Cairo University
Faculty of Engineering
Aerospace Engineering Dept.

Report (3)
AER 3110 - Aerodynamics
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Finite Wing Project For the NACA 23012 Airfoil

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Clearing any old data

In[168]:=
```
ClearAll["Global`*"]
```

Initialization of the variables

In[169]:=
```
SEC = 2.; Bn = 14.;
V∞ = 51.;
ρ = 1.225;
Cr = SEC/2. + Bn/80.;
Ct = SEC/3. + Bn/120.;
b = 4.*(Cr + Ct);
α = (10. - Bn/10.)*π/180.;
α0 = -1.1*π/180.;
a0 = 6.178;
S = b*(Cr + Ct)/2.;
AR = b^2/S;
Δy = b/6;
y = {0.5*Δy, 1.5*Δy, 2.5*Δy};
θ = ArcCos[-2*y/b];
c = Cr - y*(Cr - Ct)/(b/2);
μ = c*a0/(4 b);
```

Solving the monoplane equation

In[185]:=
```
AMOGUS = μ (α - α0) Sin[θ];
SUS = Table[((2 i - 1)*μ[[j]] + Sin[θ[[j]]])*Sin[(2 i - 1)*θ[[j]]], {j, 3}, {i, 3}];
SUSSY = LinearSolve[SUS, AMOGUS];
```

Calculations of the lift coefficient and the drag coefficient

In[188]:=
```
CL = π*SUSSY[[1]]*AR;
δ = Sum[n*(SUSSY[[n]]/SUSSY[[1]])^2, {n, 2, 3}];
CDi = CL^2 (1 + δ)/(π*AR);
Lift = 0.5*ρ*V∞^2*S*CL;
Drag = 0.5*ρ*V∞^2*S*CDi;
```

Displaying the output

In[193]:=
```
Row[{HoldForm@CL, " = ", ReleaseHold@CL}]
Row[{HoldForm@CDi, " = ", ReleaseHold@CDi}]
Row[{HoldForm@Lift, " = ", ReleaseHold@Lift, " N"}]
Row[{HoldForm@Drag, " = ", ReleaseHold@Drag, " N"}]
```

Out[193]= CL = 0.816719

Out[194]= CDi = 0.0268875

Out[195]= Lift = 9979.81 N

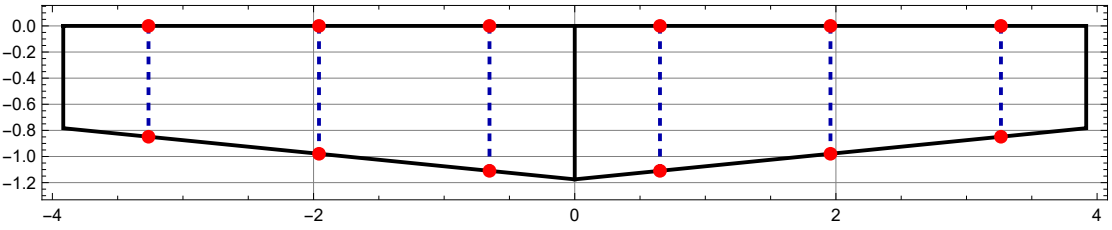
Out[196]= Drag = 328.548 N

Drawing the wing planform

In[197]:=
```
RStations = Line[Table[{{y[[i]], 0}, {y[[i]], -c[[i]]}}, {i, 3}]];
LStations = Line[Table[{{-y[[i]], 0}, {-y[[i]], -c[[i]]}}, {i, 3}]];
P1 = Table[{y[[i]], 0}, {i, 3}];
P2 = Table[{y[[i]], -c[[i]]}, {i, 3}];
P3 = Table[{-y[[i]], 0}, {i, 3}];
P4 = Table[{-y[[i]], -c[[i]]}, {i, 3}];
Append[Append[Append[P1, P2], P3], P4];
points = ArrayReshape[Append[Append[Append[P1, P2], P3], P4], {1, 12, 2}];
WingEq = Line[{{-b/2, 0}, {-b/2, -Ct}, {0, -Cr}, {b/2, -Ct}, {b/2, 0}, {-b/2, 0}}];
CenterLine = Line[{{0, 0}, {0, -Cr}}];
```

