Assignment 1 -Spirometry

1. **What parameters can be extracted from this data?**
Solution: Following parameters can be extracted from the flow rate and sampling rate data provided

1. FEV1: Forced expiratory volume in 1 second. It is the volume of air that can be forcefully expired in 1 second.
2. FVC: Forced Vital capacity. It refers to the amount of air that can be forcefully moved out of the lungs.
3. FEV1/FVC Ratio

2. **Using relevant measures comment on the status of the subjects' respiratory system and display relevant plots.**

Python Coding:

```
import pandas as pd

import numpy as np

import matplotlib.pyplot as plt


#importing and reading the txt files of the 3 subjects. Pls change the path if running

subj1_flow=pd.read_csv("J:\MTech Notes\Biomedical devices\Assignment 1\subj1.txt",names='f',engine='python')

subj2_flow=pd.read_csv("J:\MTech Notes\Biomedical devices\Assignment 1\subj2.txt",names='f',engine='python')

subj3_flow=pd.read_csv("J:\MTech Notes\Biomedical devices\Assignment 1\subj3.txt",names='f',engine='python')

#time axis for sampling rate of 500 Hz

b=np.linspace(0,4,2000)


#Plot 1: Flow rate vs Time graph

x1=b

y1=subj1_flow

plt.plot(x1, y1, label="Subject 1")
```

```
plt.xlabel("Time in sec")
plt.ylabel("Flow rate in L/sec")
plt.title("Subject 1")
plt.show()

x2=b
y2=subj2_flow
plt.plot(x2, y2, label="Subject 2")
plt.xlabel("Time in sec")
plt.ylabel("Flow rate in L/sec")
plt.title("Subject 2")
plt.show()

x3=b
y3=subj3_flow
plt.plot(x3, y3, label="Subject 3")
plt.xlabel("Time in sec")
plt.ylabel("Flow rate in L/sec")
plt.title("Subject 3")
```

#finding FVC by integrating to find Area under curve using Simpson numerical rule

```
def simpson(y,a,b,n):
    h=(b-a)/n
    p,q=0,0
    for i in range(0,2000):
        if(i%2!=0):
            p= p+y.loc[i]['f']
    for i in range(0,2000):
        if(i%2==0):
```

```
            q= q+y.loc[i]['f']
    fvc= (h/3)*((y.loc[0]['f']+y.loc[1999]['f'])+4*p+2*q)
    return round(fvc,5)
fvc=[]
for y in (subj1_flow,subj2_flow,subj3_flow):
    fvc.append(simpson(y,0,4,2000))
print ("FVC Value of Subj1, Subj2 and Subj3 respectively ", fvc )
```

#finding FEV1 by integrating using Simpson numerical rule till 1 sec

```
def fev1(y,a,b,n):
    h=(b-a)/n
    p,q=0,0
    for i in range(0,500):
        if(i%2!=0):
            p= p+y.loc[i]['f']
    for i in range(0,500):
        if(i%2==0):
            q= q+y.loc[i]['f']
    fev= (h/3)*((y.loc[0]['f']+y.loc[499]['f'])+4*p+2*q)
    return round(fev,5)

fev1_val=[]
for y in (subj1_flow,subj2_flow,subj3_flow):
   fev1_val.append(fev1(y,0,1,500))
print ("FEV1 Value of Subj1, Subj2 and Subj3 respectively ", fev1_val )
```

#finding FEV1/FVC value

```
from operator import truediv
ratio=list(map(truediv,fev1_val,fvc))
```

```
print ("FEV1/FVC ratio of Subj1, Subj2 and Subj3 respectively ", ratio )
```

#plot2: Flow rate vs volume curve

```
def volume(y):
    vol=[]
    vol.append(0)
    for i in range(1,2000):
        vol.append(y.loc[i]['f']*0.002+vol[i-1])
    return vol
x1=volume(subj1_flow)
y1=subj1_flow
plt.plot(x1, y1, label="Subject 1")

x2=volume(subj2_flow)
y2=subj2_flow
plt.plot(x2, y2, label="Subject 2")
x3=volume(subj3_flow)
y3=subj3_flow
plt.plot(x3, y3, label="Subject 3")
plt.xlabel("Volume in L")
plt.ylabel("Flow rate in L/sec")
plt.title("Flow rate vs Volume graph")
plt.legend()
plt.show()
```

#Plot 3: Volume vs time curve

```
x1=b
y1=volume(subj1_flow)
plt.plot(x1, y1, label="Subject 1")
```

