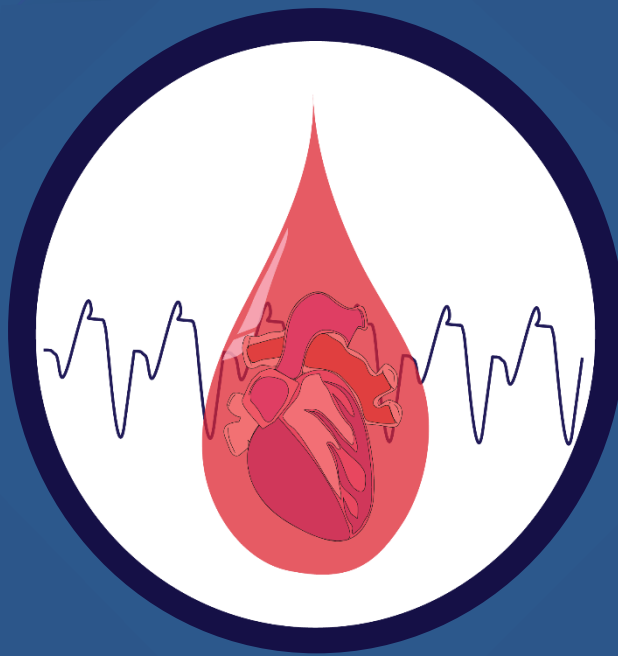


BLOODSIM



User Manual

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Chapter 1 – Introduction

The BloodSim user interface is built with minimal complexity and is straight forward in obtaining user inputs and displaying the waveforms. Simulating blood pressure and flow waveforms is made easy, and is organized into a menu bar, three dock widgets and two PyQt graphs.

BLOODSIM OVERVIEW

BloodSim is developed entirely in python and is designed to simulate the pressure and flow of blood in any part of the arterial tree. Effect of stenosis on the blood pressure and flow is modelled. In addition to the simulation of blood in the arterial tree, the software also simulates the volume and flow waveforms of blood in the cardiac system, i.e. the heart chambers, valves and the vessels that deliver blood to and from the heart.

Currently, BloodSim is able to simulate the blood behaviour in the following anatomical locations,

1. Ascending aorta
2. Aortic arch
3. Subclavian artery
4. Common carotid
5. Thoracic aorta
6. Cerebral artery
7. Abdominal aorta
8. Brachial artery
9. Hepatic artery

- 10. Renal artery
- 11. Femoral artery
- 12. Ulnar artery
- 13. Heart Chambers
 - a. Left atrium
 - b. Right atrium
 - c. Left ventricle
 - d. Right ventricle
- 14. Heart valves
 - a. Mitral valve
 - b. Tricuspid valve
 - c. Aortic valve
 - d. Pulmonary valve
- 15. Vessels to and from the heart
 - a. Vena cava
 - b. Pulmonary artery
 - c. Aorta
 - d. Pulmonary veins

ABOUT THE USER MANUAL

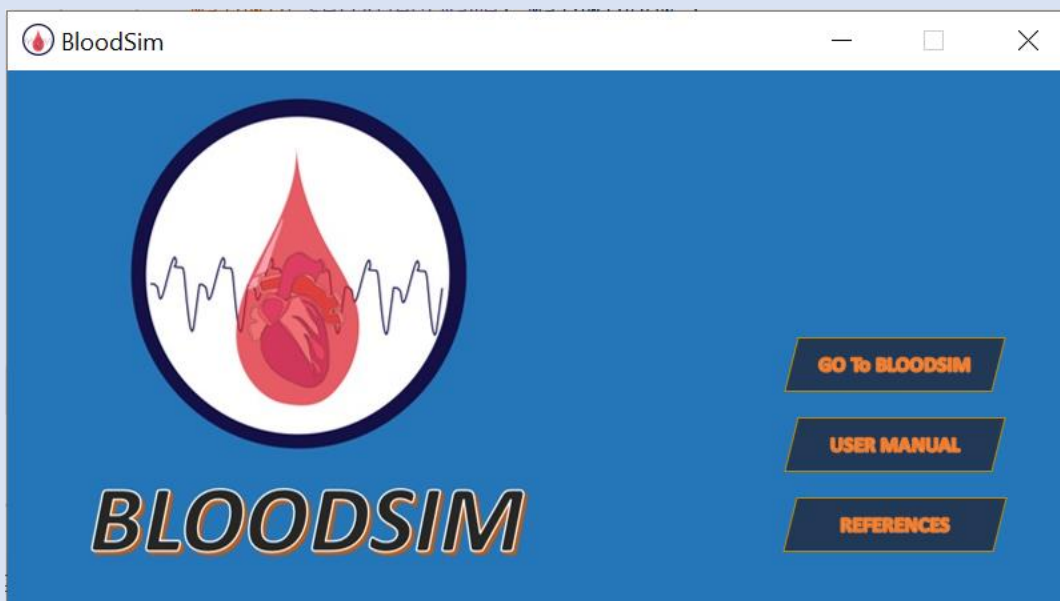
The user manual covers all the features in BloodSim. First about the installation procedures, on how to install BloodSim and the installation files. Then the user manual discusses about the interface, and what each section and icon do. The next section is about the different menu bar options and the three dock widgets and their use. The final section is about the simulation and graph options.

