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A COMPUTER PROGRAM FOR CALCULATING AERODYNAMIC CHARACTERISTICS OF LOW ASPECT-RATIO WINGS WITH PARTIAL LEADING-EDGE SEPARATION

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## LIST OF SYMBOLS

<table>
<thead>
<tr>
<th>Symbols</th>
<th>Description</th>
<th>Dimensions</th>
</tr>
</thead>
<tbody>
<tr>
<td>b</td>
<td>Wing span</td>
<td>m (ft)</td>
</tr>
<tr>
<td>c</td>
<td>Local chord</td>
<td>m (ft)</td>
</tr>
<tr>
<td>$C_R$</td>
<td>Root chord</td>
<td>m (ft)</td>
</tr>
<tr>
<td>M</td>
<td>Number of spanwise strips plus one</td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>Number of bound elements</td>
<td></td>
</tr>
<tr>
<td>$x,y,z$</td>
<td>Wing rectangular coordinate system with $x$ in the streamwise direction and $y$ to the right</td>
<td>m (ft)</td>
</tr>
</tbody>
</table>

### Greek

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\alpha$</td>
<td>Angle of attack</td>
</tr>
</tbody>
</table>

### Subscripts

<table>
<thead>
<tr>
<th>Subscript</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>cp</td>
<td>Control point</td>
</tr>
<tr>
<td>i</td>
<td>Chordwise bound element number</td>
</tr>
<tr>
<td>j</td>
<td>Spanwise strip number</td>
</tr>
<tr>
<td>k</td>
<td>Chordwise bound element number</td>
</tr>
<tr>
<td>L</td>
<td>Leading-edge</td>
</tr>
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</table>
1. **INTRODUCTION**

This document describes in detail the necessary information for using a computer program to predict distributed and total aerodynamic characteristics for low aspect-ratio wings with partial leading-edge separation. This program is based on the numerical method developed in reference 1. The flow is assumed to be steady and inviscid. The wing boundary condition is formulated by the Quasi-Vortex-Lattice method. The leading-edge separated vortices are represented by discrete free vortex elements which are aligned with the local velocity vector at mid-points to satisfy the force free condition. The wake behind the trailing-edge is also force free. The flow tangency boundary condition is satisfied on the wing, including the leading- and trailing-edges.

The program is restricted to delta wings with zero thickness and no camber. It is written in Fortran language and runs on CDC 6600 Computer.
2. COMPUTER PROGRAM DESCRIPTION

2.1 PROBLEM DEFINITION

In steady symmetric flight at a high angle of attack, the flow over a thin low aspect-ratio highly sweptback wing separates along the leading-edge and the tips. In the following, only delta wings are considered. The wing can be represented by a bound vortex sheet, across which there exists a pressure difference, and the separated flow along leading-edges by force free vortex sheets, across which there is no pressure difference. In the present method, the Quasi-Vortex-Lattice method (reference 2) is used to simplify the induced velocity expressions due to the bound vortex sheet and discrete force free vortex elements for separated vortex sheets. The following boundary conditions are imposed on the flow model:

a. The flow must be tangential to the wing surface.

b. The leading-edge boundary condition and the trailing-edge Kutta condition are to be satisfied.

c. The vortex elements over the wing and wake behind the trailing-edge are force free.

This is a non-linear problem because the strengths of the wing bound vortices and free vortices, and the locations of the free vortex elements are unknown. Thus, the problem is solved by an iterative method.

2.2 PROGRAM CAPABILITIES

This computer program provides a theoretical method for determining the aerodynamic characteristics of low aspect-ratio thin delta wings without camber, with partial leading-edge separation. The following is a list of the aerodynamic characteristics the program calculates:

a. Spanwise and chordwise $\Delta C_p$ distributions
b. Spanwise distribution of sectional lift, induced-drag and pitching moment coefficients.

c. Total lift, induced-drag, pitching-moment and leading-edge thrust coefficients.

2.3 GEOMETRY DESCRIPTION

The origin of the rectangular coordinate system is at the wing apex. The wing lies in the x-y plane and the x-axis is taken along the wing center-line. The wing span is given by b and the surface area S.

2.3.1 WING GEOMETRY

The location of bound- and trailing-vortex elements for a typical case are shown in figure 1. The x-location of bound elements is given by the cosine law and is illustrated in figure 1.

\[
x_i = x_L + \frac{c}{2} (1 - \cos\left(\frac{2i - 1}{2N} \pi\right)), \quad i = 1, 2, \ldots, N
\]

where \( x_L \) is the leading-edge x-coordinate, \( c \) is the chord and \( N \) is the number of bound elements in a chordwise direction. The spanwise location of trailing elements is given by,

\[
y_j = \frac{b}{4} (1 - \cos\left(\frac{2j - 1}{2M} \pi\right)), \quad j = 1, 2, \ldots, M
\]

where \( b \) is the span and \( M \) is the number of legs of trailing vorticity, which is one higher than the number of spanwise strips of bound elements. The locations of control points are given by,
Figure 1. Wing geometry without leading-edge vortex system
\[ x_{cp_k} = x_{L_j} + \frac{c_{j}}{2} \left(1 - \cos\left(\frac{\pi k}{N}\right)\right), \quad (3) \]

\[ k = 0,1,2,\ldots,N \]

\[ y_{cp_j} = \frac{b}{4} \left(1 - \cos\left(\frac{\pi j}{M}\right)\right), \quad (4) \]

\[ j = 1,2,\ldots,(M-1) \]

where \( x_{L_j} \) and \( c_{j} \) are the leading-edge x-coordinate and chord at \( y_{cp_j} \) respectively.

It has been found numerically that the aerodynamic characteristics depended on the number of spanwise strips, i.e. \( M \) of equation (2). Therefore, a parametric study has been made to find a relation between the aspect ratio and the number of spanwise strips for reasonably accurate results (Fig. 2) (Section 3 of ref. 1). It is to be noted that as the aspect ratio is decreased, the number of spanwise strips has to be increased. This is due to the fact that the spanwise variation of aerodynamic characteristics, such as pressure coefficient and thrust coefficient, is large for small aspect ratio wings. This study was performed by matching the lift coefficients obtained by using the present method to those obtained by using suction analogy (ref. 3) at one angle of attack.

2.3.2 LEADING-EDGE VORTEX SYSTEM GEOMETRY

The leading-edge vortex system is superimposed on the regular quasi-vortex-lattice grid. A typical vortex element is shown by points A through J in figure 3. These points are connected by a series of short straight segments. The initial location of these segments is shown by dashed lines and final
Figure 2. Variation of number of spanwise strips with aspect ratio
Figure 3. A typical vortex element of leading-edge vortex system
location by solid lines. These segments have the following characteristics:

a. Points A through E lie along a wing trailing vortex element.
Initially point A is one root chord away from the trailing-edge in the downstream direction and the line segments between A and D are parallel to the axis of symmetry. The line segments between points A and B are of equal length. In the final converged position these segments are aligned in the direction of the local velocity vector. The segments B-C and C-D are 0.1 CA long. B-C is allowed to move only in the vertical direction whereas C-D is fixed in the wing plane because the flow is tangential to the trailing-edge. Segment D-E is also fixed in the wing plane.

b. Points E, F, G and H also lie in the wing plane. The location of segment E-F is ahead of the wing first bound element and is given by,

\[ x_E = x_{E|F} + \frac{c_E}{2} \left( 1 - \cos\left( \frac{\pi}{2(N + 1)} \right) \right) \]  
(5.a)

\[ x_F = x_{F|E} + \frac{c_F}{2} \left( 1 - \cos\left( \frac{\pi}{2(N + 1)} \right) \right) \]  
(5.b)

where the subscripts E and F refer to the points under consideration. The above two equations are similar to equation (1). It is to be noted that segment E-F is located at the first bound element for a grid of \((N + 1)\) bound elements in a chordwise direction. The segments F-G and G-H are of the same length and point G lies on the leading-edge. The segment G-H is fixed in the wing plane due to the leading-edge boundary condition.
c. The initial location of point I is given by,

\[ x_I = x_F \]  \hspace{1cm} (6.a) \\
\[ y_I = y_F \]  \hspace{1cm} (6.b) \\
\[ z_I = 0.1 C_R \tan(22.5 - 0.5\alpha) \text{ for } \alpha \leq 15^\circ \]  \hspace{1cm} (6.c) \\
\text{or } \[ z_I = 0.1 C_R \tan \alpha \text{ for } \alpha > 15^\circ \]  \hspace{1cm} (6.d)

where \( C_R \) is the root chord and \( \alpha \) is the angle of attack.

Initially point J is one root chord away from the trailing-edge.
The segments between point I and J are of equal length and lie in a plane parallel to the x-z plane. These segments are approximately at a height of 0.1 \( C_R \) above the wing plane. In the final converged position all the segments between points H and J are aligned in the direction of the local velocity vector.

d. The semi-infinite segments from points A to infinity and J to infinity are straight and are parallel to the undisturbed free-stream direction.

2.4 SOLUTION PROCEDURE

The basic unknowns of the problem are the bound vortex density on the wing, and the strengths and the locations of the elements of the leading-edge vortex system and the wake. The problem is nonlinear because the locations of the leading-edge vortex system and the wake are unknown a priori. Therefore, the problem is solved by the iterative process described below:
a. Prescribe the vortex lattice for the wing surface, and the initial locations of the free elements over the wing and in the wake.

b. By satisfying the wing boundary condition, obtain the bound vortex density of the wing and the strengths of free elements.

c. Calculate all the aerodynamic characteristics.

d. Calculate the forces acting on the free elements over the wing surface.

e. Adjust the free elements of the leading-edge vortex system and the wake in the local velocity vector direction.

f. Repeat steps b through e until a converged solution is obtained.

The initial locations of the free vortex elements are assumed by letting them leave the leading-edge in the undisturbed free-stream direction up-to a height of about ten percent of the root chord beyond which the elements are parallel to the wing plane. Initially, all the elements of the wake lie in the plane of the wing. In the iteration process, the force free condition is satisfied on the free elements from the root to the tip in the down-stream direction. The elements over the wing are adjusted before the elements of the wake. In the first iteration the segments over the wing are moved 100 percent according to the velocity computed at their mid-points. This movement is gradually reduced in steps of 90, 80 and 75 percent in the next three iterations, after which it remains at 75 percent (Section 2.5.2 of ref. 1). The segments in the wake are moved only 50 percent in each iteration. Thus, exact force free condition is not enforced because whenever the free elements come close to each other they induce unreasonably large velocities because viscous effects are not included in the present theory. These large velocities increase the forces on the segments and induce fluctuations in their locations.
The solution is assumed to have converged if in two consecutive iterations the difference between the total strengths of leading-edge free vortex elements is less than one percent and the absolute force acting on the free elements is in the neighborhood of a minimum. Thus, an exact force free condition is not enforced as discussed in the previous paragraph.
3. INPUT DATA FORMAT

The following is the description of input data cards for this program.

Card 1. Format (16A5)

TTL     Any title identifying the case to be run. END in first three columns terminates the job.

Card 2. Format (6I5)

NCW     Number of chordwise lines (limited to nine)
NSW     Number of spanwise lines (one higher than number of spanwise strips of panels, limited to twenty). It depends on aspect-ratio and is determined by using figure 2.
NBRR    Number of constant x-locations where $\Delta C_p$'s are to be interpolated (limited to twenty-five).
NCONTS  = 0, Initial locations of free elements will be calculated in the program.
         = 1, Initial locations of free elements will be read from data cards.
MITER   Maximum number of iterations to be performed (usually between 10 and 15)
IPUNCH  = 0, Coordinates of free elements will not be punched out after last iteration.
         = 1, Coordinates of free elements will be punched out after last iteration.

Card 3. Format (6F10.5)

XXL(1)   Leading-edge x-coordinate of the root chord.
XXT(1) Trailing-edge x-coordinate of the root chord.
YL(1) y-coordinate of the root chord
XXL(2) Leading-edge x-coordinate of the tip chord.
XXT(2) Trailing-edge x-coordinate of the tip chord.
YL(2) y-coordinate of the tip chord.

Card 4. Format (7F10.5)

ALPHA Angle of attack (in degrees).
AMACH Mach number.
DELTA Length of a segment of leading-edge free vortex elements (may be taken as 0.15 CR).
DL Length of a segment of wake elements (may be taken as 0.15 CR).
XEND x-coordinate beyond which free elements of leading-edge and wake system are represented by a single element going to infinity.
CBAR Reference chord.
AREA Total reference wing area.

Card 5. Format (8F10.5)

XBRR(I), Constant x-locations where
I = 1, NBRR ΔCp's are to interpolated.

Card 6. Format (8F10.5)

CTT(I), Sectional leading-edge thrust coefficients for
I = 1, (NSW-1) spanwise strips. All these values are set equal to zero for complete leading-edge separation.

*** If NCONTs = 0, go back to card number 1 ***
Card 7. Format (10I2)

NELM(I), One higher than the number of segments for each leading-
I = 1, (NSW-1) edge free vortex element (numbered from root to tip).

Card 8. Format (8F10.5)

XE(K) x-coordinates of the end-points of segments of Ith
K = 1,NELM(I) leading-edge free vortex element.

Card 9. Format (8F10.5)

YE(K), y-coordinates of the end-points of segments of Ith
K = 1,NELM(I) leading-edge free vortex element.

Card 10. Format (8F10.5)

ZE(K) z-coordinates of the end-points of segments of Ith
K = 1,NELM(I) leading-edge free vortex element.

*** Cards 8 thru 10 are repeated (NSW-1) times.***

Card 11. Format (10I2)

NNELM(I), One higher than the number of segments for each wake
I = 1,NSW element (numbered from root to tip).

Card 12. Format (8F10.5)

XXE(K) x-coordinates of the end-points of segments of Ith
K = 1,NNELM(I) trailing wake element.

Card 13. Format (8F10.5)

YYE(K) y-coordinates of the end-points of segments of Ith
K = 1,NNELM(I) trailing wake element.

Card 14. Format (8F10.5)

ZZE(K), z-coordinates of the end-points of segments of Ith
K = 1,NNEM(I) trailing wake element.

*** Cards 12 thru 14 are repeated NSW times.***
*** Go back to card number 1.***

Note: The punched data cards obtained by running this program with IPUNCH = 1, can be directly used for cards 7 thru 14 for further iterations.
4. OUTPUT DATA FORMAT

All the input data cards for each case are listed at the beginning of the output. The output data at each iteration step is as follows:

The title card (input data card number 1) is printed-out as it is inputted. The angle-of-attack (in degrees), Mach Number and iteration number are also listed. The end-point locations of the leading-edge free elements are listed next. The first row of numbers in each group are the x-coordinates, second row the y-coordinates and third row the z-coordinates. The end-point locations of the wake elements are listed in the similar manner. On the next two pages, x-y and y-z digital plots for leading-edge free-elements are made. It is to be noted that the leading-edge elements lying in the plane of the wing and along center line are not plotted. So, the elements next to the center line are represented by "1". When similar numbers are connected by straight lines, they represent the path of a free vortex element. A "+" sign represents a duplicate point. In these two plots there are (NSW-2) rows of free elements.

The digital plots for wake elements are made on next two pages. The elements along center line are again not plotted. There are (NSW-1) elements.

Some of the intermediate variables are listed under following labels:

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>X/C</td>
<td>Percent chord location</td>
</tr>
<tr>
<td>2Y/B</td>
<td>Percent span location</td>
</tr>
<tr>
<td>GAMAY</td>
<td>Bound vortex density over the wing ( \gamma_y ) at the given ( (X/C, 2Y/B) )</td>
</tr>
<tr>
<td>CAPGAMA</td>
<td>Strength of leading-edge free element ( \Gamma ) at the given ( 2Y/B )</td>
</tr>
<tr>
<td>DELTA-CP</td>
<td>The total ( \Delta C_p ) at the given ( (X/C, 2Y/B) )</td>
</tr>
</tbody>
</table>
The sectional properties are listed under the following labels:

- I: Spanwise station number (numbered from root to tip)
- CLI: The sectional lift coefficient
- CMI: The sectional pitching moment coefficient about the y-axis
- CDI: The sectional induced drag coefficient
- CTI: The sectional leading-edge thrust coefficient.

