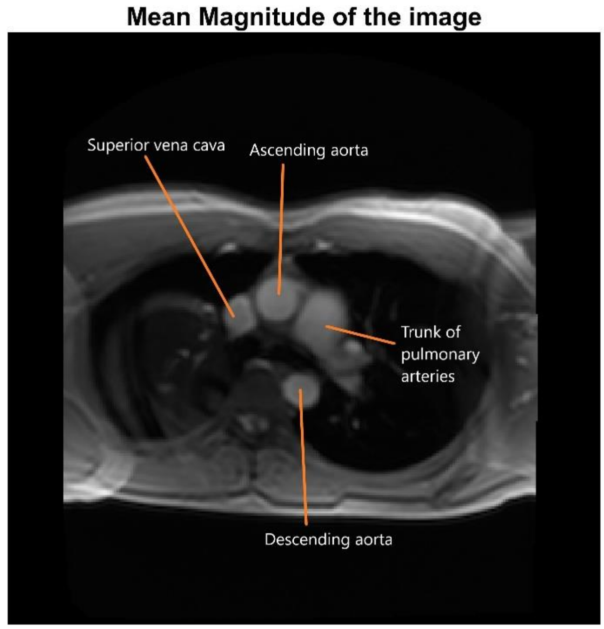
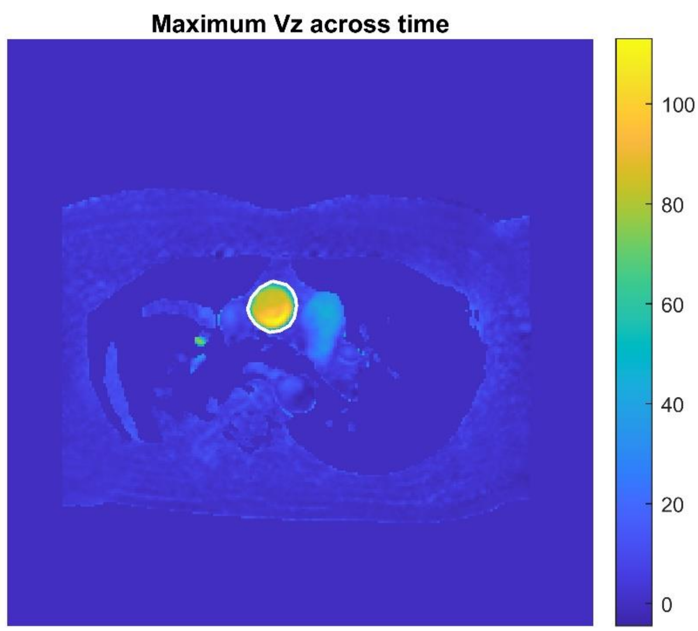
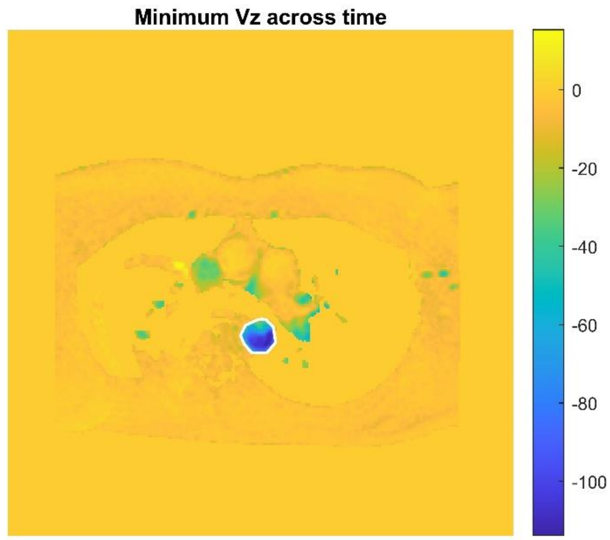
Mean Magnitude Image

