**PROJECT-1**

**Name-Anshul**

**Roll no –M22ME052**

1 matlab code:-

clear all;

close all;

clc;

%%

%naca 2412 nomenclature

u=input('first digit of naca = ');

v=input('second digit of naca = ');

w=input('last two digit of naca = ');

ymc\_c=u\*0.01;

xmc\_c=v\*0.1;

tm=w\*0.01;

c=1;

z=input("alpha value = ");

alpha=z\*pi/180;

U=10;

%%

%cosine clustring

%choose even number of points on circle

n=160;

theta=2\*pi/(n-1);

i=1:n/2;

x\_c=0.5\*(1-cos((i-0.5)\*theta));

[xl,yl,xu,yu]=surface\_coordinate(tm,xmc\_c,ymc\_c,c,x\_c);

x=[fliplr(xl),xu];

y=[fliplr(yl),yu];

for i=1:n-1

dx(i)=x(i+1)-x(i);

dy(i)=y(i+1)-y(i);

x\_cp(i)=(x(i+1)+x(i))/2;

y\_cp(i)=(y(i+1)+y(i))/2;

l(i)=sqrt((x(i+1)-x(i))^2+(y(i+1)-y(i))^2);

end

%%

A=zeros(n,n);

T=zeros(n,n);

B=zeros(n,1);

v\_in\_t=zeros(n,1);

for i=1:n-1

for j=1:n-1

[P]=influence\_matrix\_vortex(x(j),x(j+1),y(j),y(j+1),l(j),x\_cp(i),y\_cp(i));

A(i,j)=A(i,j)+(-P(1,1)\*(y(i+1)-y(i))/l(i)+P(2,1)\*(x(i+1)-x(i))/l(i));

A(i,j+1)=A(i,j+1)+(-P(1,2)\*(y(i+1)-y(i))/l(i)+P(2,2)\*(x(i+1)-x(i))/l(i));

end

end

for i=1:n-1

for j=1:n-1

[P]=influence\_matrix\_vortex(x(j),x(j+1),y(j),y(j+1),l(j),x\_cp(i)+0.001\*(-(y(i+1)-y(i))/l(i)),y\_cp(i)+0.001\*((x(i+1)-x(i))/l(i)));

T(i,j)=T(i,j)+(P(1,1)\*(x(i+1)-x(i))/l(i)+P(2,1)\*(y(i+1)-y(i))/l(i));

T(i,j+1)=T(i,j+1)+(P(1,2)\*(x(i+1)-x(i))/l(i)+P(2,2)\*(y(i+1)-y(i))/l(i));

end

end

A(n,[1,end])=1;

T(n,[1,end])=1;

for i=1:n-1

B(i,1)=U\*((y(i+1)-y(i))\*cos(alpha)-(x(i+1)-x(i))\*sin(alpha))/l(i);

v\_in\_t(i,1)=U\*((x(i+1)-x(i))\*cos(alpha)+(y(i+1)-y(i))\*sin(alpha))/l(i);

end

gamma=A\B;

T\_vel=T\*gamma+v\_in\_t;

%%

%cp variation

cp=1-(T\_vel.^2./U^2);

figure(1)

plot(x\_cp,cp(1:n-1));

xlabel('---- x/c ---->');

ylabel('---- cp ---->');

title("cp on upper and lower surface");

set(gca, 'YDir','reverse');

%%

% naca profile

figure(2)

plot(x,y);

xlabel('---- x/c ---->');

ylabel('---- y/c ---->');

title('naca 2412');

%%

cl=0;

cm\_le=0;

for j=1:n-1

cl=cl+l(j)\*(gamma(j)+gamma(j+1))/(U\*c);

cm\_le=cm\_le-l(j)\*((2\*x(j)\*gamma(j)+x(j)\*gamma(j+1)+x(j+1)\*gamma(j)+2\*x(j+1)\*gamma(j+1))\*cos(alpha)+(2\*y(j)\*gamma(j)+y(j)\*gamma(j+1)+y(j+1)\*gamma(j)+2\*y(j+1)\*gamma(j+1))\*sin(alpha))/(3\*U\*c^2);

end

cm\_qc=cm\_le+cl\*(0.25);