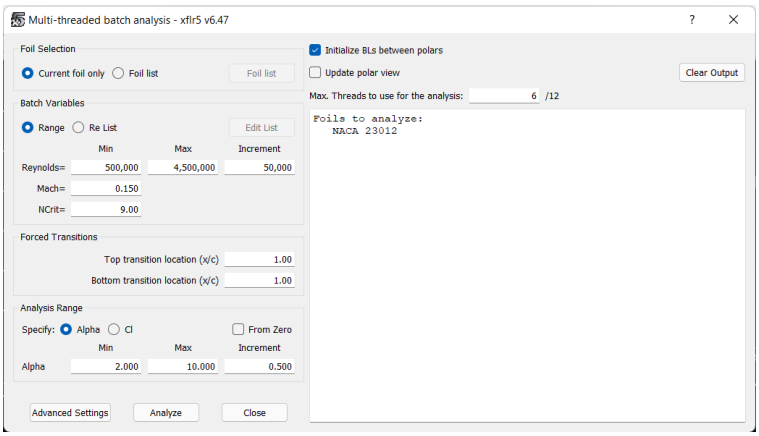
In[207]:=
```
Show[Graphics[{{Thick, WingEq}, {Thick, CenterLine},
    {Thick, Dashed, Darker[Blue], RStations}, {Thick, Dashed, Darker[Blue], LStations}}, ImageSize → Large,
  GridLines → Automatic, Frame → True], Graphics[ListPlot[points, PlotStyle → {Red}]]]
```

Out[207]=

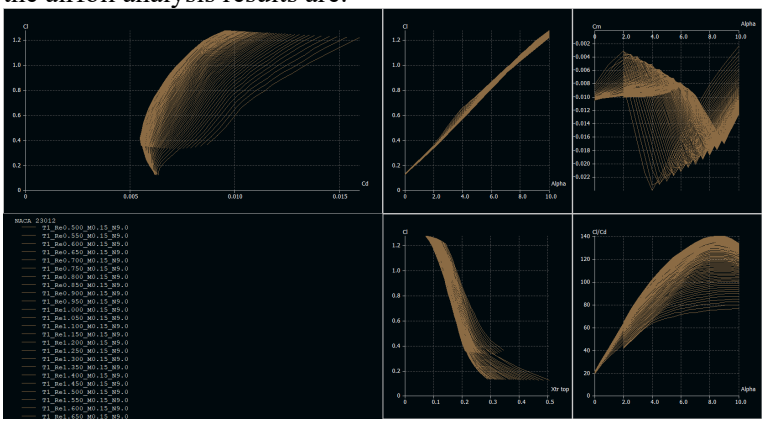


Xflr5 Analysis

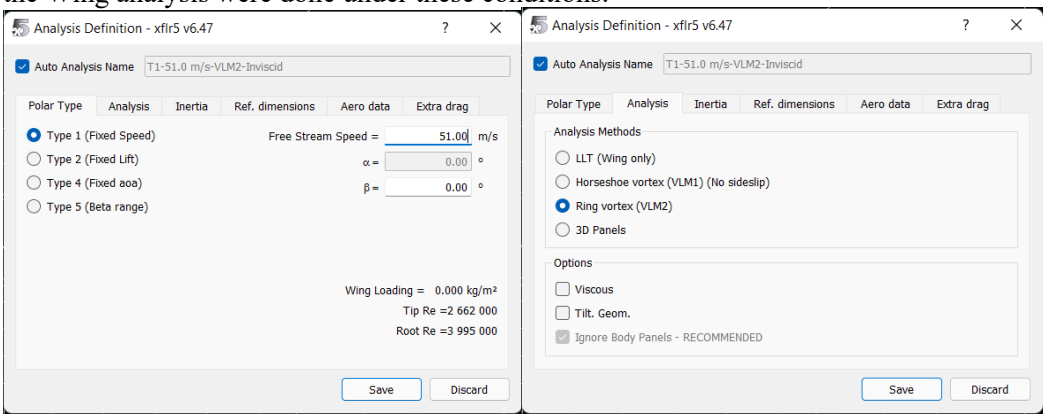
the airfoil analysis were done under these conditions:



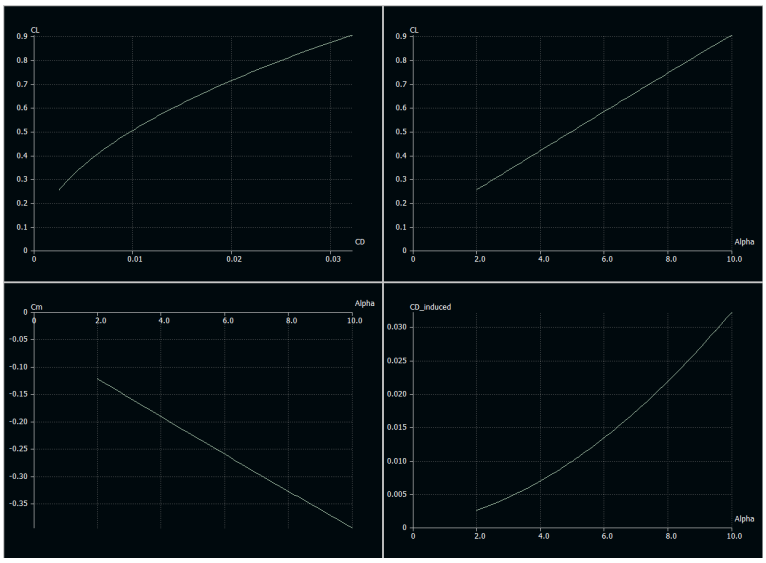
the airfoil analysis results are:



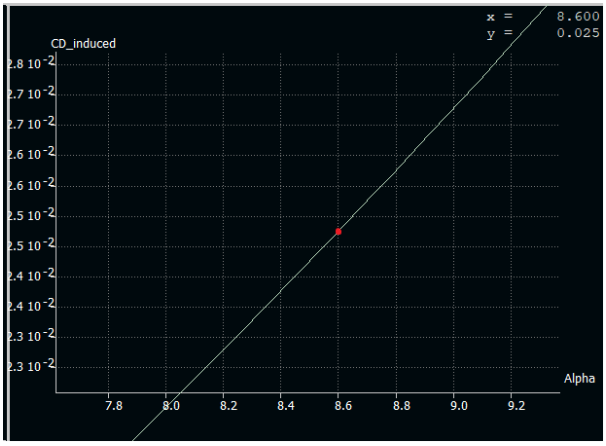
the Wing analysis were done under these conditions:



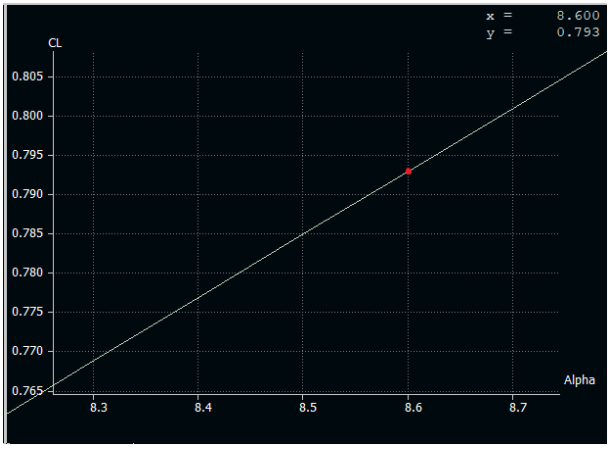
the wing analysis are:

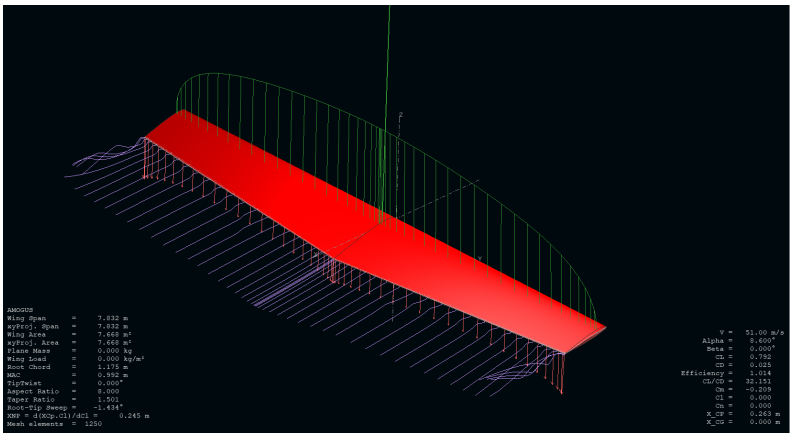


CDi vs α



CL vs α





for the given A.O.A (8.6)
CL=0.792799
CDi=0.024729

In[208]:=
```
Xflr5CL = 0.792799;
Xflr5CDi = 0.024729;
ErrorPrecentageCL = Abs[(Xflr5CL - CL)/Xflr5CL] * 100;
ErrorPrecentageCDi = Abs[(Xflr5CDi - CDi)/Xflr5CDi] * 100;
Xflr5Lift = 0.5 * ρ * V∞^2 * S * Xflr5CL;
Xflr5Drag = 0.5 * ρ * V∞^2 * S * Xflr5CDi;
Row[{HoldForm@Xflr5CL, " = ", ReleaseHold@Xflr5CL}]
Row[{HoldForm@Xflr5CDi, " = ", ReleaseHold@Xflr5CDi}]
Row[{HoldForm@ErrorPrecentageCL, " = ", ReleaseHold@ErrorPrecentageCL, " %"}]
Row[{HoldForm@ErrorPrecentageCDi, " = ", ReleaseHold@ErrorPrecentageCDi, " %"}]
Row[{HoldForm@Xflr5Lift, " = ", ReleaseHold@Xflr5Lift}]
Row[{HoldForm@Xflr5Drag, " = ", ReleaseHold@Xflr5Drag}]
```

Out[214]= Xflr5CL = 0.792799

Out[215]= Xflr5CDi = 0.024729

Out[216]= ErrorPrecentageCL = 3.01713 %

Out[217]= ErrorPrecentageCDi = 8.72845 %

Out[218]= Xflr5Lift = 9687.52

Out[219]= Xflr5Drag = 302.173