ASEN 3111 - Computational Assignment 01 - Main

We are trying to find the effect of the number of integration points or panels on the accuracy of the lift and drag of objects.

```
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Contents

Problem 1

```
clear,clc,close all

toL = zeros(997);
toD = zeros(997);
i = 1;
found = false;
panels = 4:1000;
% N is the number of panels

for N=panels
    % N since we want half the panels for upper and lower and twice as many
    % sub panels as panels +1 for the extra point
    thetaUp = linspace(0,pi,N+1);
    thetaLo = linspace(pi,2*pi,N+1);
    rho = 1.225; % kg/m^3
    V = 30; % m/s
    pfree = 101.3*10^3; % Pa

    % Pressure distribution calculations
    pUp = (1-4*sin(thetaUp).^2).*(1/2*rho*V^2)+pfree;
    pLo = (1-4*sin(thetaLo).^2).*(1/2*rho*V^2)+pfree;

    % Seting up the integration equations given in the book for lift and
    % drag
    intLup = pUp.*cos(pi/2-thetaUp); % Pa
    intLlo = pLo.*cos(-pi/2-thetaLo); % Pa

    intDup = pUp.*sin(pi/2-thetaUp); % Pa
    intDlo = pLo.*sin(-pi/2-thetaLo); % Pa

    % Integrating the lift and drag
    toLup = mySimp(N,intLup); % N/m
    toLlo = mySimp(N,intLlo); % N/m

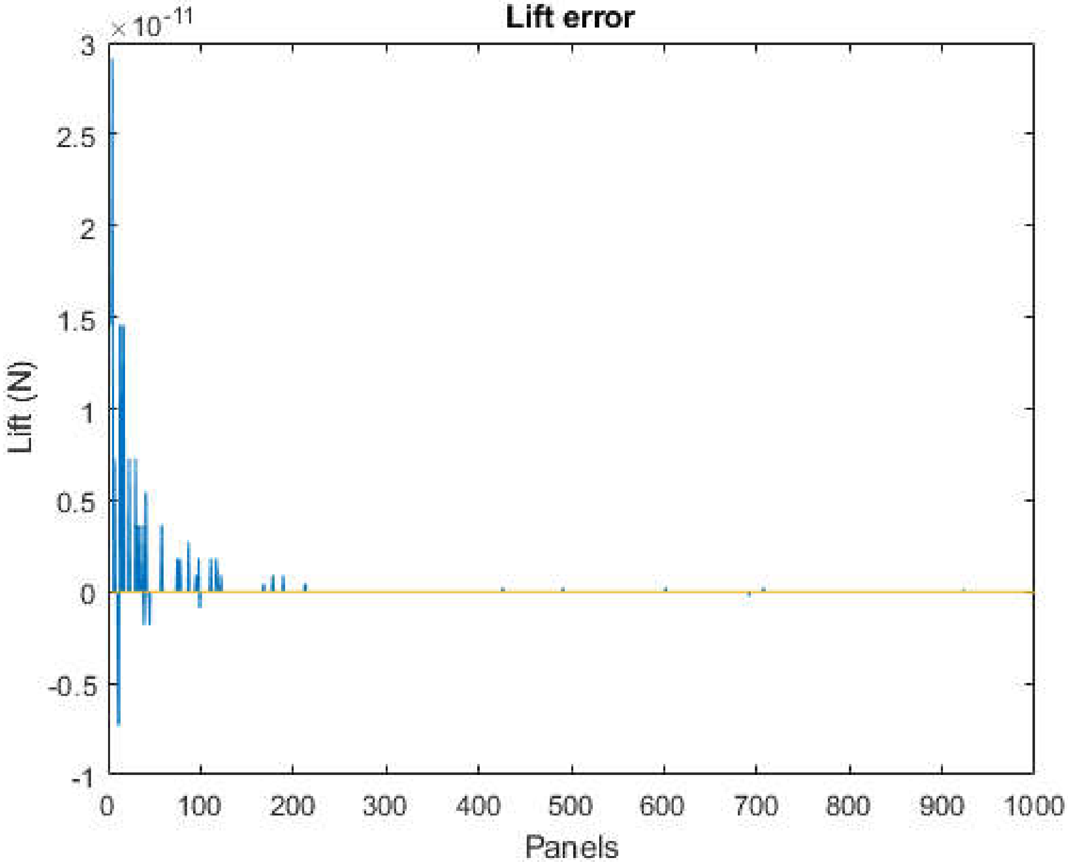
    toDup = mySimp(N,-intDup);
    toDlo = mySimp(N,intDlo);
```

