# Question 1

Since, it is given that e{t}=IIDN(0,1), therefore, we are considering mean as 0 and variance as 1 for error terms in all parts below.

```
import numpy as np
import matplotlib.pyplot as plt
from statsmodels.graphics.tsaplots import plot_acf,plot_pacf
from statsmodels.tsa.stattools import adfuller
```

```
/usr/local/lib/python3.7/dist-packages/statsmodels/tools/_testing.py:19: FutureWarnir
  import pandas.util.testing as tm
```

Defining ADF, mean and autocovariance functions.

```
#Stationarity Check
def perform_adf_test(series):
    result = adfuller(series)
    print('ADF Statistic: %f' % result[0])
    print('p-value: %f' % result[1])
```

```
#Defining function to calculate mean
def meanfunction(arr):
  sum=0
  for i in arr:
    sum += i
  meanvalue = sum/len(arr)
  return meanvalue
```

```
#Defining function to calculate autocovariance
def autocovariance(a,n,lag,mean):  # n=len of data
    autocov = 0
    for i in np.arange(0, n-lag):
        autocov += ((a[i+lag])-mean)*(a[i]-mean)
    return (1/(n-1))*autocov
```

## Part (a)

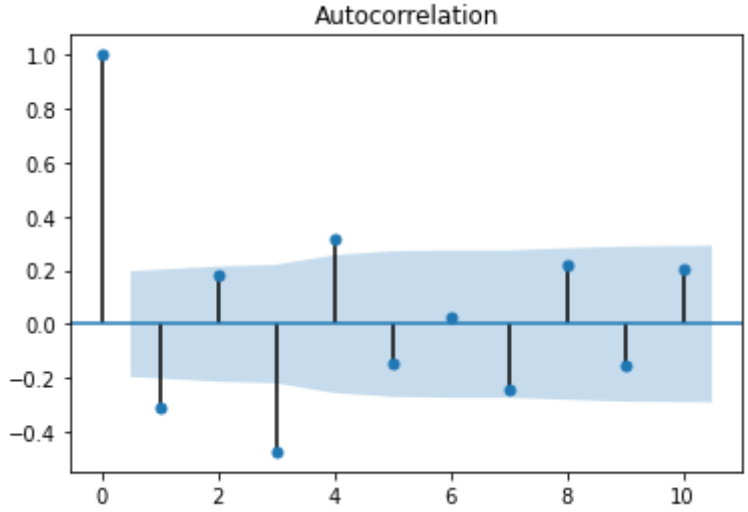
```
#creating error list
error_list=np.random.normal(0,1,103)
e=error_list
```

```
#Creating 100 Y observations

Y = []
for i in range(100):
  Yt = e[i+3] - e[i]
  Y.append(Yt)


#Check stationarity
perform_adf_test(Y)

     ADF Statistic: -4.552389
     p-value: 0.000158
```

*Since p-value is well below 0.05, thus we can say that the data set is stationary data set.*

Now, since, data set is stationary, we can give mean and autocovariance function.