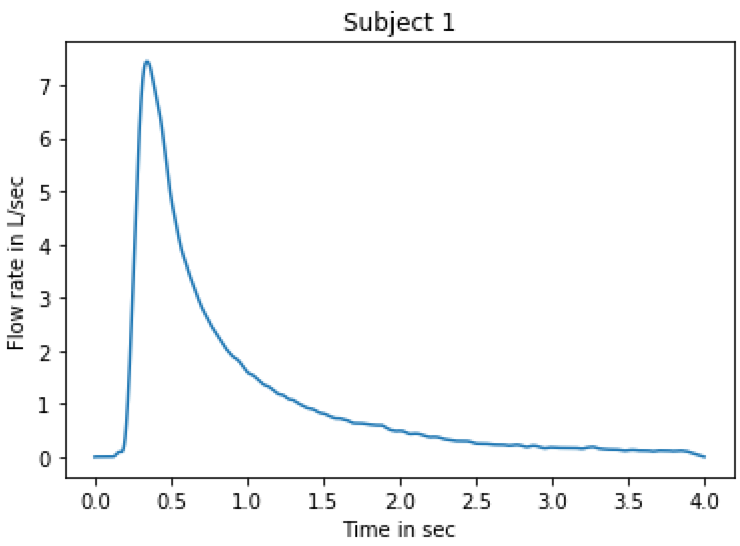
```
x2=b
y2=volume(subj2_flow)
plt.plot(x2, y2, label="Subject 2")
x3=b
y3=volume(subj3_flow)
plt.plot(x3, y3, label="Subject 3")
plt.xlabel("Time in sec")
plt.ylabel("Volume in L")
plt.title("Volume vs Time graph")
plt.legend()
plt.show()
```

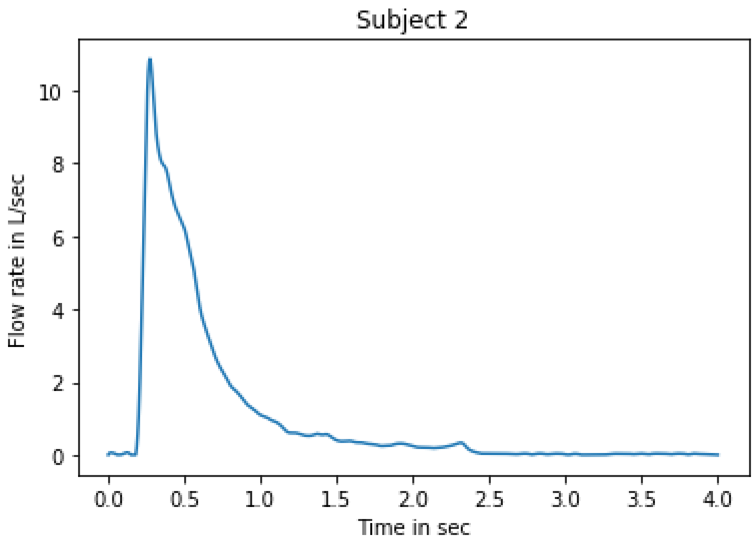
Parameter values extracted from the data given:

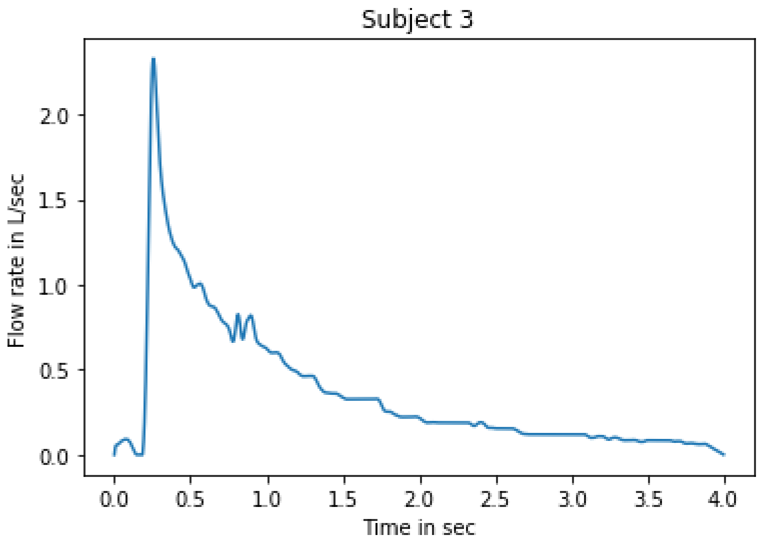
Parameters	**Subject 1**	**Subject 2**	**Subject 3**
FEV1	3.02843	3.6518	0.83749
FVC	4.34994	4.27137	1.4526
FEV1/FVC	69.62	85.495	57.654

Relevant Plots:

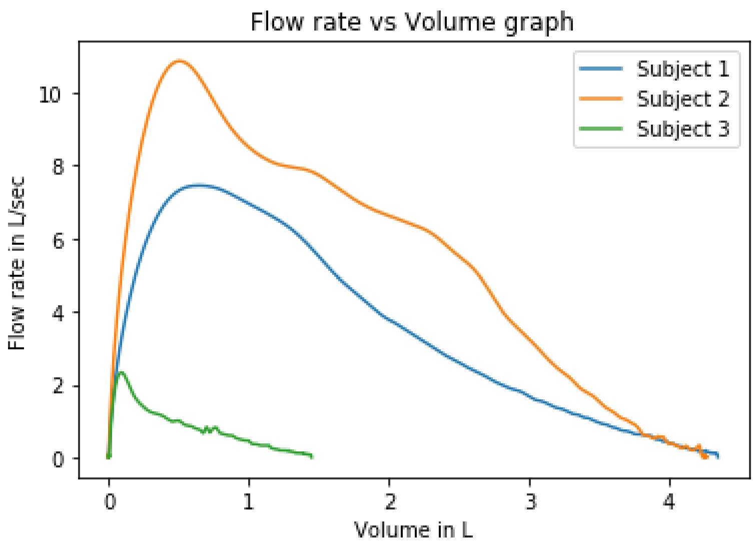
I. Flow rate(L/sec) vs time (sec):