```
    % Since L=N and D=A this calculation is valid
    toL(i) = toLlo-toLup; % N/m
    toD(i) = toDlo+toDup; % N/m
    if i ~= 1
        if abs(toL(i)-toL(i-1))<0.001 && abs(toD(i)-toD(i-1))<0.001 && found ~= true
            noPanels = N;
            found = true;
        end
    end
    i = i+1;
end

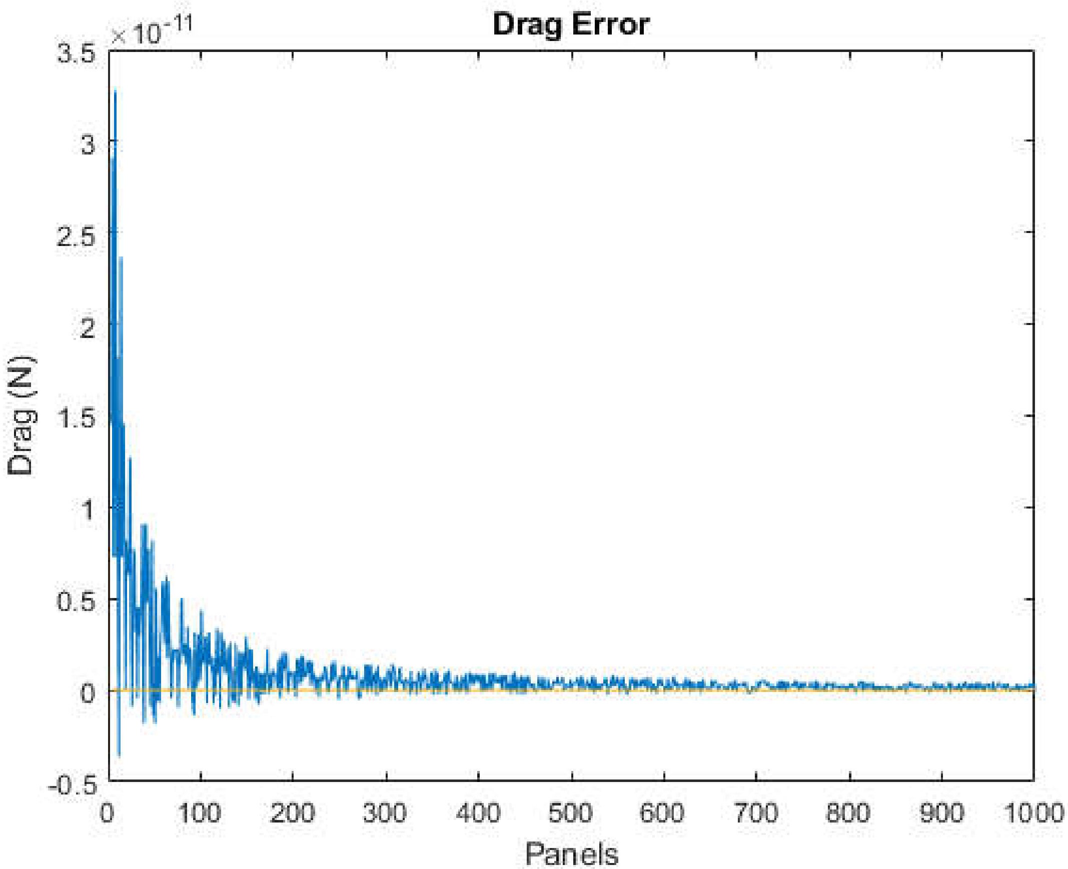
figure(1)
plot(panels,toD)
xlabel("Panels")
ylabel("Lift (N)")
title("Lift error")
figure(2)
plot(panels,toL)
xlabel("Panels")
ylabel("Drag (N)")
title("Drag Error")