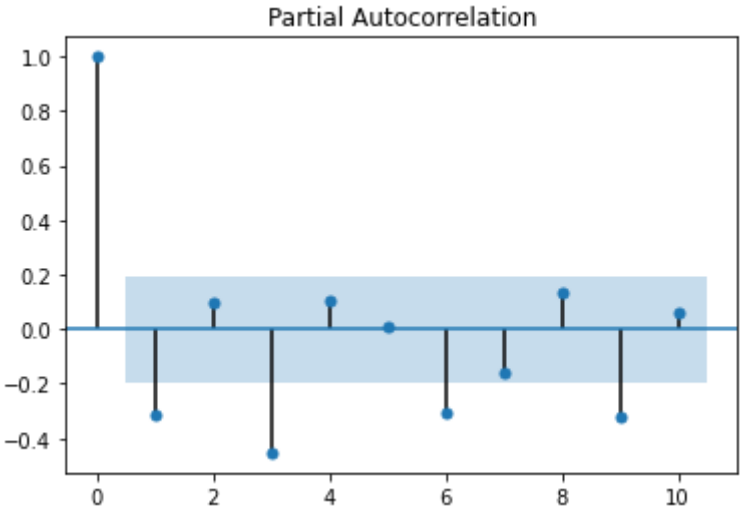
```
#Mean Function
mean=meanfunction(Y)
print("The mean of the dataset is: ",mean)

     The mean of the dataset is:  -0.02804511495127577


#Autocovariance Function
a=autocovariance(Y,100,1,mean)
print("The Autocovariance of the dataset is: ",a)

     The Autocovariance of the dataset is:  -0.8254429799872585


#Plotting ACF
plot_acf(Y,lags=10)
plt.show

     <function matplotlib.pyplot.show>
```




```
#plotting PACF
```

```
plot_pacf(Y,lags=10)
plt.show
```

```
<function matplotlib.pyplot.show>
```




## Part (b)

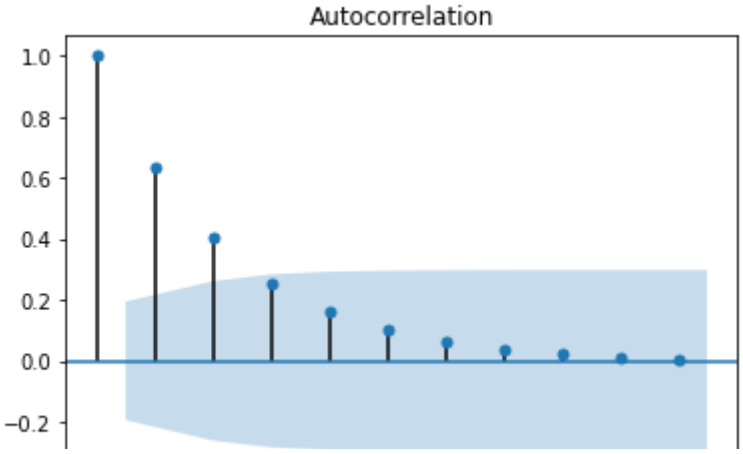
```
#creating error list

error_list=np.random.normal(0, 1, 102)
e=error_list


#assuming random 2 intial values for Y

Y=list(np.random.randint(0,100,2))


#Creating 100 Y observations

for i in range(2,102):
  Y.append(Y[i-1]+0.9*Y[i-2]+e[i])


#Check stationarity
perform_adf_test(Y)
```

```
ADF Statistic: 97048385424817968.000000
p-value: 1.000000
```

*Since p-value is above 0.05, thus we can say that the data set is non-stationary data set.*

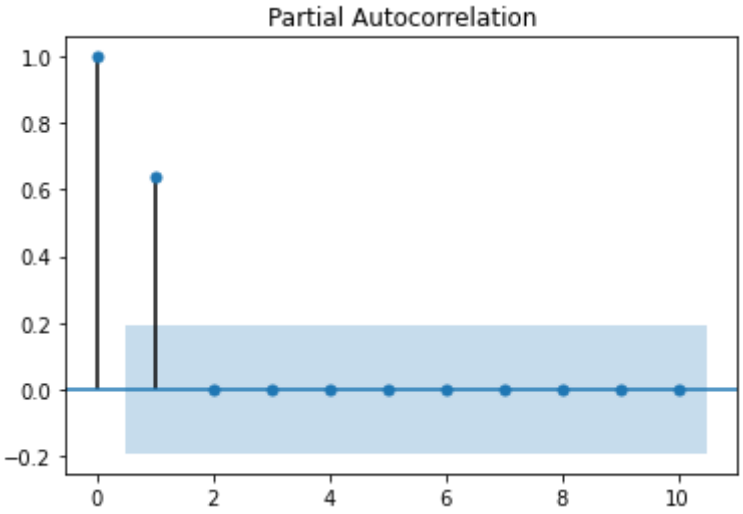
```
#Plotting ACF
plot_acf(Y,lags=10)
plt.show
```

```
<function matplotlib.pyplot.show>
```




```
#plotting PACF
plot_pacf(Y,lags=10)
plt.show
```

```
<function matplotlib.pyplot.show>
```




