Generate 1000 random numbers in [0, 1] and obtain an exponential random variable with mean 5, representing the inter-arrival times of packets to a buffer. Then plot the probability density function of this random variable and determine the mean and variance. Subsequently obtain a Poisson random variable for the number of packet arrivals and plot the probability mass function. Similarly, determine the mean and variance.

Step-1: Random Number Generation[0 to 1].

```
clc
clear all
L_limit=0
```

```
L_limit = 0
```

```
U_limit=1
```

```
U_limit = 1
```

```
total=1000
```

```
total = 1000
```

```
R=L_limit+(U_limit-L_limit)*rand(total,1)
```

```
R = 1000×1
    0.8147
    0.9058
    0.1270
    0.9134
    0.6324
    0.0975
    0.2785
    0.5469
    0.9575
    0.9649
      ⋮
```

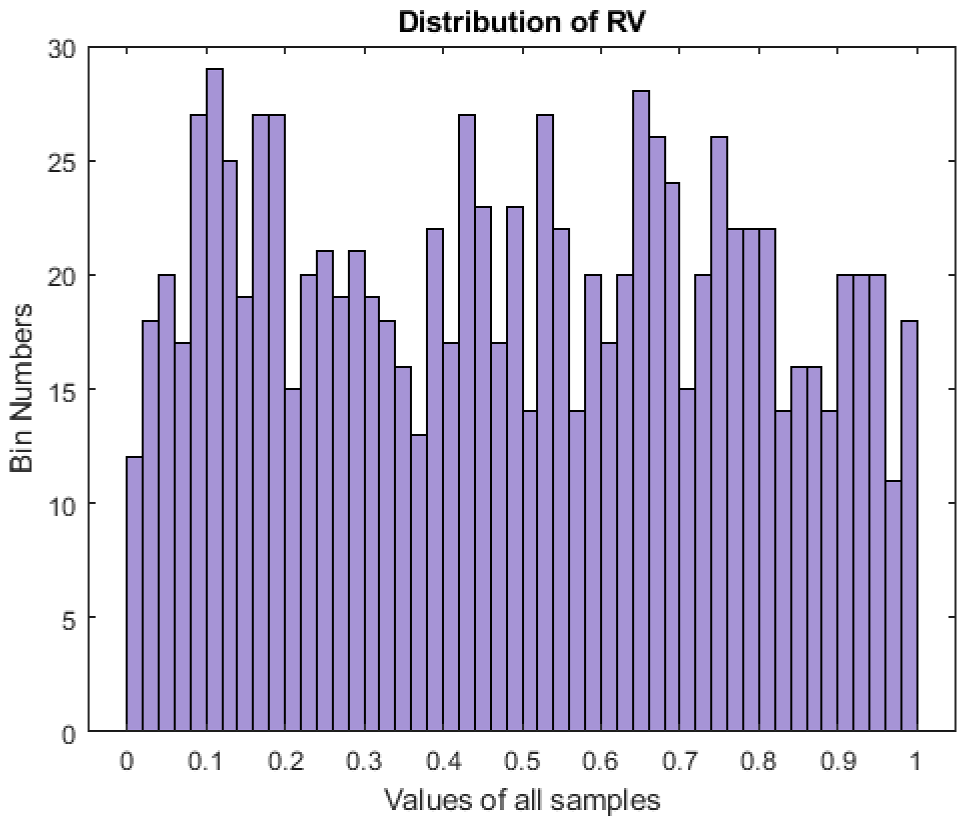
```
Bin=50;
X=histogram(R,Bin)
```

```
X = 
  Histogram with properties:

             Data: [1000×1 double]
           Values: [12 18 20 17 27 29 25 19 27 27 15 20 21 19 21 19 18 16 13 22 17 27 23 17 23 14 27 22 14 20 17 20
          NumBins: 50
         BinEdges: [1×51 double]
         BinWidth: 0.0200
        BinLimits: [0 1]
    Normalization: 'count'
        FaceColor: 'auto'
        EdgeColor: [0 0 0]

  Show all properties
```

```
xlabel('Values of all samples');
ylabel('Bin Numbers');
title('Distribution of RV')
X.FaceColor = [.42 .3 .73]
```




```
X =
  Histogram with properties:

             Data: [1000×1 double]
           Values: [12 18 20 17 27 29 25 19 27 27 15 20 21 19 21 19 18 16 13 22 17 27 23 17 23 14 27 22 14 20 17 20
          NumBins: 50
         BinEdges: [1×51 double]
         BinWidth: 0.0200
        BinLimits: [0 1]
    Normalization: 'count'
        FaceColor: [0.4200 0.3000 0.7300]
        EdgeColor: [0 0 0]

  Show all properties
```

```
m_1 = 0;
for count_1=1:total
    m_1=m_1+R(count_1);
end

Mean_R=(m_1/total)  %Raw code of Mean
```

```
Mean_R = 0.4888
```

```
Var_R=sum((R(1:end)-sum(R(1:end))./length(R)).^2)/(length(R)-1) %Raw code of Variance
```

```
Var_R = 0.0802
```

```
Mean_R1 =mean(R)  %Using Matlab function
```

```
Mean_R1 = 0.4888
```

```
Var_R1 =var(R)    %Using Matlab function
```

```
Var_R1 = 0.0802
```

