MEMO Number CMPE320-S21-PROJ1 CODE
DATE: 02/27/2021
TO: EFC LaBerge and CMPE320 classmates
FROM: Nem Negash
SUBJECT: Project 1 Code

1 MATLAB PROJECT CODE

1.1 PMF for a single fair die

```
function diePMF()
    %120 trials
    figure(1)
    list120 = randi(6,1,120);
    hist = histogram(list120,'Normalization', 'probability');
    xlabel('Role of the fair die');
    ylabel('Probability of occurances');
    title('PMF for Occurances for 120 trials');
    M = mean(list120);
    V = var(list120);
    fprintf('The sample mean for 120 trials: %.3f\n',M);
    fprintf('The sample variance for 120 trials: %.3f\n\n',V);

    %1200 trials
    figure(2)
    list1200 = randi(6,1,1200);
    hist = histogram(list1200,'Normalization', 'probability');
    xlabel('Role of the fair die');
    ylabel('Probability of occurances');
    title('PMF for Occurances for 1,200 trials');
    M = mean(list1200);
    V = var(list1200);
    fprintf('The sample mean for 1,200 trials: %.3f\n',M);
    fprintf('The sample variance for 1,200 trials: %.3f\n\n',V);

    %12000 trials
    figure(3)
    list12000 = randi(6,1,12000);
    hist = histogram(list12000,'Normalization', 'probability');
    xlabel('Role of the fair die');
    ylabel('Probability of occurances');
    title('PMF for Occurances for 12,000 trials');
    M = mean(list12000);
    V = var(list12000);
    fprintf('The sample mean for 12,000 trials: %.3f\n',M);
    fprintf('The sample variance for 12,000 trials: %.3f\n\n',V);

    %120000 trials
    figure(4)
    list120000 = randi(6,1,120000);
    hist = histogram(list120000,'Normalization', 'probability');
```

```
    xlabel('Role of the fair die');
    ylabel('Probability of occurances');
    title('PMF for Occurances for 120,000 trials');
    M = mean(list120000);
    V = var(list120000);
    fprintf('The sample mean for 120,000 trials: %.3f\n',M);
    fprintf('The sample variance for 120,000 trials: %.3f\n\n',V);

end
```

