AE 504 - Compressible Flow

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Homework 4

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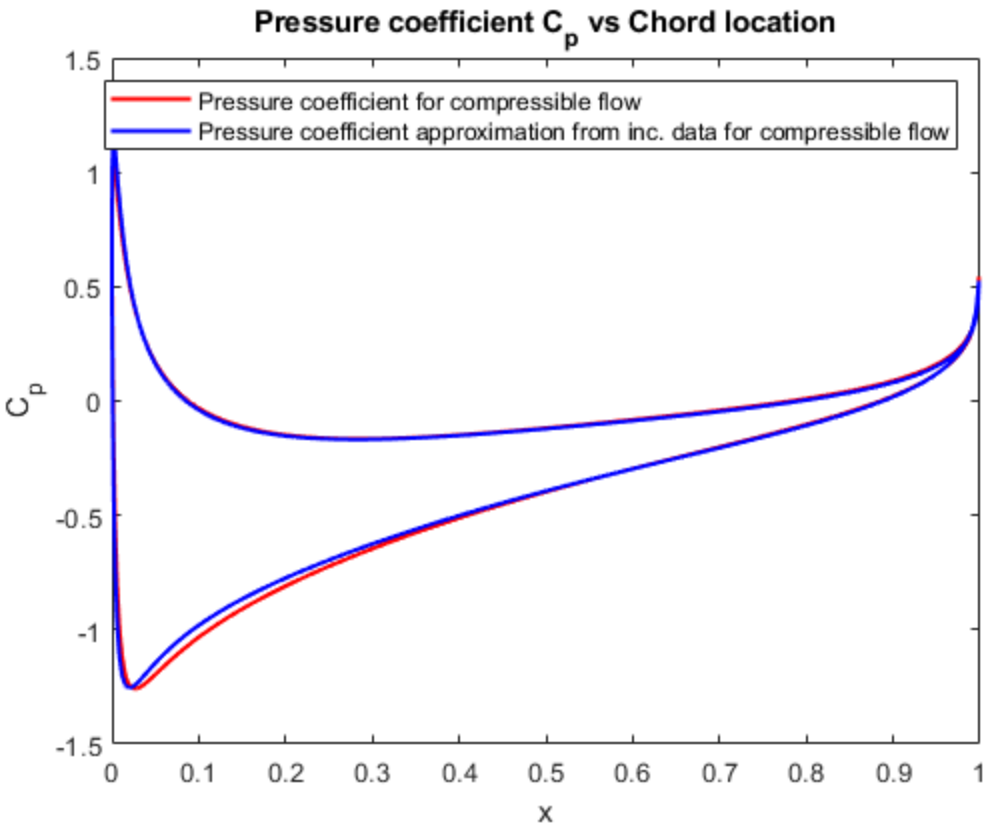
```
clear all; close all; clc
```

Ex. 1

Part 1

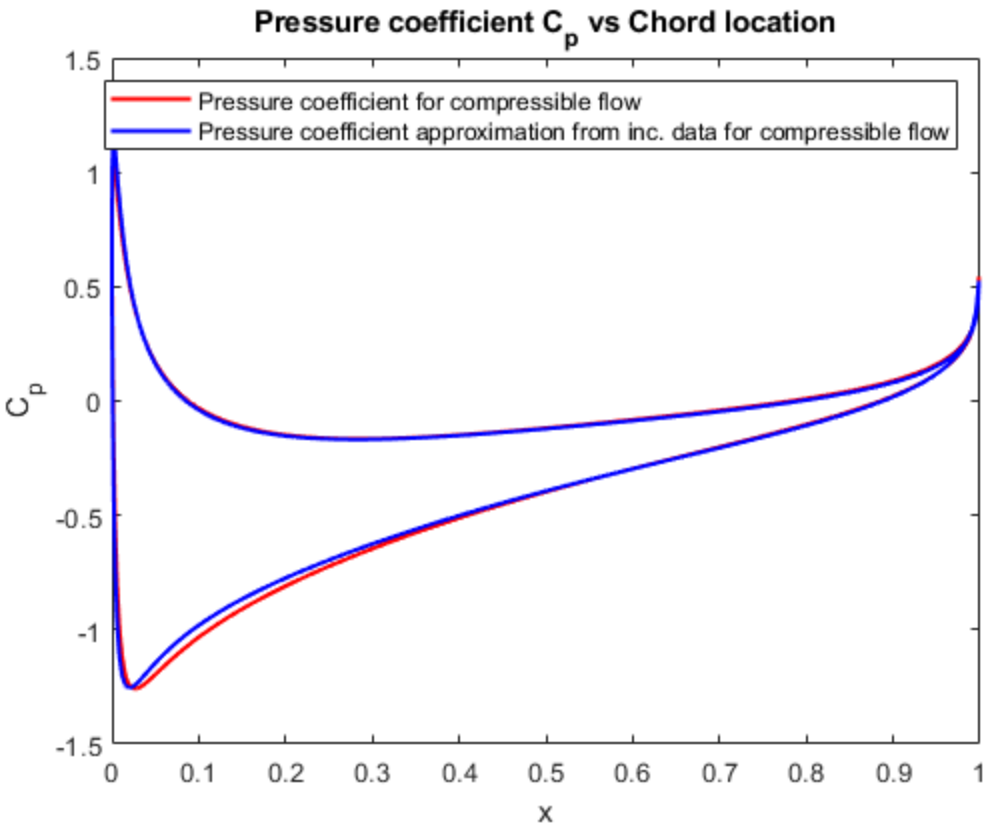
```
%file reading
[x,y,Cp,P]=readvars('NACA_0012_a3_inc.txt');
[x3,y3,Cp3,P3]=readvars('NACA_0012_a3_Mach_0.5.txt');
%mach number
M1=0.5;
%Prandtl-Glauert approximation
Cp_compressible=Cp/sqrt(1-M1^2);

%plot
figure(1)
plot(x3,Cp3,'-r','LineWidth',1.5)
hold on
plot(x,Cp_compressible,'-b','LineWidth',1.5)
legend('Pressure coefficient for compressible flow','Pressure
 coefficient approximation from inc. data for compressible flow')
xlabel('x')
ylabel('C_p')
title('Pressure coefficient C_p vs Chord location')
hold off
```



