Functions for Modelling Lift, Drag and Moment

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The lift sloop can be divided into to extrems. One is for attached flow where the lift is CL1alpha alpha, and the other when there is no attached flow where the lift coefficient is CL2alpha y1. Similiary the induced drag is divided into the same two extremes corresponding to Cdi1 and Cdi2 respectively. Two new variables are introduced y1 and y2 are used instead of alpha to calculate lift and drag. for small alpha they are aproximately the same. The transition is handled with the transition variable f1.

In[2184]:=
```
LogisticFunc[x_] := 1/(1 + N[E, 6]^-x);
```

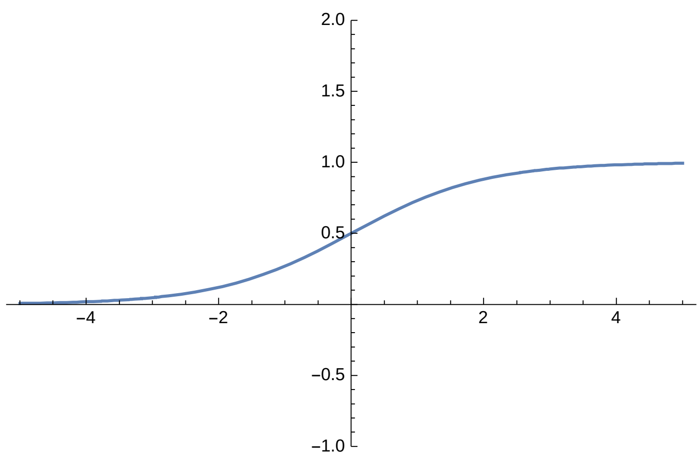
To generat C code

In[2185]:=
```
CForm[1/(1 + N[E, 6]^-x)]
```

Out[2185]//CForm=
```
1/(1 + Power(2.71828,-x))
```

In[2186]:=
```
Plot[LogisticFunc[alpha], {alpha, -5, 5}, PlotRange → {-1, 2}]
```

Out[2186]=



A bias x0 is introduced as well as a width xw

In[2187]:=
```
fw[x_, x0_, xw_] = LogisticFunc[2 (x - x0)/xw];
```

The weight function used to select the region

In[2188]:=
```
f1 = fw[alpha, ap, awp] + fw[-alpha, an, awn];
```

Functions used for the fully separated flow

```
y1 = Sin[2 alpha];
y2 = Sin[alpha]^2;
```

The lift coefficient CL

```
In[2191]:= CL1 = CLalpha alpha;
CL2 = N[(1/Sqrt[2]), 6] y1;
```

The total CL

```
In[2193]:= CL := (1 - f1) CL1 + f1 CL2;
```

Induced drag coefficient CDi

```
In[2194]:= Cdi1 := (CLalpha alpha)^2 / (Pi e AR);
```

```
In[2195]:= Cdi2 := y2 ;
```

The total Cdi

```
In[2196]:= Cdi := (1 - f1) Cdi1 + f1 Cdi2;
```

The moment coefficient Cm

```
In[2197]:= Cm := (1 - f1) Cm0 + f1 Cmfs Sign[alpha];
```

These functions in C-code have been copied and implemented in Hopsan

```
In[2198]:= CForm[CL]
Out[2198]//CForm=
(1 - 1/(1 + Power(2.71828,(-2*(-alpha - an))/awn)) -
      1/(1 + Power(2.71828,(-2*(alpha - ap))/awp)))*alpha*CLalpha +
   0.707107*(1/(1 + Power(2.71828,(-2*(-alpha - an))/awn)) +
      1/(1 + Power(2.71828,(-2*(alpha - ap))/awp)))*Sin(2*alpha)
```

```
In[2199]:= CForm[Cdi]
Out[2199]//CForm=
((1 - 1/(1 + Power(2.71828,(-2*(-alpha - an))/awn)) -
        1/(1 + Power(2.71828,(-2*(alpha - ap))/awp)))*Power(alpha,2)*Power(CLalpha,2))/
    (AR*e*Pi) + (1/(1 + Power(2.71828,(-2*(-alpha - an))/awn)) +
      1/(1 + Power(2.71828,(-2*(alpha - ap))/awp)))*Power(Sin(alpha),2)
```

```
In[2200]:= CForm[Cm]
Out[2200]//CForm=
(1 - 1/(1 + Power(2.71828,(-2*(-alpha - an))/awn)) -
      1/(1 + Power(2.71828,(-2*(alpha - ap))/awp)))*Cm0 +
   (1/(1 + Power(2.71828,(-2*(-alpha - an))/awn)) +
      1/(1 + Power(2.71828,(-2*(alpha - ap))/awp)))*Cmfs*Sign(alpha)
```

