\[ a \cdot x + b \cdot x^2 + c \cdot x^3 \]

Figure 4-1
Figure 4.2

The figure illustrates the relationship between inputs and outputs in a system. The inputs are labeled as $x_a(t)$, $x_b(t)$, and $x_c(t)$, and the outputs as $y_a(t)$, $y_b(t)$, and $y_c(t)$. The figure shows three time points: $t_1$ and $t_2$.

The nonlinearity is demonstrated by the equation:

$$y_c(t) \neq y_a(t) + y_b(t)$$

The figure also indicates that the nonlinearity occurs between $t_1$ and $t_2$.
Figure 4.5

A

$\begin{align*}
x(t) & \rightarrow g(\tau) \\
g(\tau) & \rightarrow w(t) \\
w(t) & \rightarrow aw + bw^2 \\
aw + bw^2 & \rightarrow y(t)
\end{align*}$

B

First-order Kernel

$h_1(\tau)$

C

Second-order Kernel

$h_2(\tau_1, \tau_2)$
Figure 4.6
Figure 4.7

GWN input → $x(t)$ → SYSTEM $S$ → $y(t)$ → Response

Response → $y(t)$ → $h_0$ → AVERAGER → $h_0$ → Response (zero mean)

$y(t)$ → $h_0$ → $y_0(t)$

$y_0(t)$ → $h_0$ → $y_1(t)$

$y_0(t)$ → Cross-Correlate → $h_f(\tau)$ → First-order Kernel $h_f(\tau)$

$x(t)$ → $y(t)$ → $y_L(t)$ → kernel-predicted linear response $y_L(t)$

$y_L(t)$ → $h_f(\tau)$ → nonlinear response component

$\tau_2$

$\tau_1$

Cross-Correlate

$x(t-\tau_1)$ → $y(t)$ → $h_2(\tau_1 \tau_2)$

$\tau_2$

$\tau_1$
Figure 4.8
Figure 4-9

A. CF=109 Hz, Th=35 dB SPL, SR=108/s

B. $h_2$ (9.0%)

C. $h_0+h_1$ (75.6%)

D. $h_0+h_1+h_2$ (83.4%)

Firing Rate (spikes/s)

Time (ms)
Figure 4.10

Sound → Outer Ear → Middle Ear → Basilar Membrane → Inner Hair Cells → Auditory Nerve
Figure 4.11
\[ y(t) = S[x(t); T; k(\tau)] \]
\[ h(\tau) = A \exp(-k\tau) \sin(m\tau) \]

**Figure 4.13**