Lesson 3: Fourier Methods

In this activity you will learn a little about Fourier analysis theory and how a signal can be thought of as a combination of many different sine and cosine signals. This will provide some understanding of the role of a Fast Fourier Transform block, which is an important component of a spectrometer program and will be investigated in Lesson 4.

Building a Square Wave

• Open your 6 function signal generator from Lesson 2.

• **Save as . . .** using a new file name.

• Run the program. Then change the frequency and volume values to those shown in the table below. You can use the slider, but typing the values in the boxes is probably easier.

Signal Source	Frequency (Hz)	Amplitude
1	100	1.000
2	300	0.333
3	500	0.200
4	700	0.143
5	900	0.111
6	1100	0.091

• Observe the Time Domain Display. You should notice a square wave pattern in time.

Building a Triangle Wave

• In each of the amplitude **QT GUI Range** blocks, change the **Start** value from 0 to -1.

• Now set the frequencies and volumes of sources 1-6 according to the following chart.

Signal Source	Frequency (Hz)	Amplitude
1	100	-1.000
2	300	0.111
3	500	-0.040
4	700	0.020
5	900	-0.012
6	1100	0.008

• Run the program, and observe the Time Domain Display. You should notice a triangular wave pattern.

Discussion

- The above two activities illustrate an extremely useful principle that any function can be represented as a sum of sine and cosine functions, called a **Fourier series**.

- The Fourier series has many such applications in science and engineering.

- In the first example above, notice that the six terms summed result in a pattern that is mostly a repeated rectangular pattern, but it is not an exact rectangle. Including more terms would result in a more rectangular pattern. If enough sine and cosine terms are included in the sum, many functions can be accurately represented by a Fourier series.

- In DSP we are interested in determining which sine and cosine functions are included in a signal. To do this, we need to do what was done in the activities above **in reverse**. That is, given a signal pattern, we want to apply a procedure that will tell us what sine and cosine functions make up the Fourier series of that signal, and what their amplitudes are. This is accomplished using a **Fast Fourier Transform** (FFT).

- In Lesson 4 we will investigate the reverse process of determining the frequencies in a given signal by using an *FFT block* with the 6 function signal generator from Lesson 2.

Explore

- Adjust the amplitudes and frequencies in your program to create different wave patterns.