## Part (c)

```
#creating error list
error_list=np.random.normal(0,1,104)
e=error_list


#assuming random 4 intial values for Y
Y=list(np.random.randint(0,100,4))


#Creating 100 Y observations

for i in range(4,104):
  Y.append(0.7*Y[i-1]+0.2*Y[i-2]-0.1*Y[i-3]-0.3*Y[1-4]+e[i])



#Stationarity Check
```

```
perform_adf_test(Y)
```

```
ADF Statistic: -28.659329
p-value: 0.000000
```

*Since p-value is well below 0.05, thus we can say that the data set is stationary data set.*

Now, since, data set is stationary, we can give mean and autocovariance function.

```
#Mean Function
mean=meanfunction(Y)
print("The mean of the dataset is: ",mean)
```

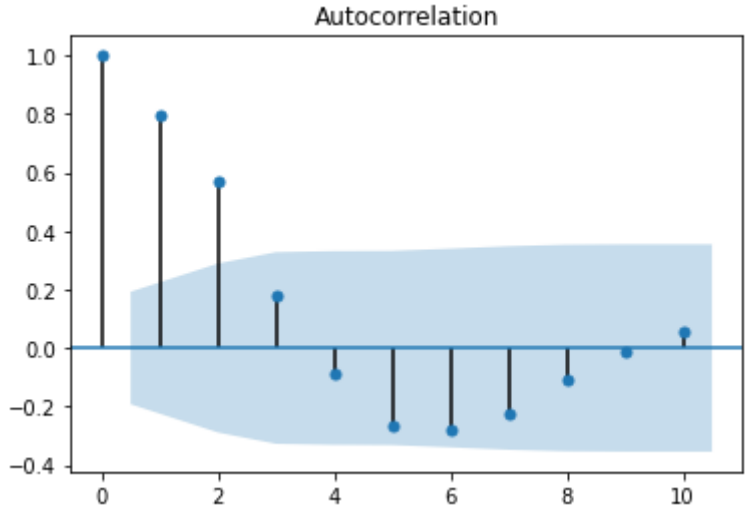
```
The mean of the dataset is:  2.37924256034017
```

```
#Autocovariance Function
a=autocovariance(Y,100,1,mean)
print("The Autocovariance of the dataset is: ",a)
```

```
The Autocovariance of the dataset is:  192.95591551861006
```

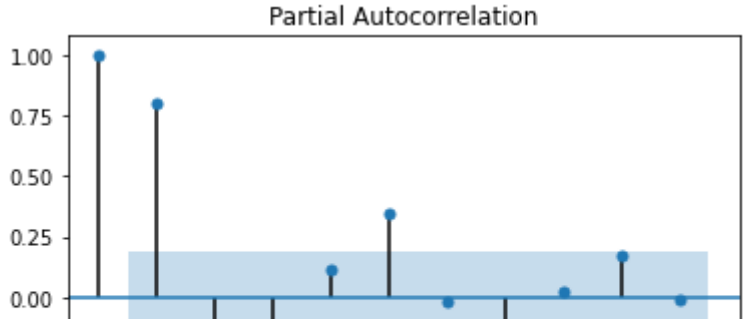
```
#plotting ACF
plot_acf(Y, lags=10)
plt.show
```

```
<function matplotlib.pyplot.show>
```




```
#plotting PACF
plot_pacf(Y,lags=10)
plt.show
```

```
<function matplotlib.pyplot.show>
```




## Part (d)

```
#creating error list
error_list=np.random.normal(0, 1, 100)
e=error_list


#Creating t list
t= list(range(1, 101))


#Y=t+et equation for 100 observations
Y=t+e


#Stationarity Check

perform_adf_test(Y)
```

```
ADF Statistic: 0.187821
p-value: 0.971570
```