Above function can generate 1000 random numbers between [0] to [1] with their Mean along with Variance and plot histogram with all samples and number of Bins.

Step-2: Exponential conversion from RV(Random Variable).

Now, we have to obtain an exponential random variable with mean 5 and representing the inter-arrival times of packets to a buffer.

From the formula of Exponential RV, we know:

$$FX(x) = 1-e^{-\lambda x}...(i)$$

As we have taken random variables from 0 to 1 and PDF also operates between 0 to 1. We can consider to use our RV as a function of PDF(Fx).

$$FX(x) = R$$

Now, if we put this value to equation (i), it will become:

$FX(x) = 1-e^{-\lambda * x}$

\> $R = 1 - e^{-\lambda * x}$

\> $e^{-\lambda * x} = 1 - R$

\> $-\lambda * x = \log(1- R)$ % 'log' in both sides. %

$$\mathbf{x = -(1/\lambda)*\log(1-R)}$$

Here, (1-R) = R   %Because it varies from 1 to 0.%

Now, It's give in the question that we need to generate a set where mean is 5. So, 1/Lamda =5.

$$\mathbf{x = -(1/0.2)*\log(R)}$$

```
mean_x=5;
x = -((mean_x)*log(R))
```

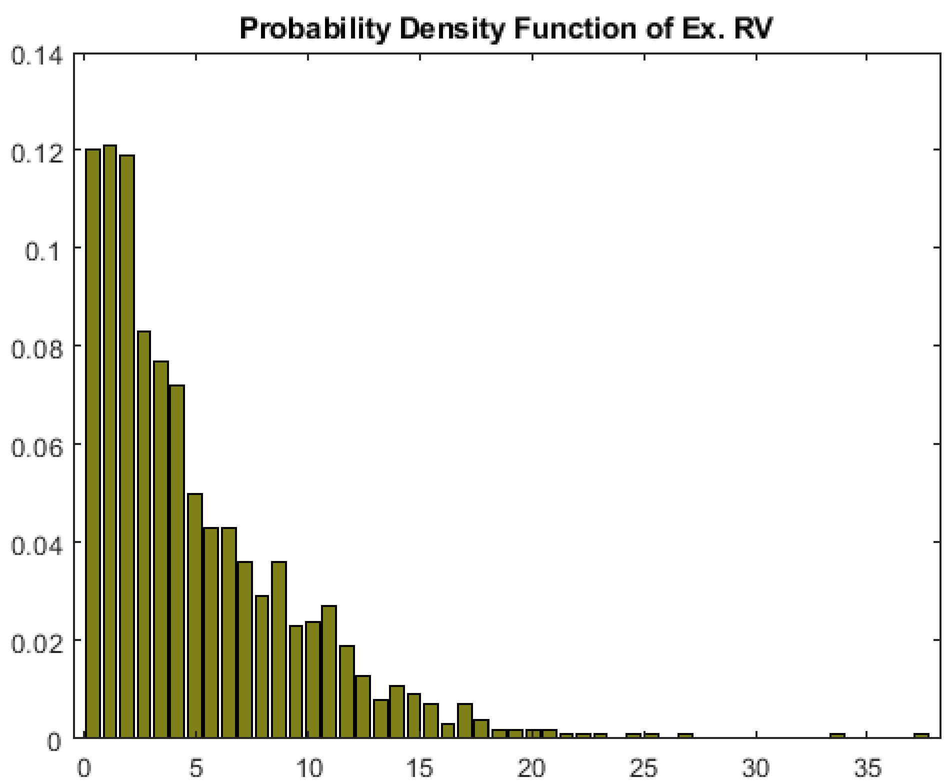
```
x = 1000×1
    1.0245
    0.4947
   10.3184
```

```
    0.4530
    2.2915
   11.6374
    6.3917
    3.0176
    0.2171
    0.1787
      ⋮
```

```
Bin=50;
%x1=x/1000;