Part 2

```
syms msol
%Critical pressure coefficient (minimum Cp)
Cp_cr=min(Cp);
g=1.4;          %heat air coefficient
%critical mach no.
M_cr=double(vpasolve(Cp_cr==(2/g/msol^2)*((((1+((g-1)/2)*msol^2)/...
    (1+(g-1)/2))^(g/(g-1)))-1),msol,0.5));

%outputs
disp('Critical Mach number:')
disp(M_cr)
```

```
Critical Mach number:
    0.6351
```

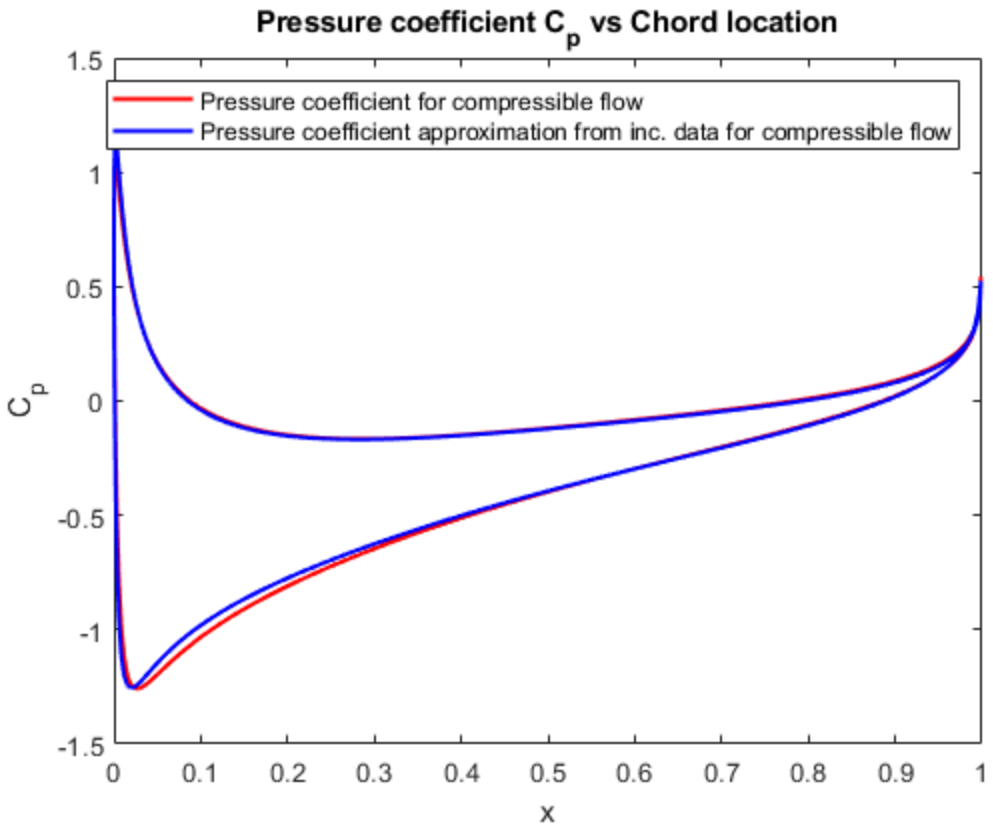


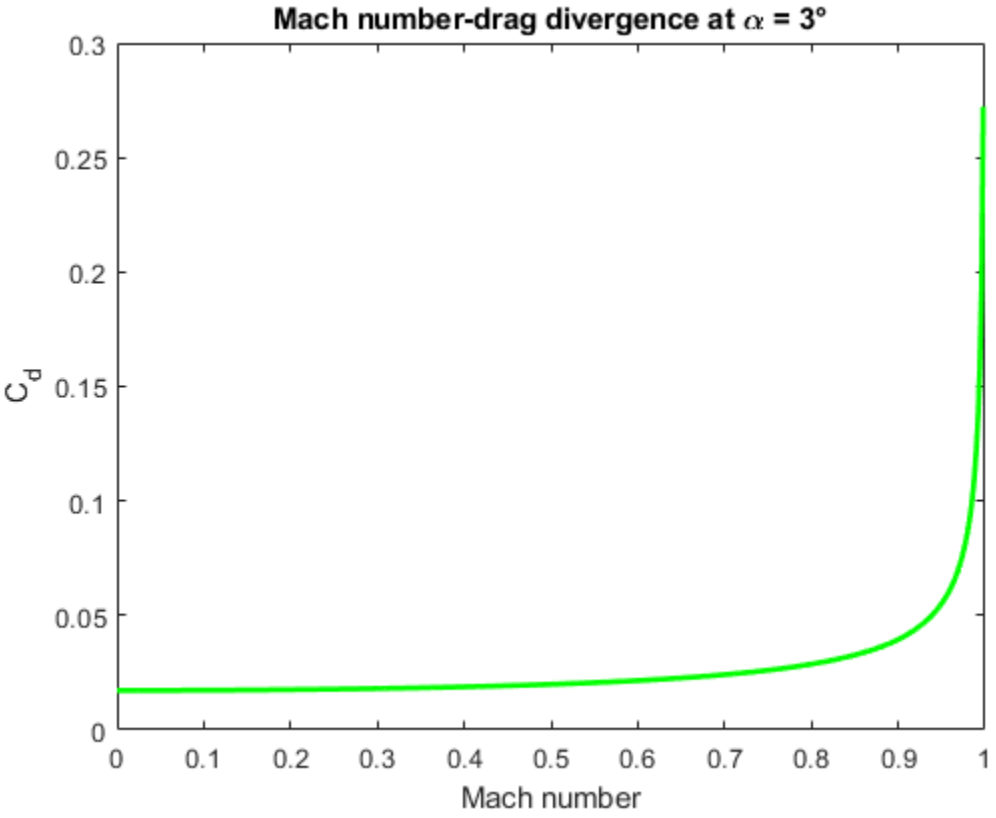
Part 3

```
%file reading
[x2,y2,Cp2,P2]=readvars('NACA_0012_a3_Mach_0.8.txt');
%mach number for drag-M divergence
M2=linspace(0,1,200);
%dynamic pressure assuming M=0.1 for this example, since we are
 analyzing
%an incompressible airfoil
q=g*0.1^2*101325/2;
%angle of attack in radians
alpha=3*pi/180;
%Cl and Cd
dyup=(y(101:200,1)-y(100:199,1))/(x(101:200,1)-x(100:199,1));
dylo=[];
cpup=[Cp(101:200,1)];
cplo=[];
for i=101:-1:2
    dylo=[dylo; (y(i,1)-y(i-1,1))/(x(i,1)-x(i-1,1))];
end
for i=100:-1:1
    cplo=[cplo;Cp(i,1)];
end
range=[x(101:200,1)];
cn=trapz(range,cplo-cpup);
```

```
