



Leading-edge suction distribution for plane thin wings at subsonic speeds

Associated software: ESDUpac A9438

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LEADING-EDGE SUCTION DISTRIBUTION FOR PLANE THIN WINGS AT SUBSONIC SPEEDS

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LEADING-EDGE SUCTION DISTRIBUTION FOR PLANE THIN WINGS AT SUBSONIC SPEEDS

1. NOTATION AND UNITS

		<i>SI</i>	<i>British</i>
A	aspect ratio		
a_1	lift-curve slope	rad^{-1}	rad^{-1}
C_{Dv}	trailing-vortex wake drag coefficient		
C_L	lift coefficient		
C_s	total leading-edge suction coefficient normal to leading edge		
c	chord	m	ft
$\bar{c}$	geometric mean chord	m	ft
c_s	local leading-edge suction coefficient normal to leading edge		
k	empirical parameter used in normalisation correction, see Appendix A		
M	Mach number		
n	index used in normalisation correction, see Appendix A		
α	angle of attack	rad	rad
β	$(1 - M^2)^{1/2}$		
δ	$(1 + \delta)$ is lift-dependent drag factor due to trailing-vortex wake, see Equation (3.2)		
η	spanwise distance from centre-line as fraction of semispan		
Λ_0	leading-edge sweep	deg	deg
Λ'_0	transformed leading-edge sweep, $\tan^{-1}(\beta^{-1} \tan \Lambda_0)$	deg	deg
$\Lambda_{1/2}$	mid-chord sweep	deg	deg
λ	taper ratio (ratio of tip chord to centre-line chord)		

2. INTRODUCTION

This Item gives a method for calculating the total theoretical leading-edge suction and its normalised spanwise distribution for plane, thin wings of straight taper at subsonic speeds. Values of the normalised distribution have been obtained mainly from parametric runs of the vortex-lattice program described in Derivation 4. Some small corrections were made, particularly in the vicinity of the wing centre-line chord, to ensure that the integrated distributions had a value of unity.

The data are presented in both tabular and graphical form for a systematic series of planforms and the suction distribution for any planform may be obtained by cross-plotting.

Section 3 describes the method and the presentation of the data, Section 4 discusses accuracy and applicability, Section 5 lists the Derivation and References and Section 6 presents a worked example. Appendix A details the modifications that had to be made to the basic output from the vortex-lattice program.

3. LEADING-EDGE SUCTION

Section 3.1 describes the evaluation of the total leading-edge suction coefficient C_s and Section 3.2 the presentation of the normalised spanwise suction distribution $c_{sc}/C_s \bar{c}$.

3.1 Calculation of C_s

To first order in α the far-field wake-integral solution for the trailing-vortex drag in incompressible flow, by itself, gives the result

$$C_{Dv} = C_L \alpha - C_s \cos \Lambda_0. \quad (3.1)$$

The present analysis implies that this result is equivalent to the near-field solution obtained from a spanwise integration of the resolved components of local lift and leading-edge suction.

The trailing-vortex wake drag coefficient can be written in the form

$$C_{Dv} = \frac{(1 + \delta) C_L^2}{\pi A}, \quad (3.2)$$

where δ allows for any departure from elliptic spanwise loading.

With the lift coefficient given as

$$C_L = a_1 \alpha, \quad (3.3)$$

Equation (3.1) can be rearranged as

$$\frac{C_s}{\alpha^2} = \left(a_1 - \frac{a_1^2 (1 + \delta)}{\pi A} \right) \sec \Lambda_0. \quad (3.4)$$

First-order compressibility effects can be allowed for via Prandtl-Glauert transformations (Derivations 2 and 5), so that the general form of Equation (3.4) becomes

$$\begin{aligned}\frac{C_s}{\alpha^2} &= \beta \left(a_1 - \frac{a_1^2(1+\delta)}{\pi A} \right) \frac{\sec \Lambda'_0 \sec \Lambda_0}{[\beta^2 + \tan^2 \Lambda_0]^{\frac{1}{2}}} \\ &= \beta A \left(\frac{a_1}{A} \right) \left(1 - \left(\frac{a_1}{A} \right) \frac{1+\delta}{\pi} \right) \frac{\sec \Lambda'_0 \sec \Lambda_0}{[\beta^2 + \tan^2 \Lambda_0]^{\frac{1}{2}}}\end{aligned}\quad (3.5)$$

where the transformed leading-edge sweep is given by

$$\Lambda'_0 = \tan^{-1}(\beta^{-1} \tan \Lambda_0). \quad (3.6)$$

Values of a_1/A and $(1+\delta)$ are obtainable from Item Nos 70011¹ and 74035³, respectively, in terms of βA , $A \tan \Lambda_{1/2}$ and λ . Using those values the predictions of Equation (3.5) and the values of C_s/α^2 calculated within the vortex-lattice program (Derivation 4) are in excellent agreement.

3.2 Normalised Spanwise Loading

The normalised distributions $c_s c / C_s \bar{c}$ for the 185 wing geometries indicated in Table 3.1 are tabulated in Figures 1 to 35. Each Figure also contains a sketch that illustrates the distributions. Some distributions are omitted from the sketches for clarity when loadings at different βA values are very similar.

Sketches 3.1 to 3.3 illustrate the effect of varying aspect ratio, leading-edge sweep or taper ratio for some typical planforms. Both aspect ratio (Sketch 3.1) and sweep (Sketch 3.2) are important in the determination of the spanwise position and size of the distribution peak. The effect of taper ratio (Sketch 3.3) is small for low and moderate aspect ratios and sweeps, $\beta A < 5$ and $\Lambda'_0 < 45^\circ$, but it becomes more important as aspect ratio or sweep increases. In all cases the most marked effect of taper ratio becomes apparent as λ nears zero.