Chapter 2 – Get Started

Home window

The home window appears once the application is opened, and has three options,

1. Go to BloodSim
2. User manual
3. References

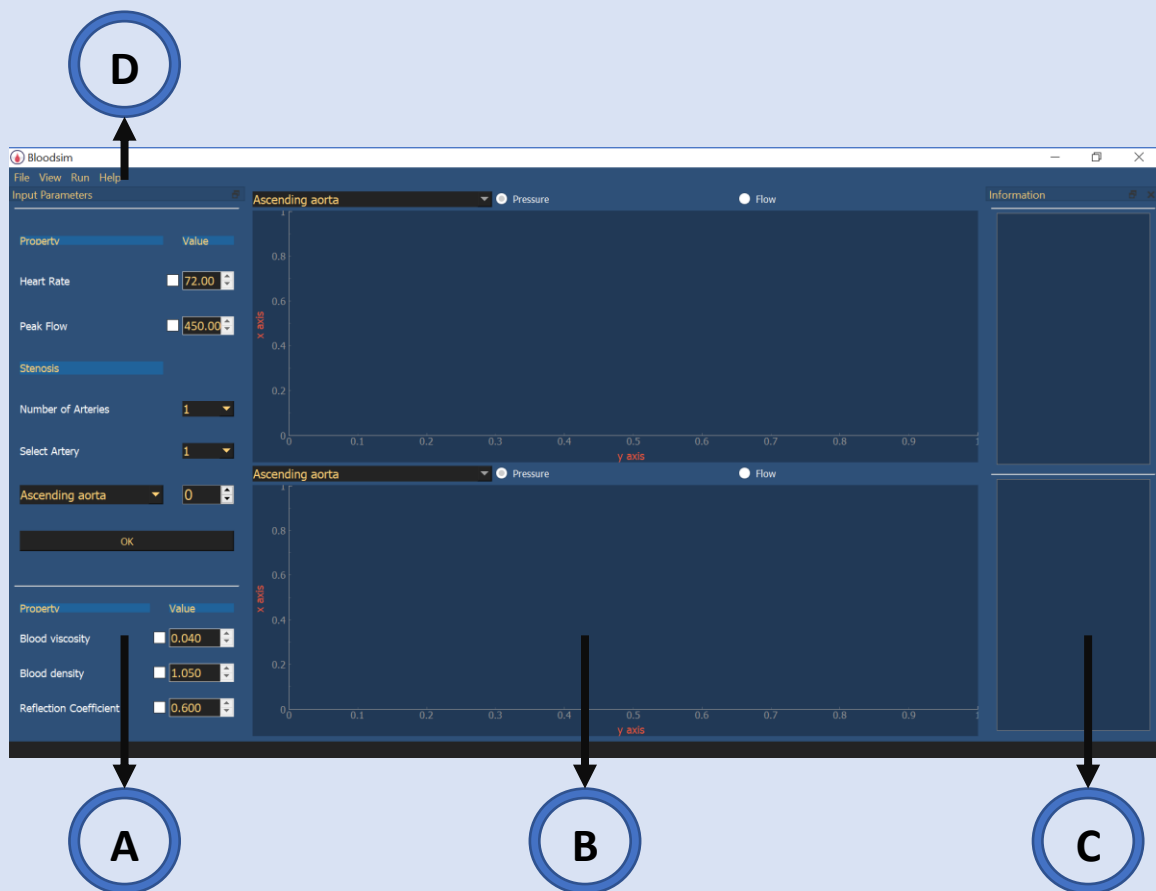


The first button opens the application. The user manual button leads to this document, and the references open a text browser pop up detailing the literature and websites referred to make this project.