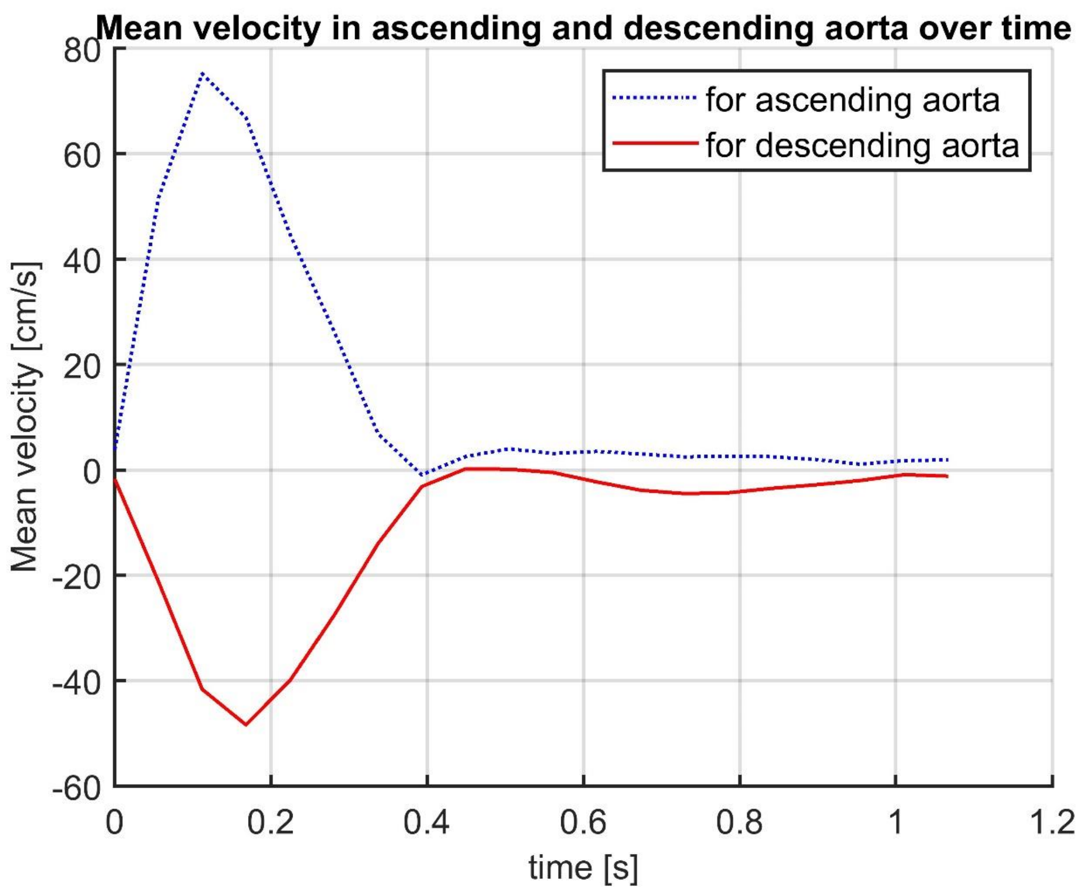


Velocity Maps

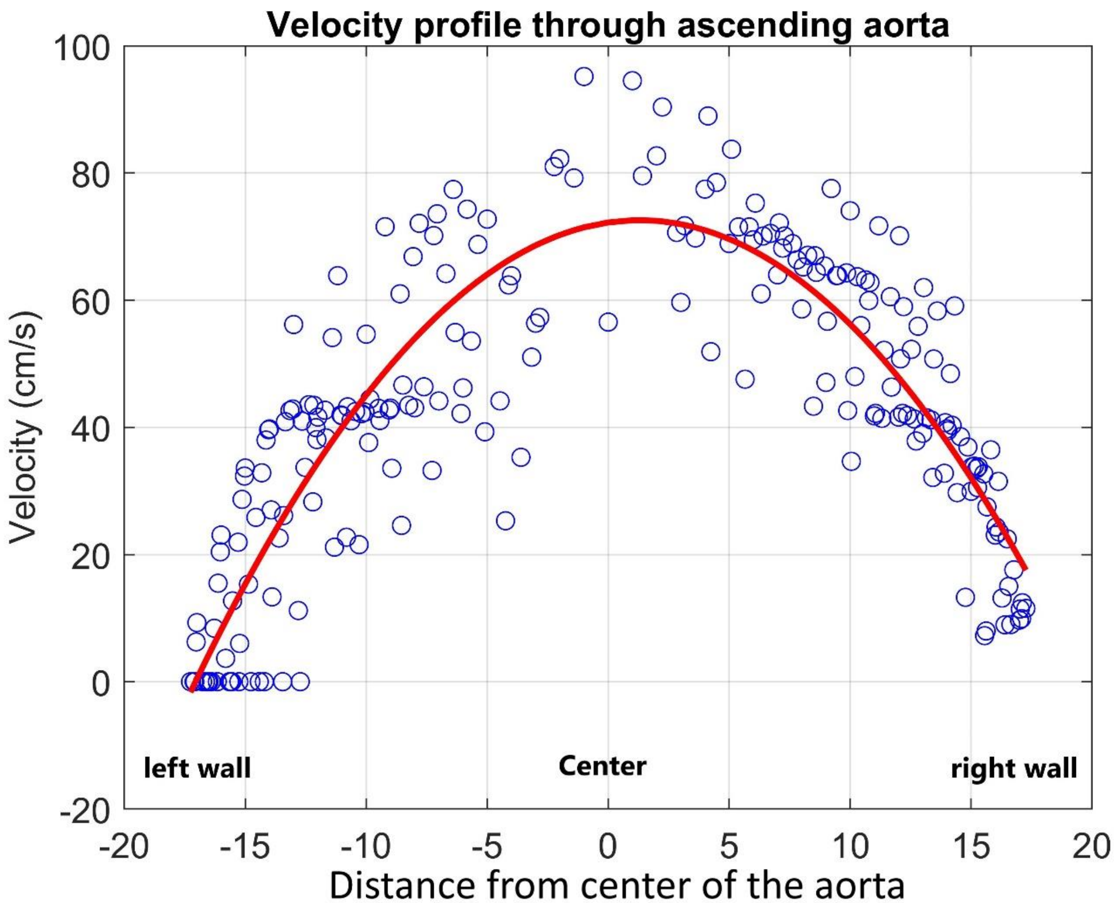




- **Mean velocity vs time plot**



Mean velocity vs radius in ascending aorta



Questions

1. *What is the total volume of blood pumped through the ascending aorta in one cardiac cycle? What is the total volume passing through the descending aorta?*

   Answer:

   Blood volume pumped through the ascending aorta = 105.4719 cc. And for descending aorta, it was about 75.3237 cc.

2. *How does the total volume pumped through the ascending aorta compare to your results in Project 2? How should these quantities be related?*

   Answer:

   In project 2, I found diastolic volume of left ventricle was about 154.1322 cc and systolic volume was about 52.8530 cc. So, about (154.1322 – 52.8530) = 101.2792 cc blood was ejected from the left ventricle. This very similar to the amount of blood pumped through the ascending aorta. Ans ideally these two values should be the same since left ventricle eject blood on the ascending aorta.

3. *If the total volumes of blood flowing in the ascending and descending aorta are not the same, why do you think they are different? Where is the 'missing' blood flowing?*

   Answer:

   The volumes of blood flowing through the ascending aorta is greater than the descending aorta. The reason behind that is ascending aorta receives all the blood ejected by left ventricle. Then it creates branches (e.g., coronary arteries, carotid arteries, subclavian, descending, brachiocephalic); descending aorta takes blood to distribute to the lower part of the body while the other branches carry the blood to distribute to the upper part of the body like heart, brain, eyes, etc.

4. *Is the velocity profile parabolic at high flow rates?*

   Answer:

   Although it is not exactly like a parabola, but it is quite similar as expected. Because blood velocity at the center of the vessel is maximum and this reduces as we go far from the center.