1.2 PMF for binary strings

```
function binarystrings()
    %for 20 trials
    figure(1)
    trial05_20 = trial(0.5,20);
    disp(trial05_20);
    hist = histogram(trial05_20,'Normalization', 'probability');
    hist.BinEdges = [0:100];
    hist.NumBins = 100;
    xlabel('Indices');
    ylabel('Probability of first occurances at given index');
    title('Indices vs. Number of first occurances for 20 trials with p
= 0.5');
    M = mean(trial05_20);
    V = var(trial05_20);
    fprintf('Mean for 20 trials @ p = 0.5 = %0.4f\n',M);
    fprintf('Variance for 20 trials @ p = 0.5 = %0.4f\n',V);


    figure(2)
    trial09_20 = trial(0.9,20);
    hist = histogram(trial09_20,'Normalization', 'probability');
    hist.BinEdges = [0:100];
    hist.NumBins = 100;
    xlabel('Indices');
    ylabel('Probability of first occurances at given index');
    title('Indices vs. Number of first occurances for 20 trials with p
= 0.9');
    M = mean(trial09_20);
    V = var(trial09_20);
    fprintf('Mean for 20 trials @ p = 0.9 = %0.4f\n',M);
    fprintf('Variance for 20 trials @ p = 0.9 = %0.4f\n',V);


    figure(3)
    trial01_20 = trial(0.1,20);
    hist = histogram(trial01_20,'Normalization', 'probability');
    hist.BinEdges = [0:100];
    hist.NumBins = 100;
    xlabel('Indices');
    ylabel('Probability of first occurances at given index');
    title('Indices vs. Number of first occurances for 20 trials with p
= 0.1');
    M = mean(trial01_20);
```

```
    V = var(trial01_20);
    fprintf('Mean for 20 trials @ p = 0.1 = %0.4f\n',M);
    fprintf('Variance for 20 trials @ p = 0.1 = %0.4f\n\n',V);

    %for 200 trials
    figure(4)
    trial05_200 = trial(0.5,200);
    hist = histogram(trial05_200,'Normalization', 'probability');
    hist.BinEdges = [0:100];
    hist.NumBins = 100;
    xlabel('Indices');
    ylabel('Probability of first occurances at given index');
    title('Indices vs. Number of first occurances for 200 trials with p
= 0.5');
    M = mean(trial05_200);
    V = var(trial05_200);
    fprintf('Mean for 200 trials @ p = 0.5 = %0.4f\n',M);
    fprintf('Variance for 200 trials @ p = 0.5 = %0.4f\n',V);


    figure(5)
    trial09_200 = trial(0.9,200);
    hist = histogram(trial09_200,'Normalization', 'probability');
    hist.BinEdges = [0:100];
    hist.NumBins = 100;
    xlabel('Indices');
    ylabel('Probability of first occurances at given index');
    title('Indices vs. Number of first occurances for 200 trials with p
= 0.9');
    M = mean(trial09_200);
    V = var(trial09_200);
    fprintf('Mean for 200 trials @ p = 0.9 = %0.4f\n',M);
    fprintf('Variance for 200 trials @ p = 0.9 = %0.4f\n',V);


    figure(6)
    trial01_200 = trial(0.1,200);
    hist = histogram(trial01_200,'Normalization', 'probability');
    hist.BinEdges = [0:100];
    hist.NumBins = 100;
    xlabel('Indices');
    ylabel('Probability of first occurances at given index');
    title('Indices vs. Number of first occurances for 200 trials with p
= 0.1');
    M = mean(trial01_200);
    V = var(trial01_200);
    fprintf('Mean for 200 trials @ p = 0.1 = %0.4f\n',M);
    fprintf('Variance for 200 trials @ p = 0.1 = %0.4f\n\n',V);

    %for 2000 trials

    figure(7)
    trial05_2000 = trial(0.5,2000);
    hist = histogram(trial05_2000,'Normalization', 'probability');
    hist.BinEdges = [0:100];
```

```
    hist.NumBins = 100;
    xlabel('Indices');
    ylabel('Probability of first occurances at given index');
    title('Indices vs. Number of first occurances for 2,000 trials with
p = 0.5');
    M = mean(trial05_2000);
    V = var(trial05_2000);
    fprintf('Mean for 2,000 trials @ p = 0.5 = %0.4f\n',M);
    fprintf('Variance for 2,000 trials @ p = 0.5 = %0.4f\n',V);


    figure(8)
    trial09_2000 = trial(0.9,2000);
    hist = histogram(trial09_2000,'Normalization', 'probability');
    hist.BinEdges = [0:100];
    hist.NumBins = 100;
    xlabel('Indices');
    ylabel('Probability of first occurances at given index');
    title('Indices vs. Number of first occurances for 2,000 trials with
p = 0.9');
    M = mean(trial09_2000);
    V = var(trial09_2000);
    fprintf('Mean for 2,000 trials @ p = 0.9 = %0.4f\n',M);
    fprintf('Variance for 2,000 trials @ p = 0.9 = %0.4f\n',V);


    figure(9)
    trial01_2000 = trial(0.1,2000);
    hist = histogram(trial01_2000,'Normalization', 'probability');
    hist.BinEdges = [0:100];
    hist.NumBins = 100;
    xlabel('Indices');
    ylabel('Probability of first occurances at given index');
    title('Indices vs. Number of first occurances for 2,000 trials with
p = 0.1');
    M = mean(trial01_2000);
    V = var(trial01_2000);
    fprintf('Mean for 2,000 trials @ p = 0.1 = %0.4f\n',M);
    fprintf('Variance for 2,000 trials @ p = 0.1 = %0.4f\n\n',V);

    %for 200,000 trials
    figure(10)
    trial05_200000 = trial(0.5,200000);
    hist = histogram(trial05_200000,'Normalization', 'probability');
    hist.BinEdges = [0:100];
    hist.NumBins = 100;
    xlabel('Indices');
    ylabel('Probability of first occurances at given index');
    title('Indices vs. Number of first occurances for 200,000 trials
with p = 0.5');
    M = mean(trial05_200000);
    V = var(trial05_200000);
    fprintf('Mean for 200,000 trials @ p = 0.5 = %0.4f\n',M);
    fprintf('Variance for 200,000 trials @ p = 0.5 = %0.4f\n',V);
```

```
    figure(11)
    trial09_200000 = trial(0.9,200000);
    hist = histogram(trial09_200000,'Normalization', 'probability');
    hist.BinEdges = [0:100];
    hist.NumBins = 100;
    xlabel('Indices');
    ylabel('Probability of first occurances at given index');
    title('Indices vs. Number of first occurances for 200,000 trials
with p = 0.9');
    M = mean(trial09_200000);
    V = var(trial09_200000);
    fprintf('Mean for 200,000 trials @ p = 0.9 = %0.4f\n',M);
    fprintf('Variance for 200,000 trials @ p = 0.9 = %0.4f\n',V);


    figure(12)
    trial01_200000 = trial(0.1,200000);
    hist = histogram(trial01_200000,'Normalization', 'probability');
    hist.BinEdges = [0:100];
    hist.NumBins = 100;
    xlabel('Indices');
    ylabel('Probability of first occurances at given index');
    title('Indices vs. Number of first occurances for 200,000 trials
with p = 0.1');
    M = mean(trial01_200000);
    V = var(trial01_200000);
    fprintf('Mean for 200,000 trials @ p = 0.1 = %0.4f\n',M);
    fprintf('Variance for 200,000 trials @ p = 0.1 = %0.4f\n',V);

end
function o_list = trial(p,m)
   %first 20
   list = [];
   for x = 1:m
       temp = [];
       for y = 1:100
           z = rand;
           if z < p
               temp(y) = 1;
           else
               temp(y) = 0;
           end
       end
       list = [list;temp];

   end
   %disp(list);
   o_list = [];
   indx = 1;
   while indx <= (m*100)
       if list(indx) == 1
           o_list = [o_list,mod(indx,100)];
           indx = indx +(100 - mod(indx,100));
       end
       indx = indx + 1;
```

```
   end

end
```