Workspace Basics

The overall layout of the software is designed over four sections,

- A. Input parameter section
- B. Graph section
- C. Information window
- D. Menu bar

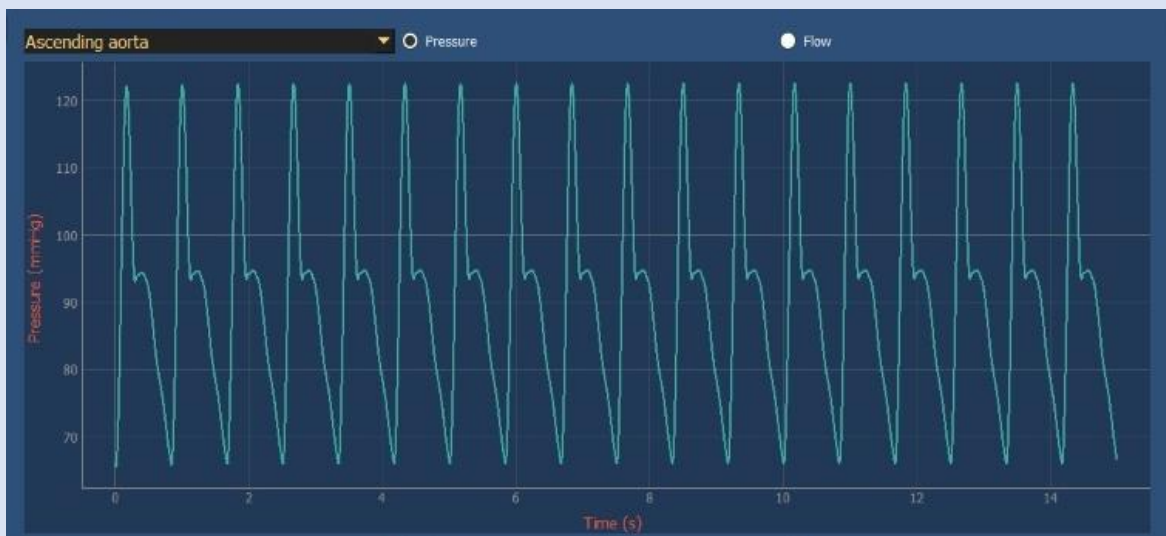


Overall layout of BloodSim

The input parameter section is where the user sets in the inputs and the stenosis in terms of percentage reduction in size of radius. The flowing parameters are user set,

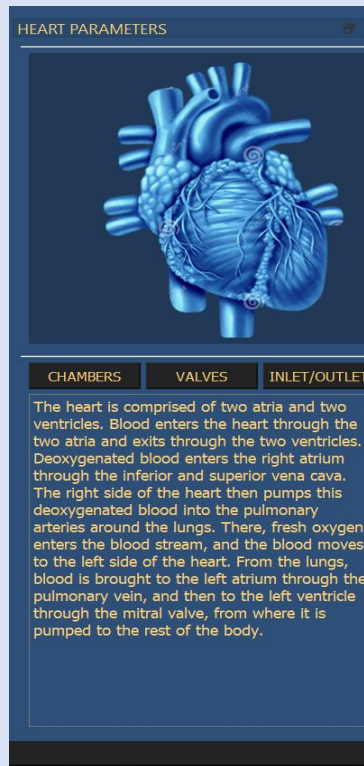
1. Heart rate (bpm)
2. Peak flow of blood (ml/sec)
3. Percentage reduction in radius of artery (stenosis)
4. Reflection coefficient of blood
5. Blood density (Kg/m^3)
6. Blood viscosity (poise)

The graph section is where the simulated waveforms are displayed.



PyQt graph

The information window is where, the information about the waveform such as peak values, minimum values and average values. Pathological information is also displayed in the information section.