TABLE 3.1

Λ'_0 (deg)	βA	Figure No.				
		$\lambda = 0$	$\lambda = 0.125$	$\lambda = 0.25$	$\lambda = 0.5$	$\lambda = 1$
0	1, 1.5, 3, 5, 8, 12	1	8	15	22	29
15	1, 1.5, 3, 5, 8, 12	2	9	16	23	30
30	1, 1.5, 3, 5, 8, 12	3	10	17	24	31
45	1, 1.5, 3, 5, 8, 12	4	11	18	25	32
60	1, 1.5, 3, 5, 8	5	12	19	26	33
67.5	1, 1.5, 3, 5	6	13	20	27	34
75	1, 1.5, 3, 5	7	14	21	28	35

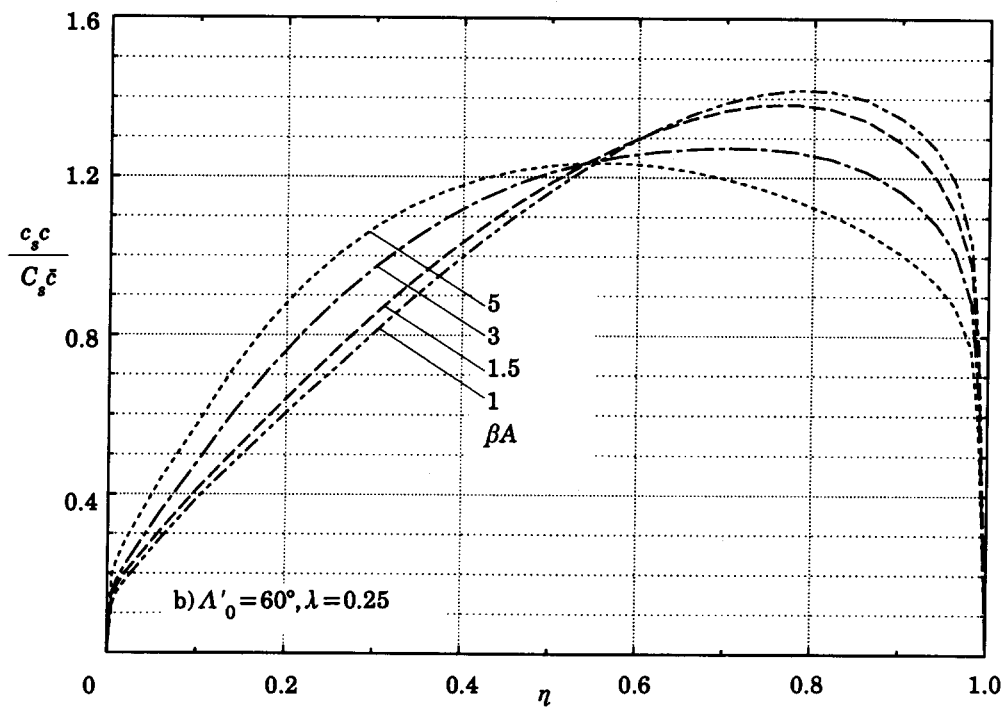
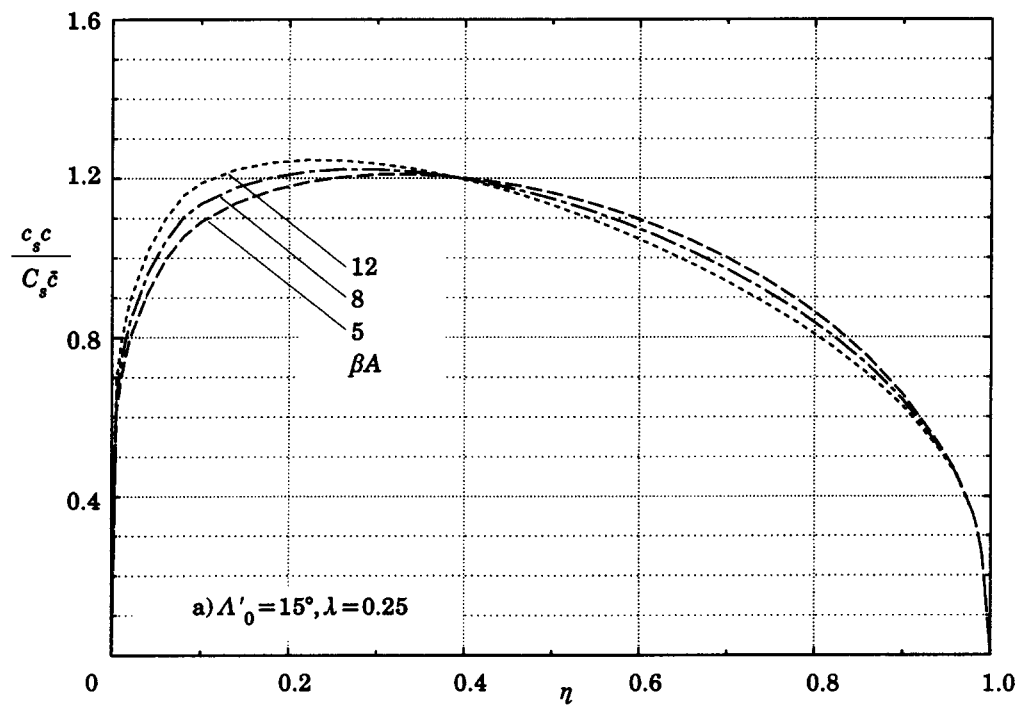
The tabulated data are given at $\eta = 0, 0.005, 0.01, 0.02$ and then in steps of 0.04 to $\eta = 0.98$ and at $\eta = 0.99$ and 1.0. These intervals are sufficiently close to ensure a smooth spanwise distribution, certainly between $\eta = 0.005$ and 0.99.

Except for cases where $\Lambda'_0 = 0$, the suction distribution falls rapidly to zero at $\eta = 0$, and in all cases* it appears to fall to zero at $\eta = 1$. To obtain additional values of the distribution for $0 < \eta < 0.005$, $c_s c / C_s \bar{c}$ is taken as constant when $\Lambda'_0 = 0$ but otherwise the value of $c_s c / C_s \bar{c}$ at $\eta = 0.005$ may be factored by $(\eta/0.005)^{1/2}$.

