \leq m \leq 3$, by taking $T = 1$.

[12 marks]

Question 4) Consider a Voltage source which gives the output waveform similar to that of a bridge rectifier outut, assuming ideal devices.

In figure, the voltage $v_i(t)$ is the source, and $v_o(t)$ is the desired output. Also marked in the figure are the impedance values associated with each passive element, by taking $\omega = 2\pi f$. Assume ideal components for the bridge rectifier (not shown here).



(a) Write the Frequency Response (Fourier Transform of the impulse response) $H(f)$ for this filter.

[5 marks]

(b) If the supply $20\cos(120\pi t)$ was rectified to obtain $v_i(t)$, find the DC output value.

[5 marks]

(c) Given the values of L and C, find the value of R for which the filter response has magnitude

$$|H(f)| = \frac{1}{\sqrt{1 + \left(\frac{f}{f_c}\right)^4}},$$

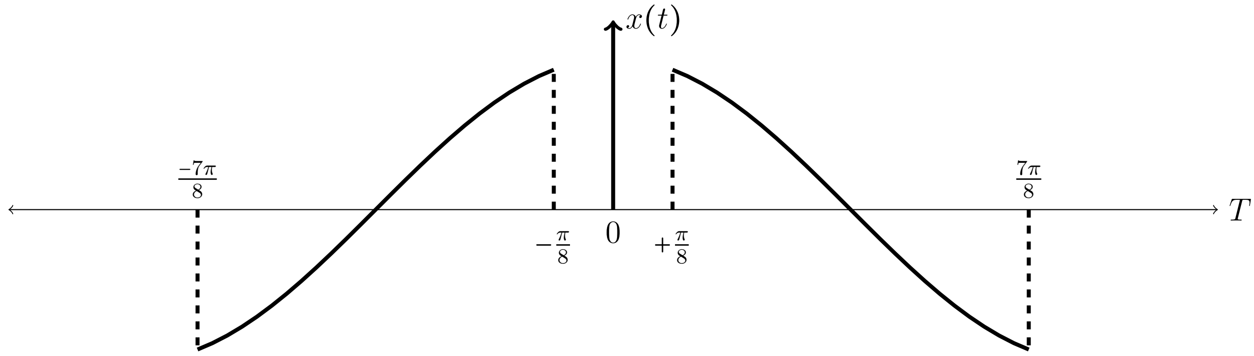
for some appropriate positive constant f_c.

[5 marks]

(d) Now choose the values for L and C to attenuate the peak-to-peak amplitude of the ripple at the minimal frequency (or first harmonic) to 1% of the (ideal) DC voltage.

[5 marks]

Question 5) Let the Fourier Series coefficients of a π−periodic repetition of the following function (see figure below) be $a_m, m \in \mathbb{Z}$. The curved segments in figure are part of an appropriate cosine wave of unit amplitude and period π. Find the coefficients a_m for $|m| \leq 2$.



[5 marks]

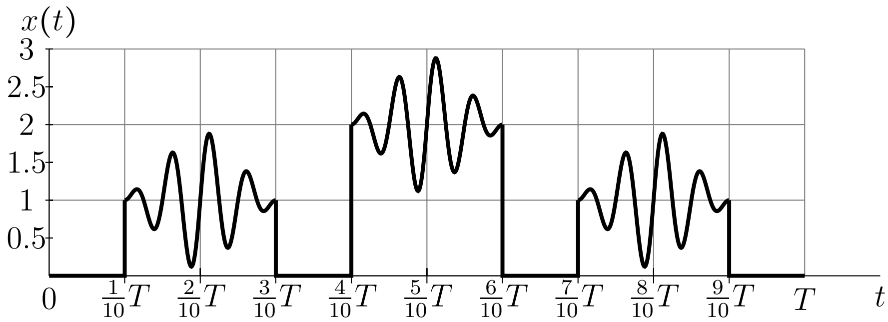
Indian Institute of Technology Bombay

Dept of Electrical Engineering

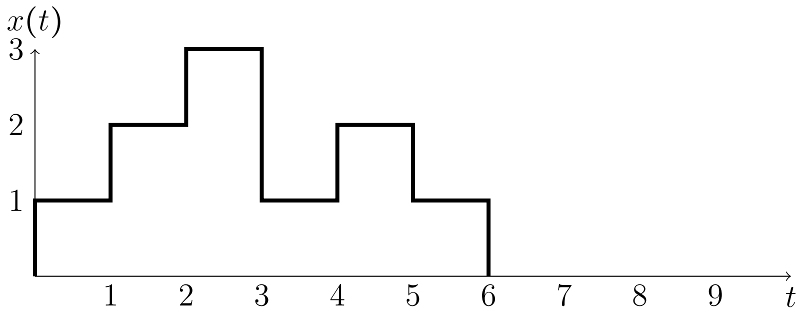
Handout Mid-Sem II — EE 210 Signals and Systems

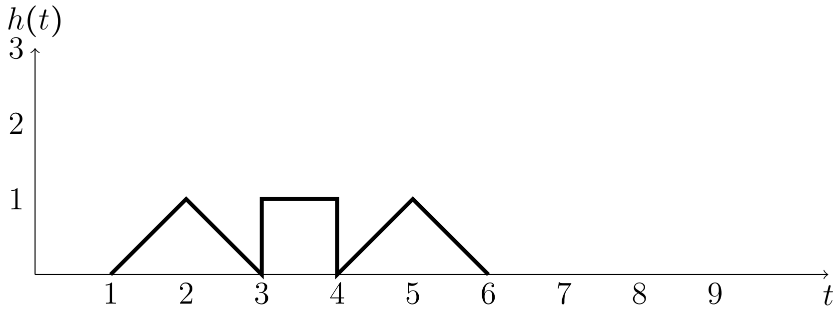
xx marks — Oct 3, 2017

Question 1) Consider the T−periodic function, shown in the figure below. Observe that the curve shown is a sine-wave multiplied by a suitable function (if it is not clear to you). Find the first three Fourier Series coefficients.



Question 2) Consider the waveforms $x(t)$ and $h(t)$ shown below. Find and sketch the convolution of $x(t)$ and $h(t)$.





Question 3) A guitar string of length $60cm$, when plucked at $10cm$ from one of the ends to a height of $1cm$, produced a set of frequencies, say $f_i, i \in \mathbb{N}$ with respective magnitudes α_i.

a) Suppose the guitarist replaced the string with another one having double the coefficient of tension. He then repeated the above procedure. Choose the option that you expect to happen.

1. The output frequencies remain the same, but amplitudes α_i become higher.
2. Each frequency will get replaced by double the frequency, but the same amplitude.
3. Each frequency gets scaled by $\sqrt{2}$, but no change in amplitude.

4. Each frequency gets doubled, but the amplitudes get multiplied by $\sqrt{2}$.
5. Each frequency gets halved and the amplitude scaled by $\sqrt{2}$.
6. Each frequency gets halved and the amplitude scaled by $\frac{1}{\sqrt{2}}$.

b) Reason your answer to part (a) in less than 3 lines.