Information section

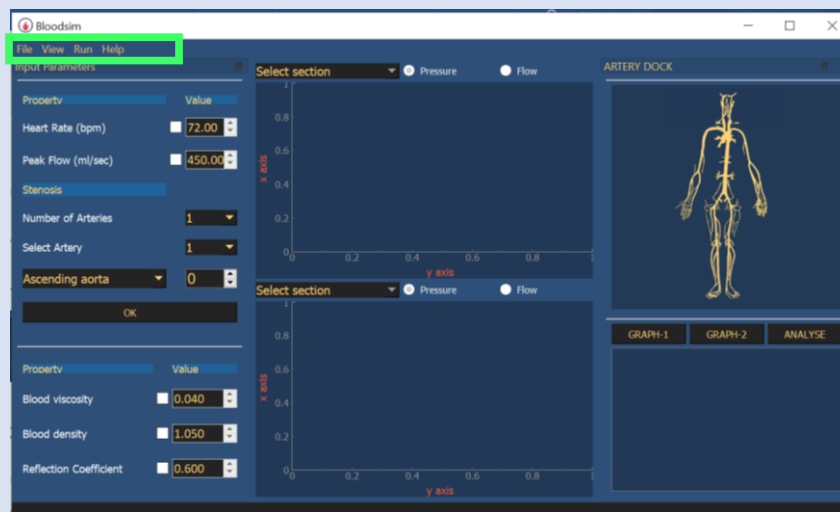
The menu bar provides options such as switching docks, clearing and resetting the graphs and also the option to run the program.

Menu bar options

The menu bar has four menus,

1. File
 - a. Clear
 - b. Quit
2. View
 - a. Input parameters

- b. Artery parameters
- c. Heart parameters
- 3. Run
 - a. Artery model
 - b. Heart model
 - c. Reset
- 4. Help
 - a. BloodSim help
 - b. About BloodSim



FILE:

The file menu has the two options clear and quit.

CLEAR:

This option is used to clear all the graphs in display, and it DOES NOT reset the program and the parameters set by the user.

QUIT:

The quit option is pressed in order to exit the software.

VIEW:

The view menu has three options, input parameter, artery parameters and the heart parameters.

INPUT PARAMETERS:

This option is checked by default and is used to display the dock where the user inputs are taken from. This dock can be closed and later be attached by checking this option.

ARTERY PARAMETERS:

This option is checked by default, and is used to display the information about the arterial waveform on the right side of the software. This dock can be attached and closed by checking and unchecking this option. When the heart parameters option is checked, this option becomes un checked.

HEART PARAMETERS:

This option is unchecked by default and when checked, it displays the heart properties dock replacing the artery parameters dock. Once this option is selected the second graph (bottom) is allocated for displaying the heart parameters.

RUN:

The run menu has three options, Artery model, Heart model and reset.

ARTERY MODEL:

This option has to be clicked to start the simulation of the arterial model, to simulate the pressure and flow waveforms in the arterial segments. Once completed the waveforms would be displayed in the two graphs.

HEART MODEL

This option is to be pressed to start the simulation of the cardiac model to simulate the volume and flow equations of the heart. Once completed the waveforms would be displayed in the second graphs.

HELP:

The help menu has two options, BloodSim help and About BloodSim.

BLOODSIM HELP:

This option is clicked to open this user manual.

ABOUT BLOODSIM:

This option is used to open a pop-up window that gives a brief introduction to the software.

Dock widgets

This software has three docks that are detachable and can be brought back by checking the file menu options. The three dock widgets are,

1. Input parameters
2. Artery parameters
3. Heart parameters

INPUT PARAMETER DOCK:

This dock is on the left side of the GUI and is where the user parameters are set.

The screenshot shows the 'Input Parameters' dock with two sections. The top section is titled 'Stenosis' and contains three parameters: 'Heart Rate' (72.00), 'Peak Flow' (450.00), and 'Number of Arteries' (1). The bottom section contains three parameters: 'Blood viscosity' (0.040), 'Blood density' (1.050), and 'Reflection Coefficient' (0.600). An 'OK' button is located between the two sections. Numbered callouts 1 through 8 point to specific elements: 1 points to the Heart Rate value, 2 points to the Peak Flow value, 3 points to the Number of Arteries dropdown, 4 points to the Select Artery dropdown, 5 points to the OK button, 6 points to the Blood viscosity value, 7 points to the Blood density value, and 8 points to the Reflection Coefficient value.

