# iSpy: Detection of Signals in Noise
# (EECE4688)
# Spring 2019

## Homework 6
## (Assigned Mar.21, 2019; due Mar.27, 2019 in class.)

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**Objective:** The objective of this exercise is to experiment with angle-of-arrival estimation.

**Task:** A radio signal of frequency $f_0 = 3$ GHz is detected by an array of $M = 16$ elements. The array elements are equally spaced by $d = 0.2$ m. The signal arriving at the array element # 0 is $s_0(t) = A\cos(2\pi f_0 t + \varphi_0)$. This signal is observed in noise as $r_0(t) = s_0(t) + n_0(t)$. The remaining elements, numbered $m = 1, \dots M-1$, observe the waveforms $r_m(t) = s_0(t - m\Delta\tau) + n_m(t)$. The differential delay between the array elements is $\Delta\tau = \frac{d\sin\theta}{c}$, where $\theta$ is the angle of signal arrival, and $c = 3 \cdot 10^8$ m/s. The noise processes are zero-mean white Gaussian, and uncorrelated between the array elements. The $M$ waveforms are processed over $T_0 = 1$ ns, yielding observations $y_m = \frac{1}{T_0}\int_0^{T_0} r_m(t)e^{-j2\pi f_0 t}dt$, $m = 0, \dots M-1$. These observations are stored in the Matlab file `hwk7.mat`. Your task is to download the file and use the observations to tell from which direction $\theta$ is the signal arriving. Support your answer by theory, and illustrate your approach by figures. Consider also a "sanity check," in which you generate a noiseless signal arriving from a certain angle, and apply your technique to show that it indeed provides a correct estimate.

**Reporting:** Your report should be typed, and not exceed two single-sided pages. It should be written in a professional manner. Figures and mathematical expressions should be used whenever meaningful. Figures should always have axes labeled in appropriate units (e.g. time [s], time [ms], frequency [Hz], frequency [kHz], SNR or SNR [dB], etc.). Include any Matlab code as an appendix. Please put your name on top of the report.