[y1,y2]=hist(x,Bin)     %Histogram plot of PDF.
```

```
y1 = 1×50
   120   121   119    83    77    72    50    43    43    36    29    36    23 ···
y2 = 1×50
    0.3804    1.1360    1.8917    2.6474    3.4030    4.1587    4.9143    5.6700 ···
```

```
l_1=bar(y2,y1/1000);    %Normalizing y axis.
%x2=histogram(x1,Bin)
title('Probability Density Function of Ex. RV')
l_1.FaceColor = [.5 0.5 .1]
```




```
l_1 = 
  Bar with properties:

    BarLayout: 'grouped'
     BarWidth: 0.8000
    FaceColor: [0.5000 0.5000 0.1000]
    EdgeColor: [0 0 0]
    BaseValue: 0
        XData: [1×50 double]
```

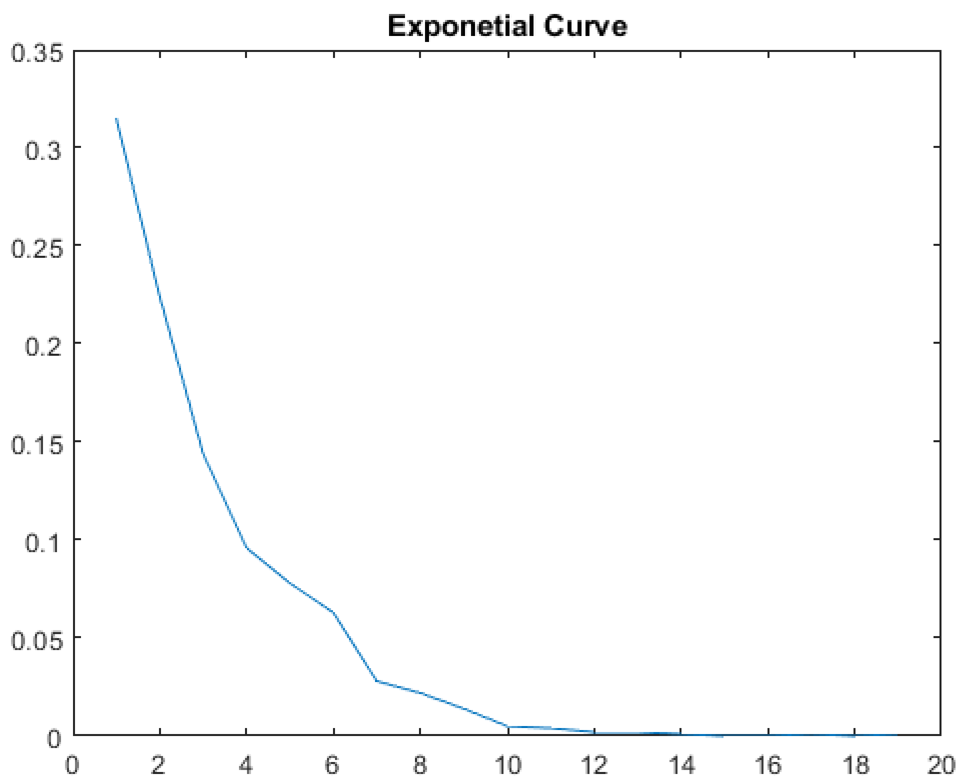
```
        YData: [1×50 double]

  Show all properties
```

```
E=(histcounts(x))/total
```

```
E = 1×19
    0.3150    0.2240    0.1440    0.0960    0.0780    0.0630    0.0280    0.0220 ···
```

```
plot(E)
title('Exponetial Curve')
```




```
m_2 = 0;
for count_3=1:total
    m_2=m_2+x(count_3);
end
Mean_X=(m_2/total)  %Raw code of Mean
```

```
Mean_X = 5.0129
```

```
Var_X=sum((x(1:end)-sum(x(1:end))./length(x)).^2)/(length(x)-1) %Raw code of Variance
```

```
Var_X = 21.7870
```

```
Mean_X1=mean(x)    %%Mean of the function
```

```
Mean_X1 = 5.0129
```

```
Var_X1=var(x)     %%Variance of the function
```

```
Var_X1 = 21.7870
```

