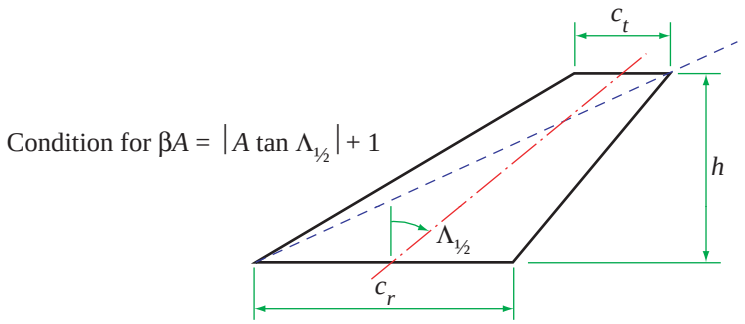
LIFT-CURVE SLOPE OF ISOLATED LIFTING SURFACE AT SUPERSONIC SPEEDS

1. NOTATION AND UNITS (see Sketch 1.1)

		SI	*British*
A	aspect ratio, h^2/S		
a_1	lift-curve slope of surface based on S	radian^{-1}	radian^{-1}
c_r	root chord of surface	m	ft
c_t	tip chord of surface	m	ft
h	span of surface	m	ft
M	free-stream Mach number		
S	area of surface	m^2	ft^2
β	compressibility parameter, $(M^2 - 1)^{½}$		
$\Lambda_{½}$	sweepback of mid-chord line	degree	degree
λ	ratio of tip chord to root chord, c_t/c_r		



Sketch 1.1

2. NOTES

This Item presents the lift characteristics of an isolated lifting surface with straight edges and streamwise tips. These characteristics are fundamental to the estimation of the effectiveness of a control or stabilising surface but require modification for the effects of wing and body interference. Such interference effects are, however, very dependent upon the particular configuration considered; they are not, therefore, taken into account in this Item.

The surface is regarded as an isolated lifting surface in which the tips can be of unequal length. The longer "tip" is herein referred to as the root.

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Figures 1 to 6 give, in parametric form, the theoretical lift-curve slope of an isolated surface as a function of Mach number, aspect ratio and sweep for values of λ of 0, 0.2, 0.4, 0.6, 0.8 and 1.0 respectively. The Figures are based on linearised supersonic flow theory (Derivations 1 to 3) and refer to thin surfaces at small incidence; they are valid for both positive and negative values of $\Lambda_{½}$ provided that both leading and trailing edges are supersonic and that the Mach line from the leading edge of the root chord intersects the trailing edge of the surface, *i.e.*

$$\beta A \geq 1 \left| A \tan \Lambda_{½} \right| + 1 . \tag{2.1}$$

For a swept-back wing this implies that the condition of supersonic leading and trailing edges is fulfilled.

However, for the case of $\lambda = 0$, the curves for positive values of $\Lambda_{½}$ are extended to include surfaces having subsonic leading edges and supersonic trailing edges (Figure 1). It should be noted that in this range the limit of a supersonic trailing edge, *i.e.*

$$\beta A \geq \left| A \tan \Lambda_{½} - 1 \right| , \tag{2.2}$$

must be applied.

3. DERIVATION

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

1. MARTIN, J.C. MALVESTUTO, F.S. — Theoretical forces and moments due to sideslip of a number of vertical tail configurations at supersonic speeds. NACA tech. Note 2412, 1951.
2. MALVESTUTO, F.S. — Theoretical supersonic force and moment coefficients on a sideslipping vertical- and horizontal-tail combination with subsonic leading edges and supersonic trailing edges. NACA tech. Note 3071, 1953.
3. MARGOLIS, K. BOBBITT, P.J. — Theoretical calculations of the pressures, forces and moments at supersonic speeds due to various lateral motions acting on thin isolated vertical tails. NACA Rep. 1268, 1956.

