Task 1: Describe the following files

- Describe in words what setup_lung.m plots on lines 60-67

  Lines 60-67 generate a pair of random distributions, takes the average of their logs, and plots the relationship between blood flow and ventilation based on a given value of beta.

- Describe in words what cvsolve.m does

  cvsolve calculates the concentration of oxygen in venous blood based on Mdiff and camax.

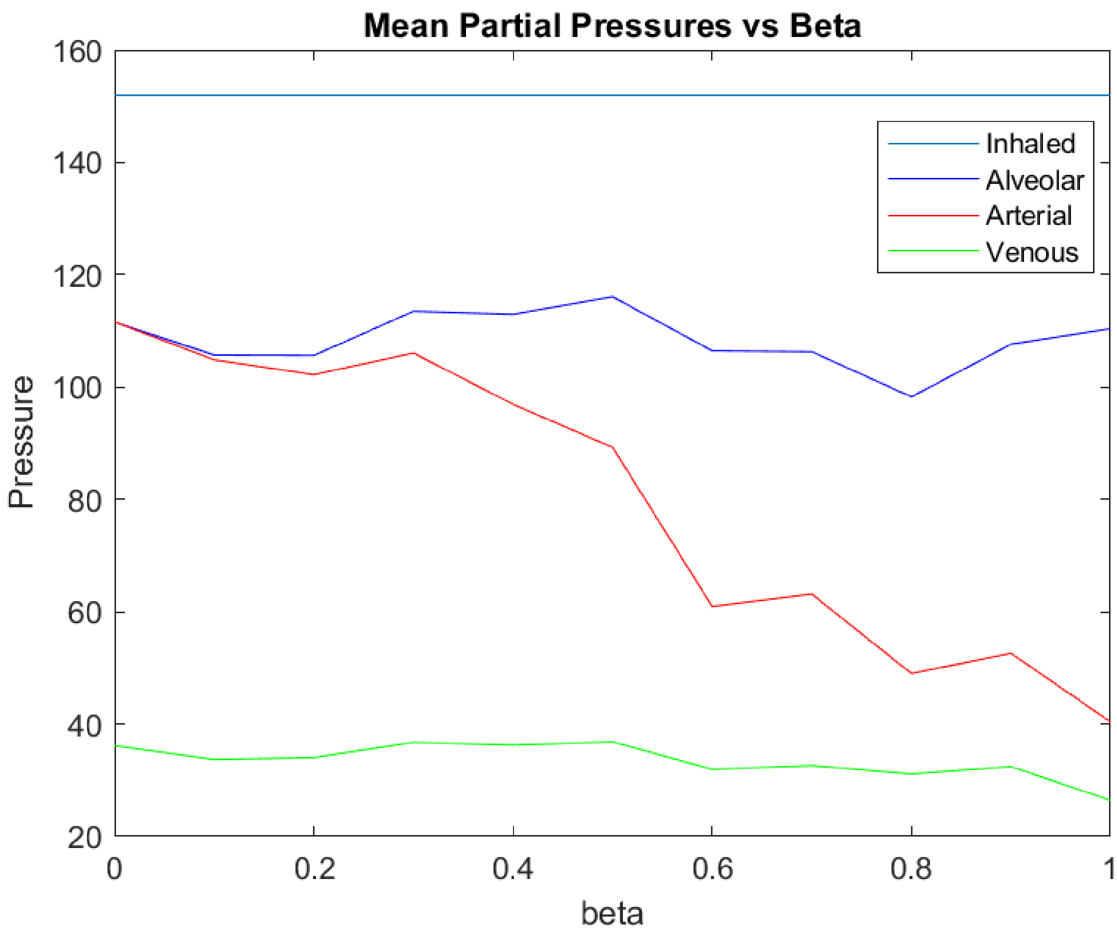
- Compare and contrast carterial.m and cvsolve.m

  carterial and cvsolve both follow essentially the same format, assigning an upper, mid, lower interval and correcting the signs along the function using a for loop. Some key differences would be that cvsolve has an error check for invalid Mdiff values, and carterial generates interval bounds using the zeros and ones functions.