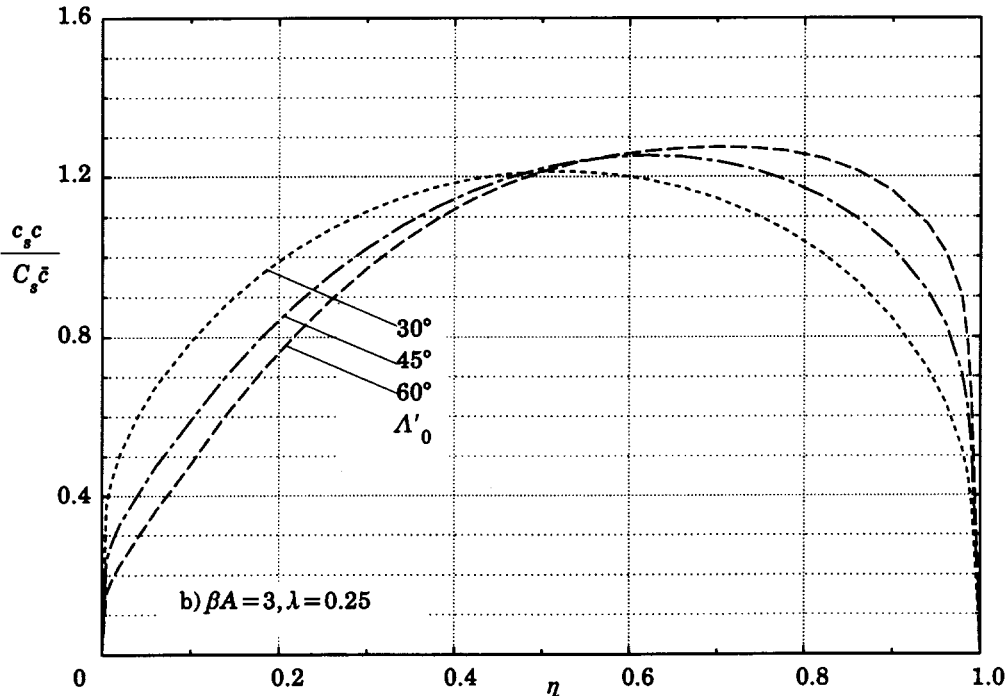
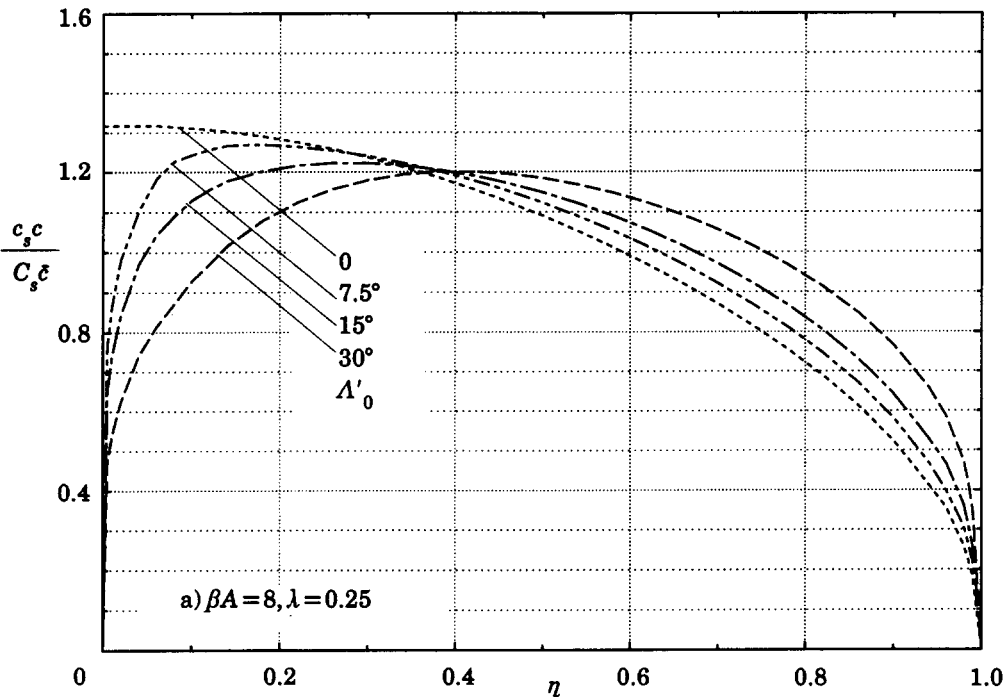
Construction of the suction distribution for an arbitrary wing planform is performed by interpolation at each value of η . The first step is to interpolate linearly in βA . The second step is to interpolate in Λ'_0 , and this may be carried out linearly when $\Lambda'_0 \geq 15^\circ$. However, the special shape of the distributions for $\Lambda'_0 = 0$ necessitates a non-linear cross plot in Λ'_0 between 0 and 45° to cover the inboard region $\eta < 0.4$ when $\Lambda'_0 < 15^\circ$; linear interpolation still suffices when $\eta > 0.4$. The final interpolation is with respect to λ . This may be carried out linearly for a good first approximation, although because of the increasingly rapid variation in loading that occurs as $\lambda \rightarrow 0$ a more accurate answer for $0 < \lambda < 0.125$ will be obtained if a non-linear cross plot in λ is made between $\lambda = 0$ and 0.5.

A computer program, ESDUpac A9438, has been written that holds the tabulated values given in this Item and carries out any necessary interpolation internally. The program is described in Item No. 94038 (Reference 9).