The total lift, pitching moment, induced drag and leading-edge thrust coefficients are listed after sectional properties. The spanwise pressures at constant x-locations are listed under following labels:

- Y: y-coordinate
- 2Y/B(LOCAL): Percent span location based on local span
- DELTA-CP: The total ΔCP at the given (x,y)

The last item listed for each iteration is the absolute force acting on leading-edge free elements.

The last page of the output is the "Summary Sheet", which is used to pick up final converged solution. It has the following format:

The title (input data card number 1) is printed again. The angle of attack (in degrees) and Mach Number are also listed. The other variables listed are,

<table>
<thead>
<tr>
<th>ITERATION</th>
<th>Iteration number</th>
</tr>
</thead>
<tbody>
<tr>
<td>CL</td>
<td>The total lift coefficient</td>
</tr>
<tr>
<td>CM</td>
<td>The total pitching moment coefficient about y-axis</td>
</tr>
<tr>
<td>CD</td>
<td>The total induced drag coefficient</td>
</tr>
<tr>
<td>CT</td>
<td>The total leading-edge thrust coefficient</td>
</tr>
<tr>
<td>GMSUM</td>
<td>Total sum of the strengths of leading-edge free vortex elements, except the one at the center line.</td>
</tr>
</tbody>
</table>
FERR  Percent change in ONSUM values of two consecutive iterations

TFARS  Total absolute force acting on leading-edge free elements

This program has not yet been completely automated and the converged solution is to be picked by the user, from the Summary Sheet, by using the following criteria:

The solution is assumed to have converged if in two consecutive iterations the difference between the total strengths of leading-edge free vortex elements is less than one percent and the absolute force acting on the free elements is in the neighborhood of a minimum.
5. REFERENCES


6. **APPENDICES**

6.1 **APPENDIX A: EXAMPLE INPUT AND OUTPUT**

The following is an example of delta wing of aspect-ratio 2 at an angle-of-attack of 30 degrees. The flow is assumed to be completely separated from the leading-edge and so sectional leading-edge thrust coefficients are set to zero on card number 6. Listing of input data cards is given below:

**Listing of Input Data Cards**

<table>
<thead>
<tr>
<th>CARD NUMBER</th>
<th>ASPECT RATIO = 2.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0. 6 7 9 0 10 0</td>
</tr>
<tr>
<td>2</td>
<td>30. 0. 0.0 0.0 4. 1. 0.</td>
</tr>
<tr>
<td>3</td>
<td>1. 0. 0. 0. 3.5 3.75 0. 0.</td>
</tr>
<tr>
<td>4</td>
<td>0. 0. 0. 0. 0. 0.</td>
</tr>
</tbody>
</table>

Output data is listed on the following pages. An inspection of the "Summary Sheet" suggests that the converged solution has been reached at 8th iteration.
**INPUT DATA CARDS**

<table>
<thead>
<tr>
<th>6</th>
<th>7</th>
<th>5</th>
<th>0</th>
<th>10</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00000</td>
<td>4.00000</td>
<td>0.00000</td>
<td>4.00000</td>
<td>4.00000</td>
<td>2.00000</td>
</tr>
<tr>
<td>30.00000</td>
<td>0.00000</td>
<td>0.60000</td>
<td>0.60000</td>
<td>7.50000</td>
<td>2.00000</td>
</tr>
<tr>
<td>1.00000</td>
<td>2.00000</td>
<td>3.00000</td>
<td>3.50000</td>
<td>3.75000</td>
<td>5.00000</td>
</tr>
<tr>
<td>0.00000</td>
<td>0.00000</td>
<td>0.00000</td>
<td>0.00000</td>
<td>0.00000</td>
<td>0.00000</td>
</tr>
</tbody>
</table>

**END OF INPUT DATA**
## Wing Vortex Stresses

<table>
<thead>
<tr>
<th>X/C</th>
<th>2Y/R</th>
<th>GAMAY</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.01704</td>
<td>0.04952</td>
<td>8.33720</td>
</tr>
<tr>
<td>0.14645</td>
<td>0.04952</td>
<td>1.56297</td>
</tr>
<tr>
<td>0.37059</td>
<td>0.04952</td>
<td>4.0264</td>
</tr>
<tr>
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<td>0.04952</td>
<td>4.4407</td>
</tr>
<tr>
<td>0.85355</td>
<td>0.04952</td>
<td>2.2943</td>
</tr>
<tr>
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<td>0.04952</td>
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<td>0.18826</td>
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<tr>
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<td>0.18826</td>
<td>1.18377</td>
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## Leading-Edge Vortices Stresses

### 2Y/R CAPGAMA
### Sectional Properties

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**Total lift coefficient:** 1.55805  
**Total pitching moment coefficient:** -1.83185  
**Total drag coefficient:** 0.89954  
**Total thrust coefficient:** 0.00000

### Spanwise Pressures at Constant X = Y 2Y/B (Local) Delta-CP

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**TOTAL ABSOLUTE FORCE ACTING ON LEADING-EDGE FREE ELEMENTS = 1.28618**
### ASPECT RATIO = 2.0

**ALPHA(DEG.)=30.000**  **MACH NUMBER= 0.000**  **ITERATION NUMBER= 1**

**LEADING EDGE ELEMENTS**

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**Summary Table**

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**Notes:**

- The table provides data on the leading edge elements of a structure with specified aspect ratio and iteration numbers.
- The data is presented in a structured format with columns for element number, length, width, height, and angle.
- The summary table provides an overview of the population statistics including mean, standard deviation, minimum, and maximum values.

**Original Page IS**

**Poor Quality**
SECTIONAL PROPERTIES

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TOTAL LIFT COEFFICIENT = 1.66094
TOTAL PITCHING MOMENT COEFFICIENT = -2.07341
TOTAL DRAG COEFFICIENT = 0.95894
TOTAL THRUST COEFFICIENT = 0.00000

SPANWISE Pressures at constant X = 1.00000
Y 2Y/B (LOCAL) DELTA-CP
-0.09903  -0.19806  2.52115
-0.37651  -0.75302  3.26689

SPANWISE Pressures at constant X = 2.00000
Y 2Y/B (LOCAL) DELTA-CP
-0.09903  -0.09903  1.40484
-0.37651  -0.37651  1.92070
-0.77748  -0.77748  2.89741

SPANWISE Pressures at constant X = 3.00000
Y 2Y/B (LOCAL) DELTA-CP
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-0.37651  -0.25101  1.41881
-0.77748  -0.51832  1.89848
-1.22252  -0.81501  1.03833

SPANWISE Pressures at constant X = 3.50000
Y 2Y/B (LOCAL) DELTA-CP
-0.09903  -0.05659  0.47866
-0.37651  -0.21515  1.01330
-0.77748  -0.44427  1.84657
-1.22752  -0.69858  1.23075
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Similar type of output data is printed for iterations 2 through 7.
### ASPECT RATIO = 2.0

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<td>2.58121</td>
<td>1.00204</td>
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<tr>
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<td>-2.19754</td>
<td>.72210</td>
</tr>
<tr>
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<td>-1.80956</td>
<td>.52399</td>
</tr>
<tr>
<td>6</td>
<td>.72602</td>
<td>-1.60437</td>
<td>.41917</td>
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</tbody>
</table>

**Total Lift Coefficient = 1.45997**

**Total Pitching Moment Coefficient = -1.86231**

**Total Drag Coefficient = .84292**

**Total Thrust Coefficient = 0.00000**

### Spanwise Pressures at Constant X = 1.00000

Y 2Y/8 (Local) DELTA-CP

| .09903 | .19606 | 2.34255 |
| .37651 | .75302 | .68275 |

### Spanwise Pressures at Constant X = 2.00000

Y 2Y/8 (Local) DELTA-CP

| .09903 | .09903 | 1.29612 |
| .37651 | .37651 | 1.66734 |
| .77748 | .77748 | 2.47956 |

### Spanwise Pressures at Constant X = 3.00000

Y 2Y/8 (Local) DELTA-CP

| .09903 | .06602 | .57516 |
| .37651 | .25101 | 1.27410 |
| .77748 | .51832 | 1.69580 |
| 1.22252 | .81501 | 1.06014 |

### Spanwise Pressures at Constant X = 3.50000

Y 2Y/8 (Local) DELTA-CP

| .09903 | .05659 | .31908 |
| .37651 | .21515 | .89992 |
| .77748 | .44427 | 1.69877 |
| 1.22252 | .69858 | 1.17457 |
| 1.62349 | .92771 | 1.05241 |
Similar type of output data is printed for iterations 9 and 10.
### SUMMARY SHEET

**ASPECT RATIO = 2.0**

**ALPHA (DEG.) = 30.000 MACH NUMBER = 0.000**

<table>
<thead>
<tr>
<th>ITERATION</th>
<th>CL</th>
<th>CM</th>
<th>CD</th>
<th>CT</th>
<th>GMSUM</th>
<th>PERR</th>
<th>TFABS</th>
</tr>
</thead>
<tbody>
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<td>-1.8319</td>
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<td>0.0000</td>
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<td>1.2862</td>
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<tr>
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<td>-2.0734</td>
<td>0.0000</td>
<td>0.0000</td>
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<td>0.2571</td>
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<td>0.0000</td>
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<td>0.3423</td>
</tr>
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<td>0.0000</td>
<td>3.1270</td>
<td>0.0318</td>
<td>0.1732</td>
</tr>
</tbody>
</table>

**ALL CASES COMPLETED**
6.2 APPENDIX B: COMPUTER PROGRAM LISTING

A listing of the computer program is given on the following pages.
OVERLAY (LEVSP,0,0)  LEV 10
PROGRAM LEVSP (INPUT,OUTPUT,TAPE1,TAPE2,TAPE3,TAPE5,INPUT,TAPE6,OUTPUT)  LEV 20
1INPUT,PUNCH,TAPE4,TAPE7)  LEV 30

AERODYNAMICS OF LOW ASPECT-RATIO WINGS WITH PARTIAL LEADING-EDGE SEPARATION (LEADING-EDGE VORTEX SEPARATION PROGRAM)  LEV 50
BY - SUDHIR C. MHPUTRA AND C. EDWARD LAN
UNIVERSITY OF KANSAS

THIS PROGRAM IS RESTRICTED TO DELTA AND ARROW WINGS

PROGRAM IS DIVIDED INTO FIVE OVERLAYS.
OVERLAY (1,0) READS ALL THE DATA CARDS AND SETS UP INITIAL GEOMETRY OF THE WING AND THE FREE ELEMENTS  LEV 30
OVERLAY (2,0) PLOTS FREE ELEMENTS OVER THE WING AND IN THE WAKE ON THE LINE PRINTER OUTPUT  LEV 140
OVERLAY (3,0) SOLVES FOR THE STRENGTHS OF WING AND LEADING-EDGE VORTEX SYSTEM  LEV 170
OVERLAY (4,0) COMPUTES THE AERODYNAMIC CHARACTERISTICS  LEV 190
OVERLAY (5,0) COMPUTES THE NEW LOCATIONS OF THE LEADING-EDGE AND TRAILING-EDGE VORTEXES AS THE PROBLEM IS NONLINEAR, IT IS SOLVED BY ITERATION. ITERATION IS PERFORMED OVER OVERLAYS (2,0) THRU (4,0) TO OBTAIN THE FINAL CONVERGED SOLUTION.

THE DIMENSIONS OF THE FOLLOWING VARIABLES MUST BE CHECKED BEFORE RUNNING THE PROGRAM.

-D- APPEARS IN BLANK COMMON OF MAIN LINE (OVERLAY(0,0))
MUST BE DIMENSIONED MAXIMUM OF THE FOLLOWING VARIABLES
N1=228
N2=3*NMAX*(NSW-1)+NSW
N3=3*NSW*(NMAX+2)+NSW+1
N4=(NCPPTL+1)**2/4+10*NWNG+10*NSW+3*NCW-6
N5=29*NWNG+25*NSW+10*NCW-14
N6=21*NWNG+14*NSW+NCW-9

-W- APPEARS IN PROGRAM LOADS (OVERLAY(4,0))
MUST BE DIMENSIONED AT LEAST (N+NG,NCW+3)*(NWNG+NCW+4)
-E- APPEARS IN PROGRAM NEWSMAP (OVERLAY(5,0))
MUST BE DIMENSIONED AT LEAST (3*NSW*(NMAX+NNMAX)-3*NMAX+1)

WHERE
NMAX  = MAXIMUM NUMBER OF END-POINTS IN ANY ONE FREE
LEADING-EDGE VORTEX ELEMENT

NNMAX  = MAXIMUM NUMBER OF END-POINTS IN ANY ONE WAKE
ELEMENT

NCW  = NUMBER OF CHORDWISE LINES

NSW  = NUMBER OF SPANWISE LINES (ONE HIGHER THAN
NUMBER OF SPANWISE ROWS OF PANELS)

NCPTTL  = TOTAL NUMBER OF CONTROL POINTS OVER THE WING
INCLUDING THOSE AT THE LEADING-EDGE ((NCW+1)*
(NSW-1))

NWNG  = TOTAL NUMBER OF CONTROL POINTS OVER THE WING
EXCLUDING THOSE AT THE LEADING-EDGE (NCW*
(NSW-1))

COMMON D(3000)
COMMON /ALL1/ NSW,NSW1,NCW,NWNG,NCPTTL,MITER,IPUNCH
COMMON /ALLRA/ TTL(16),ALPHA,SINA,COSA,SAMPLE,BETA,BETA2,TANPH1,B?PLE
141,RSQD4P,D4,CO4,PI,D4SQ2,CRA,HALFB,AREA
COMM/N /ALLRA/ XE(40),YE(40),ZE(40),XXE(30),YXE(30),ZZE(30),ZMIN,MLE 620
LELM(11),NNELM(12)
COMMON /XPLDT/ XMN,YNM,ZMN,XMY,YNX,ZMX
COMMON /GM/ ITER,L1,L2,L3,L4,L5,L6,L7,L8
COMMON /XSTN/ XBRP(25),NBRK
10 CALL OVERLAY (SMLEVP,1,0)
ITER=0
CONTINUE
ALP=ALPHA*180./PI
AMACH=SIGN(1.-BETA2)
WRITE FREE ELEMENTS LOCATIONS
WRITE (6,100) TTL,ALP,AMACH,ITER
REWIND 4
DO 30 I=1,NSW
30 WRITE (6,150) I
```
WRITE (6,140) (XE(J),J=1,K)
WRITE (6,140) (YE(J),J=1,K)
WRITE (6,140) (ZE(J),J=1,K)
WRITE (6,140)
DO 40 I=1,NSW
C
READ (4) K,(XXE(J),YJ,ZZE(J),J=1,K)
C
WRITE (6,150) I
WRITE (6,140) (XXE(J),J=1,K)
WRITE (6,140) (YVE(J),J=1,K)
WRITE (6,140) (ZZE(J),J=1,K)
CALL OVERLAY (5MLEVSP,2,0)
CALL OVERLAY (5MLEVSP,3,0)
CALL OVERLAY (5MLEVSP,4,0)
CALL OVERLAY (5MREVSP,5,0)
ITER=ITER+1
IF (ITER.LE.ITER) GO TO 20
IF (IPUNCH.EQ.0) GO TO 70
C
PUNCH-OUT FREE ELEMENTS LOCATIONS AFTER LAST ITERATION
REWIND 4
C
PUNCH 170, (NELW(I),I=1,NWL)
DO 50 I=1,NWL
C
READ (4) K,(XXE(J),YJ,ZZE(J),J=1,K)
C
PUNCH 160, (XXE(J),J=1,K)
PUNCH 160, (YVE(J),J=1,K)
PUNCH 160, (ZZE(J),J=1,K)
PUNCH 170, (NNELW(I),I=1,NWL)
DO 60 I=1,NWL
C
READ (4) K,(XXE(J),YJ,ZZE(J),J=1,K)
C
PUNCH 160, (XXE(J),J=1,K)
PUNCH 160, (YVE(J),J=1,K)
PUNCH 160, (ZZE(J),J=1,K)
C
FORMULATION OF SUMMARY SHEET
```