Now, we have calculated Mean and Variance of 1000 exponential random variables.

We got Mean ≈ 5

From the formula, E[X] =1/λ= 5

So, Both are almost simiar.

And , We got Variance ≈22

From the formula, E[X]^2 =1/(λ)^2= 25

So, It's also simiar to our calculated value.

Step-3: Poisson RV generation(PMS)

It is given in the qustion, When the packets sent the inter arraival time is exponential.

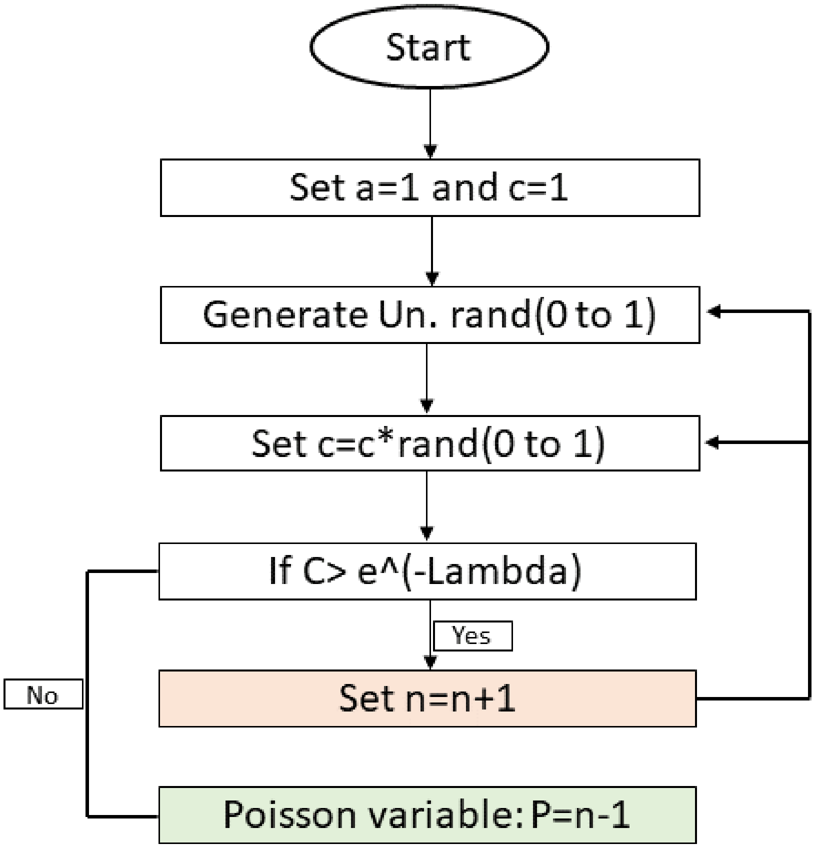
We know,Mean(Lambda)= 5

for, T=20sec.

