The frequency response of the simple IIR system (diference equation given in a previous example ([Discrete-Time Systems in the Time-Domain (Page 228)](#_bookmark395)) is given by



(5.50)

This Fourier transform occurred in a previous example; the exponential signal spectrum ([Figure 5.10](#_bookmark382): Spectra of exponential signals) portrays the magnitude and phase of this transfer function. When the flter coefcient *a* is positive, we have a lowpass flter; negative *a* results in a highpass flter. The larger the coefcient in magnitude, the more pronounced the lowpass or highpass fltering.

###### Example 5.8

The length-*q* boxcar flter (diference equation found in a previous example ([Discrete-](#_bookmark395)

[Time Systems in the Time-Domain (Page 228)](#_bookmark395)) has the frequency response



(5.51)

This expression amounts to the Fourier transform of the boxcar signal (5.13). There we found that this frequency response has a magnitude equal to the absolute value of **dsinc(π*f*)**; see the length-10 flter's frequency response ([Figure 5.11](#_bookmark383): Spectrum of length-ten pulse). We see that boxcar flters length-***q*** signal averages have a lowpass behavior, having a cutof frequency of



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###### Exercise 5.13.1

Suppose we multiply the boxcar flter's coefcients by a sinusoid:



Use Fourier transform properties to determine the transfer function. How would you characterize this system: Does it act like a flter? If so, what kind of flter and how do you control its characteristics with the flter's coefcients?

These examples illustrate the point that systems described (and implemented) by diference equations serve as flters for discrete-time signals. The flter's **order** is given by the number *p* of denominator coefcients in the transfer function (if the system is IIR) or by the number q of numerator coefcients if the flter is FIR. When a system's transfer function has both terms, the system is usually IIR, and its order equals

*p* regardless of *q*. By selecting the coefcients and flter type, flters having virtually any frequency response desired can be designed. This design fexibility can't be found in analog systems. In the next section, we detail how analog signals can be fltered by computers, ofering a much greater range of fltering possibilities than is possible with circuits.