(ORIGIN PAGE 30)

(ORIGINAL PAGE 04)

(Poor QUALITY)
70  REWIND 7
WRITE (6,110) TTL,ALP,AMACH
*MIT=MITER+1
GM1=0.
DO 90 I=1,MIT
J=I-1
C
*** Corresponding to above subroutine
READ (7) GMSUM
READ (7) CL,CM,CD,CTT
READ (7) TFABS,TAVRG,TLNTH
C
*** Corresponding to above subroutine
GM2=GMSUM
PERR=200.0*(ABS(GM1-GM2))/(GM1+GM2)
GM1=GM2
IF (I.EQ.1) GO TO 80
WRITE (6,120) J,CL,CM,CD,CTT,GMSUM,PERR,TFABS
GO TO 90
80 WRITE (4,130) J,CL,CM,CD,CTT,GMSUM,TFABS
90 CONTINUE
GO TO 10
C
C
100 FORMAT (11H1,15A5,1X,12HALPHA(EDG)=F6.3,14H MACH NUMBER=F6.3)
1.3,19H ITERATION NUMBER=12,1X,21H LEADING EDGE ELEMENTS,1X,2N
21H
110 FORMAT (11H1,23X,13H SUMMARY SHEET,23X,13H MACH NUMBER=F6.3)
1A5,2X,12HALPHA(EDG)=F6.3,14H MACH NUMBER=F6.3,66H Iteration
2TON CL CM CD CT GMSUM PERR TFABS,66H
3 *** Corresponding to above subroutine
120 FORMAT (17,4X,F8.4)
130 FORMAT (17,4X,5F8.4)
140 FORMAT (14F9.4)
150 FORMAT (5H ****,I2,4H****)
160 FORMAT (10F8.5)
170 FORMAT (10I2)
180 FORMAT (11H1,14H WAKE ELEMENTS,14H
END
LE1190
LE1200
LE1210
LE1220
LE1230
LE1240
LE1250
LE1260
LE1270
LE1280
LE1290
LE1300
LE1310
LE1320
LE1330
LE1340
LE1350
LE1360
LE1370
LE1380
LE1390
LE1400
LE1410
LE1420
LE1430
LE1440
LE1450
LE1460
LE1470
LE1480
LE1490
LE1500
LE1510
LE1520
LE1530
LE1540
LE1550
LE1560
LE1570
LE1580
LE1590
LE1600
LE1610
LE1620
LE1630
LE1640
LE1650
LE1660
LE1670
LE1680
LE1690
LE1700
LE1710
LE1720
LE1730
LE1740
LE1750
LE1760
LE1770
LE1780
LE1790
LE1800
LE1810
LE1820
LE1830
LE1840
LE1850
LE1860
LE1870
LE1880
LE1890
LE1900
LE1910
LE1920
LE1930
LE1940
LE1950
LE1960
LE1970
LE1980
LE1990
LE2000
LE2010
LE2020
LE2030
LE2040
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LE2060
LE2070
LE2080
LE2090
LE2100
LE2110
LE2120
LE2130
LE2140
LE2150
LE2160
LE2170
LE2180
LE2190
LE2200
LE2210
LE2220
LE2230
LE2240
LE2250
LE2260
LE2270
LE2280
LE2290
LE2300
LE2310
LE2320
LE2330
LE2340
LE2350
LE2360
LE2370
LE2380
LE2390
LE2400
LE2410
LE2420
LE2430
LE2440
LE2450
LE2460
LE2470
LE2480
LE2490
LE2500
LE2510
LE2520
LE2530
LE2540
FUNCTION ARCOS (X)
C    CALCULATES ARC-COSINE OF X
    ARCOS=0.
    IF (X.EQ.1.) RETURN
   10 IF (X.EQ.(-1.)) GO TO 10
    XX=X/(SORT(1.-X*X))
   20 ARCOS=1.5707963-ATAN(XX)
    RETURN
10   ARCOS=3.1415926
    RETURN
    END
SUBROUTINE DOTPRO (A,B, SUM)
CALCULATES DOT-PRODUCT OF TWO VECTORS
DIMENSION A(3), B(3)
SUM = 0.
DO 10 I = 1, 3
  SUM = SUM + A(I) * B(I)
10 RETURN
END
SUBROUTINE CRSPRD (A, B, C)
C CALCULATES CROSS-PRODUCT OF TWO VECTORS
DIMENSION A(3), B(3), C(3)
C(1) = A(2) * B(3) - A(3) * B(2)
C(2) = A(3) * B(1) - A(1) * B(3)
C(3) = A(1) * B(2) - A(2) * B(1)
RETURN
END
SUBROUTINE VOTWNG (C,THETP,XX,YY,ZZ,XN,YN,XTE,YTE,CONS,CONJ,CONK,CONW 10
1,CONJ1,CONJ2,CONJ3,CONK1,CONK2,CONK3,CON1,CONJ,CONK,SI,NSW1,NCW,NEWNG 20
2NG)
C EVALUATES INFLUENCE COEFFICIENTS FOR CALCULATION OF INDUCED
C VELOCITY DUE TO WING ELEMENTS
C
COMMON /ALLI/ NSW
COMMON /ALLRA/ XXE(30),YYE(30),ZZE(30)
COMMON /NCTT/ NCT,NCON
COMMON /XITYIZI/ XI,Y1,Z1
DIMENSION THETP(1),C(1),CONS(1),XTE(1),YTE(1),SI(1),CON1(1) 100
1,CONJ1(1),CONJ2(1),CONJ3(1),CONK1(1),CONK2(1),CONK3(1),CONW(10)
23(1),CONI(1),CONJ(1),CONK(1),XN(NEWNG,2),YN(NEWNG,2),R(3),D(3NW 120
3)
C
C DIMENSIONS OF FJ1,FJ2,FJ3-(2*NSW) ** SEE GEOM **
C DIMENSIONS OF FI2,FI3-(2*NCPTTL) ** SEE GEOM **
DIMENSION FJ1(40), FJ2(40), FJ3(40), FI2(418), FI3(418)
XI=XX
YI=YY
ZI=ZZ
NC1=NEWNG+NCW
NC2=NEWNG-NCW
C VELOCITY DUE TO AROUND ELEMENTS
DO 10 I=1,NSW
DO 10 J=1,NCW
NP=(I-1)*NCW+J
CALL INFL2 (XN(NP,1),YN(NP,1),0.,XN(NP,2),YN(NP,2),0.,B)
A1=-YN(NP,1)
A2=-YN(NP,2)
CALL INFL2 (XN(NP,1),A1,0.,XN(NP,2),A2,0.,D)
CONI(NP)=CONS(I)*R(1)-D(1)
CONJ(NP)=CONS(I)*R(2)-D(2)
CONK(NP)=CONS(I)*R(3)-D(3)
10
C VELOCITY DUE TO TRAILING ELEMENTS ON THE WING SURFACE
DO 20 I=1,NSW
DO 20 J=1,NCW
NP=(I-1)*NCW+J
CALL INFL2 (XN(NP,1),YN(NP,1),0.,XTE(I),YN(NP,1),0.,B)
FI2(NP)=R(2)
FI3(NP)=B(3)
AYN=-YN(NP,1)
C
NO=NC1+NP
CALL INFL2 (YN(NP,1),AYN,O.,XTE(I),AYN,O.,B)
FI2(NQ)=B(2)
FI3(NQ)=B(3)
CONTINUE
DO 30 J=1,NCW
NP1=MNG+J
NP2=NC1+NP1
NP=NC2+J
CALL INFL2 (YN(NP,2),YN(NP,2),O.,XTE(NSW),YN(NP,2),O.,B)
FT2(NP1)=B(2)
FI3(NP1)=R(3)
AYN=YN(NP,2)
CALL INFL2 (YN(NP,2),AYN,O.,XTE(NSW),AYN,O.,B)
FT2(NP2)=R(2)
FI3(NP2)=R(3)
CONTINUE
DO 40 I=1,NSW1
NC=40 J=1,NCW
NP1=(I-1)*NCW+J
I1=NP1+NC1
I2=NP1+NCW
I3=I1+NCW
CONJ2(NP)=CONS(I1)*(FI2(I1)-FI2(NP)+FI2(I2)-FI2(I3))
CUNK2(NP)*CONS(I1)*(FI3(I1)-FI3(NP)+FI3(I2)-FI3(I3))
C VELOCITY DUE TO TRAILING ELEMENTS BEYOND TRAILING EDGE
C
************
REWIND 4
CALL SKTPR (4,NSW)
DO 40 I=1,NSW
READ (4) KK,(XXE(J),YXE(J),ZXE(J),J=1,KK)
C
************
FJ1(I)=0
FJ2(I)=0
FJ3(I)=0
IF (I.EQ.NCT) GN TO 60
DO 50 J=2,KK
CALL INFL2 (XXE(J-1),YXE(J-1),ZXE(J-1),XXE(J),YXE(J),ZXE(J),B)
FJ1(I)=FJ1(I)+B(1)
WNG 410
WNG 420
WNG 430
WNG 440
WNG 450
WNG 460
WNG 470
WNG 480
WNG 490
WNG 500
WNG 510
WNG 520
WNG 530
WNG 540
WNG 550
WNG 560
WNG 570
WNG 580
WNG 590
WNG 600
WNG 610
WNG 620
WNG 630
WNG 640
WNG 650
WNG 660
WNG 670
WNG 680
WNG 690
WNG 700
WNG 710
WNG 720
WNG 730
WNG 740
WNG 750
WNG 760
WNG 770
WNG 780
WNG 790
DO 90 J=1,NCW
NP=(I-1)*NCW+J
CONI3(NP)=EFJ1
CONJ3(NP)=EFJ2
CONK3(NP)=EFJ3
90 TOTAL INDUCED VELOCITY
C I=1
DO 100 J=1,NWNG
CONI(J)=(CONI(J)+CONI3(J))*SI(I)
CONJ(J)=(CONJ(J)+CONJ3(J)+CONJ3(J))*SI(I)
CONK(J)=(CONK(J)+CONK2(J)+CONK3(J))*SI(I)
I=I+1
IF (I.GT.NCW) I=1
100 CONTINUE
RETURN
END
SUBROUTINE VDTFRE (X,Y,Z,CI,CJ,CK,NSW1,BSQD4P,XLE,YLE)
C EVALUATES INFLUENCE COEFFICIENTS FOR CALCULATION OF INDUCED
C VELOCITY DUE TO FREE ELEMENTS
COMMON /ALLPR/ XE(40),YE(40),ZE(40),XXE(30),YYE(30),ZZE(30)
COMMON /NCTT/ NCT,NC0N
COMMON /YIYIYI/ YI,YI,YI
DIMENSION CI(1),CJ(1),CK(1),XLE(1),YLE(1),V(3),VVV(3)
C DIMENSION OF VDTL-(NSW1,3) ** SEE GEDM **
DIMENSION VDTL(19,3)
XI=X
YI=Y
ZI=Z
NCT1=0
C
10 REWIND 4
C
DO 60 I=1,NSW1
V(1)=0.
V(2)=0.
V(3)=0.
FJ1=0.
FJ2=0.
FJ3=0.
C
60 READ (4) KK,(XE(J),YE(J),ZE(J),J=1,KK)
C
K=KK-1
C VELOCITY DUE TO FREE ELEMENTS AHEAD OF TRAILING-EDGE AND THOSE
C OVER THE WING
C
DO 20 J=1,K
IF (1.EQ.NC0N.AND.J.GT.4.AND.YI.GT.0.) GO TO 20
CALL INFL2 (XE(J),YE(J),ZE(J),XXE(J),YYE(J+1),ZZE(J+1),VVV)
V(1)=V(1)+VVV(1)
V(2)=V(2)+VVV(2)
V(3)=V(3)+VVV(3)
20 CONTINUE
IF (1.EQ.NC0N.AND.YI.GT.0.) GO TO 30
CALL FUNA (XE(K+1),YE(K+1),ZK1,FJ1,FJ2,FJ3)
C
30 VDTL(I,1)=V(1)+FJ1
VDTL(I,2)=V(2)+FJ2
VDTL(I,3)=V(3)+FJ3
C
VTDL(I,3)=V(3)+FJ3
FJ1=0.
FJ2=0.
FJ3=0.
I1=I+1
C
*****************************************************************************
CALL SKIPR (4,NSW1)
READ (4) II,(XXE(J),YYE(J),ZZE(J),J=1,II)
*****************************************************************************
C
*****************************************************************************
IF (II.EQ.NCT.AND.YI.GT.0.) GO TO 50
C
VELOCITY DUE TO WAKE ELEMENTS
DO 40 J=7,IT
CALL INFPL (XXE(J-1),YYE(J-1),ZZE(J-1),XXE(J),YYE(J),ZZE(J),V)
FJ1=FJ1+V(1)
FJ2=FJ2+V(2)
FJ3=FJ3+V(3)
40 CONTINUE
CALL FUNA (XXE(II),YYE(II),ZZE(II),V(1),V(2),V(3))
FJ1=FJ1+V(1)
FJ2=FJ2+V(2)
FJ3=FJ3+V(3)
50 CONTINUE
VTDL(I,1)=VTDL(I,1)-FJ1
VTDL(I,2)=VTDL(I,2)-FJ2
VTDL(I,3)=VTDL(I,3)-FJ3
C
*****************************************************************************
REWIND 4
*****************************************************************************
C
*****************************************************************************
IF (NCT1.GT.1) GO TO 50
DO 70 I=1,NSW1
CI(I)=VTDL(I,1)
CJ(I)=VTDL(I,2)
CK(I)=VTDL(I,3)
70 CONTINUE
GO TO 10
SUBROUTINE FUNA (XT, YT, ZT, FJ1, FJ2, FJ3)

C

INDUCED VELOCITY DUE TO A VORTEX ELEMENT OF UNIT STRENGTH TRAILING

FROM (XT, YT, ZT) TO INFINITY

COMMON /ALLRA/ AA(21), BETA2, TANPH1, B2PH1, AB, D4, AC(2), D4S02

COMMON /XIYIZI/ XI, YI, ZI

DIMENSION A(3), B(3), C(3)

A(1) = XT - XI
A(2) = YT - YI
A(3) = ZT - ZI
B(1) = XT + 1 - XI
B(2) = YT - YI
B(3) = ZT + TANPH1 - ZI

CALL CRSPPD (A, B, C)

CC = SQRT(C(1) * C(1) + C(2) * C(2) + C(3) * C(3))

IF (CC .LE. 1.E-10) GO TO 10

D5 = 2 * (R2PH1 * (ZT - YI - XT * TANPH1) - XI)
D4 = XI * XI + BETA2 * ((YI - YT) * ZT - ZI - XT * TANPH1) * 2
Q = 4 * D4 * D4 - D5 * D5

IF (Q .LE. (1.E-10)) GO TO 10

R8 = SQRT(Q4 * XT * XT + D5 * XT + D6)
FJ4 = 2 * (D4S02 - (2 * D4 * XT + D5) / R8) / Q
FJ1 = (YT - YI) * TANPH1 * FJ4
FJ2 = (ZT - ZI + (XT - XT) * TANPH1) * FJ4
FJ3 = -(YT - YI) * FJ4

RETURN

10

FJ1 = 0
FJ2 = 0
FJ3 = 0
RETURN

END
SUBROUTINE INFL2 (X1,Y1,Z1,X2,Y2,Z2,VACL)

INDUCED VELOCITY DUE TO A VORTEX ELEMENT OF UNIT STRENGTH LYING

BETWEEN (X1,Y1,Z1) AND (X2,Y2,Z2)

COMMON /ALLRA/ AA(20),BETA

COMMON /X1Y1Z1/ X1,Y1,Z1

DIMENSION VA(3), VL(3), VAP(3), VBP(3), VLP(3), VAACL(3), VAAPCLP(3)