%%

% streamline

%from trailing edge

% t\_T(1)=1;

% s\_T(1)=0;

% k=[1;0];

% for i=2:10

% v=zeros(2,1);

% [v]=global\_vel(x,y,l,t\_T(i-1),s\_T(i-1),v,gamma,n,alpha,U);

% %euler method

% k=k+0.01\*v;

% t\_T(i)=k(1);

% s\_T(i)=k(2);

% end

[t\_T,s\_T]=sl\_by\_point(x,y,l,gamma,n,alpha,U,1,0,0.01,30);

%%

a=[x(0.5\*n-1),0,x(0.5\*n+1)];

b=[y(0.5\*n-1),0,y(0.5\*n+1)];

vt=zeros(3,1);

for i=1:3

h=zeros(2,1);

[h]=global\_vel(x,y,l,a(i)+10^(-4),b(i)+10^(-4),h,gamma,n,alpha,U);

vt(i)=[(x(0.5\*n-1+i)-a(i))/sqrt((x(0.5\*n-1+i)-a(i))^2+(y(0.5\*n-1+i)-b(i))^2),(y(0.5\*n-1+i)-b(i))/sqrt((x(0.5\*n-1+i)-a(i))^2+(y(0.5\*n-1+i)-b(i))^2)]\*h;

end

d\_u\_vt=-(vt(3)-vt(2))/(a(3)-a(2));

d\_l\_vt=(vt(2)-vt(1))/(a(2)-a(1));

%%

vt\_le=vt(2);

N\_R=0;

u\_vt\_n=0;

l\_vt\_n=0;

while (u\_vt\_n<10^(-5)\*U || l\_vt\_n<10^(-5)\*U)

if (vt\_le<0)%search upper

N\_R=N\_R-vt\_le/d\_u\_vt;

else%search lower

N\_R=N\_R-vt\_le/d\_l\_vt;

end

xl\_g=0;yl\_g=0;xu\_g=0;yu\_g=0;

[xl\_n,yl\_n,xu\_n,yu\_n]=surface\_coordinate(tm,xmc\_c,ymc\_c,c,N\_R);

h\_u=zeros(2,1);

h\_l=zeros(2,1);

[h\_u]=global\_vel(x,y,l,xu\_n,yu\_n,h\_u,gamma,n,alpha,U);

[h\_l]=global\_vel(x,y,l,xl\_n,yl\_n,h\_l,gamma,n,alpha,U);

xl\_n=[xl\_g,xl\_n];yl\_n=[yl\_g,yl\_n];xu\_n=[xu\_g,xu\_n];yu\_n=[yu\_g,yu\_n];

u\_vt\_n=[(xu\_n(2)-xu\_n(1))/sqrt((xu\_n(2)-xu\_n(1))^2+(yu\_n(2)-yu\_n(1))^2),(yu\_n(2)-yu\_n(1))/sqrt((xu\_n(2)-xu\_n(1))^2+(yu\_n(2)-yu\_n(1))^2)]\*h\_u;

l\_vt\_n=[(xl\_n(2)-xl\_n(1))/sqrt((xl\_n(2)-xl\_n(1))^2+(yl\_n(2)-yl\_n(1))^2),(yl\_n(2)-yl\_n(1))/sqrt((xl\_n(2)-xl\_n(1))^2+(yl\_n(2)-yl\_n(1))^2)]\*h\_l;

xl\_g=xl\_n(2);yl\_g=yl\_n(2);xu\_g=xu\_n(2);yu\_g=yu\_n(2);

end

if u\_vt\_n<l\_vt\_n

xs=xu\_g;

ys=yu\_g;

v\_s=h\_u;

else

xs=xl\_g;

ys=yl\_g;

v\_s=h\_l;

end

%%

%from leading edge

[t\_L,s\_L]=sl\_by\_point(x,y,l,gamma,n,alpha,U,xs,ys,-0.001,500);

figure(3)

plot(x,y);

xlabel('---- x/c ---->');

ylabel('---- y/c ---->');

title("streamline");

hold on;

plot(t\_T,s\_T);

hold on;

plot(t\_L,s\_L);

hold on;