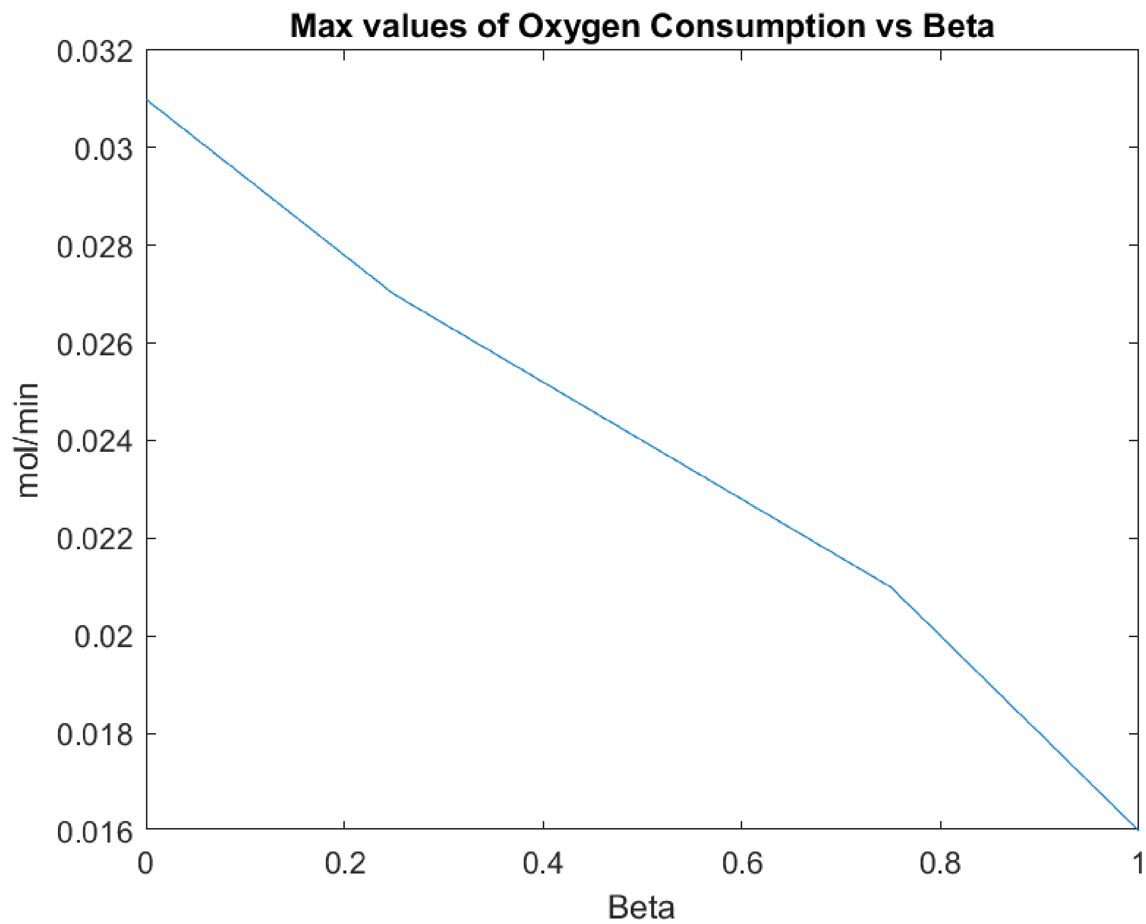
Task 2: The programs make it possible to study the consequences of changing the extent to which airflow and bloodflow are coordinated throughout the lung. What does beta = 0 represent in the model? Similarly, what does beta=1 represent? Hint: look at lines 60-67 in setup_lung.m

beta = 0 represents a completely homogeneous lung with no VQ mismatch due to a uniform distribution of equal R values across all of the alveoli. beta = 1 represents having maximum VQ mismatch since the deviation is so large that R values are completely different throughout the lung and V shares no correlation with Q.