VA(1)=X1-X1
VA(2)=Y1-Y1
VA(3)=Z1-Z1
VL(1)=X2-X1
VL(2)=Y2-Y1
VL(3)=Z2-Z1
VAP(1)=VA(1)
VAP(2)=BETA*VA(2)
VAP(3)=BETA*VA(3)
VBP(1)=X2-X1
VBP(2)=BETA*(Y2-Y1)
VBP(3)=BETA*(Z2-Z1)
VLP(1)=VL(1)
VLP(2)=BETA*VL(2)
VLP(3)=BETA*VL(3)

CALL CRSPRD (VA,VL,VAACL)
CALL CRSPRD (VAP,VLP,VAAPCLP)
CALL DOTPRD (VAAPCLP,VAAPCLP,DAPCLP)
IF (ABS(DAPCLP),LT,(1,E-10)) GO TO 10
CALL DOTPRD (VBp,VBP,DBP)
BPMOD=SORT(DRP)
CALL DOTPDD (VAP,VAP,DAP)
APMOD=SORT(DAP)
CALL DOTPDD (VBP,VLP,DBLP)
DBLP=DRPLP/APMOD
CALL DOTPDD (VBP,VLP,DAPLP)
DAPLP=DAPLP/APMOD
CONST=(DRPLP-DAPLP)/DAPCLP
GO TO 20

10 CONST=0.
CONTINUE

VAACL(1)=VAACL(1)*CONST
VAACL(2)=VAACL(2)*CONST
VAACL(3)=VAACL(3)*CONST

INF 10
INF 20
INF 30
INF 40
INF 50
INF 60
INF 70
INF 80
INF 90
INF 100
INF 110
INF 120
INF 130
INF 140
INF 150
INF 160
INF 170
INF 180
INF 190
INF 200
INF 210
INF 220
INF 230
INF 240
INF 250
INF 260
INF 270
INF 280
INF 290
INF 300
INF 310
INF 320
INF 330
INF 340
INF 350
INF 360
INF 370
INF 380
INF 390
INF 400
SUBROUTINE NEWVEL (C,THETP,XEE,YEE,ZEE,XN,YM,XTE,YLE,CONS,DUMMY,COWL,VEL 10
INIT,CONJ,CONK,SI,NSW1,NCW, MWG,CI,CJ,CK,XLE,UU,VV,WW,CPCW1,XCP, YCP,VEL 20
GAMA,YYM)
C EVALUATES TOTAL VELOCITY AT POINT (XEE,YEE,ZEE) VEL 30
COMMON /ALLRA/ AA(17), SINA,COSA,AB(5),BSQD4P
COMMON /GAM/ ITER,L1,L2,L3,L4,L5,L6,L7,L8
DIMENSION DUMMY(1), CONI(1), CONJ(1), CONK(1), CI(1), CJ(1), CK(1) VEL 70
1, C(1), THETP(1), XTE(1), XLE(1), YLE(1), CONS(1), SI(1), CPCW1(1) VEL 80
2, XCP(1), YCP(1), GAMA(1), YYM(1), XN(MWG,2), YM(MWG,2), NP(4) VEL 90
3U(4,3), V(3)
C IF POINT IS IN THE WING PLANE, THE REGULAR METHOD FOR VELOCITY VEL 110
C EVALUATION IS USED.
IF (ZEE.LE.0.00001) GO TO 110
IF (YEE.GT.YYM(NSW1)) GO TO 110
CH1=XTE(1)-XLF(1)
CH2=XTE(2)-XLE(2)
XYL=XLE(1)*(YEE-YLE(1))*(XLE(2)-XLF(1))/(YLF(2)-YLE(1)) VEL 150
CHY=CH1/(YLF(1))/(CH2-CH1)/(YLF(2)-YLE(1)) VEL 160
XC=(XEE-XYL)/CHY
IF (X.EQ.LT.0.0).OR.(X.GT.1.0) GO TO 110
ZC=ZEE/CHY
C IF THE POINT (XEE,YEE,ZEE) IS AT Z/CLOCAL) LESS THAN ZTOL, THE VEL 210
C VELOCITY IS OBTAINED BY LINEAR INTERPOLATION OF THE VELOCITIES VEL 220
C CALCULATED AROUND FOUR WING CONTROL POINTS AMONG WHICH THE POINT IS VEL 230
C LOCATED. BY NUMERICAL EXPERIMENTATION ZTOL HAS BEEN OBTAINED TO BE VEL 240
C 0.2.
ZTOL=0.2
C IF (Z.CGE.ZTOL) GO TO 110
I=1
10 IF (YEE.LE.YYM(1)) GO TO 20
IF (YEE.GT.YYM(1).AND.YEE.LE.YYM(I+1)) GO TO 20
I=I+1
20 IF (I.LT.NSW1) GO TO 10
J=1
30 IF (X.CLE.CPCW1(1)) GO TO 50
IF (X.GT.CPCW1(1).AND.X.LE.CPCW1(J+1)) GO TO 40
J=J+1
40 IF (J.LT.NCW) GO TO 30
NP(1)=(J-1)*NCW+J
NP(2)=NP(1)+1
NP(3)=NP(1)+NCW
NP(4)=NP(3)+1
XC1=CPCW1(J)
XC2=CPCW1(J+1)
GO TO 50

50 NP(1)=NCW+NSW1+1
NP(2)=NP(1)+1
NP(3)=NP(1)+1
NP(4)=NP(2)+NCW
XC1=0.
XC2=CPCW1(1)
CONTINUE

C EVALUATION OF INDUCED VELOCITY AT FOUR POINTS
DO 80 J=1,4
NN=NP(J)
CALL VOTWNG (C, THETP, XCP(MN), YCP(MA), ZEE, XN, YN, XTE, YLE, CONJ, DSMY(VEL 560
1L1), DUMMY(L2), DUMMY(L3), DUMMY(L4), DUMMY(L5), DUMMY(L6), DUMMY(L7), DUVEL 570
2MY(L9), CONI, CONJ, CONK, SI, NSW1, NCW, NWNG)
U(I,1)=0.
U(I,2)=0.
U(I,3)=0.
DO 70 J=1,NWNG
U(I,J)=U(I,1)+CONI(J)*GAMA(J)
70 CONTINUE

C INTERPOLATION
MN1=NP(1)
MN2=NP(3)
Y1=YCP(MN1)
Y2=YCP(MN2)
DO 90 J=1,3
UA=U(I,J)+U(I,3)-U(I,1)
UR=U(I,J)+U(I,1)-U(I,3)
90 V(I,J)=UA+(UB-UA)*(XC-XC1)/(XC2-XC1)
UU=V(I,1)*COSA
VV=V(I,2)
WW=V(I,3)*SINA
CALL VOTFRE (XEE, YEE, ZEE, CI, CJ, CK, NSW1, B- : D4P, XLE, YLE)
C  FINAL TOTAL VELOCITY
DO 100 J=1,NSW1
   JJ=NNWNG+J
   UU=UU*CI(JJ)*GAMA(JJ)
   VV=VV*CI(JJ)*GAMA(JJ)
100  WW=WW*CK(JJ)*GAMA(JJ)
RETURN
C  EVALUATION OF VELOCITY WHEN POINT IS IN THE WING PLANE
110  CONTINUE
   CALL VDTWNG (CI,THETP,XEE,YEE,ZEE,XX,YX,XTE,YLE,CONS,DUMMY(L1),DUMMY(L2),DUMMY(L3),DUMMY(L4),DUMMY(L5),DUMMY(L6),DUMMY(L7),DUMMY(L8),VEL)
   CALL VDTFRE (YEE,YEE+ZEE,CI,CJ,CK,NSW1,BSOD4P,YLE,YLE)
C  FREE STREAM VELOCITY
   UU=CONS
   VV=0.
   WW=SINA
C  VELOCITY DUE TO FREE ELEMENTS
   DO 120 I=1,NSW1
      NO=NNWNG+I
      UU=UU*CI(I)*GAMA(NO)
      VV=VV*CI(I)*GAMA(NO)
120  WW=WW*CK(I)*GAMA(NO)
C  VELOCITY DUE TO WING
   DO 130 I=1,NSW1
      NO=I+NCW
      UU=UU*CONJ(NO)*GAMA(NO)
      VV=VV*CONJ(NO)*GAMA(NO)
130  WW=WW*CONJ(NO)*GAMA(NO)
RETURN
END
OVERLAY (LEVSP,1,0)
PROGRAM GEOM
C DEFINES THE WING AND FREE ELEMENT GEOMETRY
C MAXIMUM VALUES
C ** NCW = 9
C ** NNCW = NCW+1 = 10
C ** NSW = 20
C ** NSW1 = NSW-1 = 19
C ** NWG = NNCW*NSW1 = 190
C ** NCPTTL = (NNCW+1)*NSW1 = 209
COMMON XXL(2)*XTT(2),YL(2),CPCW1(10),CPCW2(10),S1(10),SN(10),SMN1(10)
GEO 110
10),SWP(10),SLOPE(10),XL(2,10),C(19),THETP(19),CONS(19),CPSW1(19),XGEO
GEO 120
2LM(19),XTM(19),YLM(19),CTT(19),CPSW2(20),XLE(20),XTE(20),YLE(20),YLE(20)
GEO 130
3AVWNG(190),YAVWNG(190),XN(190,2),YN(190,2),XCP(209),YCP(209),X(10,GEO
GEO 140
420),Y(10,20)
COMMON /ALLI/ NSW,NSW1,NCW,NWNG,NCPTTL,MITER,IPUNCH
COMMON /ALLRA/ TTL(16),ALPHA,SINA,CUSA,SWPLE,BETA,ETA2,TANPH1,B2PGE
GEO 170
1H1,RSQ4P,D4,CON,PI,D4SQ2,CBAR,HALFB,AREA
COMMON /XSTN/ XARR(25),NBRR
GEO 190
THEN D5HEND
GEO 200
C
******************************************************************************
GEO 210
READ (5,130) TTL
GEO 220
IF (TTL(1).EQ.THEND) GO TO 120
GEO 230
READ (5,160) NCW,NSW,NBRR,NCONTS,MITER,IPUNCH
GEO 240
NSW1=NSW-1
GEO 250
READ (5,150) (XXL(I),XTT(I),YL(I),I=1,2)
GEO 260
READ (5,150) ALPHA,AMACH,DELTA,XEND,CBAR,AREA
GEO 270
READ (5,150) (XBRN(I),I=1,NBRR)
GEO 280
READ (5,150) (CTT(I),I=1,NSW1)
GEO 290
C
******************************************************************************
GEO 300
WRITE (6,170) TTL
GEO 310
WRITE (6,160) NCW,NSW,NBRR,NCONTS,MITER,IPUNCH
GEO 320
WRITE (6,150) (XXL(I),XTT(I),YL(I),I=1,2)
GEO 330
WRITE (6,150) ALPHA,AMACH,DELTA,XEND,CBAR,AREA
GEO 340
WRITE (6,150) (XBRN(I),I=1,NBRR)
GEO 350
WRITE (6,150) (CTT(I),I=1,NSW1)
GEO 360
NCCW=NCW
GEO 370
NCW=NCCW+1
GEO 380
C
NPRCY=0, USED FOR BOUND ELEMENTS = (NCW+1)
GEO 390
C
NPRCY=1, USED FOR BOUND ELEMENTS = NCW
GEO 400
10 IF (NPRCY.EQ.1) NCW=NNCW
*I=3.14159265
FN2=2.*NCW
PIJ=PI/FLOAT(NCW)
TWOP1=2.*PI
DO 20 I=1,NCW
CPCWL(I)=50.*(.1.-COS((2.*FLOAT(I)-1.)*PI/FN2))
CPSW1(I)=50.*(.1.-COS(FLOAT(I)*PI/FLOAT(NCW))))
CC=CPCWL(I)/1000.
SNN(I)=2.*SORT(CC*(1.-CC))
PSIJ=(2.*FLOAT(I)-1.)*PIJ/2.
SN(I)=SNN(PSIJ)/TWOP1
20 SI(I)=TWOP1*SN(I)
SWPLE=ATAN((XXL(I)-XXL(1))/(YL(2)-YL(1)))
FM2=2.*NSW
DO 30 J=1,NSW
30 CPSW1(J)=50.*(.1.-COS((2.*FLOAT(J)-1.)*PI/FM2))
CPSW1(1)=0.
DO 40 I=1,NSW1
40 CPSW1(I)=50.*(.1.-COS(FLOAT(I)*PI/FLOAT(NSW))))
CALL PNLWNG (NSW,NWNG,NCW)
HALFB=YL(2)
DO 50 I=1,NSW1
C(I)=XTM(I)-XLM(I)
YYLM=YLMM(I)/HALFB
50 THEP(I)=ARCSN(YYLM)
NCPTTL=NSW1+NWNG
IF (NPRCY.EQ.1) GO TO 60
NCW1=NCW
C
""""""""
REWIND 1
REWIND 7
WRITE (1) NCW,NWNG
WRITE (1) (SI(I),SN1(I),SWP(I),I=I,NCW)
WRITE (1) (XAVWNG(I),YAVWNG(I),I=I,NWNG,NCW)
C
C
NPRCY=1
GO TO 10
60  DO 70 I=1,NCW
   CPCWL(I)=CPCWL(I)/100.
70  CPCWL(I)=CPCWL(I)/100.
   DO 80 I=1,NSW
   CPCWL(I)=CPCWL(I)/100.
80  CPCWL(I)=CPCWL(I)/100.
   DO 90 I=1,NSW1
   CPCWL(I)=CPCWL(I)/100.
90  CPCWL(I)=CPCWL(I)/100.
   C E L V A T I N G  T H E  C O N S T A N T S
   ALPHA=ALPHA*PI/180.
   TANPH1=TAN(ALPHA)
   TANPH2=TANPH1*TANPH1
   BETA2=1.-AMACH*AMACH
   BETA=SQR(BETA2)
   B2PH1=BETA2*TANPH1
   D4=BETA2*TANPH2+1.
   D4SQ2=2.*SQR(D4)
   CON=BETA2/(B.*FLOAT(1.))
   BSQD4=P/BETA2/(4.*PI)
   CON1=COS(SWPL1)
   CON2=(SIN(SWPL1)/CON1
   CON3=FLOAT(1.)*SQR(BETA2+CON2+CON1)
   CW4=2.*CON1/(PI*SQR(1.-AMACH*AMACH*CON1*CON1))
   DO 100 I=1,NSW1
50  CON3=CON3*SORT(CON3*CTT(I))
100  CON=CON3*SORT(CON3*CTT(I))
   DO 110 I=1,NSW1
   110  CON=CON*C(TT(I)
   SINA=SIN(ALPHA)
   COSA=COS(ALPHA)
   C
   WRITE (1) (SNN(I),SWP(I),I=1,NCW)
   WRITE (1) (XAVWNG(I),YAVWNG(I),I=1,NSW1)
   WRITE (1) (C(I),I=1,NSW1)
   WRITE (1) (THEMP(I),I=1,NSW1)
   WRITE (1) (XTE(I),XLE(I),YLE(I),I=1,NSW1)
   WRITE (1) (XLM(I),YLM(I),I=1,NSW1)
   WRITE (1) (CONS(I),I=1,NSW1)
   WRITE (1) (SII(I),SN(I),I=1,NCW)
   WRITE (1) (XCPI(I),YCPI(I),I=1,NCPTTL)
   WRITE (1) ((XN(I,J),YN(I,J),J=1,2),I=1,NSW1)
   GED 800
   GED 810
   GED 820
   GED 830
   GED 840
   GED 850
   GED 860
   GED 870
   GED 880
   GED 890
   GED 900
   GED 910
   GED 920
   GED 930
   GED 940
   GED 950
   GED 960
   GED 970
   GED 980
   GED 990
   GED 1000
   GED 1010
   GED 1020
   GED 1030
   GED 1040
   GED 1050
   GED 1060
   GED 1070
   GED 1080
   GED 1090
   GED 1100
   GED 1110
   GED 1120
   GED 1130
   GED 1140
   GED 1150
   GED 1160
   GED 1170
   GED 1180
WRITE (1) (CTT(I), I=1,NSW1)
WRITE (1) (CPCW(L), I=1,NCW)
WRITE (1) (CPCW1(I), I=1,NCW)
WRITE (1) (CPSWL(L), I=1,NSW1)
WRITE (1) (CPSW1(I), I=1,NSW1)
C
                      CALL FRELM (XXL,XXT,YL,XLE,XTE,YLE,PI,NCW1,NSW1,XEND,DELT,ALPHA,DEO1250)
1L,NCONTS)
RETURN
120 WRITE (6,140)
STOP
C
130 FORMAT (16A5)
140 FORMAT (141/,10X,19HALL CASES COMPLETED)
150 FORMAT (SF10.5)
160 FORMAT (105)
170 FORMAT (1H1/,174 INPUT DATA CARDS/,16A5)
END

ORIGINAL PAGE: OF POOR QUALITY
SUBROUTINE PNLWNG (NSW, LPANEL, NCW)

C GENERATES THE GRID OF BOUND AND TRAILING VORTEX ELEMENTS

COMMON XXL(2), YXT(2), YL(2), CPCWL(10), CPCW1(10), SI(10), SN(10), SNW(1)

10, SWP(10), SLOPE(10), XL(2, 10), C(19), THETP(19), CONS(19), CPSW1(19), XPNL 40

2LM(19), YTM(19), YLM(19), CTT(19), CPSWL(20), XLE(20), XTE(20), YLE(20), XPNL 50

3AVNG(190), YAVNG(190), XN(190, 2), YN(190, 2), XCP(209), YCP(209), XPNL 60

420), Y(10, 20)

DO 10 I=1, 2

D=YXT(I)-XXL(I)

DO 10 J=1, NCW

10     XL(I, J)=XXL(I)+CPCWL(J)*D/100.

SPAN=YL(2)-YL(1)

DO 20 I=1, NCW

SLOPE(I)=(XL(2, I)-XL(I, I))/SPAN

20     SWP(I)=ATAN(SLOPE(I))

DO 30 K=1, NSW

YK=CPSWL(K)*SPAN/100.

