Announcements

• Experiment 2 (optional) due Friday 4/24
• TNvoice evaluations
  – 5 points EC on final if we get 100% participation
  – 64%, currently; deadline Monday 4/27
• Quiz #4 and Quiz #5 graded
• Today is final day to change grading option for all courses

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Chapter 17

FOURIER ANALYSIS
Fourier Series Representation

Assume we have some function \( f(t) \) which is periodic with period \( T_0 = \frac{2\pi}{\omega_0} \)

\[
f(t) = a_0 + \sum_{k=1}^{\infty} a_k \cos(k\omega_0 t) + b_k \sin(k\omega_0 t)
\]

Alternate forms

\[
f(t) = a_0 + \sum_{k=1}^{\infty} A_k \cos(k\omega_0 t + \varphi_k)
\]

\[
\begin{align*}
A_k &= \sqrt{a_k^2 + b_k^2} \\
\varphi_k &= \tan^{-1} \left( \frac{b_k}{a_k} \right)
\end{align*}
\]

\[
f(t) = \sum_{k=-\infty}^{\infty} c_k e^{j k \omega_0 t}
\]

\[
\begin{align*}
c_k &= \frac{1}{2} (a_k - j b_k) \\
c_{-k} &= \frac{1}{2} (a_k + j b_k) \\
c_0 &= a_0
\end{align*}
\]

Alternate forms

\[
a_k = \frac{2}{T_0} \int_{t_0}^{t_0+T_0} f(t) \cos(k\omega_0 t) \, dt
\]

\[
b_k = \frac{2}{T_0} \int_{t_0}^{t_0+T_0} f(t) \sin(k\omega_0 t) \, dt
\]

\[
c_k = \frac{1}{T_0} \int_{t_0}^{t_0+T_0} f(t) e^{-j k \omega_0 t} \, dt
\]
Symmetry in Fourier Series

Even functions
\[ f(t) = f(-t) \]
\[ b_k = 0 \]

Odd functions
\[ f(t) = -f(-t) \]
\[ a_k = 0 \]

Half-wave symmetric functions
\[ a_k, b_k = 0 \text{ for even } k \]

Non-periodic Waveforms: Fourier Transform (L19)

Non-periodic waveform is "say" it repeats after period \( T \rightarrow \infty \)

Periodic:
\[ C_n = \frac{1}{T} \int_{-T/2}^{T/2} f(t) e^{-jwn} dt \]

Non-periodic:
\[ T \rightarrow \infty \int_{-\infty}^{\infty} f(t) e^{-j\omega t} dt = F(\omega) \]

Periodic:
\[ f(t) = \sum_{n=-\infty}^{\infty} C_n e^{jwn} \]

Non-periodic:
\[ f(t) = \frac{1}{2\pi} \int_{-\infty}^{\infty} F(\omega) e^{j\omega t} d\omega \]

Transforms:
- Fourier Transform
- Laplace Transform
  - Laplace usually unilateral
  - Fourier always bilateral

Examples:
- \( L\{\sin(wt)\} = \frac{\omega}{s^2 + \omega^2} \)