3.1 Fourier analysis using IDL

Rather than write your own harmonic analysis code, you should use the canned FFT routines that most programming languages provide. FFT stands for Fast Fourier Transform. Look at the IDL documentation for the FFT function for more information. In a nutshell, you compute the power spectrum of your N element input data like this:

```
IDL> spectrum = FFT(input_data)
```

This returns a complex array with N elements. The first element (spectrum[0]) is the mean, i.e,. a_0 in Equation 16. The remaining elements, up to index $N/2$ contain the power in the positive frequencies in ascending order. Past $N/2$, the elements contain the negative frequencies in descending order. In practice, I convert the spectrum to power using only the positive frequencies:

```
IDL> power = (ABS(spectrum[0:N/2]))^2
```

And, since I typically deal with FFTs when I'm doing regression analysis, I convert this power to variance explained at each frequency. Note that I do not multiply the Nyquist by 2:

```
IDL> power[0:N/2-1] = 2.0*power[0:N/2-1]
IDL> bandwidth = 2.0*!DPI/N
IDL> variance = power/(bandwidth*Total(power))
```

Note that the sum of this *variance* (when multiplied by the bandwidth) should equal one, i.e., all of the variance should be explained, i.e., doing this:

```
IDL> print,Total(variance)*bandwidth
```

should give an answer of one.

The tricky part is determining what frequencies this power spectrum or variance spectrum corresponds to. All you have to remember is that the elements of the power spectrum array correspond to the following frequencies:

spectrum[0] =	the mean
spectrum[1] =	one cycle per total time range, T
spectrum[2] =	two cycles per total time range, T
spectrum[N/2] =	Nyquist frequency, N/2 cycles per total time range, T

Basically, all you have to do is construct a frequency array given the knowledge of the total span of your input sample and the physical units involved. Say your input data has N elements that spans a total time T. The power or variance spectrum will have $N/2 + 1$ elements with frequencies you can define by:

```
IDL> freq = FINDGEN(N/2)/T
```

And the units of *freq* are cycles per T. If the units of T are seconds, then the units of *freq* are Hz.