1.3 PDF for an exponentially distributed random variable

```
function PDF_expo()
    %10 trials
    figure(1)
    list = randx(1,10,0.5);
    hist = histogram(list,'Normalization', 'pdf');
    hist.BinWidth = 2;
    hold on
    x = [0:1:10];
    y = 0.5 * exp(-0.5*x);
    plot(x,y,'LineWidth',4);
    xlabel('x');
    ylabel('f(x)');
    title('PDF of exponentially distributed random variable for 10
trials');
    legend('Histogram','Analytical')
    M = mean(list);
    V = var(list);
    fprintf('Mean for 10 trials = %0.4f\n',M);
    fprintf('Variance for 10 trials = %0.4f\n',V);

    %1000 trials
    figure(2)
    list = randx(1,1000,0.5);
    hist = histogram(list,'Normalization', 'pdf');
    hold on
    x = [0:1:10];
    y = 0.5 * exp(-0.5*x);
    plot(x,y,'LineWidth',4);
    xlabel('x');
    ylabel('f(x)');
    title('PDF of exponentially distributed random variable for 1,000
trials');
    legend('Histogram','Analytical')
    M = mean(list);
    V = var(list);
    fprintf('Mean for 1,000 trial s= %0.4f\n',M);
    fprintf('Variance for 1,000 trials = %0.4f\n',V);

    %100000 trials
    figure(3)
    list = randx(1,100000,0.5);
    hist = histogram(list,'Normalization', 'pdf');
    hold on
    x = [0:1:10];
    y = 0.5 * exp(-0.5*x);
    plot(x,y,'LineWidth',4);
    xlabel('x');
    ylabel('f(x)');
    title('PDF of exponentially distributed random variable for 100,000
trials');
```

```
    legend('Histogram','Analytical')
    M = mean(list);
    V = var(list);
    fprintf('Mean for 100,000 trials = %0.4f\n',M);
    fprintf('Variance for 100,000 trials = %0.4f\n',V);


end

function rexp = randx(n,k,lambda)
%
%function rexp = randx(n,k,lambda)
% Generates samples of an exponentially distributed random variable
with
% parameter lambda.
% Calling parameters
%       n:    number of columns in output array rexp
%       m:    number of rows in output array rexp
%       lambda:  exponential distribution parameter, lambda > 0.
%  Returned parameters
%       rexp  an n x k array containing independent samples from an
%       exponential distribution with pdf f(x) = lambda exp( -lambda*x)
%
% Help comments updated 2/13/2021 EFCL
% Original code EFCL ~1989
%
Z = rand(n,k);  % compute a uniformly distributed random variable

% Now treating the Z value as the CDF of the desired exponential random
variable,
% invert the CDF ( F(x) = 1 - exp(-lambda*x) ) to find the equivalent x
% value.  exp(-lambda x) = 1 - F(x) = 1 - Z
%         -lambda x = log(1 - Z)
%             x = -log(1-Z)/lambda

rexp=zeros(n,k);  % establish the memory
rexp=-log(1-Z)/lambda; % invert the CDF.
end
```