Property	Value
Heart Rate	72.00
Peak Flow	450.00
Stenosis	
Number of Arteries	1
Select Artery	1
Ascending aorta	0
OK	
<hr/>	
Property	Value
Blood viscosity	0.040
Blood density	1.050
Reflection Coefficient	0.600

- 1 – Heart rate: The default value is set as 72 bpm and once changed, the checkbox needs to be checked to update the value before simulation.
- 2 – Peak Flow: The default value is set as 450 ml/sec and once changed, the checkbox needs to be checked to update the value before simulation.
- 3 – no of arteries: This is to select the number of arteries the user wants to simulate stenosis in.
- 4 – select artery This is to select the current artery.
- 5 – artery/stenosis This is to choose which artery has what stenosis (Example at the end)
- 6 Blood viscosity The default value is set as 0.040 poise and once changed, the checkbox needs to be checked to update the value before simulation.
- 7 – Blood density The default value is set as 1.050 KG/m^3 and once changed, the checkbox needs to be checked to update the value before simulation.
- 8 – Reflection coefficient

The default value is set as 0.6 and once changed, the checkbox needs to be checked to update the value before simulation.

EXAMPLE: If the user wants to simulate stenosis in 3 arteries,

STEP 1: Set number of arteries as 3

The screenshot shows the 'Input Parameters' dialog box. The 'Stenosis' section is active. The 'Number of Arteries' dropdown menu is open, showing a list from 1 to 10, with '3' selected. The 'Select Artery' dropdown menu is also open, showing a list from 1 to 10, with 'Ascending aorta' selected. The 'OK' button is visible at the bottom of the 'Stenosis' section.

Property	Value
Heart Rate	72.00
Peak Flow	450.00

Stenosis

Number of Arteries: 3

Select Artery: Ascending aorta

OK

Property	Value
Blood viscosity	0.040
Blood density	1.050
Reflection Coefficient	0.600

STEP 2: Select artery as 1 to set stenosis in first of the three arteries.

The screenshot shows the 'Input Parameters' dialog box. The 'Stenosis' section is active. The 'Number of Arteries' dropdown menu is set to '3'. The 'Select Artery' dropdown menu is open, showing a list from 1 to 3, with '1' selected. The 'Ascending aorta' dropdown menu is also open, showing a list from 1 to 3, with '1' selected. The 'OK' button is visible at the bottom of the 'Stenosis' section.

Property	Value
Heart Rate	72.00
Peak Flow	450.00

Stenosis

Number of Arteries: 3

Select Artery: 1

Ascending aorta: 1

OK

Property	Value
Blood viscosity	0.040
Blood density	1.050
Reflection Coefficient	0.600

STEP 3: Choose the artery and the stenosis percentage.

Input Parameters

Property	Value
Heart Rate	72.00
Peak Flow	450.00
Stenosis	
Number of Arteries	3
Select Artery	1
Ascending aorta	0
Ascending aorta	
Aortic arch	
Subclavian artery left	
Subclavian artery right	
Common carotid(L)	
Common carotid(R)	
Thoracic aorta	
Cerebral artery right	
Cerebral artery left	
Abdominal aorta	0.040
Blood density	1.050
Reflection Coefficient	0.600

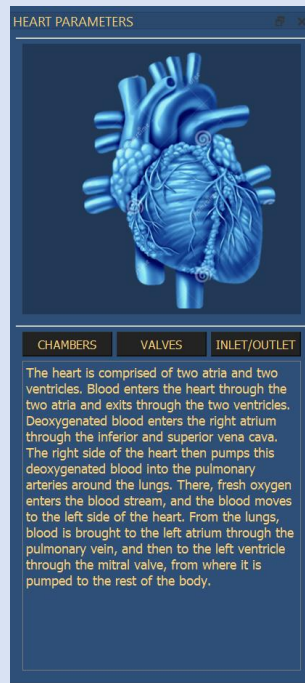
STEP 4: repeat the process by choosing the next artery as 2 and so on.

STEP 5: PRESS OK

HEART PARAMETER DOCK

This dock is on the right side of the GUI. This is unchecked by default and hence does not appear initially. Once checked, the heart parameter dock replaces the default Artery dock. This dock comprises of two parts, the image display part and text display part.

This dock also contains three buttons, CHMABERS, VALVES and INLETS/OUTLETS.



The image display displays the currently chosen section of the heart by the user, and the text display, gives physiological information about the part chosen.