%other streamlines

for i=-29:2:29

[m,o]=sl\_by\_point(x,y,l,gamma,n,alpha,U,t\_L(end),s\_L(end)+0.03\*i,0.01,100);

plot(m,o);

hold on;

end

matlab function:-

1

function [xl,yl,xu,yu]=surface\_coordinate(tm,xmc\_c,ymc\_c,c,x\_c)

%%

%camber line formation

for j=1:length(x\_c)

if(x\_c(j)>=0) && (x\_c(j)<=xmc\_c)

ycx\_c(j)=ymc\_c\*(2\*(x\_c(j)/xmc\_c)-(x\_c(j)/xmc\_c)^2);

dyc\_dx(j)=ymc\_c\*(2\*(1/xmc\_c)-(2\*(x\_c(j))/(xmc\_c)^2));

else

ycx\_c(j)=ymc\_c\*(2\*((1-x\_c(j))/(1-xmc\_c))-((1-x\_c(j))/(1-xmc\_c))^2);

dyc\_dx(j)=ymc\_c\*(2\*(-1/(1-xmc\_c))+(2\*(1-x\_c(j))/(1-xmc\_c)^2));

end

end

%%

%thickness

for j=1:length(x\_c)

% tx(j)=tm\*(2.969\*sqrt(x\_c(j))-1.260\*x\_c(j)-3.516\*x\_c(j)\*x\_c(j)+2.843\*x\_c(j)\*x\_c(j)\*x\_c(j)-1.015\*x\_c(j)\*x\_c(j)\*x\_c(j)\*x\_c(j));

tx(j)=tm\*(2.980\*sqrt(x\_c(j))-1.320\*x\_c(j)-3.280\*x\_c(j)\*x\_c(j)+2.441\*x\_c(j)\*x\_c(j)\*x\_c(j)-0.815\*x\_c(j)\*x\_c(j)\*x\_c(j)\*x\_c(j));

end

%%

%upper and lower surface

for j=1:length(x\_c)

xu(j)=x\_c(j)-0.5\*tx(j)\*dyc\_dx(j)/sqrt(1+dyc\_dx(j)\*dyc\_dx(j));

yu(j)=ycx\_c(j)+0.5\*tx(j)/sqrt(1+dyc\_dx(j)\*dyc\_dx(j));

xl(j)=x\_c(j)+0.5\*tx(j)\*dyc\_dx(j)/sqrt(1+dyc\_dx(j)\*dyc\_dx(j));

yl(j)=ycx\_c(j)-0.5\*tx(j)/sqrt(1+dyc\_dx(j)\*dyc\_dx(j));

end

2

function [P]=influence\_matrix\_vortex(x1,x2,y1,y2,l,x\_cp,y\_cp)

dx=x2-x1;

dy=y2-y1;

geta=(1/l)\*[dx,dy;-dy,dx]\*[x\_cp-x1;y\_cp-y1];

g=geta(1,1);

n=geta(2,1);

A=atan2(n\*l,g^2+n^2-l\*g);

B=0.5\*log((n^2+g^2)/((g-l)^2+n^2));

T=(1/l)\*[dx,-dy;dy,dx];

p=[(l-g)\*A+n\*B,g\*A-n\*B;n\*A-(l-g)\*B-l,-n\*A-g\*B+l];

P=(1/(2\*pi\*l))\*T\*p;

3

function [v]=global\_vel(a,b,e,f,g,v,gamma,n,alpha,U)

for j=1:n-1

[P]=influence\_matrix\_vortex(a(j),a(j+1),b(j),b(j+1),e(j),f,g);

v=v+P\*[gamma(j),gamma(j+1)]';

end

v=[U\*cos(alpha),U\*sin(alpha)]'+v;

