```
v1l = '120';
v2l = '10';
tdl = '0';
tfl = '0.5';
trl = '0.5';
pwl = '0.25';
perl = '1.5';
v1r = '25';
v2r = '4';
tdr = '0';
tfr = '0.5';
trr = '0.5';
pwr = '0.25';
perr = '1.5';
C_sas = '0.08';
L_sas = '0.000062';
R_sas = '0.003';
L_sat = '0.0017';
C_sat = '1.6';
R_sat = '0.05';
R_sar = '0.5';
R_scp = '0.52';

R_brain = '6.814';
R_liver = '5.4';
R_spleen = '0.28865';
R_kidney = '4.91';

R_svn = '0.075';
C_pas = '0.18';
R_pas = '0.002';
L_pas = '0.000052';
C_pat = '3.8';
R_pat = '0.01';
L_pat = '0.0017';
R_par = '0.05';
R_pcp = '0.25';
C_pvn = '20.5';
R_pvn = '0.006';

[time, Q_right_heart, Q_left_heart, V_left_heart,...
            V_right_heart, P_right_heart, P_left_heart, Q_sas,
 Q_sat,...
            Q_sar, Q_scp, V_sas, V_sat, V_sar, V_scp, P_sas, P_sat,...
            P_sar, P_scp, Q_svn, V_svn, P_svn, Q_organs, V_organs,...
            P_organs, Q_brain, Q_kidney, Q_spleen, Q_liver,
 V_brain,...
            V_kidney, V_spleen, V_liver, Q_pas, Q_pat, Q_par,
 Q_pcp,...
            V_pas, V_pat, V_par, V_pcp, P_pas, P_pat, P_par, P_pcp,...
            Q_pvn, V_pvn, P_pvn] = simulinkSimulator(...
```

```
                            v1l, v2l, tdl, tfl, trl, pwl, perl, v1r,
 v2r, tdr,...
                            tfr, trr, pwr, perr, C_sas, L_sas, R_sas,
 L_sat,...
                            C_sat, R_sat, R_sar, R_scp, R_brain,
 R_liver,...
                            R_spleen, R_kidney, R_svn, C_pas,...
                            R_pas, L_pas, C_pat, R_pat, L_pat, R_par,
 R_pcp,...
                            C_pvn, R_pvn);

function [time, Q_right_heart, Q_left_heart, V_left_heart,...
            V_right_heart, P_right_heart, P_left_heart, Q_sas,
 Q_sat,...
            Q_sar, Q_scp, V_sas, V_sat, V_sar, V_scp, P_sas, P_sat,...
            P_sar, P_scp, Q_svn, V_svn, P_svn, Q_organs, V_organs,...
            P_organs, Q_brain, Q_kidney, Q_spleen, Q_liver,
 V_brain,...
            V_kidney, V_spleen, V_liver, Q_pas, Q_pat, Q_par,
 Q_pcp,...
            V_pas, V_pat, V_par, V_pcp, P_pas, P_pat, P_par, P_pcp,...
            Q_pvn, V_pvn, P_pvn] = simulinkSimulator(v1l,...
                            v2l, tdl, tfl, trl, pwl, perl, v1r, v2r,
 tdr,...
                            tfr, trr, pwr, perr, C_sas, L_sas, R_sas,
 L_sat,...
                            C_sat, R_sat, R_sar, R_scp, R_brain,
 R_liver,...
                            R_spleen, R_kidney, R_svn, C_pas,...
                            R_pas, L_pas, C_pat, R_pat, L_pat, R_par,
 R_pcp,...
                            C_pvn, R_pvn)
% ------------------------------------------------------------
% Function Description:
% This function runs the simulation and plots the results. Takes in
 initial
% conditions as input defined below.
% ------------------------------------------------------------

% ------------------------------------------------------------
% Variables:
% C_sas = scalar capacitance value of the systemic aortic sinus
 modeling
%         the compliance of the vessel
% L_sas = scalar inductance value of the systemic aortic sinus
 modeling the
%         inertia of the vessel
% R_sas = scalar resistance value of the systemic aortic sinus
 modeling the
%         resistance of blood flow in the vessel
% L_sat = scalar inductance value of the systemic artery modeling the
%         inertia of the vessel
% C_sat = scalar capacitance value of the systemic artery modeling
%         the compliance of the vessel
```

```
% R_sat = scalar resistance value of the systemic artery modeling the
%         resistance of blood flow in the vessel
% R_sar = scalar resistance value of the systemic arterioles modeling
 the
%         resistance of blood flow in the vessel
% ...CONTINUE VARIABLE DEFINITIONS...