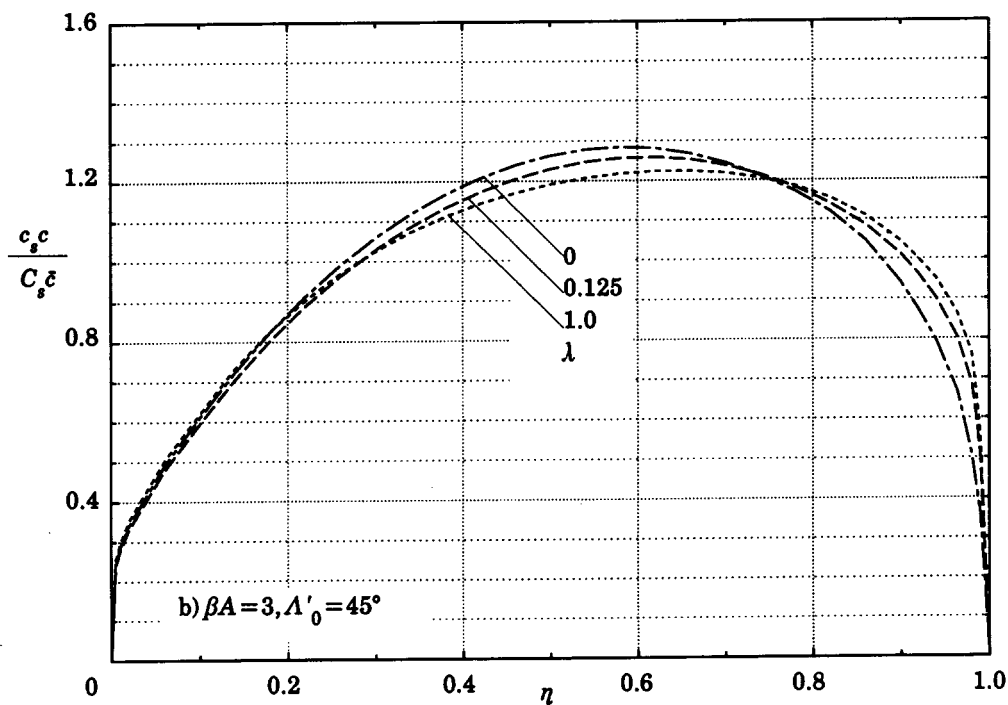
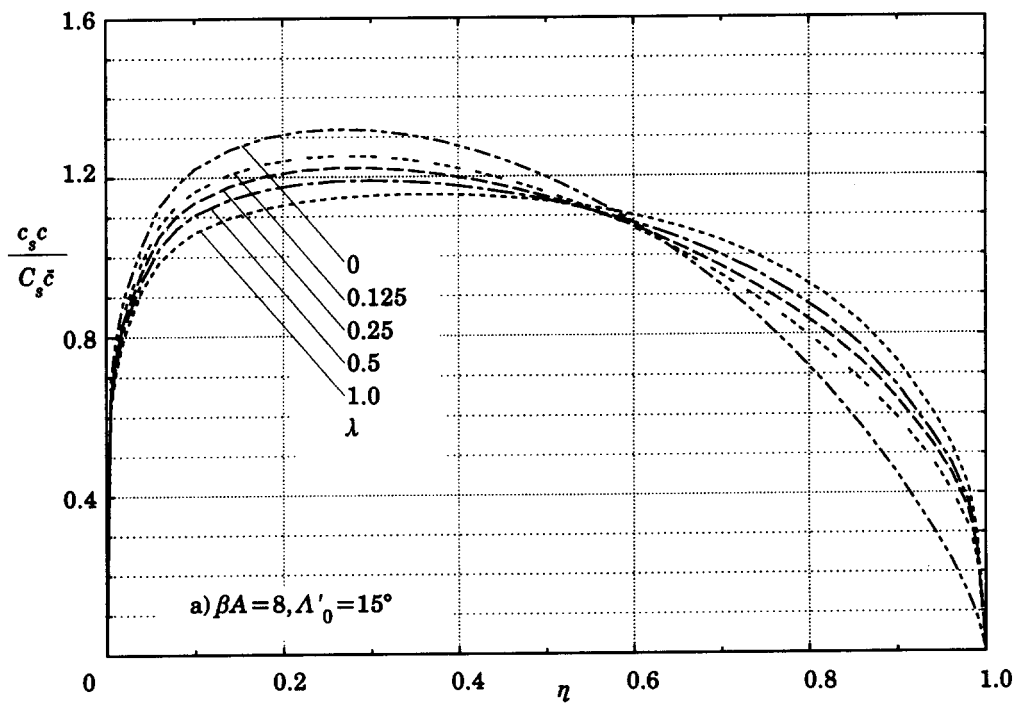
* Strictly, the value at $\eta = 1$ for $\lambda = 0$ may be indeterminate.



Sketch 3.1 Effect of aspect ratio



Sketch 3.2 Effect of sweep



Sketch 3.3 Effect of taper ratio

4. ACCURACY AND APPLICABILITY

Lifting-surface and vortex-lattice models have the capability of predicting leading-edge suction distributions. However, during the development of this Item it was found that special modelling was often necessary for certain difficult planforms, such as those of low taper ratio and low aspect ratio. In severe cases external corrections had to be made to the theoretically predicted distributions to maintain reasonable shapes. Details of how the data in the present Item were obtained are given in Appendix A. The tabulated presentation of the data in this Item provides a robust and repeatable way of obtaining suction distributions for a wide range of planforms without the need of any further ad hoc corrections.

The accuracy of the distributions is difficult to quantify. For $\beta A \geq 3$ and $\lambda \geq 0.125$ they are not expected to be subject to significant error, but an increasingly high tolerance should be allowed as βA and λ decrease below those values. It is thought that in all cases the data will be suitable for use with such analytical techniques as those described in References 6, 7 and 8, for example, where the suggested methods of predicting the drag due to lift of plain wings require a knowledge of the shape and magnitude of leading-edge suction distributions.

5. DERIVATION AND REFERENCES

5.1 Derivation

The Derivation lists selected sources that have assisted in the preparation of this Item.

- | | | |
|----|----------------------------|--|
| 1. | ESDU | Lift-curve slope and aerodynamic centre position of wings in inviscid subsonic flow.
ESDU International, Item No. 70011, 1970. |
| 2. | POLHAMUS, E.C. | Charts for predicting the subsonic vortex-lift characteristics of arrow, delta, and diamond wings.
NASA tech. Note D-6243, 1971. |
| 3. | ESDU | Subsonic lift-dependent drag due to the trailing vortex wake for wings without camber or twist.
ESDU International, Item No. 74035, 1974. |
| 4. | LAMAR, J.E.
GLOSS, B.B. | Subsonic aerodynamic characteristics of interacting lifting surfaces with separated flow around sharp edges predicted by a vortex-lattice method.
NASA tech. Note D-7921, 1975. |
| 5. | ISAACS, D. | Store carriage loads at subsonic speeds. Part 2: prediction of store wing and fin loads.
RAE tech. Rep. 88011, Appendix D, 1988. |

5.2 References

The References list sources of information supplementary to that given in this Item.

