Department of Electronic & Telecommunication Engineering
University of Moratuwa

BM2102 - Modelling and Analysis of Physiological Systems

Assignment 01
Simulation of Respiratory Mechanics

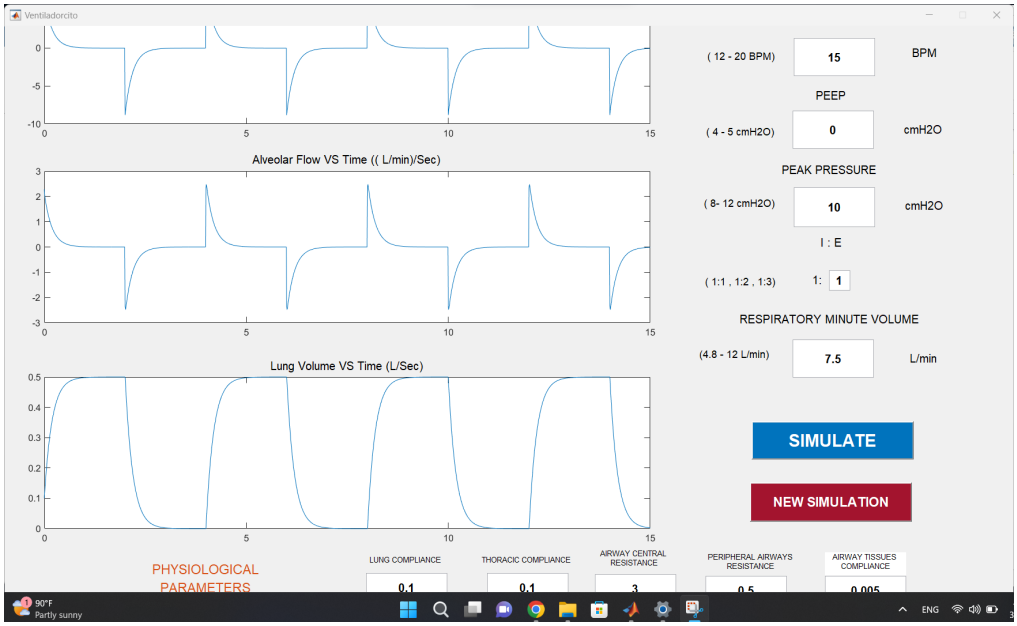
Nethmal W D I - 210421E

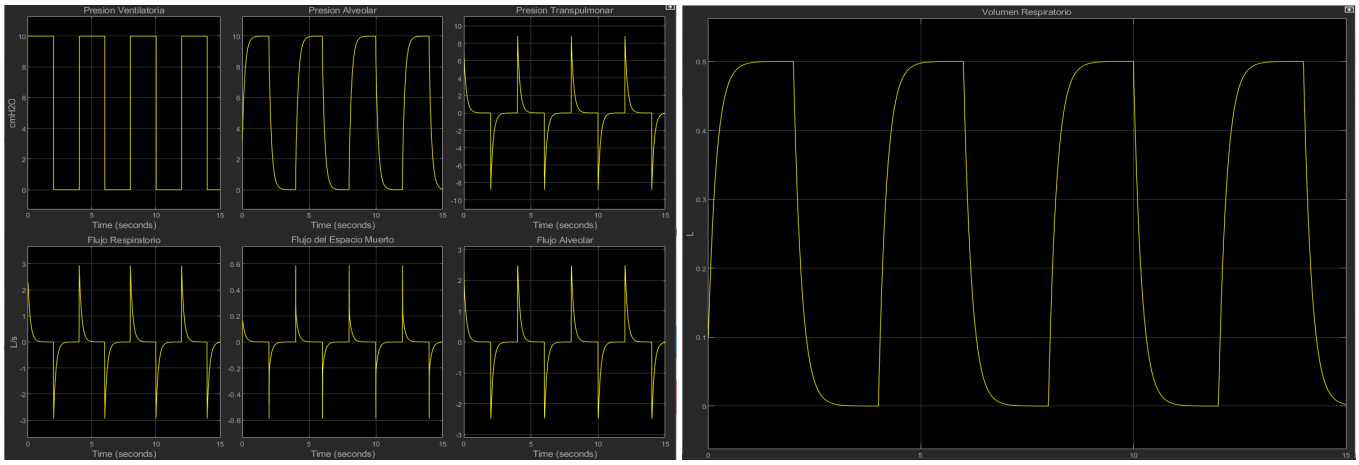
Contents

1 Normal Person

These are approximate values for the parameters of linear model respiratory system for a normal person.