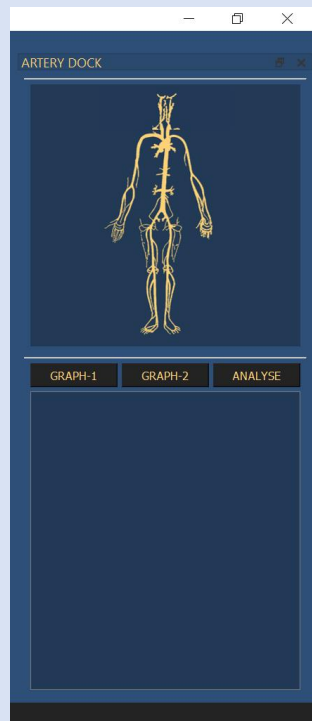
The three buttons are used to select the part of the cardiac model the user wants to simulate.

Once the user selects a button, the drop down box on top of graph 2 displays the list of anatomical locations corresponding to that section.

INPUT PARAMETER DOCK:

This dock is on the right side of the GUI. This dock opens on default. Like the heart dock, this too has three buttons, one image display window and one text display window. Depending on the artery chosen, the image highlights itself in red to indicate the selected artery, and the text below gives physiological information about the artery.

This dock contains three buttons, Graph-1, Graph-2 and Analyse.



The image highlights the section of the arterial tree chosen, and the text browser below gives the physiological information of the selected section. Once the artery model has completed running, the graphs would be displayed.

And the functions of the three buttons are as follows,

1. Graph-1

This button changes the image and text display to the selected artery in graph-1. Once the analyze button is clicked after pressing graph-1 button the features of the first graph is displayed.

2. Graph-2

This button changes the image and text display to the selected artery in graph-2. Once the analyze button is clicked after pressing graph-2 button the features of the second graph is displayed.

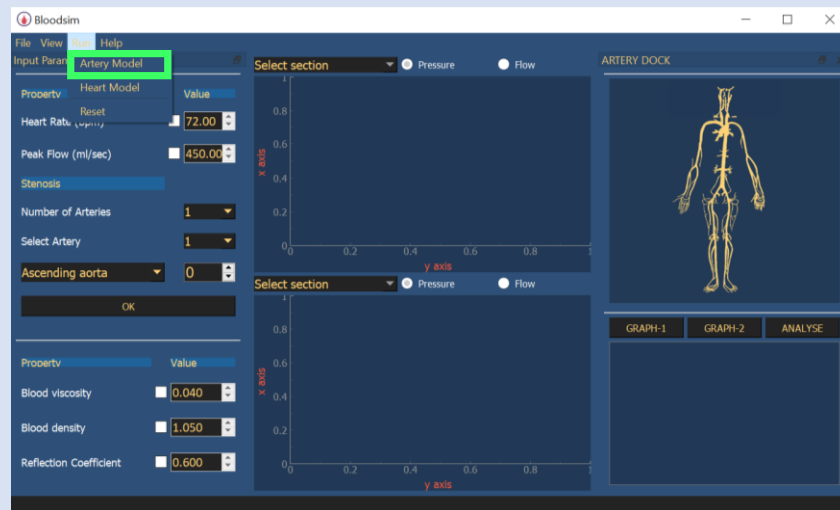
3. Analyze

Pressing this button displays the features of the graphs such as peak flow, minimum flow, mean flow, systolic blood pressure, diastolic blood pressure

Chapter 3 – Simulate

Artery model

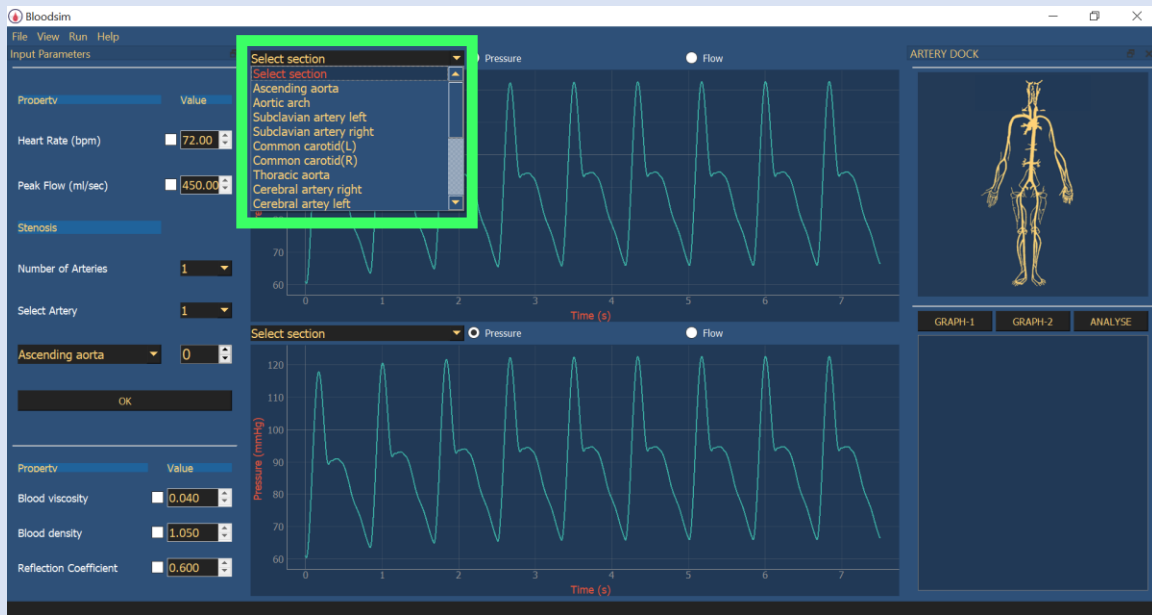
To run the artery tree model, go to **RUN>Artery model**.