YLI=YL(1)+YK

DO 30 J=1, NCW

Y(J, K)=YLI

30     X(J, K)=XL(1, J)+SLOPE(J)*YK

NSWL=NSW-1

XLE(I)=XXL(I)

XTE(I)=XXT(I)

YLE(I)=Y(I, 1)

DLE=(XXL(2)-XXL(1))/SPAN

DTE=(XXT(2)-XXT(1))/SPAN

DO 40 T=2, NSW

YLE(T)=Y(T, 1)

YLM(I-1)=YLE(I)+CPSW1(I-1)*SPAN/100.

DLEL=DLE*Y(I, I)-Y(I, I-1)

DTET=DTE*Y(I, I)-Y(I, I-1)

XLE(I)=XLE(I-1)+DLEL

XTE(I)=XTE(I-1)+DTET

XLM(I-1)=XLE(I)+SPAN*CPSW1(I-1)*DLE/100.

40     XTM(I-1)=XTE(I)+SPAN*CPSW1(I-1)*DTE/100.

DO 60 K=1, NSW

NP=(K-1)*NCW

CC=XTM(K)-XLM(K)

DO 60 J=1, NCW
SUBROUTINE FRELM (XXL,XXT,YL,XLE,XTE,YLE,PI,NCWL,NSW1,XEND,DELTA,ALFM) 10
1LPHA,DL,NCONTS)  FLM 20
C FINDS THE INITIAL COORDINATES OF FREE VORTEX ELEMENTS  FLM 30
COMMON /ALLP/ XE(40),YE(40),ZE(40),XXE(30),YYE(30),ZZE(30),ZMIN,NFLM 40
IELM(11),NTEL(12)  FLM 50
COMMON /XPLT/,XMN,YMN,ZMN,XMX,YMX,ZMX  FLM 60
DIMENSION XXL(1),XXT(1),YL(1),XLE(1),XTE(1),YLE(1)  FLM 70
AMPI=ALPHA  FLM 80
ALP=ALPHA*180./PI  FLM 90
IF (ALP.LT.15.) AHPI=(22.5-0.5*ALP)*PI/180.  FLM 100
NSW=NSW1+1  FLM 110
THI=I/(FLOAT(2*NCWL))  FLM 120
CPC=0.5*(1.-COS(THI))  FLM 130
ZMIN=.XTE(1)-XLE(1))*TAN(AHPI)/10.  FLM 140
SAHPI=SIN(AHPI)  FLM 150
CAHPI=COS(AHPI)  FLM 160
REWIND ?  FLM 170
REWIND 4  FLM 180
C EVALUATION OF COORDINATES OF LEADING-EDGE ELEMENTS  FLM 190
DO 30 I=1,NSW1  FLM 200
XE(1)=XTE(I+1)  FLM 210
YE(1)=YLE(I+1)  FLM 220
ZE(1)=0.  FLM 230
XE(2)=XLE(I+1)+CPC*(XTE(I+1)-XLE(I+1))  FLM 240
YE(2)=YLE(I+1)  FLM 250
ZE(2)=0.  FLM 260
XE(3)=XLE(I)+CPC*(YTE(I)-XLE(I))  FLM 270
YE(3)=YLE(I)  FLM 280
ZE(3)=0.  FLM 290
XE(4)=XLE(I)  FLM 300
YE(4)=YLE(I)  FLM 310
ZE(4)=0.  FLM 320
XE(5)=XLE(I)-0.05*(XTE(I)-XLE(I))  FLM 330
IF (I.EQ.1) XMN=XE(5)  FLM 340
YE(5)=YLE(I)  FLM 350
ZE(5)=0.  FLM 360
XE(6)=XE(4)+0.05*(XTE(I)-XLE(I))  FLM 370
YE(6)=YE(4)  FLM 380
ZE(6)=ZMIN  FLM 390
J=6  FLM 400
\[
\begin{align*}
&XE(7) = XE(6) + \text{DELTA} \times \text{CAHPI} \\
&YE(7) = YE(6) \\
&ZE(7) = ZE(6) + \text{DELTA} \times \text{SAHPI} \\
&\text{IF } (I.EQ.1) \text{ GO TO 20} \\
&J = 7 \\
&10 \quad XE(J+1) = XE(J) + \text{DELTA} \\
&YE(J+1) = YE(J) \\
&ZE(J+1) = ZE(J) \\
&\text{IF } (XE(J+1) \geq \text{XEND}) \text{ GO TO 20} \\
&J = J + 1 \\
&\text{GO TO 10} \\
&20 \quad \text{NELM}(I) = J + 1 \\
&K = \text{NELM}(I) \\
&\text{C} \\
&\text{IF } (\text{NCONTS} \neq 0) \text{ WRITE } (2) (XE(J), YE(J), ZE(J), J = 1, 5) \\
&30 \quad \text{WRITE } (4) K, (XE(J), YE(J), ZE(J), J = 1, K) \\
&\text{C} \\
&\text{NMAX} = 0 \\
&\text{DO } 40 \ I = 1, \text{NSW} \\
&40 \quad \text{IF } (NMAX < \text{NELM}(I)) \text{ NMAX} = \text{NELM}(I) \\
&\text{C} \quad \text{EVALUATION OF COORDINATES OF WAKE ELEMENTS} \\
&\text{DO } 70 \ I = 1, \text{NSW} \\
&\quad XXE(1) = XTE(I) \\
&\quad YYE(1) = YLE(I) \\
&\quad ZZE(1) = 0. \\
&\quad XXF(2) = XXE(1) \times (XT(1) - XXL(1)) / 10. \\
&\quad YYE(2) = YYE(1) \\
&\quad ZZE(2) = ZZE(1) \\
&\quad XXE(3) = XXE(2) \times (XT(1) - XXL(1)) / 10. \\
&\quad YYE(3) = YYE(2) \\
&\quad ZZE(3) = ZZE(2) \\
&\quad J = 3 \\
&50 \quad \text{IF } (XE(J) \geq \text{XEND}) \text{ GO TO 60} \\
&\quad XXE(J+1) = XXE(J) + DL \\
&\quad YYE(J+1) = YYE(J) \\
&\quad ZZE(J+1) = ZZE(J) \\
&\quad J = J + 1 \\
&\text{GO TO 50} \\
&60 \quad \text{NNELM}(I) = J
\end{align*}
\]
100 WRITE (4) K,(XXF(J),Y YE(J),ZZE(J),J=1,K)
WRITE (4) NMAX,NMIN,NMAX,NCONTS
REWIND 4
WRITE (6,160) (NELM(I),I=1,NSW)
DO 110 I=1,NSW
READ (4) K,(XXE(J),YE(J),Z E(J),J=1,K)
WRITE (6,140) (XXE(J),J=1,K)
WRITE (6,140) (YE(J),J=1,K)
110 WRITE (6,140) (ZZE(J),J=1,K)
WRITE (6,160) (NELM(I),I=1,NSW)
DO 120 I=1,NSW
READ (4) K,(XXE(J),YE(J),ZZE(J),J=1,K)
WRITE (6,140) (XXE(J),J=1,K)
WRITE (6,140) (YE(J),J=1,K)
120 WRITE (6,140) (ZZE(J),J=1,K)
130 WRITE (6,170)
C **********************************************
RETURN
C 140 FORMAT (14F9.4)
150 FORMAT (10F8.4)
160 FORMAT (10I2)
170 FORMAT (18H END OF INPUT DATA,///)
END
OVERLAY (LEVSP,2,0)
PROGRAM PLOT
C
SETS UP DIMENSIONS FOR PLOTTING LEADING-EDGE AND WAKE ELEMENTS
COMMON D(11)
COMMON /ALLI/ NSW,NSW1
C
******************************************************************************
REWIND 4
NN=NSW1+NSW
CALL SKIPR (4,NN)
READ (4) NMAX,NMNX,NMNX,2MIN,NCONTS
C
******************************************************************************
MXE=1
MYE=MYE+NSW1*NMAX
MZE=MZE+NSW1*NMAX
MNELM=MZE+NSW1*NMAX
MNEXT=MNELM+NSW1
C
MNEXT=3*NSW*NMAX-3*NMAX+NSW
CALL PLOTT D(MXE),D(MYE),D(MZE),D(MNELM),NSW1
MXE=1
MYE=MYE+NSW*(NMNX+2)
MZE=MZE+NSW*(NMNX+2)
MNELM=MZE+NSW*(NMNX+2)
MNEXT=MNELM+NSW
C
MNEXT=3*NSW*(NMNX+2)+NSW+1
CALL PLOTT D(MXE),D(MYE),D(MZE),D(MNELM),NSW
RETURN
END
SUBROUTINE PLOTT (XE,YE,ZE,NNM,NS)
C MANIPULATES LEADING-EDGE AND WAKE ELEMENTS COORDINATES IN A FORM
C SUITABLE FOR PLOTTING
COMMON /ALLI/ NSW,NSW1
COMMON /XPL/ XNM,YMN,ZNX,YNX,ZNX
DIMENSION NNM(1), XE(NS,1), YE(NS,1), ZE(NS,1), LABY(14), LABZ(14)
DATA LABY/$H6H$,6H VS Y,$H6H$,2H /
DATA LABZ/$H6H$,6H VS Z,$6H$,2H /
C
RENEW 4
IF (NS.NEQ.NSW) GO TO 20
DO 10 I=1,NSW1
READ (4) KK,(XE(I,J),YE(I,J),ZE(I,J),J=1,NS)
10 NNM(I)=KK
NC=0
LABY(8)=$H6H,(LEAD)
LABY(9)=$HHE-EDG
LABY(10)=$HHE ELEM
LABY(11)=$HHELEMT
LABY(12)=$HHELEMT
LABZ(9)=$HHE-EDG
LABZ(10)=$HHE ELEM
LABZ(11)=$HHELEMT
GO TO 50
70 DO 30 I=1,NSW
30 READ (4)
DO 40 I=1,NSW
READ (4) KK,(XE(I,J),YE(I,J),ZE(I,J),J=1,NS)
40 NNM(I)=KK
LABY(8)=$H(WAKE
LABY(9)=$HELEMT
LABY(10)=$HETS
LABY(11)=$H
LABZ(8)=$H(WAKE
LABZ(9)=$HELEMT
LABZ(10)=$HETS
LABZ(11)=$H
C
NC=0
50 DO 70 L=2,NS
I=L-1
K=NNM(L)-NC
DC 60 J=1,K
KE(J)=J+NC
XE(I,J)=XE(I,K)
YE(I,J)=YE(I,K)
ZE(I,J)=ZE(I,K)
XE(I,K+1)=XNN
YE(I,K+1)=YNN
ZE(I,K+1)=ZNN
XE(I,K+2)=XNY
YE(I,K+2)=YNX
ZE(I,K+2)=ZNX
NNN(I)=K+2
NS1=NS-1
CALL LNPL0T (XE,YE,NNM,NS1,NS,LABY)
CALL LNPL0T (XE,ZE,NNM,NS1,NS,LABZ)
RETURN
END
SUBROUTINE LNPLT (X,Y,NELM,M,NMAX,LABEL)  
C  
GENERATES PLOT ON LINE PRINTER (WRITTEN BY KU COMPUTATION CENTER)  
LNP 10  
DIMENSION NELM(NMAX), X(NMAX,1), Y(NMAX,1), ALINE(101), YAXIS(101)  
LNP 20  
1, SYM(20), LABEL(1)  
LNP 30  
DATA SYM/1H,1H,1H,1H,1H,1H,1H,1H,1H,1H,1H,1H/  
LNP 40  
DATA YAXIS/1H,1H,1H,1H,1H,1H,1H,1H,1H,1H,1H,1H/  
LNP 50  
1H,1H,9*1H,9*1H,1H,9*1H,1H,9*1H,1H,9*1H,1H/  
LNP 60  
DATA BLANK,UP,PLUS/1H,1H,1H,1H/  
LNP 70  
XMAX=X(1,1)  
LNP 80  
XMIN=X(1,1)  
LNP 90  
YMAX=Y(1,1)  
LNP 100  
YMIN=Y(1,1)  
LNP 110  
DO 10 I=1,N  
LNP 120  
N=NELM(I)  
LNP 130  
DO 10 J=1,N  
LNP 140  
IF (X(I,J).GT.XMAX) XMAX=X(I,J)  
LNP 150  
IF (X(I,J).LT.XMIN) XMIN=X(I,J)  
LNP 160  
IF (Y(I,J).GT.YMAX) YMAX=Y(I,J)  
LNP 170  
IF (Y(I,J).LT.YMIN) YMIN=Y(I,J)  
LNP 180  
CONTINUE  
LNP 190  
KEY=1  
LNP 200  
ZMAX=XMAX  
LNP 210  
ZMIN=XMIN  
LNP 220  
RANGE=ZMAX-ZMIN  
LNP 230  
IF (RANGE.EQ.0.0) RANGE=ZMAX/2.  
LNP 240  
SCALE=1.0E-9  
LNP 250  
SCALE=10.*SCALE  
LNP 260  
IF (SCALE.LT.RANGE) GO TO 30  
LNP 270  
ZMIN=ZMIN/SCALE  
LNP 280  
ZMAX=ZMAX/SCALE  
LNP 290  
MIN=20.*ZMIN-0.025  
LNP 300  
MAX=20.*ZMAX+0.025  
LNP 310  
BOTTOM=0.05*FLOAT(MIN)  
LNP 320  
TOP=0.05*FLOAT(MAX)  
LNP 330  
RANGE=0.1*(TOP-BOTTOM)  
LNP 340  
IF (RANGE.EQ.0.0) RANGE=0.1*(TOP/2.)  
LNP 350  
IF (BOTTOM.LE.ZMIN) GO TO 50  
LNP 360  
BOTTOM=BOTTOM-RANGE  
LNP 370  
GO TO 40  
LNP 380  
GO TO 40
50 IF (TOP.GE.ZMAX) GO TO 60
   TOP=TOP RANGE
   GO TO 50
60 CONTINUE
   IF (KEY.EQ.2) GO TO 70
   KEY=2
   ZMAX=YMAX
   ZMIN=YMIN
   YINC=0.01*(TOP-BOTTOM)
   XINC=YINC*SCALE
   XBOT=BOTTOM*SCALE
   GO TO 20
70 CONTINUE
   YINC=0.0125*(TOP-BOTTOM)
   YLOW=TOP+YINC
   YINC=2.*YINC
   WRITE (*,160)
   KEY=5
80 CONTINUE
   DO 90 IJ=2,101
90   ALINE(IJ)=BLANK
   YHIGH=YLOW
   YLOW=YHIGH-YINC
   YHS=SCALE*YHIGH
   YLS=SCALE*YLOW
   DO 110 I=1,N
   N=NELM(I)-2
   DO 110 J=1,N
   IF (Y(I,J).GT.YHS.OR.Y(I,J).LE.YLS) GO TO 110
   INDEX=(Y(I,J)-YBOT)/XINC
   INDEX=INDEX+1
   IF (INDEX.GT.100) INDEX=101
   IF (ALINE(INDEX).NE.BLANK) GO TO 100
   ALINE(INDEX)=SYM(I)
   GO TO 110
100 ALINE(INDEX)=PLUS
110 CONTINUE
   ALINE(1)=UP
   IF (KEY.NE.5) GO TO 120
TPP=TOP\*SCALE
WRITE (6, 170) TPP, ALINE
GO TO 130
120 WRITE (6, 180) ALINE
130 CONTINUE
KEY=KEY-1
IF (KEY.EQ.0) KEY=5
TOP=TOP-YINC
IF (TOP.GE.B)O\TIMM) GO TO 80
IF (KEY.NE.4) GO TO 80
WRITE (6, 210) YAXIS
XINC=10.0*XINC
ALINE(1)=XBOT
DO 140 I=2, 11
140 ALINE(I)=ALINE(I-1)+XINC
WRITE (6, 190) (ALINE(I), I=1, 11)
C
WRITE (6, 200) (LABEL(I), I=1, 14)
150 RETURN
C
160 FORMAT (1H1, /)
170 FORMAT (F10.3, 1X, 101A1)
180 FORMAT (11X, 101A1)
190 FORMAT (5X, 11F10.3)
200 FORMAT (//, 20X, 13A6, A2)
210 FORMAT (11X, 101A1)
END
SUBROUTINE AERODN (NWNG,C,THETP,XTE,XLE,YLE,CONS,SI,SN,XCP,YCP,XH,AER 10
1YN,CON1,CONJ,CONK,CI,CJ,CK,DUMMY,CT,CP' /L,CPSW1)
C SOLVES FOR THE STRENGTHS OF WING AND LEADING-EDGE VORTEX SYSTEM AER 30
COMMON /ALLI/,NSW1,NCW1,SNW1,NCW1 IWNG1,NCPTTL
COMMON /ALLRA/,AA(17),SINA,AS(6),BSQD4P
COMMON /GM/,ITER,12,L2,3,L4,L5,L6,L7,L8
COMMON /NCT/,NCT,NC1,NC2
DIMENSION C(1),THETP(1),XTE(1),XLE(1),YLE(1),CONS(1),SI(1),AER 80
1SN(1),XCP(1),YCP(1),DUMMY(1),CON1(1),CONJ(1),CONK(1),CI(1),AER 90
2 C(1),CK(1),CT(1),CPD(1),CPSW(1),XH(NWNG2),YN(NWNG2) AER 100
C
*********************************************************************************************************************************************
RE WIND 1
RE WIND 2
RE WIND 3
CALL SKIPR(1,5)
READ (1) (C(I),I=1,NSW1)
READ (1) (THETP(I),I=1,NSW1)
READ (1) (XTE(I),XLE(I),YLE(I),I=1,NSW1)
CALL SKIPR(1,5)
READ (1) (CONS(I),I=1,NSW1)
READ (1) (SI(I),SN(I),I=1,NCH1)
READ (1) (SN(I),NSW1)
READ (1) (XCPIYCP(I),I=1,NCPTTL)
READ (1) ((XH(I,J),YN(I,J),J=1,2),I=1,NWNG)
READ (1) (CT(I),I=1,NSW1)
READ (1) (CPSW(I),I=1,NSW1)
CALL SKIPR(1,2)
READ (1) (CPSW1(I),I=1,NSW1)
C
C INFLUENCE COEFFICIENT MATRIX EVALUATION
*********************************************************************************************************************************************
L1=1
L2=L1+NWNG
L3=L2+NWNG
L4=L3+NWNG
L5=L4+NWNG
L6=L5+NWNG
L7=L6+NWNG
L9=L7+NWNG
NC2=0
NCT=0
DO 10 I=1,NCPTTL
ZCP=0.
CALL VDTWNG (C,THETP,XCP(I),YCP(I),ZCP,XN,YN,XTE,YLE,CONS,DUMMY(L1)
1,DUMMY(L2),DUMMY(L3),DUMMY(L4),DUMMY(L5),DUMMY(L6),DUMMY(L7),DUMMY(A)
2Y(L9),CONJ,CONK,SI,NSW1,NCW,NWNG)
WRITE (2) (CONX(J),J=1,NWNG)
CALL VDTFRE (XCP(I),YCP(I),ZCP,CI,CJ,CX,NSW1,3504,P,XLE,YLE)
WRITE (3) (CK(J),J=1,NW11)
10 CONTINUE
C GAMA-EVALUATION
REWIND 2
REWIND 3
READ (2) (CONI(I),I=1,NWNG)
NWNG1=NWNG+1
NWNG2=NWNG2+NSW1
NWNB1=NWNB1+1
READ (3) (CONI(I),I=NWNG1,NWB)
CONI(NWNG1)=SINA
IJ=1
DO 20 I=1,NWNB
CJ(I)=CONT(I+1)/CONI(I)
IJ=2
NJ=NWNB-1
20 CONTINUE
READ (2) (CONI(I),I=1,NWNG)
READ (3) (CONI(I),I=NWNG1,NWNB)
CONI(NWNB1)=SINA
IF (IJ.GT.NWNG) CONI(NWNB1)=SINA-CJT(IJ-NWNG)
CALL VISEQN (NJ,IJ,CONI,CJ,CX)
IJ=IJ+1
NJ=NJ-1
IF (IJ.LE.NWNB) GO TO 30
WRITE (6,30)
DO 40 I=1,NSW1
DO 40 J=1,NCW
NJ(I-1)=NCW+J
40 WRITE (6,70) JPCW(J),JPCW(J),JPCW(J)
WRITE (6,100)
DO 50 I=1,NSW1
J=NWNG+1
AER 410
AER 420
AER 430
AER 440
AER 450
AER 460
AER 470
AER 480
AER 490
AER 500
AER 510
AER 520
AER 530
AER 540
AER 550
AER 560
AER 570
AER 580
AER 590
AER 600
AER 610
AER 620
AER 630
AER 640
AER 650
AER 660
AER 670
AER 680
AER 690
AER 700
AER 710
AER 720
AER 730
AER 740
AER 750
AER 760
AER 770
AER 780
AER 790
50 WRITE (6,90) CPSWI(I),CJ(J)
C EVALUATION OF SECTIONAL LEADING-EDGE THRUST
CALL THRT (CJ,CONI,CONJ)
NERR=0
DO 60 I=1,NSWI
60 IF (ABS(CONJ(I)-CT(I)),GE,(1,0E-10)) NERR=1
IF (NERR,EO.1) WRITE (6,110)
GMSUM=0.
DO 70 I=2,NSWI
70 GMSUH=GMSUM+CJ(KS)
C .................................................................AER 910
REWIN 2
WRITE (2) (CJ(I),I=1,NWNB)
WRITE (7) GMSUM
C .................................................................AER 950
RETURN
C
80 FORMAT (1H1,///,22H WING VORTEX STRENGTHS,///,22H **************AER 980
1****///,29H X/C 27/3 SAMAY,///,29H *** **** AER 990
2 ****) AER1000
90 FORMAT (3F10.5)
AER1010
100 FORMAT (///,32H LEADING-EDGE VORICES STRENGTHS,///,31H **************AER1020
1************///,29H 27/3 CAPSAN,///,29H **** AER1030
2****) AER1040
110 FORMAT (///,34H ERROR IN SECTIONAL ST CALCULATION,///,10F10.5) AER1050
END
SUBROUTINE VMSEQN (NC1, K, AA, A, CA)
C SOLVES A SYSTEM OF SIMULTANEOUS EQUATIONS
DIMENSION AA(1), CA(1), A(1)
NC=K*NC1
SUM1=0.
K1=K-1
JJ=1
DO 10 J=1,K1
  SUM1=SUM1+AA(J)*A(JJ)
10  JJ=JJ+NC1+1
SUM1=SUM1+AA(K)
DO 30 I=1,NC1
SUM2=0.
JJ=I+1
DO 20 J=1,K1
  SUM2=SUM2+AA(J)*A(JJ)
20  JJ=JJ+NC1+1
KK=K+I
SUM2=SUM2+AA(KK)
30  CA(I)=-SUM2/SUM1
M=1
L=0
KNC=(K-1)*NC1
DO 60 I=1,NC
  IF (I.GT.KNC) GO TO 50
  MM=(M-1)*NC1+1
  IF (I.EQ.MM) GO TO 70
40  KK=KK+1
  IL=I+L
  A(I)=CA(KK)*BASE*A(IL)
GO TO 60
50  II=I-KNC
  A(I)=CA(II)
60  CONTINUE
GO TO 80
70  II=MM+M-1
  BASE=A(II)
  K*0
  L=L+1
  M=M+1
VMS 10
VMS 20
VMS 30
VMS 40
VMS 50
VMS 60
VMS 70
VMS 80
VMS 90
VMS 100
VMS 110
VMS 120
VMS 130
VMS 140
VMS 150
VMS 160
VMS 170
VMS 180
VMS 190
VMS 200
VMS 210
VMS 220
VMS 230
VMS 240
VMS 250
VMS 260
VMS 270
VMS 280
VMS 290
VMS 300
VMS 310
VMS 320
VMS 330
VMS 340
VMS 350
VMS 360
VMS 370
VMS 380
VMS 390
VMS 400
SUBROUTINE THRST (SGM, CONK, CT) 
C EVALUATES SECTIONAL LEADING-EDGE THRUST COEFFICIENTS 
COMMON /ALLI/ NSW,NSW1,NCH,NWNG 
COMMON /ALLRA/ A(17),SINA,COSA,SWPE,A3,BETA2,AC(5),PI 
DIMENSION SGM(1), CONK(1), CT(1) 
AM2=1.-BETA2 
FCOS=COS(SWPE) 
FTAN=TAN(SWPE) 
VAR1=FLOAT(NCW)*SORT(FTAN*FTAN+BETA2) 
VAR2=SORT(1.-AM2*FCOS*FCOS) 
REWRIND 2 
REWRIND 3 
CALL SKIPR (2,NWNG) 
CALL SKIPR (3,NWNG) 
DO 30 I=1,NSW1 
WL=0. 
READ (2) (CONK(J),J=1,NWNG) 
DO 10 J=1,NWNG 
10 WL=WL+CONK(J)*SGM(J) 
READ (3) (CONK(J),J=1,NSW1) 
DO 20 J=1,NSW1 
JJ=NWNG+J 
20 WL=WL+CONK(J)*SGM(JJ) 
THR1=(WL+SINA)/VAR1 
30 CT(1)=(PI/2.)*VAR2*THR1*THR1/FCOS 
RETURN 
END
PROGRAM LOADS