% -------------------------------------------------------------

% -------------------------------------------------------------
% PARAMETERS FOR MODEL
% -------------------------------------------------------------

% capacitor_param = c (in Farad)
% inductor_param = l (in Henry)
% resistor_param = R (in Ohms)

% heart_params = ['V1', 'V2', 'TD', 'TR', 'TF', 'pW', 'PER'];
% V1 = initial voltage 1 (in Volts)
% V2 = initial voltage 2 (in Volts)
% TD = pulse delay time (in seconds)
% TR = pulse rise time (in seconds)
% TF = pulse fall time (in seconds)
% pW = pulse width (in seconds)
% PER = pulse period (in seconds)

% Sets parameters of Simulink model
set_param('CirculationCircuitv2021_v3/R_scp', 'R', R_scp);
set_param('CirculationCircuitv2021_v3/R_sas', 'R', R_sas);
set_param('CirculationCircuitv2021_v3/R_sat', 'R', R_sat);
set_param('CirculationCircuitv2021_v3/R_sar', 'R', R_sar);
set_param('CirculationCircuitv2021_v3/R_brain', 'R', R_brain);
set_param('CirculationCircuitv2021_v3/R_kidney', 'R', R_kidney);
set_param('CirculationCircuitv2021_v3/R_spleen', 'R', R_spleen);
set_param('CirculationCircuitv2021_v3/R_liver', 'R', R_liver);
set_param('CirculationCircuitv2021_v3/R_svn', 'R', R_svn);
set_param('CirculationCircuitv2021_v3/R_pas', 'R', R_pas);
set_param('CirculationCircuitv2021_v3/R_pat', 'R', R_pat);
set_param('CirculationCircuitv2021_v3/R_par', 'R', R_par);
set_param('CirculationCircuitv2021_v3/R_pcp', 'R', R_pcp);
set_param('CirculationCircuitv2021_v3/R_pvn', 'R', R_pvn);

set_param('CirculationCircuitv2021_v3/C_sas', 'c', C_sas);
set_param('CirculationCircuitv2021_v3/C_sat', 'c', C_sat);
set_param('CirculationCircuitv2021_v3/C_sas', 'c', C_sas);
set_param('CirculationCircuitv2021_v3/C_pas', 'c', C_pas);
set_param('CirculationCircuitv2021_v3/C_pat', 'c', C_pat);
set_param('CirculationCircuitv2021_v3/C_pvn', 'c', C_pvn);

set_param('CirculationCircuitv2021_v3/L_sas', 'l', L_sas);
set_param('CirculationCircuitv2021_v3/L_pas', 'l', L_pas);
set_param('CirculationCircuitv2021_v3/L_sat', 'l', L_sat);
set_param('CirculationCircuitv2021_v3/L_pat', 'l', L_pat);

set_param('CirculationCircuitv2021_v3/Heart_L', 'V1', v1l);
```

```
set_param('CirculationCircuitv2021_v3/Heart_L', 'V2', v2l);
set_param('CirculationCircuitv2021_v3/Heart_L', 'TD', tdl);
set_param('CirculationCircuitv2021_v3/Heart_L', 'TF', tfl);
set_param('CirculationCircuitv2021_v3/Heart_L', 'TR', trl);
set_param('CirculationCircuitv2021_v3/Heart_L', 'pW', pwl);
set_param('CirculationCircuitv2021_v3/Heart_L', 'PER', perl);

set_param('CirculationCircuitv2021_v3/Heart_R', 'V1', v1r);
set_param('CirculationCircuitv2021_v3/Heart_R', 'V2', v2r);
set_param('CirculationCircuitv2021_v3/Heart_R', 'TD', tdr);
set_param('CirculationCircuitv2021_v3/Heart_R', 'TF', tfr);
set_param('CirculationCircuitv2021_v3/Heart_R', 'TF', trr);
set_param('CirculationCircuitv2021_v3/Heart_R', 'pW', pwr);
set_param('CirculationCircuitv2021_v3/Heart_R', 'PER', perr);

simOut=sim('CirculationCircuitv2021_v3', 'StartTime','0','StopTime','60',...