Once the artery model is run, the status bar will display completed.

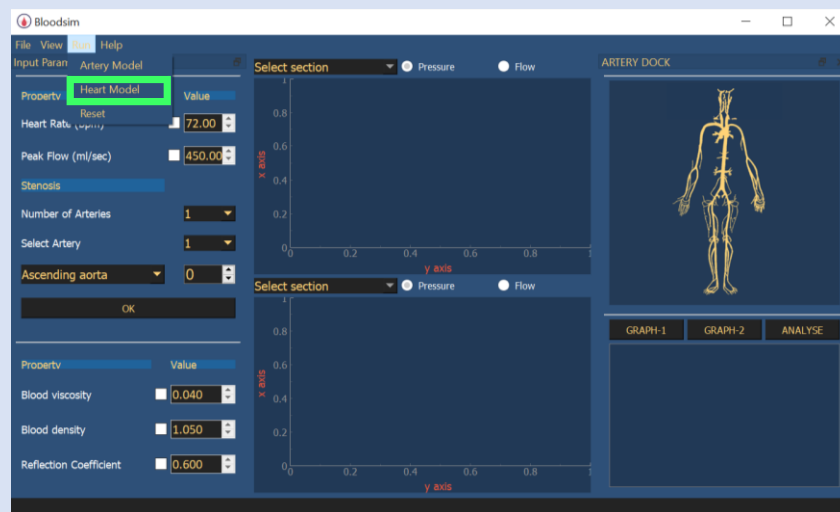


Select the artery to be displayed from the dropdown box and select pressure/flow to display the waveform. Press analyse button to view the features of the graph.

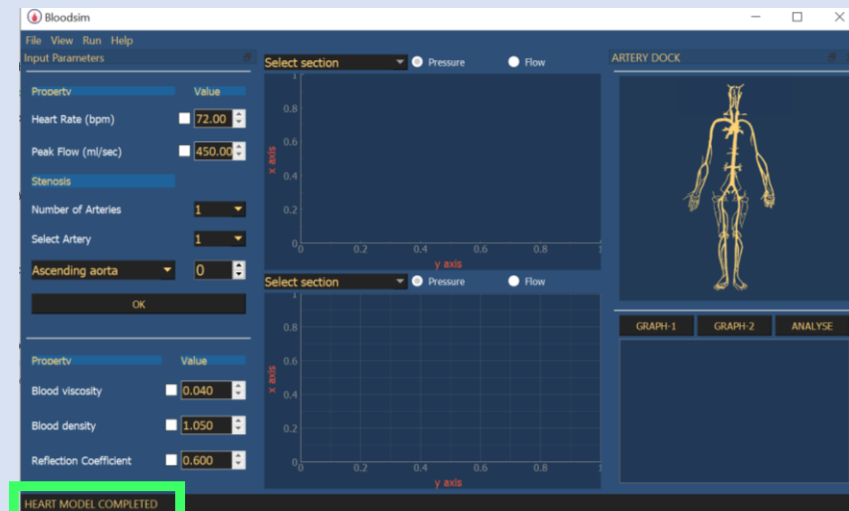


Heart model

To run the heart tree model, go to **RUN>Heart model**.



Once the heart model is run, the status bar will display completed.



Select the buttons chambers/valves or inlets/outlets. To view the volume/flow waveforms select from dropdown box.