so, Mean = α =μT= (1/5)*20=4

and Variance = α = μT = (1/5)*20 =4

Now we have to write a code for generating Poisson Random Variables.




```
l=4;                                        %Mean
t=1;                                        %Initial value
n=1000;
while t<=n                                  %loop starts here[1 to 1000]
    a=1; c=1;                               % 'c' is multiplier and 'a' is number of iteration.
    L_lim=0;                                %Random variable intial point.
    U_lim=1;                                %Random variable final point.
    Random=L_lim+(U_lim-L_lim)*rand;        %Random variable generation.
    c= c*Random;                            % 'c' multiplies with random number.
    while c >= exp(-l)                      % if this validates, program goes back to step 2 and n-
    L_lim=0;                                %if above condition does not validate, it generates,
    Random=L_lim+(U_lim-L_lim)*rand;        % random number and add with the iteration number
        c = c*Random;
        a = a+1;
    end
    P(t) = a;
    t=t+1;
end
P                                            %  'P' is the poisson variable.
```

```
P = 1×1000
    7    2    5    6    3    3    6    9    6    5    2    8    2⋯
```

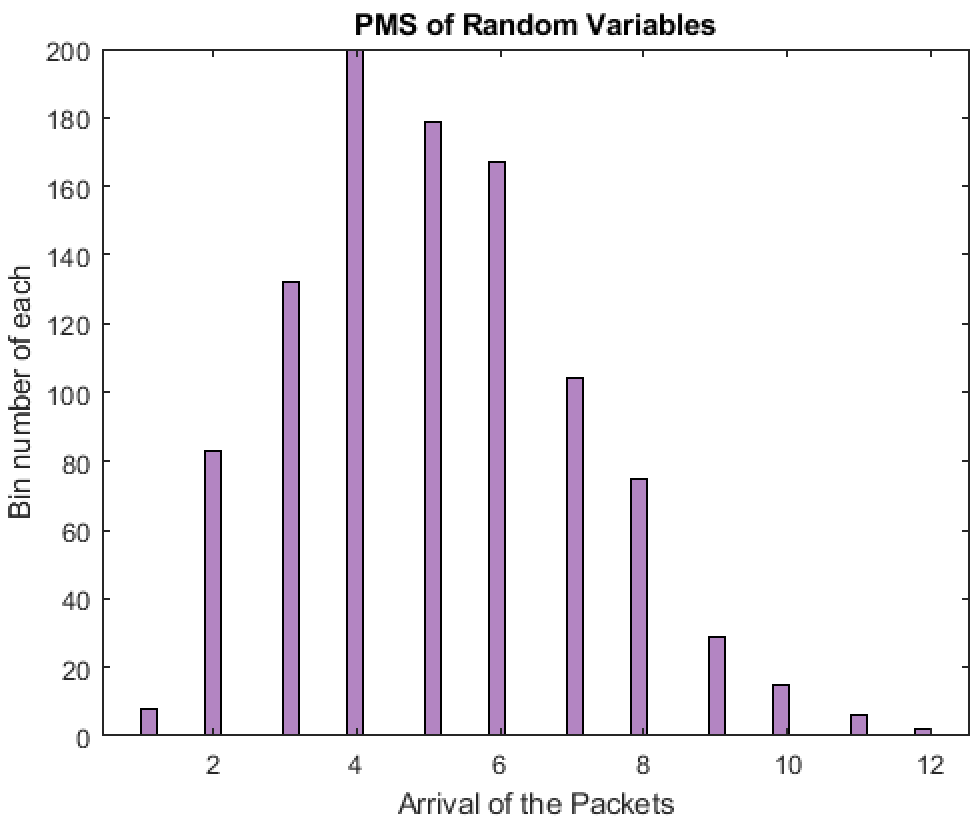
```
Bin=50;
x=histogram(P,Bin) %Plotting Poisson random Variables
```

```
x =
  Histogram with properties:

             Data: [1×1000 double]
           Values: [8 0 0 0 83 0 0 0 0 132 0 0 0 200 0 0 0 0 179 0 0 0 167 0 0 0 0 104 0 0 0 75 0 0 0 0 29 0 0 0 15
          NumBins: 50
         BinEdges: [1×51 double]
         BinWidth: 0.2200
        BinLimits: [1 12]
    Normalization: 'count'
        FaceColor: 'auto'
        EdgeColor: [0 0 0]

  Show all properties
```

```
xlabel('Arrival of the Packets');
ylabel('Bin number of each');
title('PMS of Random Variables')
x.FaceColor = [0.5 0.2 0.6]
```




```
x =
  Histogram with properties:

             Data: [1×1000 double]
           Values: [8 0 0 0 83 0 0 0 0 132 0 0 0 200 0 0 0 0 179 0 0 0 167 0 0 0 0 104 0 0 0 75 0 0 0 0 29 0 0 0 15
          NumBins: 50
         BinEdges: [1×51 double]
         BinWidth: 0.2200
        BinLimits: [1 12]
    Normalization: 'count'
        FaceColor: [0.5000 0.2000 0.6000]
        EdgeColor: [0 0 0]
```

```
Show all properties
```

```
m_3 = 0;
for count_5=1:n
    m_3= m_3 + P(count_5);
end
Mean_P=(m_3/n)  %Raw code of Mean
```

```
Mean_P = 5.0960
```

```
Var_P=sum((P(1:end)-sum(P(1:end))./length(P)).^2)/(length(P)-1) %Raw code of Variance
```

```
Var_P = 4.0088
```

```
Mean_P1=mean(P)
```

```
Mean_P1 = 5.0960
```

```
Variance_P1=var(P)
```

```
Variance_P1 = 4.0088
```