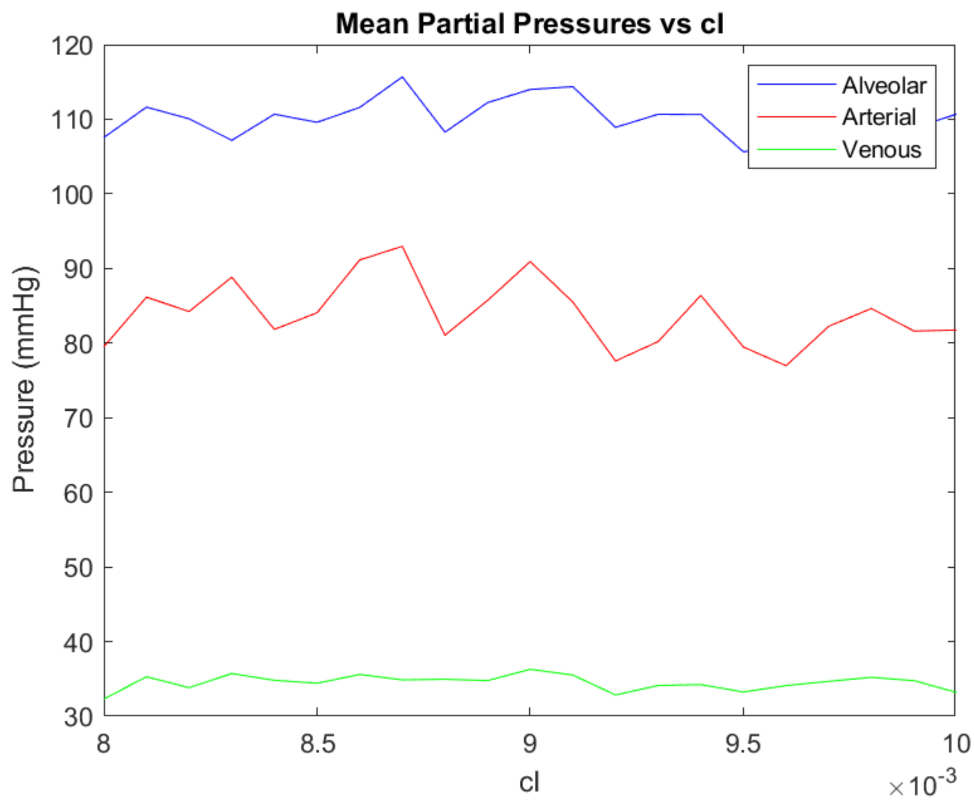
Task 3: Modify the code so you can run the experiments with various beta values. Plot the inspired partial pressure of oxygen, mean alveolar partial pressure of oxygen, the mean arterial partial pressure of oxygen, and the venous partial pressure of oxygen, all on the same graph as functions of beta. Explain the results in terms of the theory developed in this chapter.

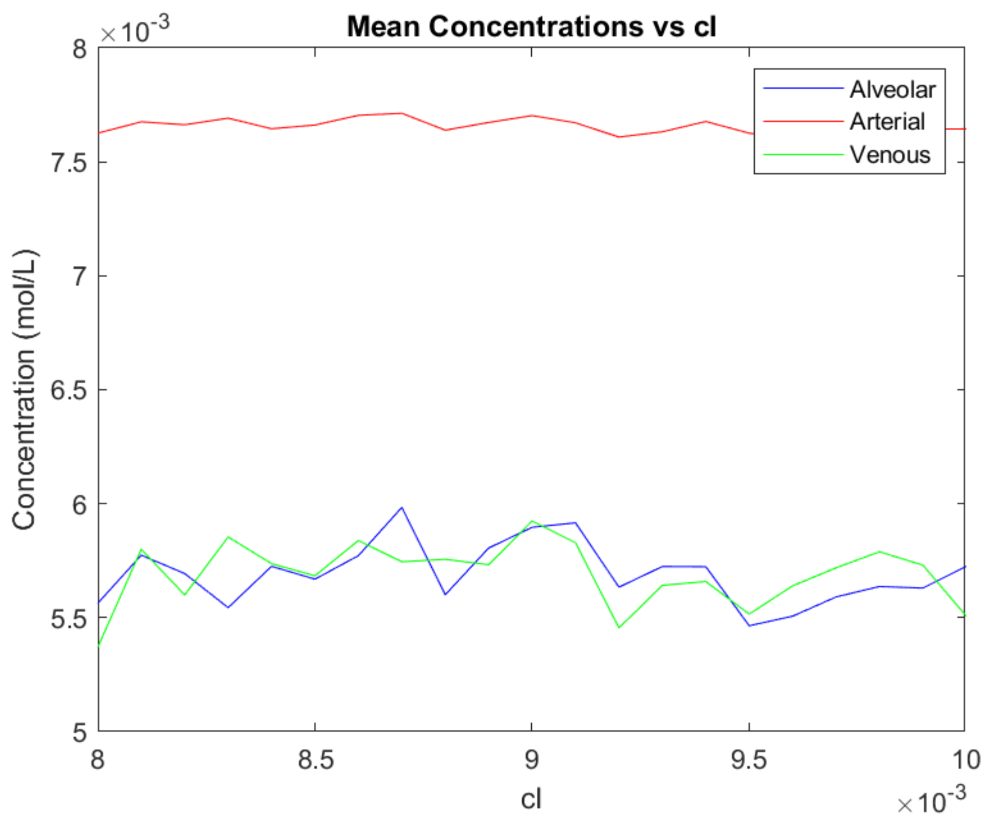


Task 4: We can also ask, what is the maximum sustainable rate of oxygen consumption for a given set of parameters, and how does it depend on the extent to which ventilation is matched to perfusion? To study this, use trial and error to find the maximum sustainable rate of oxygen consumption for each of several values of beta, and plot this rate as a function of beta. (Recall that the program will stop with an error message if the assumed rate of oxygen consumption is too high.) Keep all parameters other than beta and M constant throughout this study.