1. Resistivity of central airways(Rc) = 1 cm H2O
2. Resistivity of peripheral airways(Rp) = 0.5 cm H2O
3. Compliance of lungs and chest wall(Cl and Cw) = 0.1
4. Shunt compliance = 0.005





Here above graphs shows the respiratory parameters for a normal person under ventilator conditions as below,
1)Breathing frequency= 15BPM 2)PEEP=0 3)Peak pressure=10

2 Restrictive pulmonary diseases

Restrictive pulmonary diseases are a group of respiratory conditions characterized by a reduced ability of the lungs to expand and fill with air. This limitation in lung expansion is often associated with changes in the lung parenchyma, chest wall, or pleura, making it challenging for the lungs to inflate properly during inhalation. As a result, the total lung capacity and vital capacity are typically decreased in individuals with restrictive pulmonary diseases.

Examples for restrictive pulmonary diseases include diseases such as Idiopathic Pulmonary Fibrosis, Sarcoidosis, Asbestosis, Silicosis etc.

Here we have chosen Idiopathic Pulmonary Fibrosis (IPF) which is a progressive and often fatal lung disease characterized by the formation of scar tissue in the lungs. The cause of the disease is unknown. IPF primarily affects the interstitium, the tissue that supports the alveoli in the lungs. As the disease progresses, the fibrotic tissue replaces normal lung tissue, leading to impaired lung function. This results in some changes in the normal parameters of the respiratory system.

- Lung Compliance: (Reducing)

  The fibrotic changes in the lung tissue make it stiff and less elastic. As a result, the lungs lose their ability to expand and contract easily during breathing.

- Thoracic Compliance:(Reducing)

  The stiffening of the lungs can impact overall thoracic compliance, especially in advanced stages or when associated with chest wall abnormalities.

- Airway Central Resistance: (Not affected)

  IPF primarily affects the interstitial tissue rather than the central airways.

- Peripheral Airway Resistance:(Not affected)

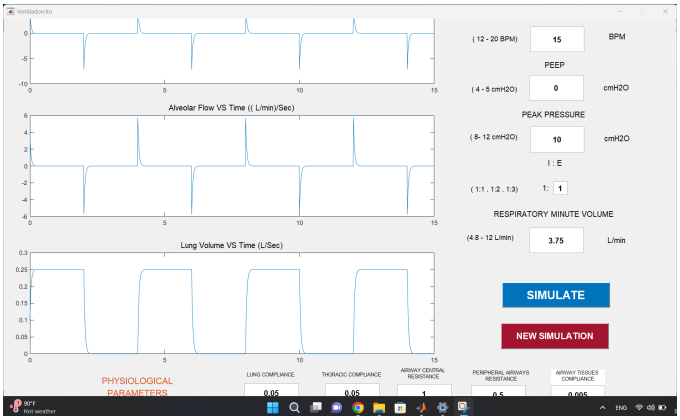
  IPF doesn't primarily involve the peripheral airways.

- Airway Tissue Compliance:(Not affected)

  The primary changes in IPF may not significantly affect the compliance of airway tissues