            'FixedStep','0.0001'); % Loads and runs model

% Reads in results of Simulink model
Q_right_heart = simOut.Q_right_heart.signals.values;
time = simOut.Q_right_heart.time;
Q_left_heart = simOut.Q_left_heart.signals.values;
V_left_heart = simOut.V_left_heart.signals.values;
V_right_heart = simOut.V_right_heart.signals.values;
P_right_heart = simOut.P_right_heart.signals.values;
P_left_heart = simOut.P_left_heart.signals.values;

Q_sas = simOut.Q_sas.signals.values;
Q_sat = simOut.Q_sat.signals.values;
Q_sar = simOut.Q_sar.signals.values;
Q_scp = simOut.Q_scp.signals.values;
V_sas = simOut.V_sas.signals.values;
V_sat = simOut.V_sat.signals.values;
V_sar = simOut.V_sar.signals.values;
V_scp = simOut.V_scp.signals.values;
P_sas = simOut.P_sas.signals.values;
P_sat = simOut.P_sat.signals.values;
P_sar = simOut.P_sar.signals.values;
P_scp = simOut.P_scp.signals.values;

Q_svn = simOut.Q_svn.signals.values;
V_svn = simOut.V_svn.signals.values;
P_svn = simOut.P_svn.signals.values;

P_organs = simOut.P_organs.signals.values;
V_organs = zeros(length(P_organs),1);

Req = 1/((1/str2double(R_liver)) + (1/str2double(R_spleen)) + ...
        (1/str2double(R_kidney)) + (1/str2double(R_brain)));

V_brain = (V_left_heart + V_right_heart).*0.15;
V_kidney = (V_left_heart + V_right_heart).*0.25;
V_spleen = (V_left_heart + V_right_heart).*0.10;
V_liver = (V_left_heart + V_right_heart).*0.20;
```

```
V_organs = (V_left_heart + V_right_heart);

Q_brain = gradient(V_brain(:)) ./ gradient(time(:));
Q_kidney = gradient(V_kidney(:)) ./ gradient(time(:));
Q_spleen = gradient(V_spleen(:)) ./ gradient(time(:));
Q_liver = gradient(V_liver(:)) ./ gradient(time(:));
Q_organs = gradient(V_organs(:)) ./ gradient(time(:));