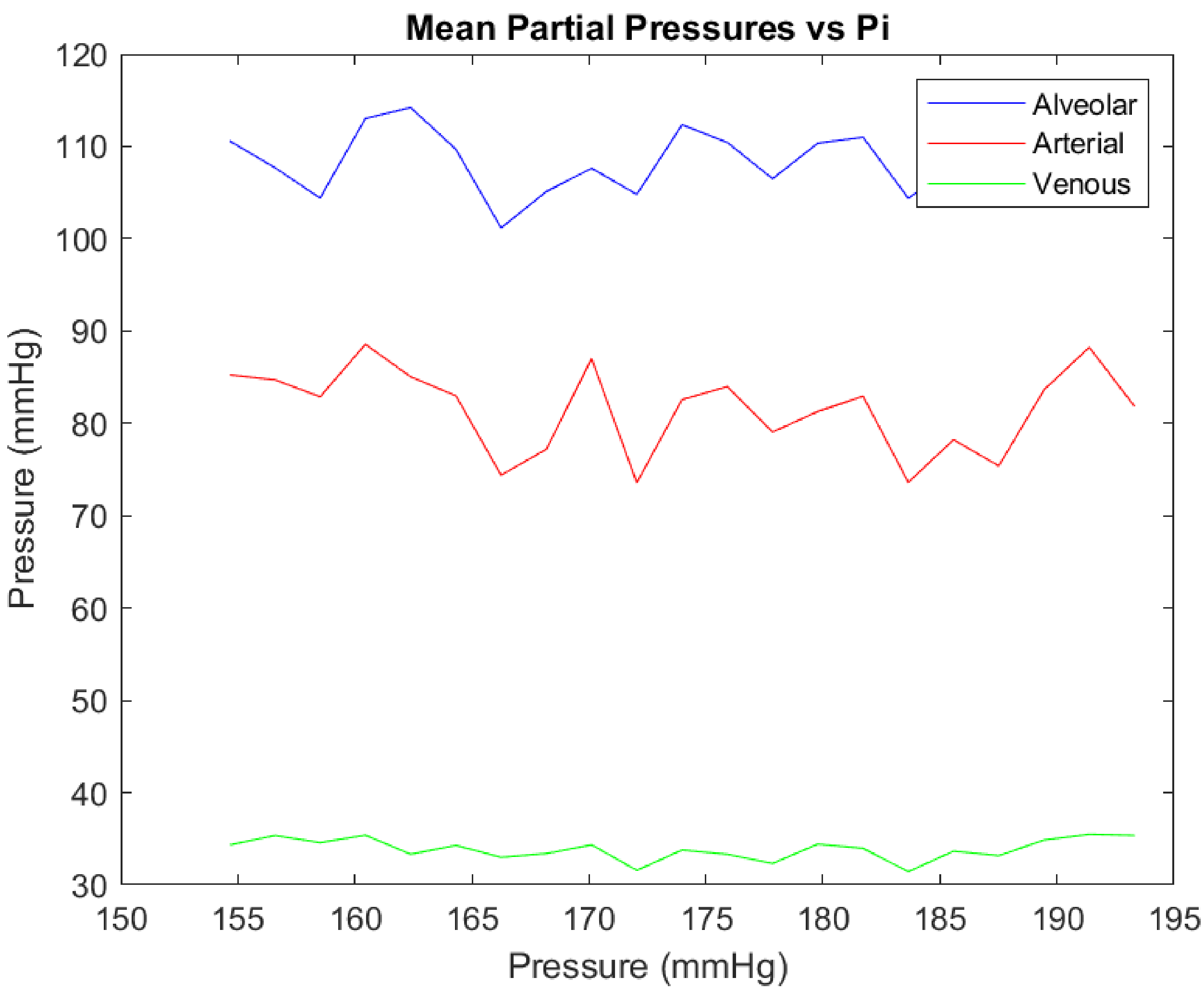


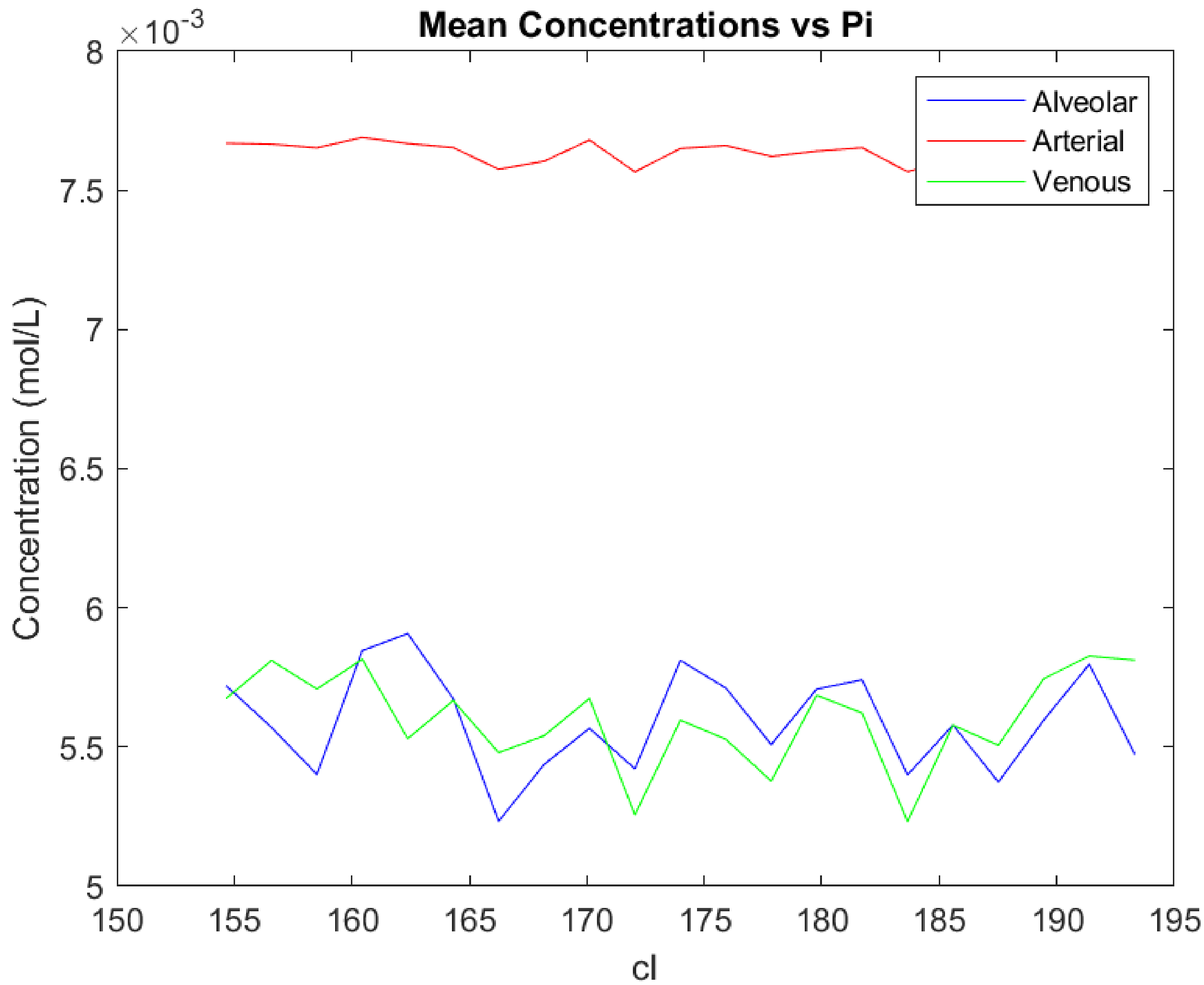
Task 5: Now consider the effects of altitude, with and without adaptation. The primary change at altitude is a reduction in the inspired partial pressure of oxygen, and also, therefore, in the corresponding concentration of oxygen in the inspired air. You can use the inspired concentration or partial pressure of oxygen as your principal independent parameter for this study. First vary cI with all other parameters constant to see the effects of acute exposure to altitude. Plot the mean alveolar, mean arterial, and venous partial pressures and concentrations of oxygen as functions of the cI.


Mean Partial Pressures vs cl
Pressure (mmHg)
120
110
100
90
80
70
60
50
40
30
8
8.5
9
9.5
10
cl
$\times 10^{-3}$
Alveolar
Arterial
Venous


$\times 10^{-3}$
Mean Concentrations vs cl
Concentration (mol/L)
8
7.5
7
6.5
6
5.5
5
8
8.5
9
9.5
10
cl
$\times 10^{-3}$
Alveolar
Arterial
Venous

