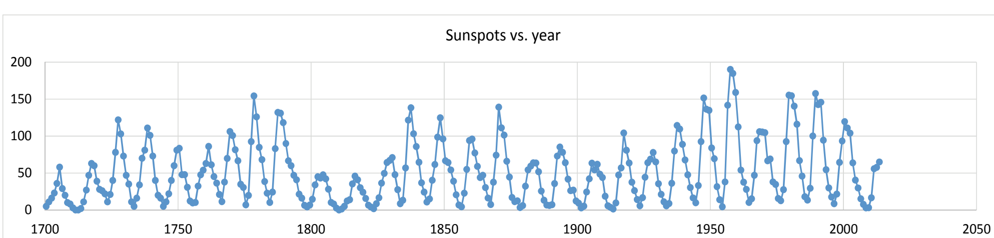
Problem Set 10.3 – Applications and Extensions of Fourier Series

6. Sunspots are directly related to solar storms, coronal mass ejections and other features of the sun's "weather" and the consequences can be destroyed satellites, irradiated astronauts and changed climate on earth. Sunspots were first observed by Galileo in 1612 when he invented the telescope. The graph below shows the number of sunspots observed per year since the year 1700. This data can be downloaded from http://sidc.oma.be/silso/DATA/yearssn.dat . It is text data that is delimited with spaces and it can be brought into an Excel spreadsheet with the command Data>get external data>from text.

Create a macro that takes the FFT of the data. Make a plot of the "energy" spectrum (Use Fig. 10.48 as a guide). Look for peaks in the spectrum which indicate cycles in the data. Calculate the period of any cycle that you find.



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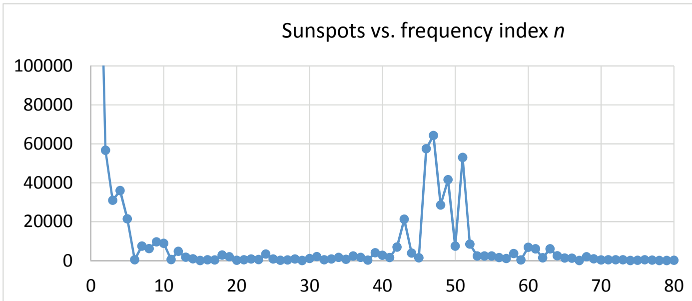
6. There are 314 years of data so let $N = 512$ to include them all and let $\Delta = 1$ year. The energy spectrum should look like the graph below. Ignore the peak at $n = 0$; that is the DC term. Notice that there is a definite peak at $n = 47$.



Since $f = \frac{n}{N\Delta} = \frac{47}{512 \cdot 1 year} \approx \frac{1}{11 years}$ and since the period is the reciprocal of the frequency this means that the data has an oscillation with a period of 11 years. Closer study shows that there are actually two peaks at $n = 47$ and $n = 51$. This implies two close frequencies that beat. The beat frequency is the difference between the two frequencies:

$$f_{beat} = \frac{n_1}{N\Delta} - \frac{n_2}{N\Delta} = \frac{n_1 - n_2}{N\Delta} = \frac{51 - 47}{512 \cdot 1\,\text{year}} \approx \frac{1}{128\,\text{years}}$$

This can also be seen in the data. Every 128 years or so sunspot activity goes to a minimum.