1.4 PDF for a normal or Gaussian distributed random variable

```
function part2_4()
    %10 trial
    figure(1)
    list = randn(1,10);
    histogram(list,'Normalization', 'pdf');
    hold on
    x = [-3:0.0001:3];
    y = ((2*pi).^-0.5)*exp((-x.^2)/2);
    plot(x,y,'LineWidth',4);
    xlabel('x');
    ylabel('f(x)');
    title('PDF for normal distributed random variable for 10 trials');
    legend('Histogram','Analytical')
    M = mean(list);
```

```
    V = var(list);
    fprintf('Mean for 10 trials= %0.4f\n',M);
    fprintf('Variance for 10 trials = %0.4f\n',V);

    %1000 trials
    figure(2)
    list = randn(1,1000);
    histogram(list,'Normalization', 'pdf');
    hold on
    x = [-3:0.0001:3];
    y = ((2*pi*(1.^2)).^-0.5)*exp((-x.^2)/2);
    plot(x,y,'LineWidth',4);
    xlabel('x');
    ylabel('f(x)');
    title('PDF for normal distributed random variable for 1,000
trials');
    legend('Histogram','Analytical')
    M = mean(list);
    V = var(list);
    fprintf('Mean for 1,000 trials= %0.4f\n',M);
    fprintf('Variance for 1,000 trials= %0.4f\n',V);

    %100000 trials
    figure(3)
    list = randn(1,100000);
    histogram(list,'Normalization', 'pdf');
    hold on
    x = [-3:0.0001:3];
    y = ((2*pi).^-0.5)*exp((-x.^2)/2);
    plot(x,y,'LineWidth',4);
    xlabel('x');
    ylabel('f(x)');
    title('PDF for normal distributed random variable for 100,000
trials');
    legend('Histogram','Analytical')
    M = mean(list);
    V = var(list);
    fprintf('Mean for 100,000 trials= %0.4f\n',M);
    fprintf('Variance for 100,000 trials= %0.4f\n',V);
end
```

1.5 PDF for a normal or Gaussian distributed random variable

```
function part2_5()
    %10 trial
    figure(1)
    list = (2*randn(1,10)) + 1;
    histogram(list,'Normalization', 'pdf');
    hold on
    x = [-8:0.0001:8];
    y = ((8*pi).^-0.5)*exp(-((x-1).^2)/8);
    plot(x,y,'LineWidth',4);
    xlabel('x');
    ylabel('f(x)');
    title('PDF for normal distributed random variable for 10 trials',
'?^2 = 4, m = 1');
```

```
    legend('Histogram','Analytical')
    M = mean(list);
    V = var(list);
    fprintf('Mean for 10 trials = %0.4f\n',M);
    fprintf('Variance for 10 trials = %0.4f\n',V);

    %1000 trials
    figure(2)
    list = (2*randn(1,1000)) + 1;
    histogram(list,'Normalization', 'pdf');
    hold on
    x = [-8:0.0001:8];
    y = ((8*pi).^-0.5)*exp(-((x-1).^2)/8);
    plot(x,y,'LineWidth',4);
    xlabel('x');
    ylabel('f(x)');
    title('PDF for normal distributed random variable for 1,000
trials', '?^2 = 4, m = 1');
    legend('Histogram','Analytical')
    M = mean(list);
    V = var(list);
    fprintf('Mean for 1,000 trials = %0.4f\n',M);
    fprintf('Variance for 1,000 trials = %0.4f\n',V);

    %100000 trials
    figure(3)
    list = (2*randn(1,100000)) + 1;
    histogram(list,'Normalization', 'pdf');
    hold on
    x = [-8:0.0001:8];
    y = ((8*pi).^-0.5)*exp(-((x-1).^2)/8);
    plot(x,y,'LineWidth',4);
    xlabel('x');
    ylabel('f(x)');
    title('PDF for normal distributed random variable for 100,000
trials', '?^2 = 4, m = 1');
    legend('Histogram','Analytical')
    M = mean(list);
    V = var(list);
    fprintf('Mean for 100,000 trials = %0.4f\n',M);
    fprintf('Variance for 100,000 trials = %0.4f\n',V);
end
```

1.6 Computing probabilities from the pdf

```
function part2_6()
    %Unscaled histogram
    list = (2*randn(1,1000000)) + 1;
    figure(1)
    hist1 = histogram(list);
    hist1.BinWidth = 0.1;
    x_values1 = find(hist1.BinEdges >= 1.0 & hist1.BinEdges < 3.0);
    pdf_sum1 = sum(hist1.Values(x_values1));
    prob = pdf_sum1 / 1000000;
```

```
    fprintf('Unscaled Sample probability: %0.4f\n',prob);

    %Scaled histogram
    figure(2)
    hist2 = histogram(list,'Normalization', 'pdf');
    hist2.BinWidth = 0.1;
    x_values2 = find(hist2.BinEdges >= 1.0 & hist1.BinEdges < 3.0);
    pdf_sum2 = sum(hist2.Values(x_values2));
    numeric_integ = pdf_sum2 * hist2.BinWidth;
    fprintf('Scaled Sample probability: %0.4f\n',numeric_integ);

    %True PDF probability
    f_x = @(x) ((8*pi).^-0.5)*exp(-((x-1).^2)/8);
    integ = integral(f_x,1,3);
    fprintf('True PDF probability: %0.4f\n',integ);
end
```