COEN 45, Spring 2010
Homework #7
Radar Detector
Due Tues. May 18

Background: A simplified radar receiver feeds a signal through an RF amplifier to a video detector which triggers an alarm when it receives a sufficiently strong signal.

The signal coming from the detector is unfortunately contaminated by thermal noise. We must establish a detection threshold that is not so high as to miss weak but genuine signals and not so low as to report too many false signals that are actually thermal noise.

The thermal noise is randomly distributed in a form called the Rayleigh distribution. To generate Rayleigh-distributed numbers, we get two normally distributed sets n_1 and n_2 (using `randn`) and combine them like so:

$$r = \sqrt{n_1^2 + n_2^2}$$

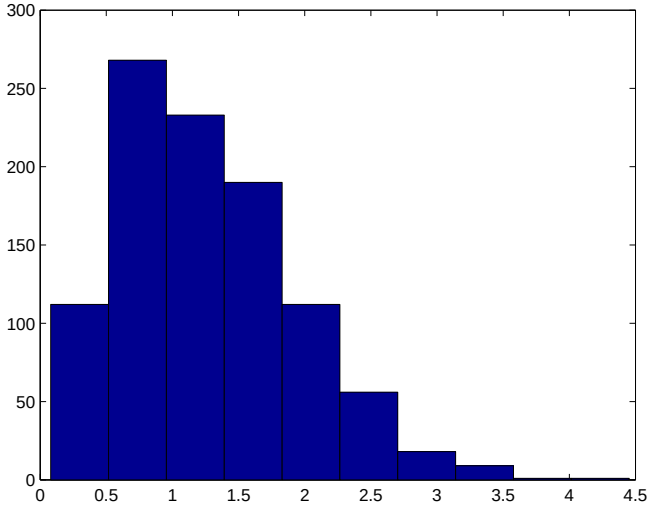
1. Write a function that generates an $m \times n$ array of Rayleigh-distributed numbers:

```
function r = rayleigh(m,n)
%function r = rayleigh(m,n)
%
%  Generate Rayleigh-distributed numbers
%  In an array size mxn (default n=m)
%
error(nargchk(1,2,nargin));
if nargin == 1
    n = m;
end;
n1 = randn(n,m);
n2 =
r =
```

   If the caller only provides m, set $n = m$. Test your function from a script or a command window like so like so:

```
hist(rayleigh(1000,1));
```

   and see if you get a histogram *approximately* like this:



Repeat the histogram several times to get a general idea of the pattern.

2. Now you're ready to use this function to select a detection threshold. Detection thresholds are usually calculated as a multiple of the mean noise level, so that if the noise level changes, the detection threshold will change with it to keep false alarms from getting out of hand. This is known as *constant false alarm rate* (CFAR) detection. A detection threshold is typically quoted in decibels (dB). The relationship between dB and voltage is

$$dB = 20 \log_{10} \left(\frac{\text{volts}}{\text{mean volts}} \right)$$

Write a script that does the following:

(a) Compute a million random Rayleigh-distributed numbers. Scale them to make their mean value 10 (volts). (Divide your numbers by their mean value and multiply 10.) If your student version of MATLAB will not allow an array this big, pick something smaller.

(b) For trial threshold values 5, 6, ... 13 dB, count the number of voltages (converted to dB) that exceed the threshold. For each threshold, calculate the probability of a false alarm by dividing the number that exceed the threshold by the total number of sample voltages. Plot the probability vs. threshhold dB.

(c) Find the lowest threshold for which the false alarm rate does not exceed one in ten thousand.

(d) Repeat the script several times to see if you ever reach a different conclusion.

Use a for loop `for dB = 5:13`. There should be no other for, if, while or switch statements – use vector operations.

Submit scripts, plot, and your written conclusion.