Q_pas = simOut.Q_pas.signals.values;
Q_pat = simOut.Q_pat.signals.values;
Q_par = simOut.Q_par.signals.values;
Q_pcp = simOut.Q_pcp.signals.values;
V_pas = simOut.V_pas.signals.values;
V_pat = simOut.V_pat.signals.values;
V_par = simOut.V_par.signals.values;
V_pcp = simOut.V_pcp.signals.values;
P_pas = simOut.P_pas.signals.values;
P_pat = simOut.P_pat.signals.values;
P_par = simOut.P_par.signals.values;
P_pcp = simOut.P_pcp.signals.values;

Q_pvn = simOut.Q_pvn.signals.values;
V_pvn = simOut.V_pvn.signals.values;
P_pvn = simOut.P_pvn.signals.values;

% ------------------------------------------------------------
% Heart Dynamics
% ------------------------------------------------------------
figure
subplot(2,3,1)
plot(time,Q_right_heart);
title('Q_{Right Heart}');
xlabel('Time (s)');
ylabel('Flow Rate (mL/s)');

subplot(2,3,4)
plot(time,Q_left_heart);
title('Q_{Left Heart}');
xlabel('Time (s)');
ylabel('Flow Rate (mL/s)');

subplot(2,3,2)
plot(time,V_right_heart);
title('V_{Right Heart}');
xlabel('Time (s)');
ylabel('Blood Volume (mL)');

subplot(2,3,5)
plot(time,V_left_heart);
title('V_{Left Heart}');
xlabel('Time (s)');
ylabel('Blood Volume (mL)');

subplot(2,3,6)
```

```
plot(time,P_left_heart);
title('P_{Left Heart}');
xlabel('Time (s)');
ylabel('Blood Pressure (mmHg)');

subplot(2,3,3)
plot(time,P_right_heart);
title('P_{Right Heart}');
xlabel('Time (s)');
ylabel('Blood Pressure (mmHg)');

sgtitle('Heart Blood Flow Dynamics');
set(gcf, 'Units', 'Normalized', 'OuterPosition', [0 0 1 1]);


% ------------------------------------------------------------
% Systemic Arterial Loop Dynamics
% ------------------------------------------------------------
figure
subplot(4,3,1)