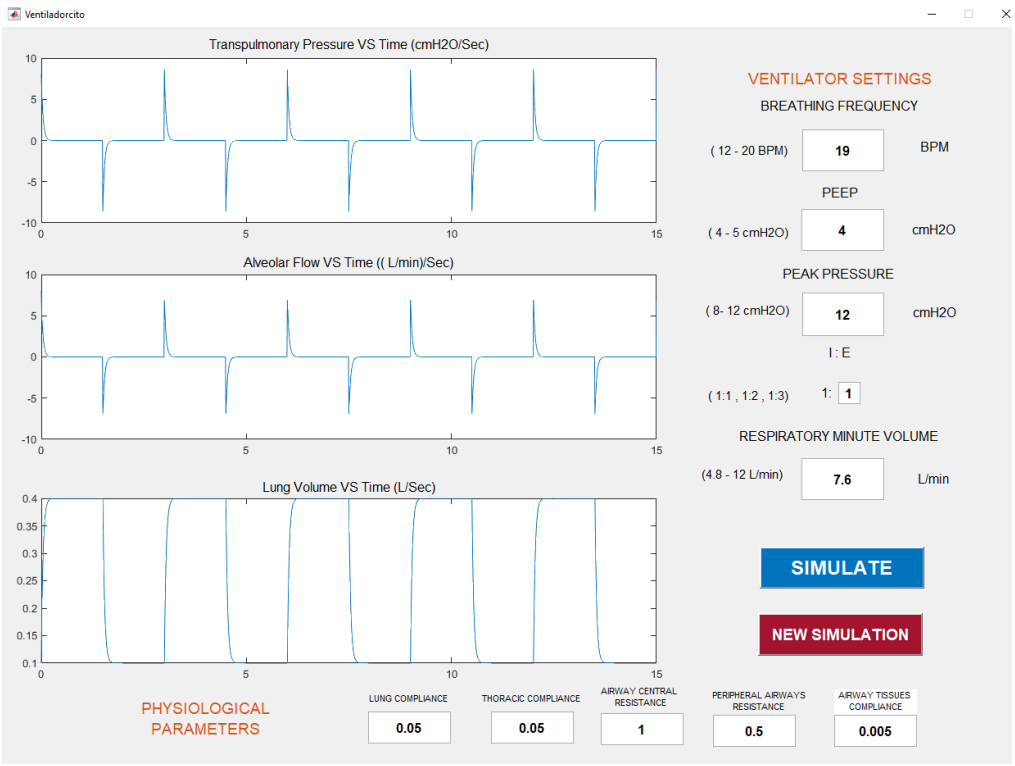
These are approximate values for the parameters for the linear model respiratory system to indicate a Restrictive pulmonary disease situation.

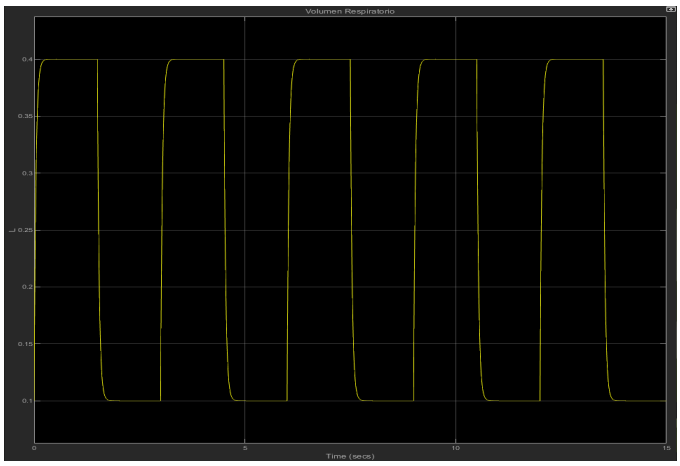
1. Resistivity of central airways(Rc) = 1 cm H2O
2. Resistivity of peripheral airways(Rp) = 0.5 cm H2O
3. Compliance of lungs and chest wall(Cl and Cw) = 0.05
4. Shunt compliance = 0.005

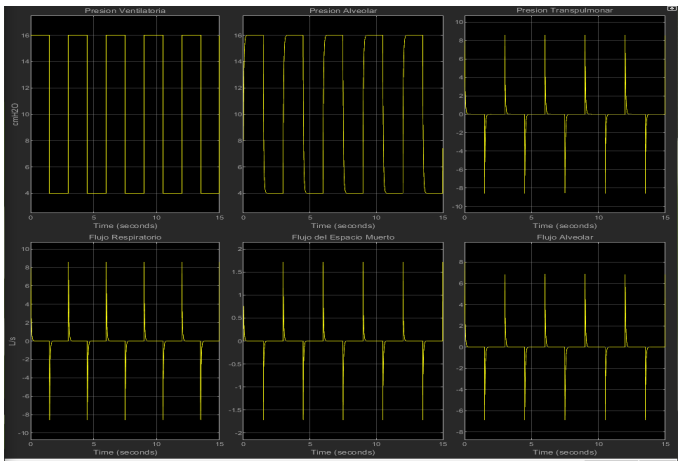


Here above window shows the respiratory parameters for a normal person under ventilator conditions as below,
1)Breathing frequency= 15BPM 2)PEEP=0 3)Peak pressure=10

It clearly indicates that the respiratory minute volume has been reduced in Restrictive pulmonary disease under the above ventilator conditions and the below values will give better results.
1)Breathing frequency= 19BPM 2)PEEP=4 3)Peak pressure=12







3 Obstructive pulmonary diseases

These are a group of respiratory conditions characterized by increased resistance to airflow due to narrowing or obstruction of the airways. This obstruction makes it difficult for individuals to exhale air effectively, leading to a prolonged expiration and increased residual volume in the lungs.

