Graduate Course – Term 1, Sept-Dec 2018
30.502: Research Methods

SINGAPORE UNIVERSITY OF TECHNOLOGY AND DESIGN
Established in collaboration with MIT

Assessed Problem Set 5

Due: Wed, 5th Dec, 23:59
Delivery method: eDimension
Format: Portable Document Format (PDF)

For all the python questions in this problem set, please copy and past the code that you used for each function/operation and the result of the calculation.

Problem 1:

a. Draw a flow diagram for an algorithm to compute the Fourier components of a discretised signal

b. Plot a signal composed of two cosine waves; one of frequency 10 Hz and amplitude 5 units, and one of frequency 1 Hz and amplitude, 3 units.

c. Write **your own** python function to compute the Fourier transformed waveform (the frequency spectrum).

d. Plot the magnitude squared frequency spectrum.

e. Use the `scipy` library functions to compute the inverse Fourier transform of the complex spectra computed with your own Fourier transform algorithm.

Problem 2
You are developing a battery and aim to understand whether the electrode material, temperature, and their interaction significantly effect the battery lifetime. You randomly perform a set of two measurements for each electrode material – temperature combination. The lifetimes (in hours) are presented in table 1.

Table 1: Battery lifetime (hours) dependence on temperature and electrode material

		Factor B –Temperature		**Average**
		Level 1	Level 2	
Factor A –Material	Level 1	100, 140	180, 140	140
	Level 2	230, 210	160, 200	200
	Level 3	310, 270	210, 250	260
Average		210	190	200

Using the data in table 1, use a two factor ANOVA analysis to determine whether the factor A, factor B, and their interaction effect, AB, are statistically significant at $\alpha = 0.05$. Which parameter would you try to improve in order to extend the lifetime of the batteries?

Problem 3

Plot the graph of the signal $f(t) = 20 + 10\cos(2\pi \times 50t) + 5\cos(2\pi \times 10t) + 20\cos(2\pi \times 100t)$ over a time span of 0.4 sec. Using **twice the minimum number of sampling points** that are required to properly represent the signal (clearly state the number of sampling points used). When answering the following questions, copy and paste the commands and plot the filtered function in your answer script.

a. Plot the magnitude squared spectrum. How many Fourier components are required to synthesise the signal?

b. Remove the 0 Hz signal from the frequency spectrum, inverse Fourier transform the signal and replot it against the f(t) after removing the offset from the equation.

c. Remove the time varying signal and plot it against f(t) after removing the time varying components from the equation.

d. Remove only the 50 Hz signal and plot it against the f(t) after removing the 50 Hz component from the equation.

e. Remove all frequencies below 100 Hz and plot it against the f(t) after removing all the frequency components below 100 Hz from the equation.