ca0=trapz(range,((cpup.*dyup)-(cplo.*dylo)));
ca=trapz(range,ca0);
cl=cn*cos(alpha)-ca*sin(alpha);
cd=cn*sin(alpha)+ca*cos(alpha);
L=cl*q;
D=cd*q;

M2=linspace(0,1,500);
for i=1:length(M2)
    Cd2(i)=(2*pi*alpha^2)/sqrt(1-M2(i)^2);
end



%outputs and plots
fprintf('Lift:\n%1.4f N\n\n',L)
fprintf('Drag:\n%1.4f N\n\n',D)
disp('Lift coefficient:')
disp(cl)
disp('Drag coefficient:')
disp(cd)
figure(2)
plot(M2,Cd2,'-g','LineWidth',2)
xlabel('Mach number')
ylabel('C_d')
title('Mach number-drag divergence at \alpha = 3°')
```

```
Lift:
248.2841 N

Drag:
22.7099 N

Lift coefficient:
    0.3501

Drag coefficient:
    0.0320
```


Pressure coefficient C_p vs Chord location
Pressure coefficient for compressible flow
Pressure coefficient approximation from inc. data for compressible flow
C_p
x
1.5
1
0.5
0
-0.5
-1
-1.5
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1


Mach number-drag divergence at α = 3°
C_d
Mach number
0.3
0.25
0.2
0.15
0.1
0.05
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1

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