Examples for obstructive pulmonary diseases such as Chronic Bronchitis, Emphysema, Asthma, Bronchiectasis etc.

In this report, we consider Chronic Bronchitis for further modeling approximations. This is a type of Chronic Obstructive Pulmonary Disease (COPD) characterized by persistent inflammation of the bronchial tubes accompanied by excessive mucus production. This leads to chronic cough, increased sputum production, and airflow limitation. This results in some changes in normal parameters of the respiratory system.

- Lung Compliance:(Not affected)

  Chronic Bronchitis primarily affects the airways, and the compliance of the lung tissue itself is not significantly compromised.

- Thoracic Compliance:(Not affected)

  Unless there are concurrent chest wall abnormalities, the compliance of the thoracic cage remains relatively normal.

- Airway Central Resistance; (Increases)

  Chronic inflammation and bronchoconstriction lead to narrowing of the central airways, resulting in increased resistance to airflow during exhalation.

- Peripheral Airway Resistance: (Increases)

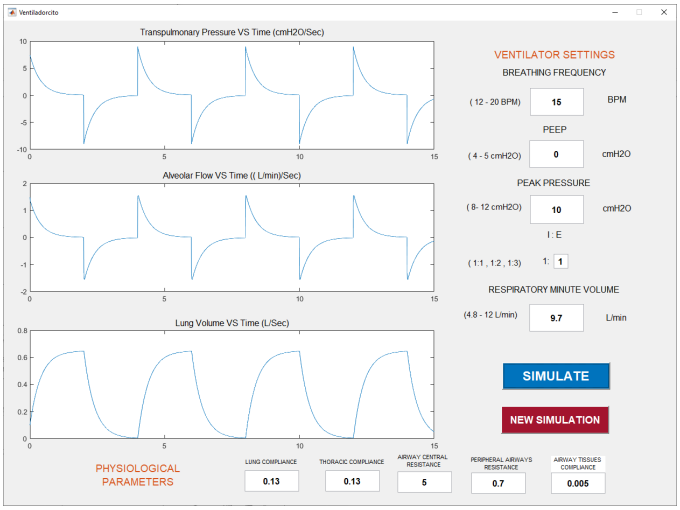
  Excessive mucus production and inflammation in the smaller airways contribute to increased resistance, particularly during expiration.

- Airway Tissue Compliance: (Not affected)

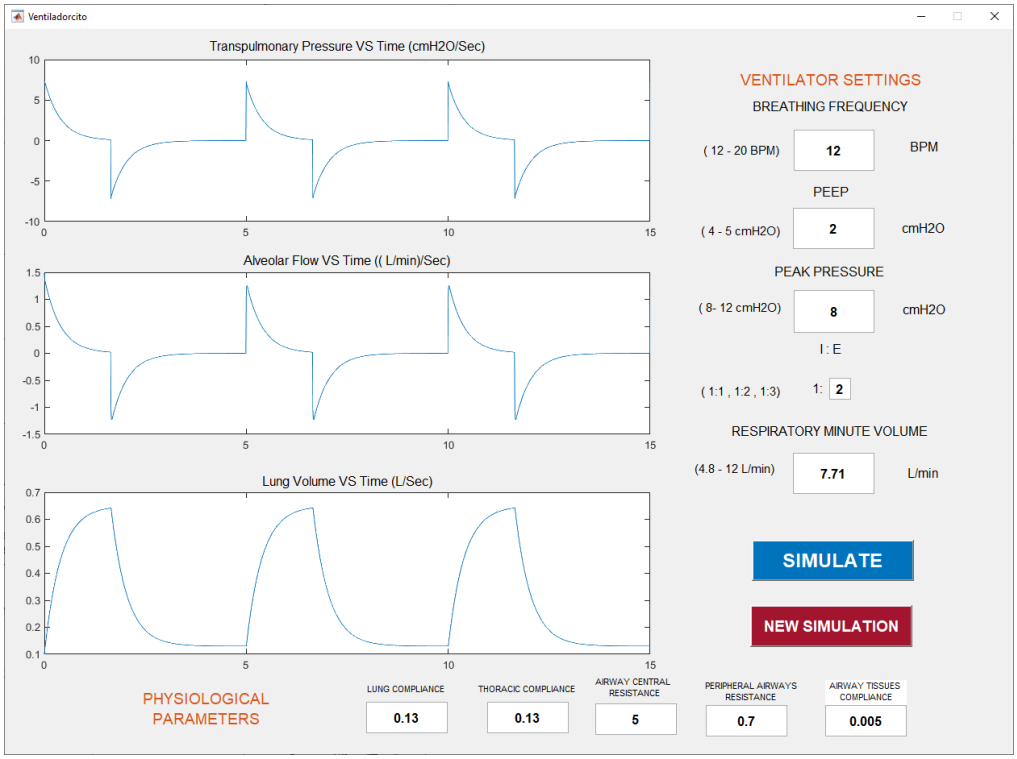
  The primary changes in Chronic Bronchitis are in the airway lumen due to inflammation and mucus, and the compliance of