SETS UP DIMENSIONS FOR EVALUATING AERODYNAMIC CHARACTERISTICS

COMMON 3(1)
COMMON ALLI/NSW,NSW1,NCW,NWNG

DIMENSION W(4100)

NCW=NCW+1
NWNP=NNCW+NSW1
LCI=1
LCJ=LCI+NWNG
LCK=LCJ+NWNG
LCONI=LCK+NWNG
LCONJ=LCONI+NWNG
LCONK=LCONJ+NWNG
LVXNG=LCONK+NWNG
LYVNG=LVXNG+NWNG
LXLE=LYVNG+NWNG
LXTE=LXLE+NSW
LYLE=LXTE+NSW
LST=LYLE+NSW
LC=LSI+NCW
LSWP=LC+NSW1
LXN=LSWP+NCW
LYN=LXN+2*NWNG
LSNN=LYN+2*NSW1
LTHETP=LSNN+NCW
LCONS=LTHETP+NSW1
LDUMHY=LCONS+NSW1
LCT=LDUMHY+3*NWNG
LOI=LCT+NSW1
LCON=LOI+NCW
LCUP=LCON+NNCW
LYVNG=LCUP+NWNG
LYVNA=LYVNG+NSW1
LGAMA=LYVNA+NSW1
LGL=LGAMA+NWNG+NSW1
LXYLN=LGML+NSW1
LTIT=LXYLN+NSW1
LSC=LXIT+NCW
LSCN=LSC+NSW1