plot(time, Q_sas);
title('Q_{sas}');
xlabel('Time (s)');
ylabel('Flow Rate (mL/s)');

subplot(4,3,4)
plot(time, Q_sat);
title('Q_{sat}');
xlabel('Time (s)');
ylabel('Flow Rate (mL/s)');

subplot(4,3,7)
plot(time, Q_sar);
title('Q_{sar}');
xlabel('Time (s)');
ylabel('Flow Rate (mL/s)');

subplot(4,3,10)
plot(time, Q_scp);
title('Q_{scp}');
xlabel('Time (s)');
ylabel('Flow Blood VolumeRate (mL/s)');

subplot(4,3,2)
plot(time, V_sas);
title('V_{sas}');
xlabel('Time (s)');
ylabel('Blood Volume (mL)');

subplot(4,3,5)
plot(time, V_sat);
title('V_{sat}');
xlabel('Time (s)');
ylabel('Blood Volume (mL)');
```

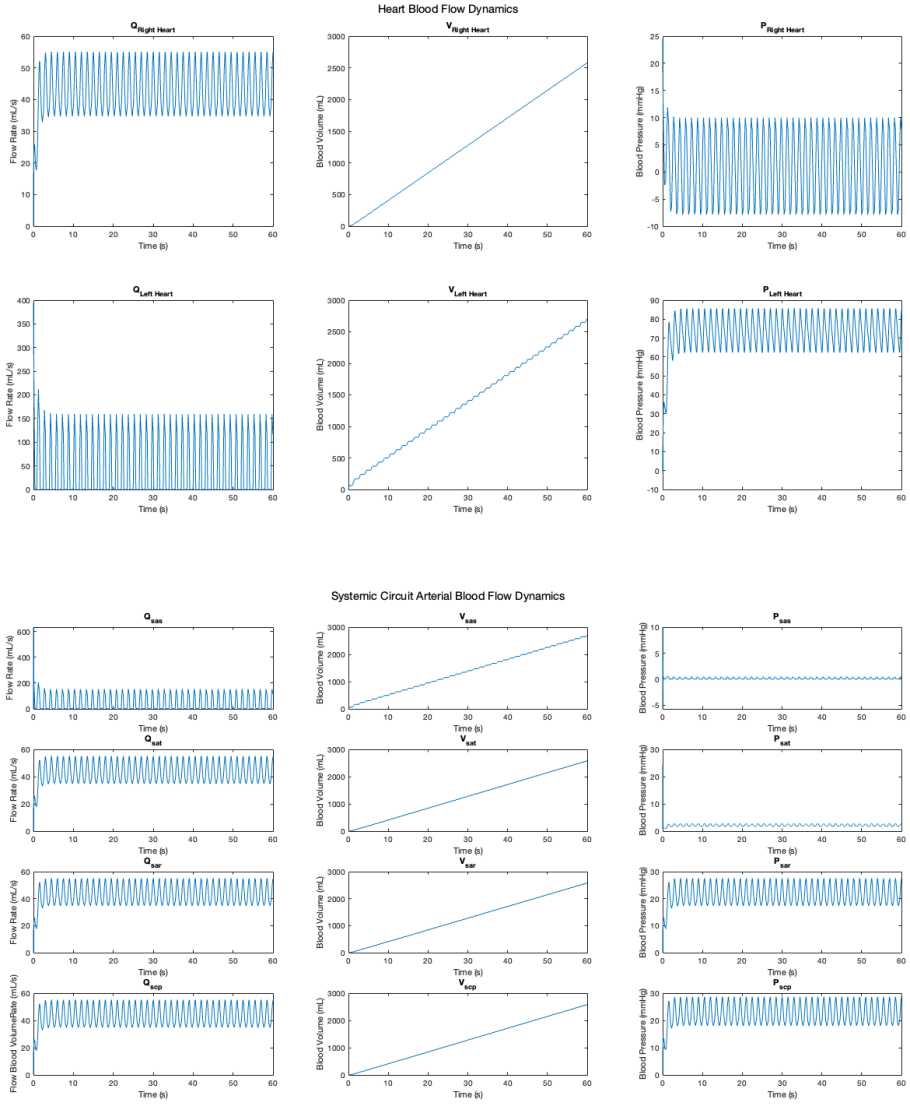
```
subplot(4,3,8)
plot(time, V_sar);
title('V_{sar}');
xlabel('Time (s)');
ylabel('Blood Volume (mL)');

subplot(4,3,11)
plot(time, V_scp);
title('V_{scp}');
xlabel('Time (s)');
ylabel('Blood Volume (mL)');

subplot(4,3,3)
plot(time,P_sas);
title('P_{sas}');
xlabel('Time (s)');
ylabel('Blood Pressure (mmHg)');

subplot(4,3,6)
plot(time,P_sat);
title('P_{sat}');
xlabel('Time (s)');
ylabel('Blood Pressure (mmHg)');

subplot(4,3,9)
plot(time,P_sar);
title('P_{sar}');
xlabel('Time (s)');
ylabel('Blood Pressure (mmHg)');

subplot(4,3,12)
plot(time,P_scp);
title('P_{scp}');
xlabel('Time (s)');
ylabel('Blood Pressure (mmHg)');

sgtitle('Systemic Circuit Arterial Blood Flow Dynamics');
set(gcf, 'Units', 'Normalized', 'OuterPosition', [0 0 1 1]);

% ------------------------------------------------------------
% Systemic Venous Loop Dynamics
% ------------------------------------------------------------

figure
subplot(3,1,1)
plot(time, Q_svn);
title('Q_{svn}');
xlabel('Time (s)');
ylabel('Flow Rate (mL/s)');

subplot(3,1,2)
plot(time, V_svn);
title('V_{svn}');
```