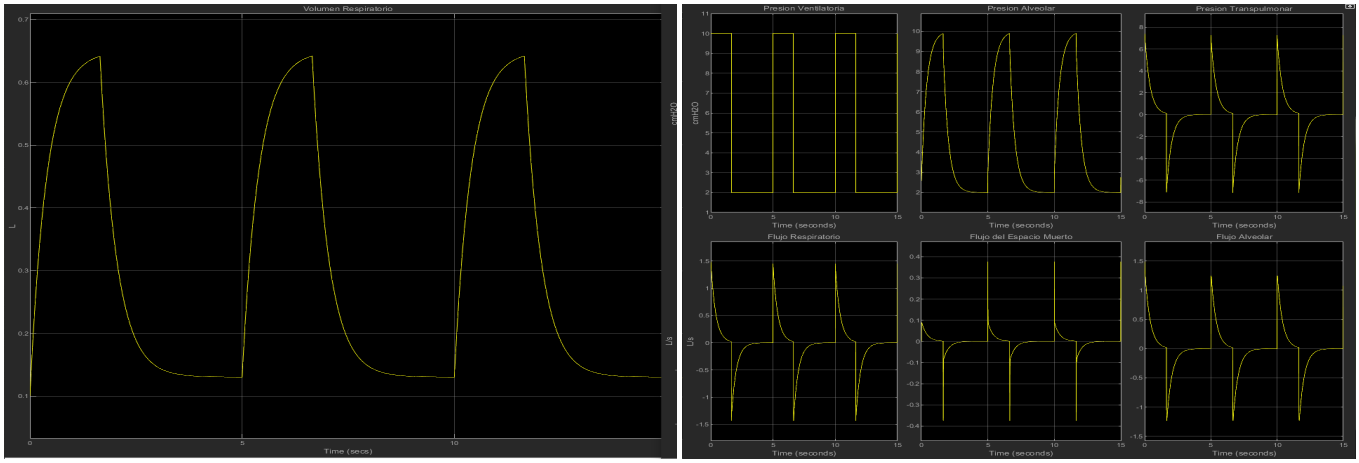
These are approximate values for the parameters for the linear model respiratory system to indicate an Obstructive pulmonary disease situation under earlier ventilator conditions.

1. Resistivity of central airways(Rc) = 5 cm H2O
2. Resistivity of peripheral airways(Rp) = 0.7 cm H2O
3. Compliance of lungs and chest wall(Cl and Cw) = 0.13
4. Shunt compliance = 0.005



Here we can see that by using the ventilator patient is having a good minute volume under new conditions.





Condition	**Minute Ventilation (L/min)**	**Deviation**
Normal	7.5	-
Restrictive Pulmonary Disease	3.75	Low
Obstructive Pulmonary Disease	9.7	High

Table 1: Deviation of the MV from the general conditions

4 Difference in MV for the same settings of the ventilator

Minute ventilation is a respiratory parameter that represents the total volume of air (in liters) that a person breathes in or out per minute. It is a measure of the respiratory rate multiplied by the tidal volume and is expressed in liters per minute . Despite consistent ventilator settings, MV can vary due to several factors.

- The patient's underlying condition is a critical determinant. Patients with different medical conditions may exhibit distinct respiratory rates and tidal volumes
- The ventilator's setting :Different ventilator models may yield varying MVs, even when set to the same parameters
- The patient's size and behaviours : physical of the patient and some trained behaviors affect the lung size.

References

[1] David Leonardo Rodriguez Sarmiento and Daniela Acevedo Guerrero (2020). Simulation of Respiratory Mechanics on Simulink with GUI, MATLAB Central File Exchange. Retrieved May 3, 2020.web