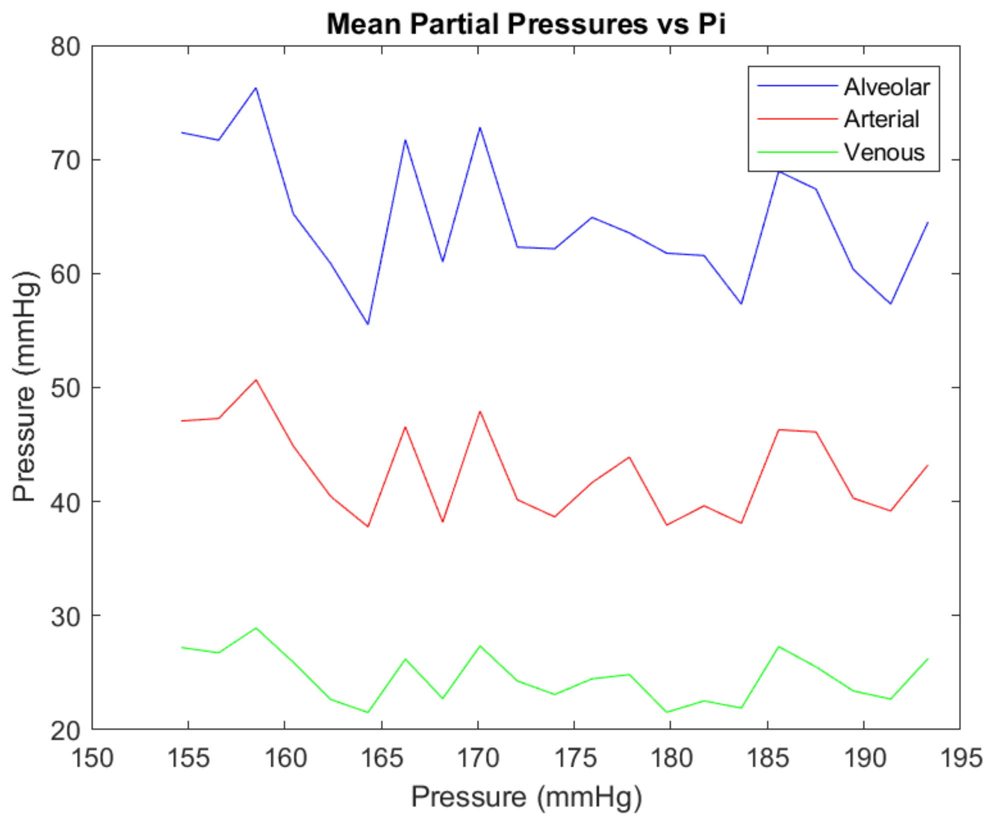
Task 6: Convert your plots such that you plot the results as a function of altitude (instead of cl). At what altitude does it become impossible to sustain the normal resting rate of oxygen consumption (without breathing harder or increasing the cardiac output)? These results are for a person adapted to sea level.

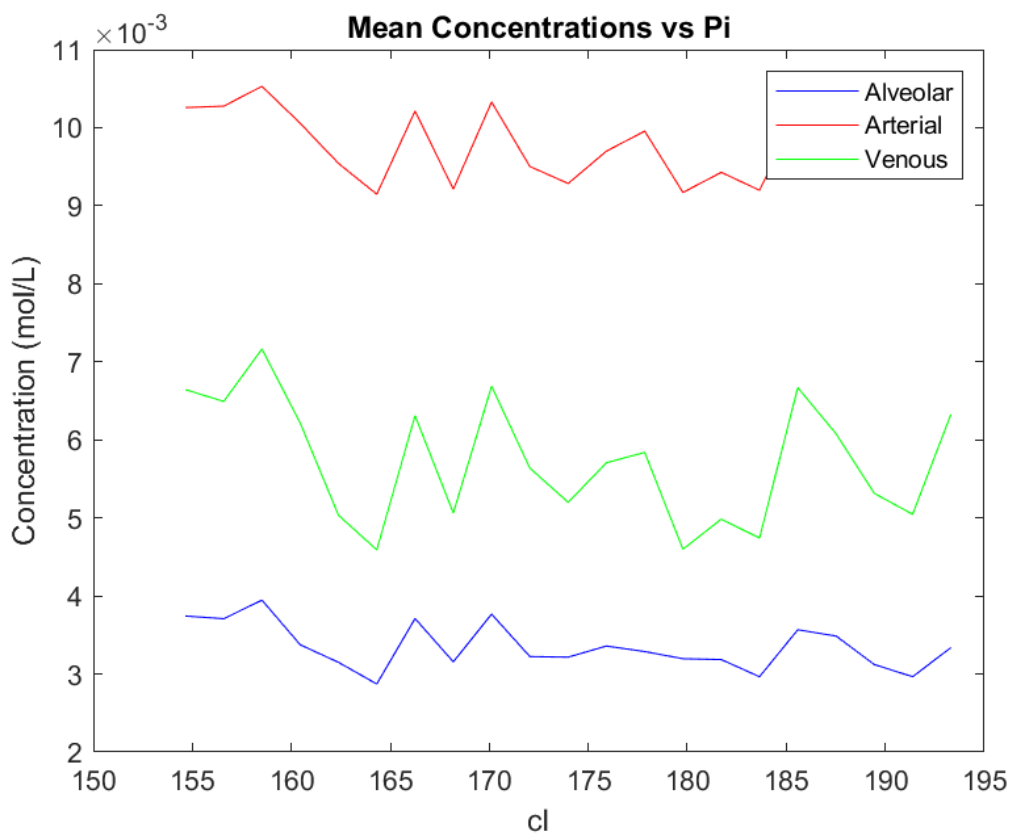




The maximum altitude I got was a partial pressure of 152 mmHg.