LOD 10
LOD 20
LOD 30
LOD 40
LOD 50
LOD 60
LOD 70
LOD 80
LOD 90
LOD 100
LOD 110
LOD 120
LOD 130
LOD 140
LOD 150
LOD 160
LOD 170
LOD 180
LOD 190
LOD 200
LOD 210
LOD 220
LOD 230
LOD 240
LOD 250
LOD 260
LOD 270
LOD 280
LOD 290
LOD 300
LOD 310
LOD 320
LOD 330
LOD 340
LOD 350
LOD 360
LOD 370
LOD 380
LOD 390
LOD 400
DO 10 J=1,NCW
10 COSP(J)=COS((2.*FLOAT(J)-1.)*PIJ)
CONST=HALF*PI/(AREA*FLOAT(NSW))
C CALCULATION OF GNY-VALUES FOR WING SURFACE
NCN=0.
NCN=0.
DO 20 I=1,NSW1
DO 20 J=1,NCW
I=(I-1)*NCW+J
XEE=XAVNG(I)
YEE=YAVNG(I)
ZEE=0.
CALL NEWVEL (C,THETP,XEE,YEE,ZEE,XN,YN,XE,YLE,CONS,DUMMY,CONT,CONCOF 530
1J,CONT,S1,NSW1,NCW,NWNG,C1, CJ, CK, XLE, UU, VV, WW, ADUM, BDUM, CDUM, GAMA, COF 540
2YLM)
TNSP=TAN(SWP(J))
GNY(I)=GAMA(I)*(UU-VV*TNSP)
CONTINUE
C READING LARGEP SRTD FOR THE WING
C CALCULATION OF INDUCED VELOCITIES AT SOUND ELEMENT ENO-POINTS ON
C WING SURFACE
DO 40 I=1,NSW1
DO 40 J=1,NCW
NP=(I-1)*NCW+J
XEE=XN(NP+2)
YEE=YN(NP+2)
CALL NEWVEL (C,THETP,XEE,YEE,ZEE,XE,YLE,CONS,DUMMY,CONT,CONCOF 670
1J,CONT,S1,NSW1,NCW,NWNG,C1, CJ, CK, XLE, UU, VV, WW, ADUM, BDUM, CDUM, GAMA, COF 680
2YLM)
VV(NP)=VV
CONTINUE
CONTINUE
CONTINUE
C CALCULATION OF GAY-VALUES FOR JOUND ELEMENTS NEAR LEADING-EDGE
DO 50 J=1,NCW
50 TII(J)=(2.*FJ-1.)*PI/(2.*FLOAT(NCW))
SURA=0.*FLOAT(NCW)/(4.*PI*SIN(TII(J)))
DO 40 I=1,NSW1
NS1=NWNG+1
60  GML(I)=GAMA(NGI)*SURA/C(I)          COF 800
C
REWIND 3                                    COF 810
WRITE (3) (GML(I),I=1,NSW1)                 COF 820
C
TNSP=TAN(OSWP(I))                            COF 830
DO 70 II=1,NSW1                              COF 840
XEE=XAVWNA(II)                               COF 850
YEE=YAVWNA(II)                               COF 860
CALL NEWVEL (C,THETP,XEE,YEE,ZEE,XN,YN,XTE,YLE,CONS,DUMMY,CONI,CONC)
1J,CONK,SI,NSW1,NCW,NWNG,CJ,CJ,CK,XLE,UU,YY,WW,ADUM,BDUM,CDUM,GAMA)
2YLM)
    NWNGII=NWNG+II
    GMY(NWNGII)=GML(II)*(UU-VY*TNSP)
70 CONTINUE
C
CALCULATION OF DCP-VALUES FOR WING POINTS
PN=PI/(FLOAT(NCW))                           COF 910
DO 80 I=1,NCW                                COF 920
W(I)=0.                                     COF 930
WX(I)=XN(I,1)                                COF 940
80 WY(I)=YN(I,1)                             COF 950
    DO 150 I=1,NSW1                           COF 960
    DO 140 J=1,NCW                           COF 970
    NP=(I-1)*NCW+J                          COF 980
    VYY=VY(NP)                               COF 990
    CPG=0.                                  COF1000
    CPH=0.                                  COF1010
    CPI=0.                                  COF1020
    DO 100 JJ=1,J                            COF1030
    NPIN=(I-1)*NCW+JJ                        COF1040
    IF (J.EQ.JJ) GO TO 70                  COF1050
    CPG=CPG+GAMA(NPIN)*SI(JJ)               COF1060
    GO TO 100                                COF1070
70   CPG=CPG+0.5*GAMA(NPIN)*SI(JJ)          COF1080
100 CONTINUE
    CPG=-CPG*PN*C(I)*VYY                   COF1090
    IF (I.EQ.NSW1) GO TO 130                COF1100
    DO 120 JJ=1,J                          COF1110
    NPDT=I*NCW+JJ                         COF1120
120 CONTINUE
IF (J.EQ.JJ) GO TO 110
CPH=CPH+GAMA(NPOT)*SI(JJ)
GO TO 120
110  CPH=CPH+0.5*GAMA(NPOT)*SI(JJ)
120  CONTINUE
CPH=CPH*PN*C(I+1)*VYY
130  CPI=2.*GAMA(NWNG+I)*VYY
W(NP+NCW)=CPG*CPH+CPI
WX(NP+NCW)=XN(NP,2)
WY(NP+NCW)=YN(NP,2)
140  CONTINUE
150  CONTINUE
N3=NWNG+NCW+3
CALL SURFSET (N3,WX,XY,WZ,CI)
DO 170 K=1,NCW
DO 160 J=1,NSW1
NP=(J-1)*NCW+K
DCP1=2.*GMY(NP)
XEE=XAVWNG(NP)
YEE=YAVWNG(NP)
CALL SURFORD (W,XEE,YEE,VV,N3)
DCPD=VV/(YLE(J+1)-YLE(J))
DCP(NP)=DCP+DCPD
160  CONTINUE
170  CONTINUE
C CALCULATION OF INDUCED VELOCITIES AT END-POINTS OF BOUND ELEMENTS
C NEAR LEADING-EDGE
CPG=0.5*(1.-COS(THT(1)))
DO 180 l=2,NSW
XEE=XLE(I)+CPC*(XLE(I)-XLE(I))
YEE=YLE(I)
CALL NEWVEL IC,THT(1),XEE,YEE,ZEE,XY,ZY,XE,YE,YS,WNS,CON,CON,
1J,CON,SI,NSW1,NCW,NWNG,CI,CJ,CX,XE,YY,ZY,WNS,CON,CON,GAMA
2YLM)
180  YV(I)=VV
190  DCY-INTERPOLATION FOR BOUND ELEMENTS OF WING
CALL INTGMY (NCW,NSW1,DCY,SNN,DCYDUM,Y(1),DUMY(INC))
C CALCULATION OF DECREASE IN DCP-VALUES AT THE LEADING-EDGE
DCPA(1)=0.
DCPA(NSW)=0.
DO 190 I=Z,NSW1
DCPA(I)=2.0*GAHA(NWNG+I)*VY(I)
190 CONTINUE
DO 200 I=1,NSW1
CNC(I)=2.0*GMY(NWNG+I)
200 CONTINUE
C FINAL DCP-VALUES AT LARGER WING GRID
DO 230 I=1,NSW1
DO 220 J=1,NHCW
NP=(I-1)*NHCW+J
GMNW(NP)=COEF(I,J)
DO 210 K=1,NCW
FK=K
AMI1=COS(FK*THT(J))
AMI2=AMI1*COEF(I,K+1)
GMNW(NP)=GMNW(NP)+AMI2
210 CONTINUE
GMNW(NP)=GMNW(NP)/(SIN(THT(J)))
IF (J.NE.1) GO TO 220
NGI=NWNG+I
GMNW(NP)=GMNW(NP)+CNC(I)
220 CONTINUE
230 CONTINUE
DO 240 I=1,NWNP
DCP(I)=GMNW(I)
PIJ=PI/(2.0*FLOAT(NHCW))
WRITE (4,370)
DO 290 I=1,NSW1
DO 290 J=1,NHCW
NP=(I-1)*NHCW+J
CPC=0.63*(1.0-COS((2.0*FLOAT(J)-1.0)*PIJ))
290 CONTINUE
WRITE (4,330) CPCW,CPSW1(I),DCP(NP)
DO 260 J=1,NHCW
260 CPCJ=1.0-COS((2.0*FLOAT(J)-1.0)*PIJ)
250 CONTINUE
C EVALUATION OF SECTIONAL AND TOTAL AERODYNAMIC CHARACTERISTICS
CL=0.
CM=0.
CD=0.
CTT=0.
DO 280 I=1,NSW1
SECCL(I)=0.
SECCH(I)=0.
PHII=PI*FLOAT(I)/FLOAT(NSW1)
DO 270 J=1,NNCW
NP=(I-1)*NNCW+J
SECCL(I)=SECCL(I)+DCP(NP)*2I(J)
SECCH(I)=SECCH(I)-DCP(NP)*GI(J)*(XLM(I)+0.5*C(I)*(1.-COSP(J)))/CBAC
1R
CONTINUE
SECCCL(I)=SECCCL(I)*PI/(2.*FLOAT(NNCW))
SECCCH(I)=SECCCH(I)*PI/(2.*FLOAT(NNCW))
SECCD(I)=SECCCL(I)*SINA-CT(I)*COSA
SECCM(I)=SECCCL(I)*COSA+CT(I)*SINA
CL=CL+SECCCL(I)*C(I)*SIN(PHII)
CM=CM+SECCM(I)*C(I)*SIN(PHII)
CD=CD+SECCD(I)*C(I)*SIN(PHII)
280 CTT=CTT+CT(I)*C(I)*SIN(PHII)
CL=CONST*CL
CM=CONST*CM
CD=CONST*CD
CTT=CONST*CTT
C
WRITE (7) CL,CM,CD,CTT
WRITE (6,340) (I,SECCL(I),SECCH(I),SECCD(I),CT(I),I=1,NSW1)
WRITE (6,350) CL,CM,CD,CTT
NNCW=NNCW+1
CALL INGMY (NNCW,NSW1,DCP,NNC,DJEF,DUMMY(1),DUMMY(NNCW))
REWIND 1
CALL XIP0R (1,8)
READ (1) (XLM(I),CT(I),I=1,NSW1)
C
EVALUATION OF DCP AT CONSTANT X LOCATIONS
DO 330 X=1,NBRR
XBR=XBRR(K)
KY=1
290 IF (X3R.LT.XLM(KY)) GO TO 300
KY=KY+1
IF (KY.LE.NSW1) GO TO 290

300  KY=KY-1
BLOCAL=CI(KY)+(CI(KY+1)-CI(KY))*((XBR-XLM(KY))/((XLM(KY+1)-XLM(KY)))
DO 320 I=1, KY
CJ(I)=CI(I)/BLOCAL
XC=(XBR-XLM(I))/C(I)
THTA=ARCSIN(1.-Z*X(I))
DCPN(I)=COEF(I,1)
DO 310 J=1, NNCW
310  DCPN(I)=DCPN(I)+COEF(I,J+1)*COS(FLOAT(J)*THTA)
320  DCPN(I)=DCPN(I)/(SIN(THTA))
WRITE (6,360) XBR,CJ(I),DCPN(I),I=1,KY
330  CONTINUE
RETURN
C
340  FORMAT (1H1,/,9X,20HSECTIONAL PROPERTIES,/,9X,20H************COF2510
1****,/,9X,39HI CLI CMI CDI CTI,/,9X,39H* COF2520
2 *** *** *** *,/(1I0,4F10.5)) COF2530
350  FORMAT (/,9X,23HTOTAL LIFT COEFFICIENT=,F10.5,/,9X,34HTOTAL PITCH COF2540
1MG MOMENT COEFFICIENT=,F10.5,/,9X,23HTOTAL DRAG COEFFICIENT=,F10.5COF2550
2/,9X,2SHTOTAL THRUST COEFFICIENT=,F10.5)
360  FORMAT (/,34H SPANWISE Pressures AT CONSTANT X=,F10.5,/,8X,25HY COF2570
1 2Y/8 (LOCAL) DELTA-CP,/,(1X,2F10.5,2X,F10.5)) COF2580
370  FORMAT (1H1,/,5X,21IDELTA-CP DISTRIBUTION,/,5X,21H************COF2590
1*****,/,30H X/C 2Y/8 DELTA-CP,/,30H *** ***COF2600
2* *********) COF2610
380  FORMAT (3F10.5) COF2620
END
SUBROUTINE INTGHY (NCY,NSW1,SGM,SNN,COEF,F,THETA)
C
SETS UP COEFFICIENTS OF A MATRIX FOR OCP-INTERPOLATION
DIMENSION SGM(1), SNN(1), F(1), THETA(1), COEF(NSW1,1)
PI=3.14159265
N1=NCW+1
FN=NCW
DO 40 I=1,NSW1
   DO 10 J=1,NCW
   N K=(I-1)*NCW+J
   F J=J
   TH ETA(J)=(2.*F J-1.)*PI/(2.*FN)
   F J=SGM(NK)*SNN(J)
   DO 30 J=1,N1
   COEF(I,J)=0.
   F J=J
   DO 20 K=1,NCW
   COEF(I,J)=COEF(I,J)+F(K)*COS((F J-1.)*TH ETA(K))
   IF (J.EQ.1) COEF(I,J)=COEF(I,J)/FN
   IF (J.NE.1) COEF(I,J)=COEF(I,J)*2./FN
 30 CONTINUE
40 CONTINUE
RETURN
END
SUBROUTINE SURFSET(N3,X,Y,W,IKW)
C
SET UP PROGRAM FOR SURFACE SPLINE
C
WRITTEN BY ROBERT N. DESHARAI S, STRUCTURES AND DYNAMICS DIV.
C
LANGLEY RESEARCH CENTER, HAMPTON, VA. 23665
C
DIMENSION X(1), Y(1), W(N3,1), IKW(1)

E=1.E-10
NZ=1
N=N3-3
LI=N+1
N2=N+2
N4=N3+1
RN=1.*N
N3Z=N3+NZ
NZ3=NZ+3

C
COMPUTE SCALING PARAMETERS, UB, UX, UY, VB, VX, XY
X8=0.
Y8=0.
PXX=0.
PXY=0.
PYY=0.
TH=0.

DO 10 I=1,N
X8=X8+X(I)
Y8=Y8+Y(I)
PXX=PXX+X(I)*X(I)
PXY=PXY+X(I)*Y(I)
PYY=PYY+Y(I)*Y(I)

10
X8=RN*X8
Y8=RN*Y8
PXX=RN*PXX-X8*Y8
PXY=R4*PXY-X3*Y8
PYY=R4*PYY-Y9*Y3

IF (PXY.NE.0) THEN 5, ATAN2(X2*,PXY,PYY-PXX)
CT=COS(TH)
ST=SIN(TH)
C2=CT*CT
CS=2.*CT*ST
S2=ST*ST
SU=1./SQRT(PXX*C2-PXY*CS+PYY*S2)
SV=1./SQRT(PXX*S2+PXY*CS+PYY*C2)
UX=SU*CT
UY=-SU*ST
VX=SV*ST
VY=SV*CT
UB=-(UX*X8+UY*Y8)
VB=-(VX*X9+VY*Y9)

C     PUT Z INTO ITS W LOCATION
IZ=NNNZ
DO 30 J=N4,N3Z
DO 20 I=1,3
20  W(I,J)=0
DO 30 I=4,N3
W(I,N3+4-N-J)=W(IZ,1)
30  IZ=IZ-1

C     PUT 1,U,V (SCALED X,Y) INTO THEIR W LOCATIONS
DO 40 J=N1,N3
DO 40 I=1,3
40  W(I,J)=0
DO 50 J=1,N
JR=N4+J
W(I,J)=1.
W(JR,N1)=W(1,J)
W(2,J)=UB+UX*X(J)+UY*Y(J)
W(JR,N2)=W(2,J)
W(3,J)=VB+VX*X(J)+VY*Y(J)
50  W(JR,N3)=W(3,J)
DO 60 J=1,N
JB=N4-J

C     COMPUTE W MATRIX IN W
DO 60 I=4,JB
IB=N4-I
R2=(W(2,J)-W(2,I1))**2+(W(3,J)-W(3,I3))**2
W(I,J)=R2*ALOG(R2+0.
60  W(I,I3)=W(I,J)

C     MATINV IS THE SYSTEM LIBRARY ROUTINE FOR SOLVING LINEAR EQUATIONS
N31=N3+1
CALL MATINV (N3,N3,w,1,w(1,N31),1,DET,ISC,RK,IWK,IWK(N4))

C     PUT S,U,V IN LOW W
W(1,1)=N3*(Z+N7)
SUBROUTINE SURFORD(W,XP,YP,ZP,N3)

SURFACE SPLINE INTERPOLATION (ORDINATES)

WRITTEN BY: ROBERT N. DESMARIS, STRUCTURES AND DYNAMICS DIV.

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DIMENSION W(N3,1)

N=N3-3
N1=N+1
N2=N+2
U=W(N1,2)+W(N2,2)*XP+W(N3,2)*YP
V=W(N1,3)+W(N2,3)*XP+W(N3,3)*YP
ZP=W(N1,4)+W(N2,4)*U+W(N3,4)*V

DO 10 I=1,N
R2=(U-W(I,2))**2+(V-W(I,3))**2
ZP=ZP+W(I,4)*R2*ALNG(R2+W(I,1))
10 RETURN

END
SUBROUTINE MATINV (MAX, N, A, R, B, IOP, DETERM, ISCALE, IPIVOT, IMK)

MATRIX INVERSION WITH ACCOMPANYING SOLUTION OF LINEAR EQUATIONS

PROVIDED BY - ANALYSIS AND COMPUTATION DIVISION
LANGLEY RESEARCH CENTER
HAMPTON, VA. 23665

DIMENSION IPIVOT(N), A(MAX,N), B(MAX,N), IMK(MAX,2)

EQUIVALENT (IROW, JROW), (ICOLUM, JCOLUMN), (AMAX, T, SWAP)

C

INITIALIZATION
C

ISCALE=0
R1=10.0*R1
R2=1.0/R1
DETERM=1.0
DO 10 J=1,N
10 IPIVOT(J)=0
DO 370 I=1,N
C

SEARCH FOR PIVOT ELEMENT
C

AMAX=0.0
DO 60 J=1,N
IF (IPIVOT(J)-1) 20,60,20
20 DO 50 K=1,N
IF (IPIVOT(K)-1) 30,50,410
30 IF (ABS(A(J,K))-ABS(A(J,J))) 40,50,50
40 IROW=J
ICOLUMN=K
AMAX=A(J,K)
50 CONTINUE
CONTINUE
60 IF (AMAX) 80,70,80
70 DETERM=0.0
ISCALE=0
GO TO 410
80 IPIVOT(ICOLUMN)=IPIVOT(ICOLUMN)+1
C