4. EXAMPLE

Find the theoretical lift-curve slope at $M = 4$ for an isolated fin for which $A = 1.5$, $\lambda = 0.2$ and $\Lambda_{½} = 30°$.

$$\beta A = (M^2 - 1)^{½} \times A = (4^2 - 1)^{½} \times 1.5 = 5.81$$

and $$A \tan \Lambda_{½} = 1.5 \times \tan 30° = 0.866 .$$

From Figure 2 with the above values

$$\frac{a_1}{A} = 0.615 ,$$

so that $$a_1 = 0.615 \times 1.5 = 0.923 \text{ radian}^{-1} .$$

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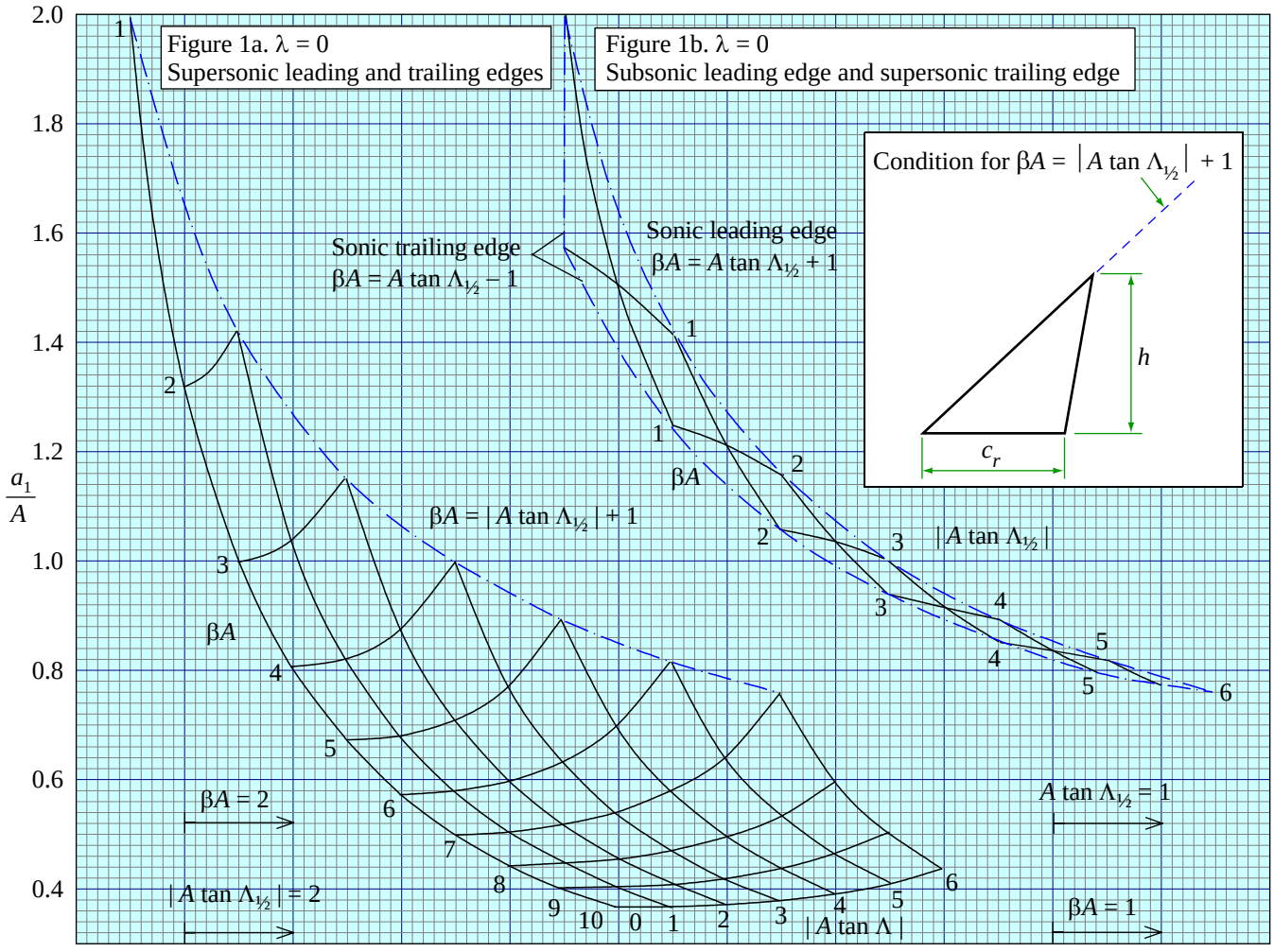

FIGURE 1 λ = 0

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