Example

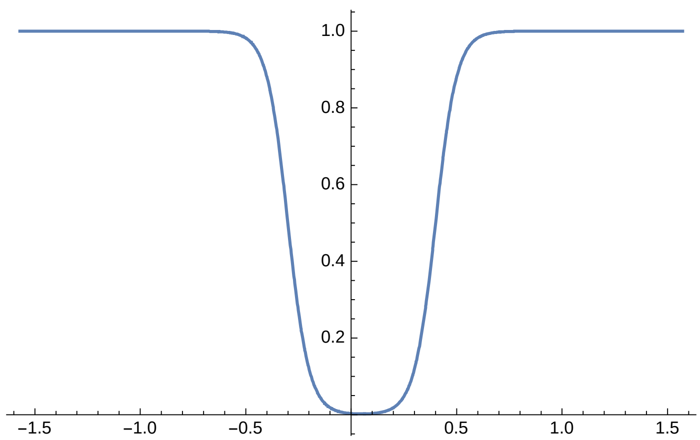
In[2201]:=
```
x0=.3;
xw=.1;
ap=.4;
an=.3;
awp=.1;
awn=.1;

expclp=6;
expcln=9;
CLalpha=5;
e=0.95;
AR=12;
Cm0=-.05;
Cmfs=-.1;
```

In[2216]:=
```
f1
```

Out[2216]=
$$\frac{1}{1+2.71828^{-20.\,(-0.3-\text{alpha})}}+\frac{1}{1+2.71828^{-20.\,(-0.4+\text{alpha})}}$$

In[2217]:=
```
Plot[{f1}, {alpha, -Pi/2, Pi/2}]
```

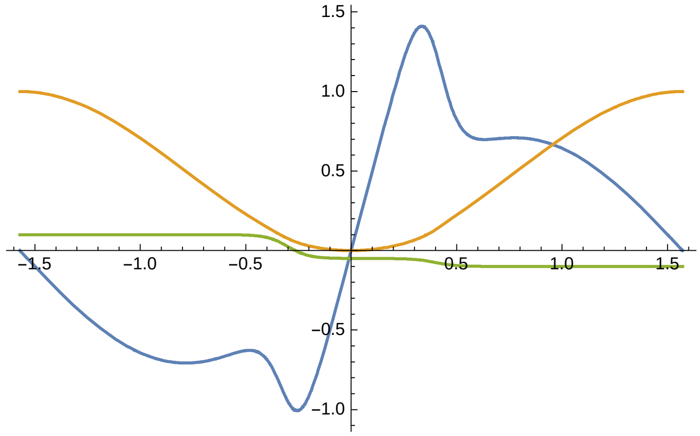
Out[2217]=



In[2218]:=

In[2219]:= `Plot[ {CL, Cdi, Cm} , {alpha, -Pi/2, Pi/2}]`

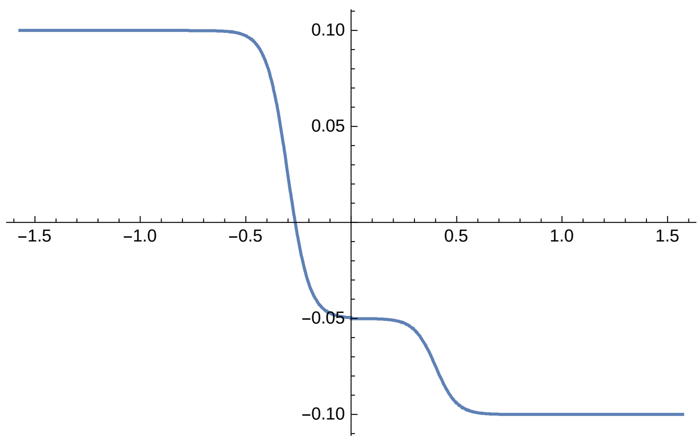
Out[2219]=



In[2220]:=

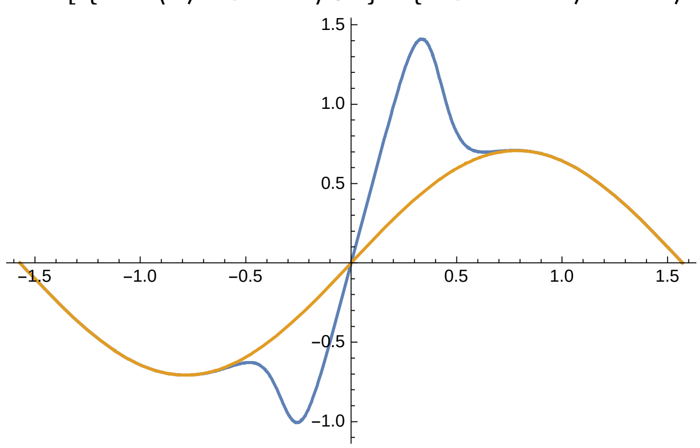
In[2221]:= `Plot[ {Cm} , {alpha, -Pi/2, Pi/2}]`