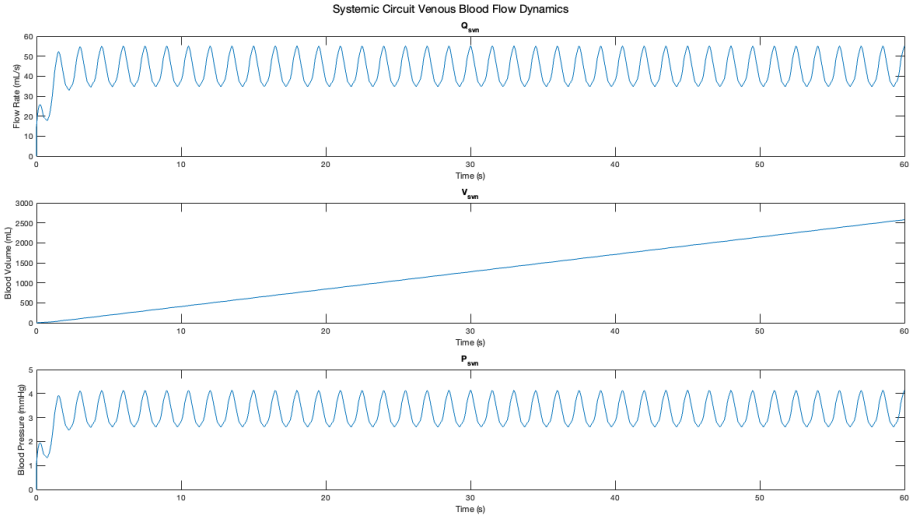
```
xlabel('Time (s)');
ylabel('Blood Volume (mL)');

subplot(3,1,3)
plot(time, P_svn);
title('P_{svn}');
xlabel('Time (s)');
ylabel('Blood Pressure (mmHg)');

sgtitle("Systemic Circuit Venous Blood Flow Dynamics");
set(gcf, 'Units', 'Normalized', 'OuterPosition', [0 0 1 1]);

% ------------------------------------------------------------
% Organ Dynamics
% ------------------------------------------------------------

figure
subplot(3,1,1)
plot(time,Q_organs);
title('Q_o');
xlabel('Time (s)');
ylabel('Flow Rate (mL/s)');

subplot(3,1,2)
plot(time, V_organs);
title('V_{o}');
xlabel('Time (s)');
ylabel('Blood Volume (mL)');

subplot(3,1,3)
plot(time, P_organs);
title('P_{o}');
xlabel('Time (s)');
ylabel('Blood Pressure (mmHg)');

sgtitle("Total Organ Blood Flow Dynamics");
set(gcf, 'Units', 'Normalized', 'OuterPosition', [0 0 1 1]);

figure
subplot(4,2,1)
plot(time, Q_brain);
title('Q_{brain}');
xlabel('Time (s)');
ylabel('Flow Rate (mL/s)');

subplot(4,2,2)
plot(time, V_brain);
title('V_{brain}');
xlabel('Time (s)');
ylabel('Blood Volume (mL)');

subplot(4,2,3)
plot(time, Q_kidney);
title('Q_{kidney}');
```

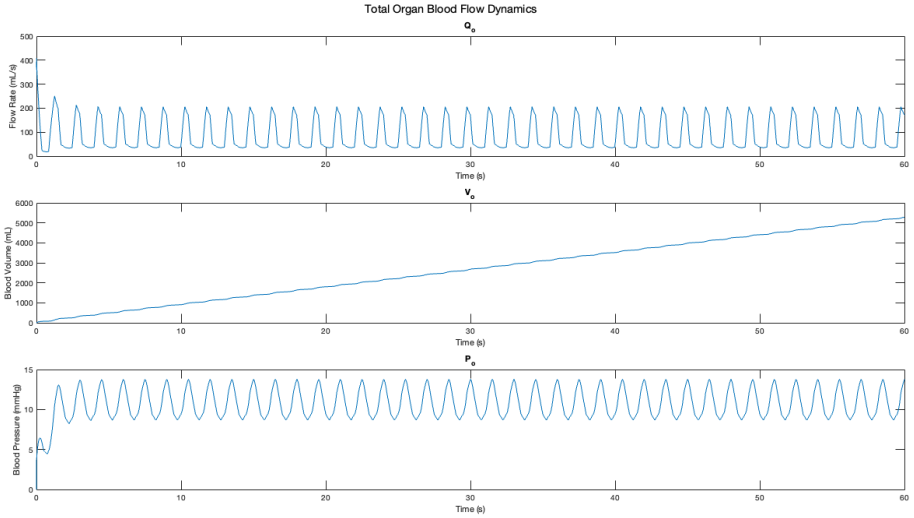
```
xlabel('Time (s)');
ylabel('Flow Rate (mL/s)');

subplot(4,2,4)
plot(time, V_kidney);
title('V_{kidney}');
xlabel('Time (s)');
ylabel('Blood Volume (mL)');

subplot(4,2,5)
plot(time, Q_liver);
title('Q_{liver}');
xlabel('Time (s)');
ylabel('Flow Rate (mL/s)');

subplot(4,2,6)
plot(time, V_liver);
title('V_{liver}');
xlabel('Time (s)');
ylabel('Blood Volume (mL)');

subplot(4,2,7)
plot(time, Q_spleen);
title('Q_{slpeen}');
xlabel('Time (s)');
ylabel('Flow Rate (mL/s)');

subplot(4,2,8)
plot(time, V_spleen);