Task 7: Now let's evaluate someone who has been living at high enough altitude for so long that his/her red blood cells make up 60% of the blood volume instead of the usual 40%. To do so, set cstar=l.5*cref instead of cstar=cref. At what altitude does it become impossible even for this altitude-adapted person to sustain the normal resting rate of oxygen consumption (without breathing harder or increasing cardiac output)? Compare the results obtained for this altitude-adapted person to those obtained above for a person who lacks such adaptation to altitude.


Mean Partial Pressures vs Pi
Alveolar
Arterial
Venous
Pressure (mmHg)
80
70
60
50
40
30
20
150
155
160
165
170
175
180
185
190
195
Pressure (mmHg)

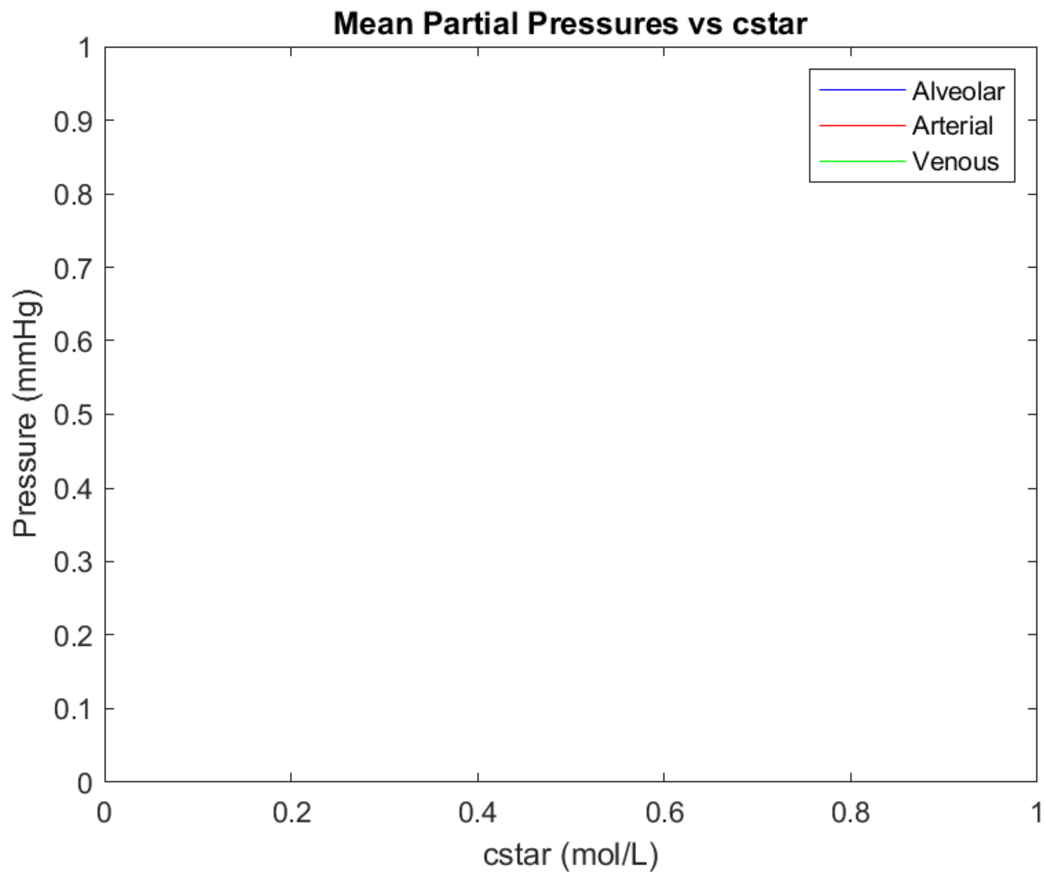

Mean Concentrations vs Pi
$\times 10^{-3}$
Alveolar
Arterial
Venous
Concentration (mol/L)
11
10
9
8
7
6
5
4
3
2
150
155
160
165
170
175
180
185
190
195
cl