4

function [t\_T,s\_T]=sl\_by\_point(x,y,l,gamma,n,alpha,U,a,b,dx,N)

t\_T(1)=a;

s\_T(1)=b;

% v=zeros(2,1);

k=[a;b];

for i=2:N

v=zeros(2,1);

[v]=global\_vel(x,y,l,t\_T(i-1),s\_T(i-1),v,gamma,n,alpha,U);

%euler method

k=k+dx\*v;

t\_T(i)=k(1);

s\_T(i)=k(2);

end

**Result:-**

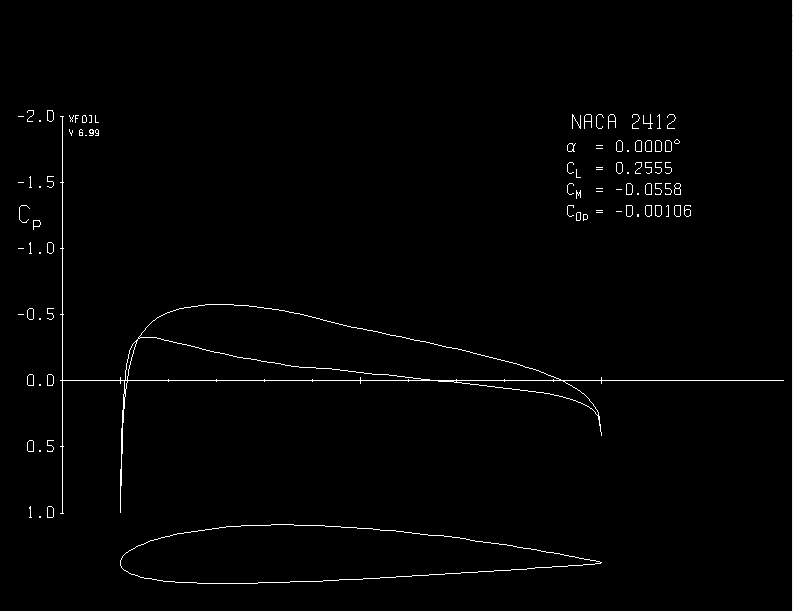
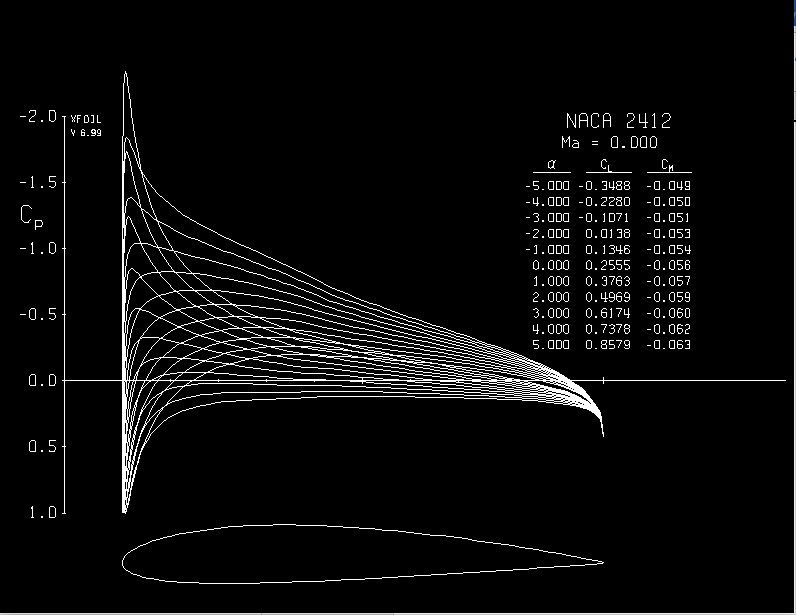
**For naca 2412 with alpha(AOA)=0**

lift\_coefficient = 0.2599

Cm\_qc = -0.1205

Cm\_le = -0.0555

Xfoil









Alpha=4



Alpha = -4