- | | | |
|----|---|--|
| 6. | CARLSON, H.W.
MACK, R.J.
BARGER, R.L. | Estimation of attainable leading-edge thrust for wings at subsonic and supersonic speeds.
NASA tech. Paper 1500, 1979. |
| 7. | KULFAN, R.M. | Wing geometry effects on leading-edge vortices.
AIAA Paper 79-1872, 1979. |
| 8. | LAN, C.E.
HSU, C.-H. | Effects of breakdown on longitudinal and lateral-directional aerodynamics of slender wings by the suction analogy.
AIAA Paper 82-1385, 1982. |
| 9. | ESDU | Computer program for estimation of leading-edge suction distribution for plane thin wings at subsonic speeds.
ESDU International, Item No. 94038, 1994.
ESDUpac A9438. |

6. EXAMPLE

Calculate the leading-edge suction distribution for a wing with leading-edge sweep $\Lambda_0 = 59^\circ$, aspect ratio $A = 3.3$ and taper ratio $\lambda = 0.08$, for a free-stream Mach number $M = 0.8$.

i) Required geometric parameters

The reduced aspect ratio is

$$\beta A = (1 - 0.8^2)^{1/2} 3.3 = 1.98,$$

the transformed leading-edge sweep is

$$\Lambda'_0 \tan^{-1}(\beta^{-1} \tan \Lambda_0) = \tan^{-1}((1 - 0.8^2)^{-1/2} \tan 59^\circ) = 70.17^\circ,$$

and the planform parameter

$$A \tan \Lambda_{1/2} = A \tan \Lambda_0 - 2 \left(\frac{1 - \lambda}{1 + \lambda} \right) = 3.3 \tan 59^\circ - 2 \left(\frac{1 - 0.08}{1 + 0.08} \right) = 3.79.$$

ii) Total leading-edge suction coefficient

With $\beta A = 1.98$, $A \tan \Lambda_{1/2} = 3.79$ and $\lambda = 0.08$, Item No. 70011 gives the ratio of lift-curve slope to aspect ratio as

$$\frac{a_1}{A} = 0.951 \text{ rad}^{-1},$$

and Item No. 74035 gives the lift dependent drag factor as

$$1 + \delta = 1.01 .$$

Therefore, from Equation (3.5)

$$\begin{aligned} \frac{C_s}{\alpha^2} &= \beta A \left(\frac{a_1}{A} \right) \left(1 - \left(\frac{a_1}{A} \right) \frac{(1 + \delta)}{\pi} \right) \frac{\sec \Lambda'_0 \sec \Lambda_0}{[\beta^2 + \tan^2 \Lambda_0]^{1/2}} \\ &= 1.98(0.951) \left(1 - (0.951) \frac{1.01}{\pi} \right) \frac{\sec 70.17^\circ \sec 59^\circ}{[(1 - 0.8^2) + \tan^2 59^\circ]^{1/2}} \\ &= 1.98(0.951)(0.694)(3.235) \\ &= 4.23 . \end{aligned}$$

iii) Normalised loading distribution

Tables 6.1 and 6.2 detail the numerical calculations that are made.

Because the taper ratio is below 0.125 a non-linear cross plot in λ is made and compared with the results of a linear interpolation between 0 and 0.125.

For $\beta A = 1.98$, $\Lambda'_0 = 70.17^\circ$ and $\lambda = 0.08$, Table 3.1 shows that numerical data for $\beta A = 1.5$ and 3 must be taken from:—

Figure 6 for $\Lambda'_0 = 67.5^\circ$	} $\lambda = 0$, entered in columns	1 and 2 of Table 6.1
Figure 7 for $\Lambda'_0 = 75^\circ$		4 and 5 of Table 6.1
Figure 13 for $\Lambda'_0 = 67.5^\circ$	} $\lambda = 0.125$, entered in columns	8 and 9 of Table 6.1
Figure 14 for $\Lambda'_0 = 75^\circ$		11 and 12 of Table 6.1
Figure 20 for $\Lambda'_0 = 67.5^\circ$	} $\lambda = 0.25$, entered in columns	1 and 2 of Table 6.2
Figure 21 for $\Lambda'_0 = 75^\circ$		4 and 5 of Table 6.2
Figure 27 for $\Lambda'_0 = 67.5^\circ$	} $\lambda = 0.5$, entered in columns	8 and 9 of Table 6.2
Figure 28 for $\Lambda'_0 = 75^\circ$		11 and 12 of Table 6.2

Linear interpolation in βA between each pair of those eight pairs of columns defines the data at $\beta A = 1.98$ in columns 3, 6, 10 and 13 of each table.

Linear interpolation in Λ'_0 between columns 3 and 6 and between columns 10 and 13 defines the data at $\Lambda'_0 = 70.17^\circ$ in columns 7 and 14 of Table 6.1 for $\lambda = 0$ and 0.125 respectively, and similarly in Table 6.2 and for $\lambda = 0.25$ and 0.5 respectively.

A linear interpolation in λ between columns 7 and 14 of Table 6.1 defines the data at $\lambda = 0.08$ shown in column 15 of that table. Otherwise a cross plot in λ at each η is necessary.

iv) Summary and comments

The results of Sections (ii) and (iii) and Tables 6.1 and 6.2 are summarised in Sketch 6.1. The manner of interpolation in λ only significantly affects the loading for $\eta > 0.9$ in this case.

Although a linear interpolation in Λ'_0 was used in this example, for $\Lambda'_0 < 15^\circ$ this would not be acceptable, see Section 3.2.

A set of blank tables are included at the end of the example for the user's own calculations.

A manual calculation of the suction distribution can be avoided by use of the computer program of ESDUpac A9438 (see Reference 9).