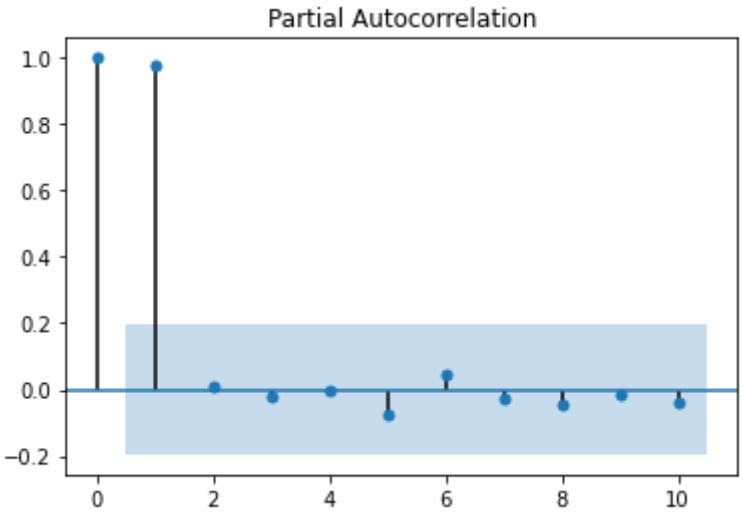
*Since p-value is above 0.05, thus we can say that the data set is non-stationary data set.*

```
#plotting ACF
plot_acf(Y,lags=10)
plt.show
```

```
<function matplotlib.pyplot.show>
```

```
#plotting PACF
plot_pacf(Y,lags=10)
plt.show
```

```
<function matplotlib.pyplot.show>
```




## Part (e)

```
#creating error list
error_list=np.random.normal(0,1,100)
e=error_list
```

```
#Y=et equation for 100 observations
Y=e
```

```
#check stationarity
perform_adf_test(Y)
```

```
ADF Statistic: -7.410084
p-value: 0.000000
```

*Since p-value is well below 0.05, thus we can say that the data set is stationary data set.*

Now, since, data set is stationary, we can give mean and autocovariance function.

```
#Mean Function
mean=meanfunction(Y)
print("The mean of the dataset is: ",mean)
```

```
The mean of the dataset is:  0.058438455058424085
```

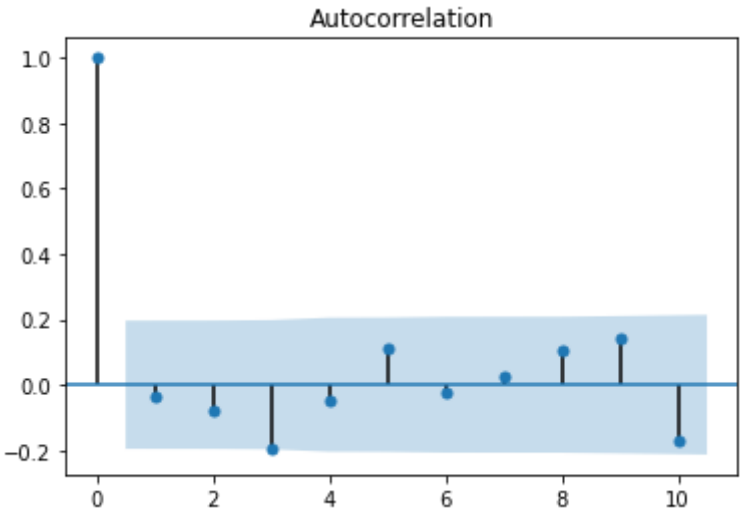
```
#Autocovariance Function
```

```
a=autocovariance(Y,100,1,mean)
print("The Autocovariance of the dataset is: ",a)
```

```
The Autocovariance of the dataset is:  -0.040108742882145665
```