Out[2221]=



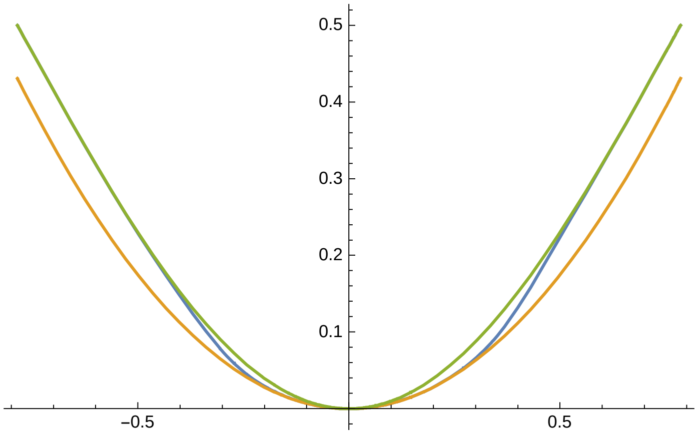
In[2222]:= `Plot[ {CL, (1/Sqrt[2]) y1} , {alpha, -Pi/2, Pi/2}]`

Out[2222]=



In[2223]:=
```
Plot[ {Cdi, Cdi1, Cdi2} , {alpha, -Pi / 4, Pi / 4}]
```

Out[2223]=



Calculation of Lift sloop

This is not used directly as a function in Hopsan but represents a simple way to calculate the lift sloop as a funciton of aspect ratio and sweep.

In[2224]:=
```
AR =.
```

In[2225]:=
```
CLalpha := 2 Pi AR/(c1+ AR)
```

In[2226]:=
```
AR=1;
```

In[2227]:=
```
c1=.
```

In[2228]:=
```
CLalpha
```

Out[2228]= $\frac{2\pi}{1 + c1}$

In[2229]:=
```
FindRoot[CLalpha Pi/180==.025,{c1,1}]
```

Out[2229]= $\{c1 \to 3.38649\}$

In[2230]:=
```
c1 = 3.39
```

Out[2230]= 3.39

In[2231]:=
```
AR=.
```

In[2232]:=
```
CLalpha:= 2 Pi AR/(c1+ AR(1+c2 Sweep))
```

In[2233]:=
```
c2=.
```

In[2234]:=
```
AR=9
```

Out[2234]= 9

In[2235]:=
```
Sweep=60 Pi/180
```

Out[2235]= $\frac{\pi}{3}$

In[2236]:= **CLalpha**

Out[2236]= $$\frac{18\,\pi}{3.39 + 9\left(1 + \frac{c2\,\pi}{3}\right)}$$

In[2237]:= **CLalpha Pi / 180 == .042**

Out[2237]= $$\frac{\pi^2}{10\left(3.39 + 9\left(1 + \frac{c2\,\pi}{3}\right)\right)} == 0.042$$

In[2238]:= **FindRoot[CLalpha Pi/180==.042,{c2,2}]**

Out[2238]= $\{c2 \to 1.17871\}$

In[2239]:= **c1 = 3.39**

Out[2239]= 3.39

In[2240]:= **c2=1.18**

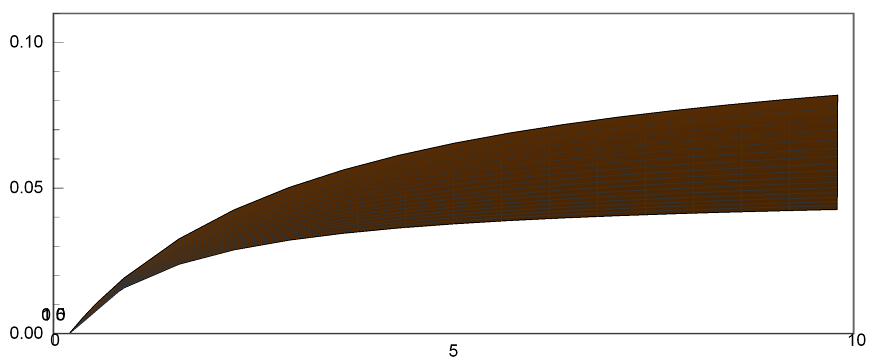
Out[2240]= 1.18

In[2241]:= **AR=.**

In[2242]:= **Sweep=.**

In[2243]:= **Plot3D[CLalpha 2 Pi/360.,{AR,0,10},{Sweep,0,Pi/3},**
PlotRange -> {0, .11},ViewPoint->{0.000, -900.000, 0.000}]

Out[2243]=



In[2244]:= **CLalpha**

Out[2244]= $$\frac{2\,AR\,\pi}{3.39 + AR\,(1 + 1.18\,Sweep)}$$