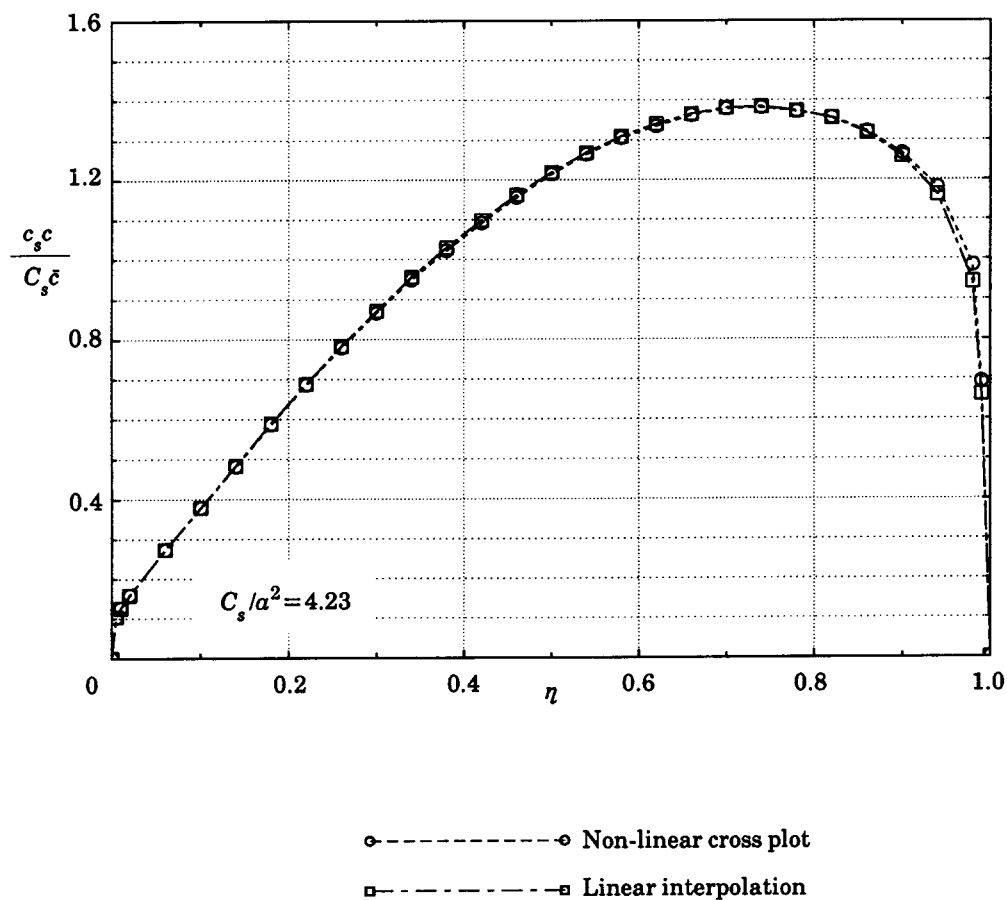
TABLE 6.1

βA	1.5	3	1.98	1.5	3	1.98	1.98	1.5	3	1.98	1.5	3	1.98	1.98	1.98
A'_0	67.5°			75°			70.17°	67.5°			75°			70.17°	70.17°
λ	0			0			0	0.125			0.125			0.125	0.08
η	Values of $c_p c / C_p \bar{c}$														
0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.005	0.118	0.123	0.120	0.089	0.095	0.091	0.110	0.108	0.137	0.117	0.069	0.081	0.073	0.101	0.104
0.010	0.134	0.146	0.138	0.110	0.118	0.113	0.129	0.135	0.163	0.144	0.087	0.103	0.092	0.125	0.126
0.020	0.163	0.184	0.170	0.138	0.160	0.145	0.161	0.165	0.203	0.177	0.118	0.143	0.126	0.159	0.160
0.060	0.267	0.312	0.281	0.234	0.321	0.262	0.274	0.261	0.337	0.285	0.226	0.301	0.250	0.273	0.273
0.100	0.356	0.437	0.382	0.335	0.457	0.374	0.379	0.351	0.461	0.386	0.321	0.462	0.366	0.379	0.379
0.140	0.444	0.565	0.483	0.430	0.612	0.488	0.485	0.440	0.579	0.484	0.411	0.622	0.479	0.482	0.483
0.180	0.533	0.686	0.582	0.525	0.761	0.601	0.589	0.531	0.702	0.586	0.508	0.775	0.593	0.588	0.588
0.220	0.622	0.796	0.678	0.620	0.899	0.709	0.689	0.617	0.806	0.677	0.609	0.912	0.706	0.687	0.688
0.260	0.711	0.910	0.775	0.712	1.029	0.813	0.789	0.698	0.897	0.762	0.710	1.028	0.812	0.780	0.783
0.300	0.800	1.005	0.866	0.802	1.148	0.913	0.883	0.783	0.976	0.845	0.797	1.120	0.900	0.865	0.871
0.340	0.890	1.090	0.954	0.897	1.242	1.007	0.973	0.866	1.043	0.923	0.891	1.187	0.986	0.945	0.955
0.380	0.971	1.166	1.033	0.975	1.312	1.083	1.051	0.941	1.101	0.992	0.977	1.236	1.060	1.016	1.029
0.420	1.054	1.227	1.109	1.058	1.359	1.154	1.125	1.018	1.152	1.061	1.052	1.269	1.121	1.082	1.097
0.460	1.121	1.277	1.171	1.142	1.388	1.221	1.189	1.094	1.198	1.127	1.129	1.289	1.180	1.146	1.161
0.500	1.194	1.312	1.232	1.213	1.406	1.275	1.247	1.160	1.239	1.185	1.205	1.303	1.236	1.203	1.219
0.540	1.250	1.344	1.280	1.278	1.407	1.319	1.294	1.220	1.274	1.237	1.268	1.308	1.281	1.253	1.268
0.580	1.307	1.365	1.326	1.339	1.398	1.358	1.337	1.273	1.300	1.282	1.317	1.303	1.313	1.293	1.309
0.620	1.352	1.378	1.360	1.391	1.380	1.387	1.370	1.318	1.314	1.317	1.352	1.289	1.332	1.322	1.339
0.660	1.380	1.380	1.380	1.432	1.351	1.406	1.389	1.369	1.317	1.352	1.385	1.271	1.349	1.351	1.365
0.700	1.412	1.367	1.398	1.467	1.304	1.415	1.404	1.406	1.306	1.374	1.409	1.238	1.354	1.367	1.380
0.740	1.433	1.338	1.403	1.479	1.244	1.404	1.403	1.433	1.283	1.385	1.419	1.197	1.348	1.372	1.383
0.780	1.439	1.290	1.391	1.479	1.176	1.382	1.388	1.444	1.250	1.382	1.419	1.155	1.335	1.365	1.373
0.820	1.434	1.226	1.367	1.467	1.082	1.344	1.359	1.448	1.215	1.373	1.417	1.106	1.317	1.353	1.355
0.860	1.410	1.137	1.323	1.429	0.963	1.280	1.308	1.428	1.171	1.346	1.404	1.039	1.287	1.325	1.319
0.900	1.365	1.009	1.251	1.334	0.809	1.166	1.221	1.395	1.107	1.303	1.368	0.966	1.239	1.280	1.259
0.940	1.274	0.812	1.126	1.190	0.585	0.996	1.080	1.339	1.022	1.238	1.296	0.875	1.161	1.211	1.164
0.980	1.013	0.412	0.821	0.766	0.242	0.598	0.742	1.169	0.875	1.075	1.153	0.751	1.024	1.057	0.944
0.990	0.691	0.291	0.563	0.542	0.121	0.407	0.507	0.827	0.619	0.760	0.815	0.531	0.724	0.747	0.661
1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Column No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