Here, Obtained mean is 5 ≈ 4, from formula E[X]=*Alpha* = 4 . Same as our calculated value.

And obtained Variance is 4 ≈ 4. From formula E[X]^2=*Alpha*=4. Same as our calculated value.

Let's check our proagram for diffrent arrival time.

Let, T=100sec.

so, Mean = α = μT = (1/5)*100=20

and Variance = α = μT = (1/5)*100 =20

```
l1=20;                              %Mean
t1=1;                               %Initial value
n1=1000;
while t1<=n1                        %loop starts here[1 to 1000]
    a1=1; c1=1;                     % 'c1' is multiplier and 'a1' is number of iteration.
    L_lim1=0;                       %Random variable intial point.
    U_lim1=1;                       %Random variable final point.
    Random1=L_lim1+(U_lim1-L_lim1)*rand; %Random variable generation.
    c1= c1*Random1;                 % 'c1' multiplies with random number.
    while c1 >= exp(-l1)            % if this validates, program goes back to step 2 and r
    L_lim1=0;                       %if above condition does not validate, it generates,
    Random1=L_lim1+(U_lim1-L_lim1)*rand; % random number and add with the iteration number
        c1 = c1*Random1;
        a1 = a1+1;
    end
    P1(t1) = a1;
```

```
    t1=t1+1;
end
P1                                          %  'P1' is the poisson variable.
```

```
P1 = 1×1000
    16    24    24    20    19    24    17    17    28    24    23    20    28 ···
```