% Since L = 0
panels = (find(abs(toL)<0.001,1)+7)/2;
fprintf("The number of panels required to get an accuracy of 0.001N is %d",panels)
```

```
The number of panels required to get an accuracy of 0.001N is 4
```



Lift error
×10^-11
3
2.5
2
1.5
1
0.5
0
-0.5
-1
Lift (N)
0 100 200 300 400 500 600 700 800 900 1000
Panels



Drag Error
×10^-11
3.5
3
2.5
2
1.5
1
0.5
0
-0.5
Drag (N)
0 100 200 300 400 500 600 700 800 900 1000
Panels

Problem 2

```
clear,clc,close all
load Cp

% Initializing values
j = 1;
p5 = false;
p1 = false;

% Givens
c = 2; % m
alpha = 9; % deg
V = 30; % m/s
rho = 1.225; % kg/m^3
pinf = 101.3*10^3; % Pa
t = 12/100; % /c

% Range of integration points
points = 5:5000;

% Initializing lift and drag vectors
L = zeros(size(points));
D = zeros(size(points));

for p=points
    % Base of trapazoid for integration
    base = c/p;
    x = linspace(0,c,p); % m
    y = t/.2.*c.*(0.2969.*sqrt(x./c)-0.1260.*(x./c)-0.3516.*(x./c).^2+...
        0.2843.*(x./c).^3-0.1036.*(x./c).^4); % m
    theta = zeros(size(x));
    % An inital theta of -pi/2 since it is the leading edge
    theta(1) = -pi/2;
    for i=1:length(x)-1
        theta(i+1) = -atan((y(i+1)-y(i))/(x(i+1)-x(i)));
    end

    % Calculation of the coefficient of pressure
    cPup = fnval(Cp_upper,x./c);
    cPlo = fnval(Cp_lower,x./c);

    % Calculation of the pressure upper and lower
    Pup = cPup*1/2*rho*V^2+pinf;
    Plo = cPlo*1/2*rho*V^2+pinf;

    % Set up for Normal and Axial force integration, not actual Normal
    % and Axial forces
    NPup = Pup.*cos(theta);
    NPlo = Plo.*cos(theta);

    APup = -Pup.*sin(theta);
    APlo = Plo.*sin(theta);

    % Integrating for the Normal and Axial forces
    N = myTrapz(base,NPlo)-myTrapz(base,NPup);
    A = myTrapz(base,APlo)+myTrapz(base,APup);

    % Calculating Lift and Drag from Axial and Normal
```

```
    L(j) = N*cosd(alpha)-A*sind(alpha);
    D(j) = N*sind(alpha)+A*cosd(alpha);