TABLE 6.2

βA	1.5	3	1.98	1.5	3	1.98	1.98	1.5	3	1.98	1.5	3	1.98	1.98	
Δ'_0	67.5°			75°			70.17°	67.5°			75°			70.17°	
λ	0.25			0.25			0.25	0.5			0.5			0.5	
η	Values of $c_s c / C_s \bar{c}$														
0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
0.005	0.105	0.135	0.115	0.078	0.102	0.086	0.105	0.095	0.133	0.107	0.067	0.150	0.094	0.102	
0.01	0.124	0.161	0.136	0.094	0.127	0.105	0.125	0.114	0.159	0.126	0.084	0.180	0.115	0.123	
0.02	0.154	0.202	0.169	0.122	0.170	0.137	0.158	0.145	0.201	0.163	0.113	0.228	0.150	0.158	
0.06	0.252	0.337	0.279	0.226	0.333	0.260	0.272	0.259	0.342	0.286	0.226	0.386	0.277	0.283	
0.10	0.345	0.462	0.382	0.331	0.492	0.383	0.382	0.356	0.472	0.393	0.341	0.531	0.402	0.396	
0.14	0.442	0.589	0.489	0.440	0.650	0.507	0.495	0.459	0.602	0.505	0.457	0.678	0.528	0.513	
0.18	0.540	0.703	0.592	0.545	0.795	0.625	0.604	0.570	0.718	0.617	0.571	0.806	0.646	0.627	
0.22	0.631	0.804	0.686	0.645	0.918	0.732	0.702	0.665	0.819	0.714	0.681	0.907	0.753	0.728	
0.26	0.720	0.893	0.775	0.742	1.017	0.830	0.795	0.755	0.906	0.803	0.777	0.983	0.843	0.817	
0.30	0.804	0.971	0.857	0.834	1.091	0.916	0.878	0.840	0.979	0.884	0.867	1.040	0.922	0.898	
0.34	0.885	1.037	0.934	0.920	1.146	0.992	0.955	0.920	1.040	0.958	0.954	1.083	0.995	0.971	
0.38	0.962	1.093	1.004	0.999	1.186	1.059	1.024	0.995	1.089	1.025	1.031	1.117	1.059	1.037	
0.42	1.035	1.142	1.069	1.069	1.215	1.116	1.086	1.064	1.130	1.085	1.098	1.144	1.113	1.095	
0.46	1.103	1.184	1.129	1.131	1.234	1.164	1.141	1.127	1.163	1.139	1.155	1.164	1.158	1.146	
0.50	1.167	1.219	1.184	1.194	1.243	1.210	1.193	1.185	1.190	1.187	1.197	1.179	1.191	1.188	
0.54	1.225	1.247	1.232	1.241	1.244	1.242	1.236	1.237	1.212	1.229	1.229	1.189	1.216	1.224	
0.58	1.285	1.268	1.280	1.282	1.238	1.268	1.276	1.282	1.229	1.265	1.261	1.194	1.240	1.256	
0.62	1.326	1.281	1.312	1.320	1.231	1.292	1.305	1.320	1.241	1.295	1.283	1.196	1.255	1.281	
0.66	1.375	1.286	1.347	1.348	1.225	1.309	1.333	1.351	1.250	1.319	1.305	1.195	1.270	1.302	
0.70	1.397	1.283	1.361	1.369	1.215	1.320	1.346	1.375	1.254	1.336	1.321	1.192	1.280	1.316	
0.74	1.419	1.272	1.372	1.385	1.198	1.325	1.355	1.392	1.254	1.348	1.337	1.187	1.289	1.327	
0.78	1.427	1.252	1.371	1.393	1.170	1.322	1.354	1.399	1.250	1.351	1.348	1.180	1.294	1.331	
0.82	1.427	1.223	1.362	1.398	1.132	1.313	1.345	1.396	1.240	1.346	1.359	1.171	1.299	1.329	
0.86	1.412	1.188	1.340	1.390	1.088	1.293	1.323	1.379	1.224	1.329	1.360	1.158	1.295	1.317	
0.90	1.369	1.146	1.298	1.361	1.045	1.260	1.284	1.343	1.196	1.296	1.348	1.142	1.282	1.291	
0.94	1.316	1.086	1.242	1.298	0.993	1.200	1.227	1.271	1.144	1.230	1.316	1.114	1.251	1.237	
0.98	1.184	0.950	1.109	1.166	0.892	1.078	1.098	1.107	1.009	1.076	1.204	1.020	1.145	1.101	
0.99	0.837	0.672	0.784	0.825	0.631	0.763	0.777	0.783	0.713	0.761	0.851	0.721	0.809	0.778	
1.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
Column No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