INTERCHANGE ROWS TO PUT PIVOT ELEMENT ON DIAGONAL
C

IF (IROW-ICOLUMN) 90,130,90
90 DETERM = DETERM
DO 100 L=1,N
SWAP = A(ROW,L)
A(ROW,L) = A(ICOLUMN,L)
100 A(ICOLUMN,L) = SWAP
IF (M) 130, 130, 140
110 DO 120 L=1,N
SWAP = B(ROW,L)
B(ROW,L) = B(ICOLUMNS,L)
120 B(ICOLUMN,L) = SWAP
130 INK(I,1) = IROW
INK(I,2) = ICOLUMN
P... (NZCOLUMNS, ICOLUMN)
IF (IOP.EQ.1) GO TO 270
IF (P...') 140, 70, 140
C C SCALE THE DETERMINANT
C C 140 P... = P...'
IF (ABS(DETERM) < R1) 170, 150, 150
150 DETERM = DETERM/R1
ISCALE ISCALE + 1
IF (ABS(DETERM) > R1) 200, 160, 160
160 DETERM = DETERM/R1
ISCALE ISCALE + 1
GO TO 200
170 IF (ABS(DETERM) < R2) 130, 130, 200
180 DETERM = DETERM/R1
ISCALE ISCALE - 1
IF (ABS(DETERM) > R2) 170, 190, 200
190 DETERM = DETERM/R1
ISCALE ISCALE - 1
200 IF (ABS(P...') < R1) 230, 210, 210
210 P... = P...'/R1
ISCALE ISCALE + 1
IF (ABS(P...') > R1) 250, 220, 220
220 P... = P...'/R1
ISCALE ISCALE + 1
GO TO 240
230 IF (ABS(PIVOT) - R2) 240, 240, 260
240 PIVOT = PIVOT*R1
ISCALE = ISCALE - 1
IF (ABS(PIVOT) - R2) 250, 250, 260
250 PIVOT = PIVOT*R1
ISCALE = ISCALE - 1
260 DETERM = DETERM*PIVOT
C
C DIVIDE PIVOT ROW BY PIVOT ELEMENT
C
270 IF (PIVOT) 280, 70, 280
280 A(1COLUM,1COLUM) = 1.0
DO 290 L = 1, N
290 A(L,L) = A(L,L)/PIVOT
IF (M) 320, 320, 300
300 DO 310 L = 1, N
310 B(1COLUM,L) = B(1COLUM,L)/PIVOT
C
C REDUCE NON-PIVOT ROWS
C
320 DO 370 L = 1, N
IF (L1-1COLUM) 330, 370, 330
330 T = A(L1,1COLUM)
A(L1,1COLUM) = 0.0
DO 340 L = 1, N
340 A(L,L) = A(L,L) - A(L1,L)*T
IF (M) 370, 370, 350
350 DO 360 L = 1, N
360 B(L1,L) = B(L1,L) - B(L1,L)*T
370 CONTINUE
C
C INTERCHANGE COLUMNS
C
DO 400 I = 1, N
L = N+1-I
IF (IWK(L,1) - IWK(L,2)) 330, 400, 330
380 JROW = IWK(L,1)
JCOLUMN = IWK(L,2)
DO 390 K = 1, N
OVERLAY (LEVSP,5,0)

PROGRAM NEWSHAPE

C

SETS UP DIMENSIONS FOR COMPUTING THE NEW LOCATIONS OF LEADING-EDGE:

C

AND TRAILING-EDGE VORTICES BY MAKING THOSE FORCE-FREE

COMMON (1)

COMMON /ALLI/ NSW,NSW1,NCW,NWNG,NCPTTL

DIMENSION E(2400)

C

REIND 4

NN=NSW1+NSW

CALL SKTPR (4,NN)

READ (4) NMAX,NNMAX,ZMIN,NCONT

C

***********

LC=1

LTHETP=LC+NSW1

LXN=LTHETP+NSW1

LXN=LXN+2*NWNG

LXE=LXN+2*NWNG

LYLX=LYLX+NSW

LYLA=LYLX+NSW

LCONS=LYLE+NSW

LSI=LCONS+NSW1

LXCP=LSI+NCW

LYCP=LXCP+NCPTTL

LCI=LYCP+NCPTTL

LCJ=LCI+NWNG

LCK=LCJ+NWNG

LCONI=LCK+NWNG

LCONJ=LCONI+NWNG

LCON=LCON+NWNG

LDUMY=LCONK+NWNG

LNELM=LDMUM+8*NWNG

LNLIM=LNELM+NSW1

LGAMA=LNLIM+NSW

LGML=LGAMA+NCPTTL

LM=LGML+NSW1

LCPCW=LYLM+NSW1

LNEXT=LCPCW+NSW1

C

LNEXT=21*NWNG+14*NSW+NCW-9

MXE=1

NSP 10

NSP 20

NSP 30

NSP 40

NSP 50

NSP 60

NSP 70

NSP 80

NSP 90

NSP 100

NSP 110

NSP 120

NSP 130

NSP 140

NSP 150

NSP 160

NSP 170

NSP 180

NSP 190

NSP 200

NSP 210

NSP 220

NSP 230

NSP 240

NSP 250

NSP 260

NSP 270

NSP 280

NSP 290

NSP 300

NSP 310

NSP 320

NSP 330

NSP 340

NSP 350

NSP 360

NSP 370

NSP 380

NSP 390

NSP 400

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OF POOR QUALITY
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SUBROUTINE NEWELM (C, THEP, XN, YN, XTE, XLE, YLE, CONS, SI, CPC, YCP, CI, CJ, NLN)
1, CK, CON1, CONJ, CONK, DUMMY, NWG, NCP, T, XE, YE, ZE, XE, YTE, ZTE, NSW1, NSW, NLN)
2, NW, ZHN, NMX, NMAX, NELM, NCONTS, GAMA, GML, YLM, CPCW1)
C COMPUTES THE NEW LOCATIONS OF LEADING-EDGE AND TRAILING-EDGE VORTICES BY MAKING THOSE FORCE-FREE
C COMMON /GMI/ ITER
COMMON /NCTT/ NCT, NCON
COMMON /ALLRA/ T (15), ALPHA, SINA (9), PI, A0 (2), HALFB, AREA
DIMENSION DUMMY (1), CON1 (1), CONJ (1), CONK (1), CI (1), CJ (1), CK (1)
1, C (1), THEP (1), XTE (1), XLE (1), YLE (1), CONS (1), SI (1), CPC (1), NLN
2, YCP (1), GAMA (1), GML (1), YLM (1), CPCW1 (1), XN (NWG, 2), YN (NWG, 2), NLN
3, NELM (1), NNELM (1), XE (NSW1, 1), YE (NSW1, 1), ZE (NSW1, 1), XE (NSW1, 1), YTE (NSW1, 1)
4, YTE (NSW1, 1), ZTE (NSW1, 1), A (3), B (3), F (3)
C
C ****************************************************** C
RENEW 1
C ****************************************************** C
CALL SKIPR (1, 5)
CALL SKIPR (1, 5)
READ (1) (CI (I), I = 1, NSW1)
READ (1) (THEP (I), I = 1, NSW1)
READ (1) (XTE (I), XLE (I), YLE (I), I = 1, NSW)
READ (1) (XLM, YLM (I), I = 1, NSW1)
READ (1) (CONS (I), I = 1, NSW1)
READ (1) (ST (I), AC, I = 1, NCW)
READ (1) (XCP (I), YCP (I), I = 1, NCP)
READ (1) (XN (I, J), YN (I, J), J = 1, 2)
CALL SKIPR (1, 2)
CALL SKIPR (1, 3)
READ (1) (CPCW1 (I), I = 1, NCW)
RENEW 2
READ (2) (GAMA (I), I = 1, NCP)
RENEW 3
READ (3) (GML (I), I = 1, NSW1)
RENEW 4
DO 10 I = 1, NSW
READ (4) XE (I, J), YE (I, J), ZE (I, J), J = 1, KK
10 NELM (I) = PK
DO 20 I = 1, NSW
READ (4) XE (I, J), YE (I, J), ZE (I, J), J = 1, KK
20 NNELM (I) = PK
C
END
```
ATL=1-.01*FLOAT(ITER)
IF (NCONTS.NE.0) ATL=0.75
IF (ATL.LT.0.75) ATL=0.75
BTL=1.-ATL

EVALUATION OF FORCE ACTING ON LEADING-EDGE ELEMENTS
TFABS=0.
TLNTH=0.

DO 40 1=2,NSTL
MCON=I
K=NELM(I)-1
FABS=0.
ALNTH=0.

DO 30 J=5,K
XEE=(XE(I,J)+XE(I,J+1))/2.
YEE=(YE(I,J)+YE(I,J+1))/2.
ZEE=(ZE(I,J)+ZE(I,J+1))/2.
CALL NEWVEL(C,THETP,XEE,YEE,ZEE,XN,YN,XTE,YLE,CONS,DUHY,CONI,CONNLM)
1J,CONK,S1,NSW1,NFW,NWNG,CI,CJ,CK,XLE,UU,VV,WW,CPCW1,XCP,YCP,GAMA,YNLM

2LM)
GMA=GAMA(NWNG+1)
A(1)=XE(I,J+1)-XE(I,J)
A(2)=YE(I,J+1)-YE(I,J)
A(3)=ZE(I,J+1)-ZE(I,J)
AAA=SQRT(A(1)*A(1)+A(2)*A(2)+A(3)*A(3))
A(1)=A(1)*GMA/AREA
A(2)=A(2)*GMA/AREA
A(3)=A(3)*GMA/AREA
B(1)=UU
B(2)=VV
B(3)=WW
CALL CRSPRD(A,B,F)
FABS=SQRT(F(1)*F(1)+F(2)*F(2)+F(3)*F(3))
FABS=FABS+FABS
ALNTH=ALNTH+AAA

30 CONTINUE
TFABS=TFABS+FABS
TLNTH=TLNTH+ALNTH

40 CONTINUE
TAURG=TFABS/TLNTH

WRITE (6,170) TFABS

C

WRITE (7) TFABS,TAURG,TLNTH

C

CALCULATION OF THE COORDINATES OF LEADING-EDGE ELEMENTS BY

SATISFYING FORCE-FREE CONDITION

DO 110 J=5,NMAX
DO 110 I=2,NSW1
NCON=I
K=NELM(I)-1
IF (J.GT.K) GO TO 110
XXX=XE(I,J+1)
YYY=YE(I,J+1)
ZZZ=ZE(I,J+1)

DLS=SORT((XE(I,J+1)-XE(I,J))*2+(YE(I,J+1)-YE(I,J))*2+(ZE(I,J+1)-NLM 950
1ZE(I,J))*2)

XEE=(XE(I,J)+XE(I,J+1))/2.
YEE=(YE(I,J)+YE(I,J+1))/2.
ZEE=(ZE(I,J)+ZE(I,J+1))/2.

CALL NEWVEL (C,THETP,XEE,YEE,ZEE,XN,YN,XTE,YLE,CONS,DUMMY,CONI,CONNL
LM100
1J,CONK,S,N,NW1,NCW,NWNG,CI,CJ,CK,XLE,UX,UY,UE,WCP,WCP1,XCP,YCP,C
LM1010
2LM)

UVW=SORT(UU*UU*VV*VV*WW*WW)

IF (J.EQ.5) GO TO 50
VVA=ATL*VV/UVW
WWA=ATL*WW/UVW
DLY=VVA+DLS*BTL*(YE(I,J+1)-YE(I,J))
DLZ=WAA+DLS*BTL*(ZE(I,J+1)-ZE(I,J))

GO TO 60

CONTINUE

50

VVA=0.5*VV/UVW
WWA=0.5*WW/UVW
DLY=VVA+DLS*0.5*(YE(I,J+1)-YE(I,J))
DLZ=WAA+DLS*0.5*(ZE(I,J+1)-ZE(I,J))

GO TO 70

CONTINUE

60

IF ((DLZ/DLS)*GT.SINA) DLZ=DLZ*SINA

70 CONTINUE
YINT=YE(I,J)+DLY
ZINT=ZE(I,J)+DLZ
IF (YINT.LE.YE(2,5)) YINT=YE(2,5)
IF (YINT.GE.BHALF) YINT=BHALF
IF (ZINT.LE.ZMIN) ZINT=ZMIN
DLYZ=YINT-YE(I,J)
DLZ2=ZINT-ZE(I,J)
DLXZ2=DLS*DLYZ-DLY2-DLZ2
IF (DLXZ2.LE.0.) DLY2=DLY2/2.
DLZ2=DLXZ2
DLX2=SORT(DLS*DLY2-DLY2-DLZ2
X(1,J+1)=X(1,J)+DLY2
YE(I,J+1)=YE(I,J)+DLY2
ZE(I,J+1)=ZE(I,J)+DLZ2
DX=X(1,J+1)-XXX
DY=YE(I,J+1)-YYY
DZ=ZE(I,J+1)-ZZZ
J2=J+2
KP=K+1
GO TO 110
10
DO 80 JK=J+2,KP
X(E(I,JK))=X(E(I,JK))+DX
Y(E(I,JK))=Y(E(I,JK))+DY
Z(E(I,JK))=Z(E(I,JK))+DZ
C

REWIND 4
DO 90 L=1,NSW
KS=NELM(L)
90 WRITE (4) KS,X(E(L,M)),Y(E(L,M)),Z(E(L,M),M=1,KS)
DO 100 L=1,NSW
KS=NNELM(L)
100 WRITE (4) KS,X(E(L,M)),Y(E(L,M)),Z(E(L,M),M=1,KS)
WRITE (4) NMAX,NNMAX,ZMIN,NCONTS
C
CALCULATION OF THE COORDINATES OF WAKE ELEMENTS BY SATISFYING
FORCE-FREE CONDITION
CTL=0.5
DTL=1.-CTL
C
C

NCON=0
DO 160 J=1,NNMAX
DO 160 I=2,NSW
NCT=I
K=NNELM(I)-1
IF (J. GT. K) GO TO 160
XXX=XXE(I,J+1)
YYY=YYE(I,J+1)
ZZZ=ZZE(I,J+1)
WLS=SQRT((XXE(I,J+1)-XXE(I,J))**2+(YYE(I,J+1)-YYE(I,J))**2+(ZZE(I,J+1)-ZZE(I,J))**2)
XXE=XXE(I,J)+XXE(I,J+1)/2.
YYE=YYE(I,J)+YYE(I,J+1)/2.
ZZE=ZZE(I,J)+ZZE(I,J+1)/2.
CALL NEWVEL (CC,THETP,XEE,YEE,ZEE,XN,YN,XTE,YLE,CONS,DUMMY,CONI,CONP,NM1720
1J,CONK,SI,NSW1,NCW,NWNG,CI,CJ,CK,XLE,UU,VS,W,WPCW1,XCP,YCP,GAMA,YNL1730
2LM)
UVW=SQRT(UU*UU+VV*VV+WW*WW)
IF (J.EQ.1) GO TO 130
VVA=CTL+VV/UVW
WVA=CTL+WW/UVW
DLY=VVA*WLS+DTL*(YYE(I,J+1)-YYE(I,J))
DLZ=WVA*WLS+DTL*(ZZE(I,J+1)-ZZE(I,J))
IF ((DLZ/WLS)*GTSINA) DLZ=WLS*SINA
YINT=YYE(I,J)+DLY
IF (YINT.LE.(YLE(2)/2)) YINT=YLE(2)/2.
IF (YINT.GE.BHALF) YINT=BHALF
DLY2=YINT-YYE(I,J)
DLZ2=DLZ
DLX2=WLS*WLS-DLY2*DLY2-DLZ2*DLZ2
IF (DLX2.LE.0.) DLX2=DLY2/2.
IF (DLX2Z.LE.0.) DLZ2=DLZ2/2.
DLX2=SQRT(WLS*WLS-DLY2*DLY2-DLZ2*DLZ2)
XXE(I,J+1)=XXE(I,J)+DLX2
YYE(I,J+1)=YYE(I,J)+DLY2
ZZE(I,J+1)=ZZE(I,J)+DLZ2
DX=XXE(I,J+1)-XXX
DY=YYE(I,J+1)-YYY
DZ=ZZE(I,J+1)-ZZZ
This document describes in detail the necessary information for using a computer program to predict distributed and total aerodynamic characteristics for low aspect-ratio wings with partial leading-edge separation. The flow is assumed to be steady and inviscid. The wing boundary condition is formulated by the Quasi-Vortex-Lattice method. The leading-edge separated vortices are represented by discrete free vortex elements which are aligned with the local velocity vector at mid-points to satisfy the force free condition. The wake behind the trailing-edge is also force free. The flow tangency boundary condition is satisfied on the wing, including the leading- and trailing-edges.

The program is restricted to delta wings with zero thickness and no camber. It is written in Fortran language and runs on CDC 6600 Computer.