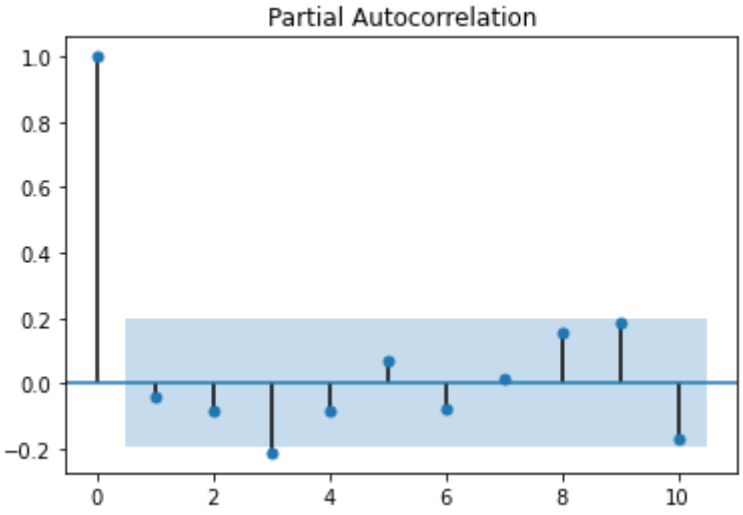
```
#plotting ACF
plot_acf(Y,lags=10)
plt.show
```

```
<function matplotlib.pyplot.show>
```




```
#plotting PACF
plot_pacf(Y,lags=10)
plt.show
```

```
<function matplotlib.pyplot.show>
```




## Part (f)

```
#creating error list
error_list=np.random.normal(0, 1, 102)
e=error_list
```

```
#Creating 100 Y observations
Y=[]
for i in range(2,102):
  Y.append(e[i-2]*e[i])


#Stationarity Check

perform_adf_test(Y)
```

```
     ADF Statistic: -8.900771
     p-value: 0.000000
```

*Since p-value is well below 0.05, thus we can say that the data set is stationary data set.*

Now, since, data set is stationary, we can give mean and autocovariance function.

```
#Mean Function
mean=meanfunction(Y)
print("The mean of the dataset is: ",mean)
```

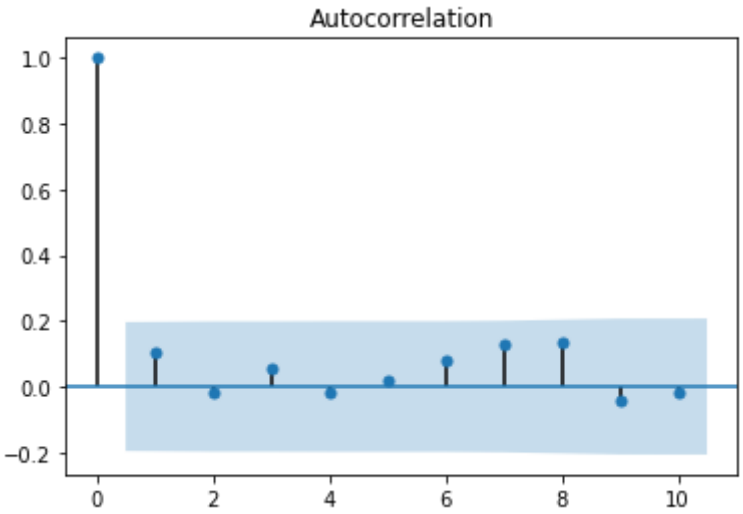
```
     The mean of the dataset is:  -0.008457438149399008
```

```
#Autocovariance Function
a=autocovariance(Y,100,1,mean)
print("The Autocovariance of the dataset is: ",a)
```

```
     The Autocovariance of the dataset is:  0.10267168074622507
```

```
#plotting ACF
plot_acf(Y, lags=10)
plt.show
```

```
     <function matplotlib.pyplot.show>
```




```
#plotting PACF
plot_pacf(Y,lags=10)
plt.show
```

```
<function matplotlib.pyplot.show>
```