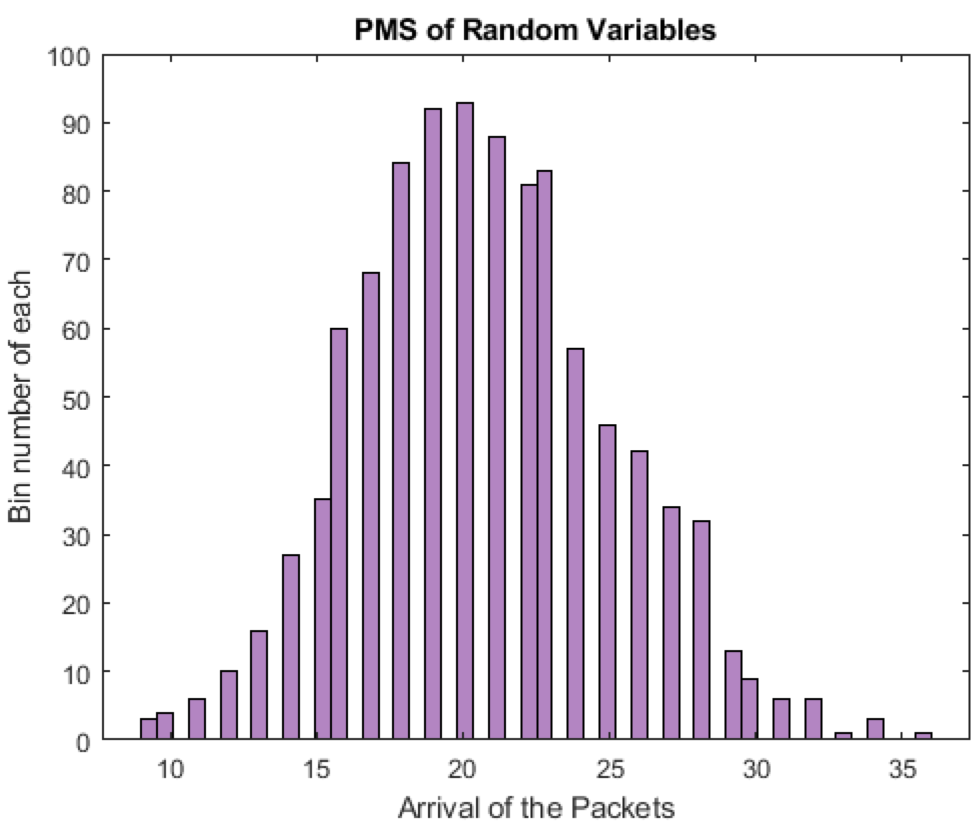
```
Bin=50;
x1=histogram(P1,Bin) %Plotting Poisson random Variables
```

```
x1 =
  Histogram with properties:

             Data: [1×1000 double]
           Values: [3 4 0 6 0 10 0 16 0 27 0 35 60 0 68 0 84 0 92 0 93 0 88 0 81 83 0 57 0 46 0 42 0 34 0 32 0 13 9
          NumBins: 50
         BinEdges: [1×51 double]
         BinWidth: 0.5400
        BinLimits: [9 36]
    Normalization: 'count'
        FaceColor: 'auto'
        EdgeColor: [0 0 0]

  Show all properties
```

```
xlabel('Arrival of the Packets');
ylabel('Bin number of each');
title('PMS of Random Variables')
x1.FaceColor = [0.5 0.2 0.6]
```




```
x1 =
```

```
Histogram with properties:

             Data: [1×1000 double]
           Values: [3 4 0 6 0 10 0 16 0 27 0 35 60 0 68 0 84 0 92 0 93 0 88 0 81 83 0 57 0 46 0 42 0 34 0 32 0 13 9
          NumBins: 50
         BinEdges: [1×51 double]
         BinWidth: 0.5400
        BinLimits: [9 36]
    Normalization: 'count'
        FaceColor: [0.5000 0.2000 0.6000]
        EdgeColor: [0 0 0]

Show all properties
```

```
m_31 = 0;
for count_51=1:n1
    m_31= m_31 + P1(count_51);
end
Mean_P11=(m_31/n1)  %Raw code of Mean
```

```
Mean_P11 = 20.7590
```

```
Var_P11=sum((P1(1:end)-sum(P1(1:end))./length(P1)).^2)/(length(P1)-1) %Raw code of Variance
```

```
Var_P11 = 18.9659
```

```
Mean_P1=mean(P1)  %Matlab function of Mean.
```

```
Mean_P1 = 20.7590
```

```
Variance_P1=var(P1) %Matlab function of Variance.
```

```
Variance_P1 = 18.9659
```

Here, Obtained mean is 20.7 ≈ 20, from formula E[X]=*Alpha* = 20 . Same as our calculated value.

And obtained Variance is 19 ≈ 20. From formula E[X]^2=*Alpha*=20. Same as our calculated value.

Discussion:

This project can be done by using default function but we have used raw scripting to understand the problem deeply. From this project we have understood how to generate exponential & poisson random variable by writing raw code using MATLAB. The main focus of this project was also determine theoratical formulas by judging the properties of Random variable that we have generated. We have checked our calculated values with formulated values by comparing Mean and Variance to prove formulas of Textbook.