Matlab Script

```matlab
clc; close all; clear all;
load('proj6_arterialFlowData_qfi.mat');

%mean magnitude image
mean_mag_m = mean(mag_3d, 3);
figure
imagesc(mean_mag_m)
colormap(gray)
axis image
axis off
title('Mean Magnitude of the image')

%creating body mask
bodyMask_m = zeros(256, 256);
max_pixel = max(mag_3d(:));
for row=1:256
    for col=1:256
        pixels = squeeze(mag_3d(row, col, :));
        if mean(pixels)>=0.1*max_pixel
            bodyMask_m(row, col) =1;
        end
    end
end
%displaying the body mask
figure
imagesc(bodyMask_m)
colormap(gray)
axis image
axis off
title("Head Mask")

vz_3d = venc*(phase_3d/pi*2);

% Showing a movie of velocity versus time. Red is flow toward head,
% blue is toward feet:
nTimes = length(time_v);
maxVz = max(vz_3d(:));
minVz = min(vz_3d(:));
figure
for timeIndex = 1:nTimes
    imagesc(bodyMask_m .* vz_3d(:, :, timeIndex))
    axis image
    axis off
    % Setting color limits to visualize slow and fast flow:
    set(gca, 'CLim', [minVz, maxVz]/2)
    drawnow
    m(timeIndex) = getframe;
end
nLoops = 2;
fps = 2; % Frames per second.
movie(m, nLoops, fps)

%identifying ascending aorta
maxVz_m = max(vz_3d, [], 3);
figure;
imagesc(maxVz_m .* bodyMask_m)
axis image
axis off
colorbar
```

```
title('Maximum Vz across time')
[aaMask_m, aaX_v, aaY_v] = roipoly;
line(aaX_v, aaY_v,'color', 'w', 'LineWidth', 1.5)

%identifying descending aorta
minVz_m = min(vz_3d, [], 3);
figure;
imagesc(minVz_m .* bodyMask_m)
axis image
axis off
colorbar
title('Minimum Vz across time')
[daMask_m, daX_v, daY_v] = roipoly;
line(daX_v, daY_v,'color', 'w', 'LineWidth', 1.5)

%calculating velocity
aaVp_m = zeros(256, 256);
daVp_m = zeros(256, 256);
nTimes = length(time_v);
aaVz_v = zeros(1, nTimes);
daVz_v = zeros(1, nTimes);
for timeIndex = 1:nTimes
    aa = aaMask_m.*squeeze(vz_3d(:,:,timeIndex));
    da = daMask_m.*squeeze(vz_3d(:,:,timeIndex));
    aaVz_v(timeIndex) = sum(aa(:))/sum(aaMask_m(:));
    daVz_v(timeIndex) = sum(da(:))/sum(daMask_m(:));
end

figure
plot(time_v/1000, aaVz_v, 'b:', time_v/1000, daVz_v, 'r-', 'LineWidth', 1.2);
title('Mean velocity in ascending and descending aorta over time')
xlabel('time [s]')
ylabel('Mean velocity [cm/s]')
box off
grid on

%measuring volume
aaVol = sum(aaMask_m(:))*(dx/10)*(dy/10)*mean(aaVz_v)*((time_v(end)-time_v(1))/1000);
daVol = sum(daMask_m(:))*dx/10*dy/10*mean(daVz_v)*(time_v(end)-time_v(1))/1000;

%calculating fraction of blood that goes from ascending aorta to descending
%aorta
fracDiff = 100 * (aaVol - abs(daVol)) / aaVol;

%to create velocity profile
all_dist = [];
[vmax, ind] = max(aaVz_v);
aaVp = aaMask_m.*squeeze(vz_3d(:,:,ind));
[~, z] = max(aaVp(:));
[xc, yc] = ind2sub([256 256],z);
for row = 1:256
    for col = 1:yc
        if aaMask_m(row, col)==1
            dist = sqrt((row-xc)^2 + (col-yc)^2);
            all_dist = [all_dist dist];
        end
    end
end
[B, I] = sort(all_dist);
Bnew1 = unique(B);
v = zeros(1, length(Bnew1));
```

```
for row = 1:256
    for col = 1:yc
        if aaMask_m(row, col)==1
            dist = sqrt((row-xc)^2 + (col-yc)^2);
            [Lia, Locb] = ismember(dist, Bnew1);
            v(1, Locb) = (v(1, Locb) + aaVp(row,col))/2;
        end
    end
end
figure
plot(Bnew1, v, 'bo');
hold on

for row = 1:256
    for col = yc:256
        if aaMask_m(row, col)==1
            dist = sqrt((row-xc)^2 + (col-yc)^2);
            all_dist = [all_dist dist];
        end
    end
end
[B, I] = sort(all_dist);
Bnew2 = unique(B);
v1 = zeros(1, length(Bnew2));
for row = 1:256
    for col = yc:256
        if aaMask_m(row, col)==1
            dist = sqrt((row-xc)^2 + (col-yc)^2);
            [Lia, Locb] = ismember(dist, Bnew2);
            v1(1, Locb) = (v1(1, Locb) + aaVp(row,col))/2;
        end
    end
end

plot(-flip(Bnew2), flip(v1), 'bo');
hold on

x= [-flip(Bnew2), Bnew1(1, 2:end)];
v_total = [flip(v1), v(1, 2:end)];
p = polyfit(x, v_total, 2);
y1 = polyval(p, x);
plot(x, y1, 'r', 'LineWidth', 2)
grid on
```