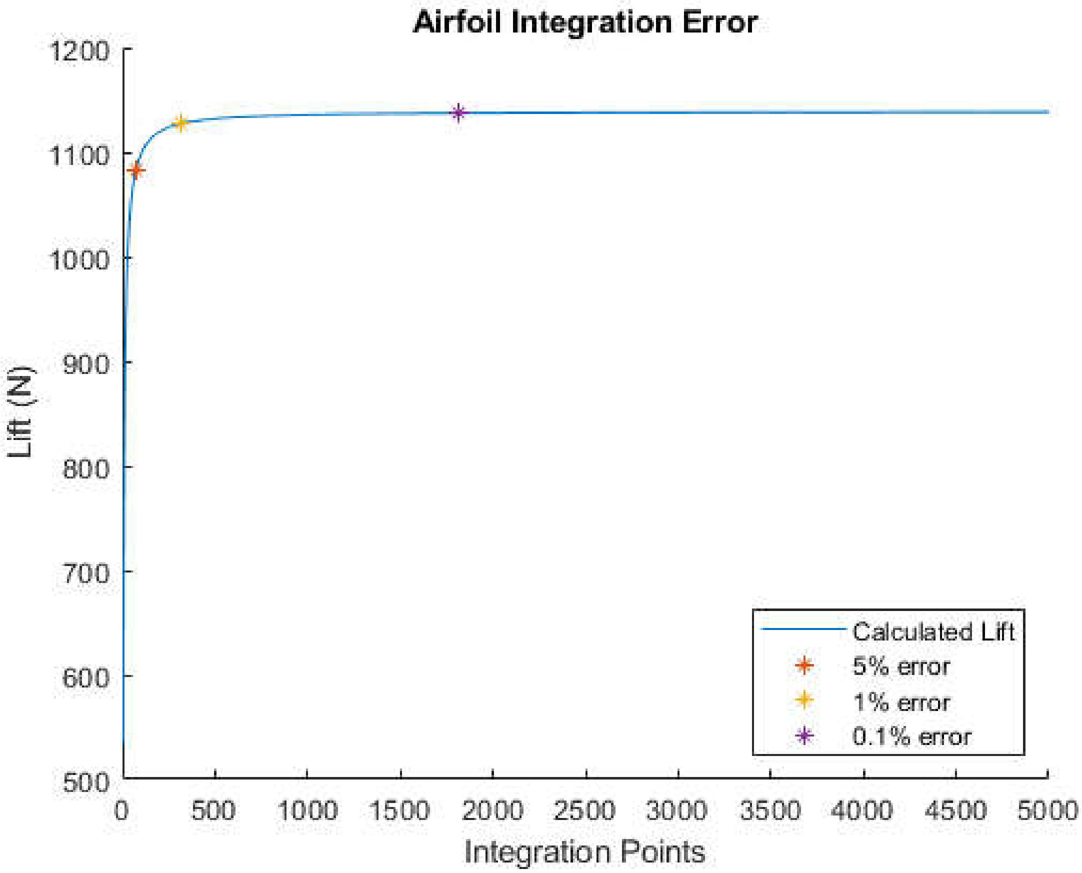
    j = j+1;
end

% Finding the number of integration points needed for the given relative
% errors
for i = 1:numel(L)
    if p5 == false && abs(L(end)-L(i))/L(end) < 0.05
        error5 = i+4;
        lift5 = L(i);
        p5 = true;
    elseif p1 == false && abs(L(end)-L(i))/L(end) < 0.01
        error1 = i+4;
        lift1 = L(i);
        p1 = true;
    elseif abs(L(end)-L(i))/L(end) < 0.001
        error10th = i+4;
        lift10th = L(i);
        break
    end
end

fprintf("Using 5000 points for the 'Actual' lift you would need\n")
fprintf("%d points to get an accuracy of  5%%\n",error5)
fprintf("%d points to get an accuracy of  1%%\n",error1)
fprintf("%d points to get an accuracy of  0.1%%\n",error10th)

figure(3)
hold on
plot(points,L)
plot(error5,lift5,'*')
plot(error1,lift1,"*")
plot(error10th,lift10th,"*")
xlabel("Integration Points")
ylabel("Lift (N)")
title("Airfoil Integration Error")
legend("Calculated Lift", "5% error", "1% error","0.1% error","location","southeast")
```

```
Using 5000 points for the 'Actual' lift you would need
73 points to get an accuracy of  5%
313 points to get an accuracy of  1%
1819 points to get an accuracy of  0.1%
```



Functions Called

The following functions were built and called as part of this assignment.

```
function [Out] = mySimp(N,pres)
%mySimp Uses the composite Simpson's rule to integrate around a circle
% Takes an input of the number of panels and a pressure distribution, then
% uses a composite Simpson's rule for a line integral over a circle
tot = zeros(length(pres),1);
h = 2*pi/N;
for k=2:2:N
   tot = pres(k-1)+4*pres(k)+pres(k+1);
end
Out = sum(tot)*h/3*.5;
end


function [Out] = myTrapz(base,height)
%myTrapz Use the composite trapazoidal rule to integrate anything
%   Given the width between each point and a vector of heights the function
%   uses the trapazoidal rule to give an approximate solution to the
%   integral of the given values

out = zeros(size(height));
for i=1:length(height)-1
    out(i) = base/2*(height(i)+height(i+1));
end

Out = sum(out);
```

```
end
```