title('V_{spleen}');
xlabel('Time (s)');
ylabel('Blood Volume (mL)');

sgtitle("Specific Organ Blood Flow Dynamics");
set(gcf, 'Units', 'Normalized', 'OuterPosition', [0 0 1 1]);

% ------------------------------------------------------------
% Pulmonary Circuit Arterial Dynamics
% ------------------------------------------------------------

figure
subplot(4,3,1)
plot(time, Q_pas);
title('Q_{pas}');
xlabel('Time (s)');
ylabel('Flow Rate (mL/s)');

subplot(4,3,2)
plot(time, V_pas);
title('V_{pas}');
xlabel('Time (s)');
ylabel('Blood Volume (mL)');

subplot(4,3,3)
```

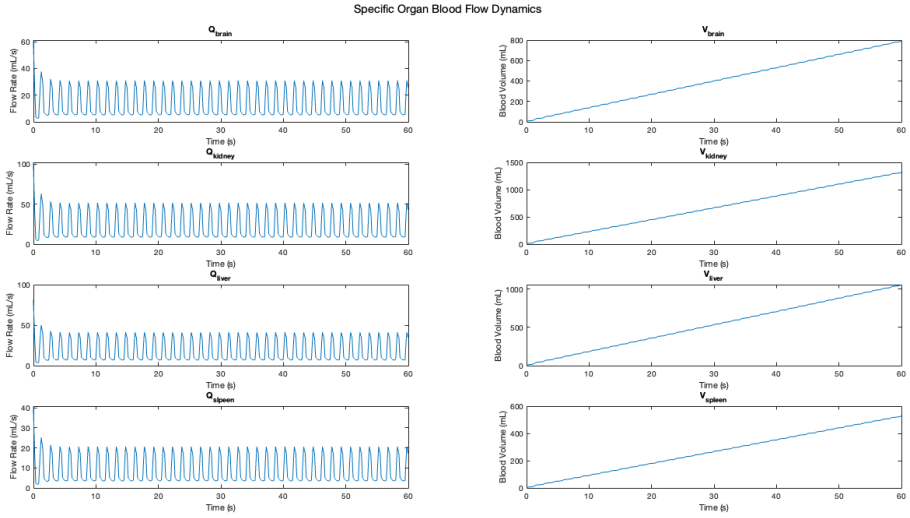
```
plot(time, P_pas);
title('P_{pas}');
xlabel('Time (s)');
ylabel('Blood Pressure (mmHg)');

subplot(4,3,4)
plot(time, Q_pat);
title('Q_{pat}');
xlabel('Time (s)');
ylabel('Flow Rate (mL/s)');

subplot(4,3,5)
plot(time, V_pat);
title('V_{pat}');
xlabel('Time (s)');
ylabel('Blood Volume (mL)');

subplot(4,3,6)
plot(time, P_pat);
title('P_{pat}');
xlabel('Time (s)');
ylabel('Blood Pressure (mmHg)');

subplot(4,3,7)
plot(time, Q_par);
title('Q_{par}');
xlabel('Time (s)');
ylabel('Flow Rate (mL/s)');

subplot(4,3,8)
plot(time, V_par);
title('V_{par}');
xlabel('Time (s)');
ylabel('Blood Volume (mL)');

subplot(4,3,9)
plot(time, P_par);
title('P_{par}');
xlabel('Time (s)');
ylabel('Blood Pressure (mmHg)');

subplot(4,3,10)
plot(time, Q_pcp);
title('Q_{pcp}');
xlabel('Time (s)');
ylabel('Flow Rate (mL/s)');

subplot(4,3,11)
plot(time, V_pcp);
title('V_{pcp}');
xlabel('Time (s)');
ylabel('Blood Volume (mL)');

subplot(4,3,12)
```

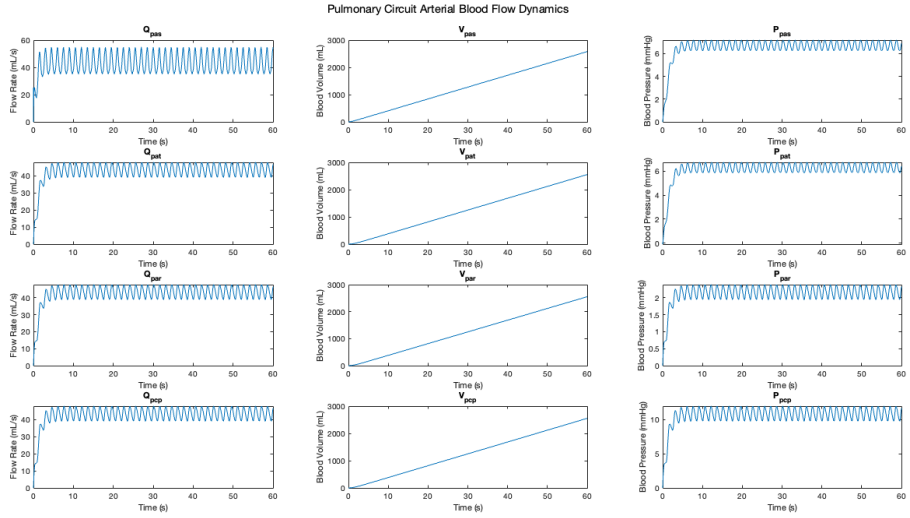
```
plot(time, P_pcp);
title('P_{pcp}');
xlabel('Time (s)');
ylabel('Blood Pressure (mmHg)');