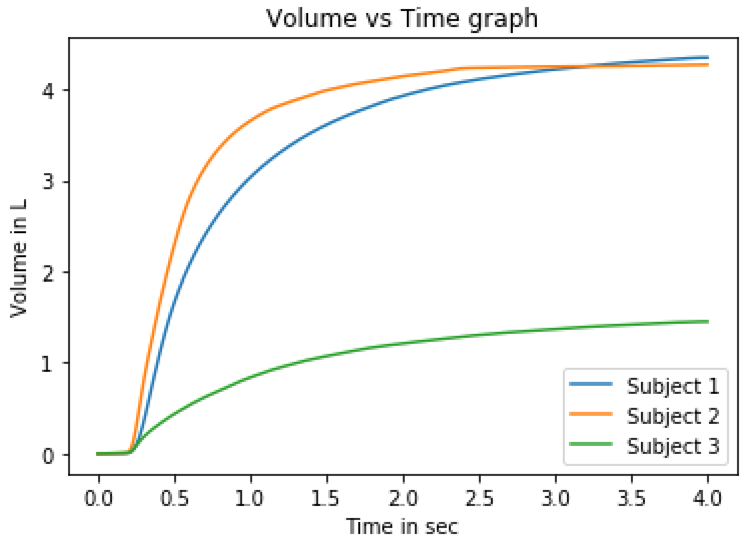




II. Flow rate vs Volume



III. Volume vs time graph



	Subject 1	Subject 2	Subject 3
Initial Interpretation From graphs	Mild Obstruction	Normal	Severe Obstruction+ Mild restriction
Reasoning	FEV1/FVC < 70% Abnormal (Slight concave)	FEV1/FVC >70%	1.FEV1/FVC << 70% 2.Shrink in Flow rate vs Volume graph 3. Spikes shows possibility of cough in Flow rate vs time graph

3. Can you comment on any disorders the subjects might have?

Solution:

Assuming the following parameters of all the 3 subjects:

Age: 24yrs

Height: 153 cms

Gender: Male

Step 1. Determining FEV1/FVC is low or not

Step 2. Determining FVC is low

Step 3. Determining the severity of abnormality wrt American Thoracic Society Grades for Severity of a Pulmonary Function Test

Referencing NHANES III (Hankinson -1999) and Global Initiative of Chronic Obstructive Lung Disease (GOLD) guidelines

Subject 1:

	FVC	FEV1	FEV1/FVC
Predicted	4.03	3.44	83.1%
Percent Predicted	107.7%	88%	84.0%
Lower limit of Normal	3.34	2.86	73.4%

Step1. FEV1/FVC < 70 %

Step 2: FVC > LLN

Step 3. FEV1 % of predicted > 70 %

Conclusion: Disorder can be Obstruction with mild severity

Subject 2:

	FVC	FEV1	FEV1/FVC
Predicted	4.03	3.44	83.1%
Percent Predicted	105.9%	106%	102.9%
Lower limit of Normal	3.34	2.86	73.4%

Step1. FEV1/FVC > 70 %

Step 2: FVC > LLN

Step 3. Not required

Conclusion: Normal with no disorder

Subject 3:

Parameters	FVC	FEV1	FEV1/FVC
Predicted	4.02	3.42	82.9%
Percent Predicted	36.1%	24.5%	69.5%
Lower limit of Normal	3.33	2.84	73.2%

Step 1. FEV1/FVC < 70 %

Step 2: FVC < LLN

Step 3. FEV1 % of predicted < 35 %

Conclusion: Disorder is both Obstructive and restrictive with very high severity.

Is the information available enough to differentiate between obstructive and restrictive lung diseases?

Solution: No. The information available can only give rough idea but is not enough to be 100% sure of the state of lungs or to differentiate between obstructive and restrictive disorder.

1. At least 3 rounds of spirometry results should be available per subject.
2. As shown in the results above, for the physician to determine the Predicted value of the subject he/she should have the below parameters before conducting the spirometry of the subject.
   Age
   Weight
   Height
   Gender

   Using the above parameters physician can easily determine Predicted value referring NHANES III (Hankinson -1999) or any other standard and then only can tell the deviation from the normal.

3. Apart from spirometry result to confirm restrictive and obstructive patterns detected other Pulmonary Function Test (PFT) and chest X-ray has to be performed to conclude on the disorders the subjects might be having.