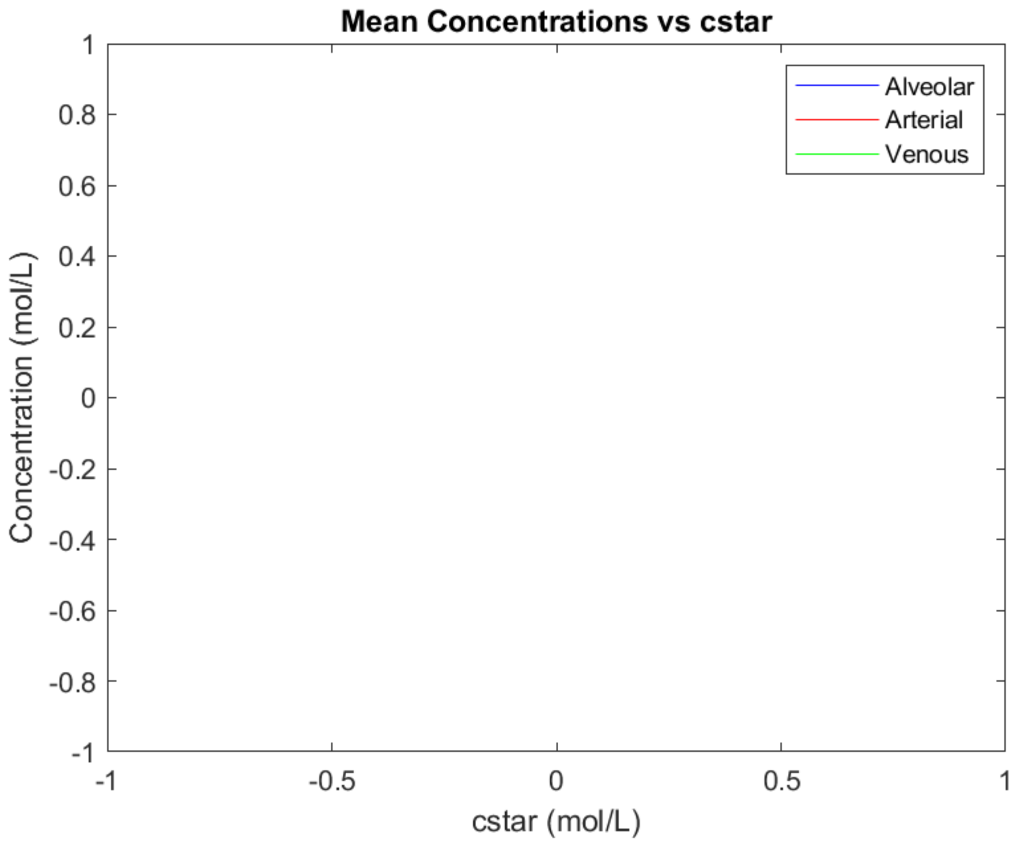
Task 8: Say I (someone used to living at sea level), fly to Peru and unfortunately get a pulmonary embolism on the flight. This causes regions of my lungs to be hypoperfused. What is the effect on ventilation-perfusion matching? Revisit your results in Task 6 for this case.

VQ mismatch increases as that part of the person's lungs experiences hypoperfusion since the rate of blood flow will decrease locally, lowering the R (V/Q) in those regions. This results in a less uniform distribution of R values across the lung as a whole, which is a metric of low efficiency.

Task 9: Another condition involving a change in the hemoglobin concentration in blood is anemia. To simulate anemia in our model, simply reduce cstar while keeping all other parameters constant. Plot the inspired, mean alveolar, mean arterial, and venous partial pressures and concentrations of oxygen as functions of cstar as that parameter is reduced below cref while all other parameters are held at their normal resting (sea-level) values.

What is the minimum value of cstar at which the normal resting rate of oxygen consumption can be maintained (without breathing harder or increasing cardiac output). How do these results depend on the ventilation-perfusion mismatch parameter beta? (Repeat the study for several different beta to find out.)





The minimum value occurred at a cstar of 0.008 (I simply can not troubleshoot this any further). This depends on the VQ mismatch beta in that a higher beta would decrease the maximum oxygen consumption that the blood is capable of.

Task 10: Revisit your findings in Task 6 for a patient who is anemic.

For an anemic patient, the maximum altitude at which it becomes impossible to sustain a normal resting rate of oxygen consumption would be lower than normal, since their blood cells are less efficient at carrying oxygen on average. They need to breathe harder or achieve a higher cardiac output to accomplish the same rate of oxygen consumption, so having less oxygen molecules the higher the altitude they go would be very punishing on the pulmonary system.