sgtitle('Pulmonary Circuit Arterial Blood Flow Dynamics');
set(gcf, 'Units', 'Normalized', 'OuterPosition', [0 0 1 1]);

% ---------------------------------------------------------
% Pulmonary Circuit Venous Dynamics
% ---------------------------------------------------------

figure
subplot(3,1,1)
plot(time, Q_pvn);
title('Q_{pvn}');
xlabel('Time (s)');
ylabel('Flow Rate (mL/s)');

subplot(3,1,2)
plot(time, V_pvn);
title('V_{pvn}');
xlabel('Time (s)');
ylabel('Blood Volume (mL)');

subplot(3,1,3)
plot(time, P_pvn);
title('P_{pvn}');
xlabel('Time (s)');
ylabel('Blood Pressure (mmHg)');

sgtitle("Pulmonary Circuit Venous Blood Flow Dynamics");
set(gcf, 'Units', 'Normalized', 'OuterPosition', [0 0 1 1]);

end
```

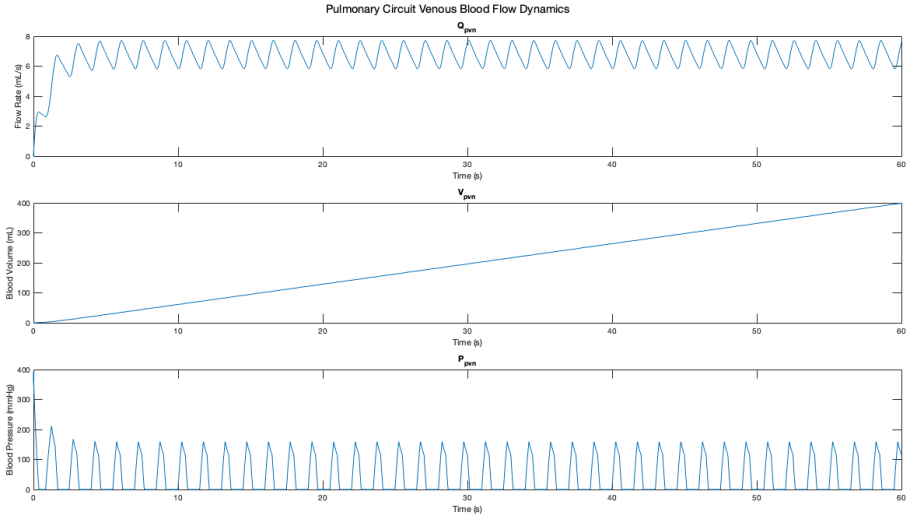

Heart Blood Flow Dynamics
$Q_{Right\ Heart}$
$V_{Right\ Heart}$
$P_{Right\ Heart}$
$Q_{Left\ Heart}$
$V_{Left\ Heart}$
$P_{Left\ Heart}$
Systemic Circuit Arterial Blood Flow Dynamics
Q_{sas}
V_{sas}
P_{sas}
Q_{sat}
V_{sat}
P_{sat}
Q_{sar}
V_{sar}
P_{sar}
Q_{scp}
V_{scp}
P_{scp}
Flow Rate (mL/s)
Blood Volume (mL)
Blood Pressure (mmHg)
Time (s)


Systemic Circuit Venous Blood Flow Dynamics
Q_{svn}
Flow Rate (mL/s)
V_{svn}
Blood Volume (mL)
P_{svn}
Blood Pressure (mmHg)
Time (s)


Total Organ Blood Flow Dynamics
Q_o
Flow Rate (mL/s)
V_o
Blood Volume (mL)
P_o
Blood Pressure (mmHg)
Time (s)


Specific Organ Blood Flow Dynamics
Q brain
V brain
Q kidney
V kidney
Q liver
V liver
Q spleen
V spleen
Flow Rate (mL/s)
Blood Volume (mL)
Time (s)


Pulmonary Circuit Arterial Blood Flow Dynamics
Q pas
V pas
P pas
Q pat
V pat
P pat
Q par
V par
P par
Q pcp
V pcp
P pcp
Flow Rate (mL/s)
Blood Volume (mL)
Blood Pressure (mmHg)
Time (s)



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