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Sketch 6.1 Results for $\beta A = 1.98$, $\Lambda'_0 = 70.17^\circ$ and $\lambda = 0.08$

βA															
Λ'_0															
λ															
η	<i>Values of $c_s c / C_s \bar{c}$</i>														
0															
0.005															
0.01															
0.02															
0.06															
0.10															
0.14															
0.18															
0.22															
0.26															
0.30															
0.34															
0.38															
0.42															
0.46															
0.50															
0.54															
0.58															
0.62															
0.66															
0.70															
0.74															
0.78															
0.82															
0.86															
0.90															
0.94															
0.98															
0.99															
1.00															
Column No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

βA															
Δ'_0															
λ															
η	Values of $c_s c / C_s \bar{c}$														
0															
0.005															
0.01															
0.02															
0.06															
0.10															
0.14															
0.18															
0.22															
0.26															
0.30															
0.34															
0.38															
0.42															
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0.70															
0.74															
0.78															
0.82															
0.86															
0.90															
0.94															
0.98															
0.99															
1.00															
Column No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

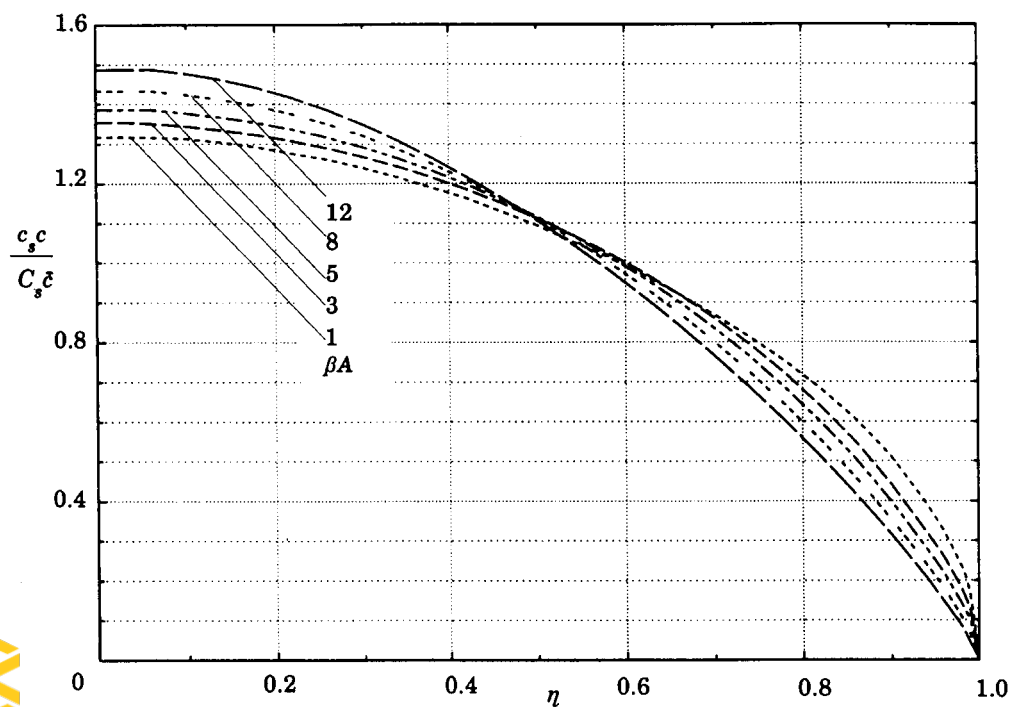


Figure 1. $c_s c / C_s \bar{c}$ for $A'_0 = 0, \lambda = 0$

$\eta \backslash \beta A$	1	1.5	3	5	8	12
0	1.318	1.329	1.355	1.386	1.432	1.487
0.005	1.318	1.329	1.355	1.386	1.432	1.487
0.01	1.318	1.329	1.355	1.386	1.432	1.487
0.02	1.318	1.329	1.355	1.386	1.432	1.487
0.06	1.316	1.329	1.351	1.386	1.432	1.487
0.10	1.313	1.325	1.344	1.376	1.423	1.476
0.14	1.304	1.316	1.334	1.366	1.411	1.461
0.18	1.291	1.303	1.322	1.353	1.395	1.440
0.22	1.276	1.286	1.307	1.336	1.374	1.415
0.26	1.261	1.267	1.289	1.316	1.349	1.384
0.30	1.240	1.246	1.268	1.292	1.321	1.349
0.34	1.217	1.222	1.243	1.264	1.288	1.309
0.38	1.189	1.196	1.216	1.233	1.250	1.265
0.42	1.163	1.167	1.185	1.198	1.209	1.217
0.46	1.129	1.135	1.151	1.159	1.164	1.164
0.50	1.094	1.100	1.113	1.116	1.114	1.108
0.54	1.054	1.062	1.071	1.070	1.061	1.047
0.58	1.014	1.020	1.025	1.018	1.003	0.983
0.62	0.969	0.974	0.975	0.962	0.940	0.915
0.66	0.921	0.925	0.921	0.902	0.873	0.843
0.70	0.869	0.871	0.861	0.836	0.801	0.767
0.74	0.813	0.812	0.795	0.764	0.724	0.686
0.78	0.752	0.747	0.721	0.685	0.642	0.602
0.82	0.684	0.673	0.640	0.600	0.554	0.512
0.86	0.606	0.589	0.548	0.505	0.458	0.418
0.90	0.513	0.489	0.444	0.400	0.355	0.317
0.94	0.394	0.367	0.322	0.281	0.240	0.208
0.98	0.238	0.221	0.182	0.143	0.109	0.087
0.99	0.168	0.156	0.129	0.101	0.065	0.043
1.00	0.000	0.000	0.000	0.000	0.000	0.000

FIGURE 1