



ESDU 70010

Issued July 1970

Supersedes Item No. Aero

S.00.03.12

Inviscid supersonic flow past cones at zero incidence: (iv) Mach number in the conical flow field

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THE PREPARATION OF THIS DATA ITEM

The work on this particular Data Item which supersedes ESDU Aero S.00.03.12, was monitored and guided by the Aerodynamics Committee. This Committee first met in 1942 and now has the following membership:

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Mr J.W.H. Thomas	—	Hawker Siddeley Aviation Ltd, Hatfield
Mr J. Weir	—	University of Salford.

The construction and subsequent development of the Data Item was undertaken by

Mr P.D. Chappell	—	Head of Aircraft Motion Group.
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INVISCID SUPERSONIC FLOW PAST CONES AT ZERO INCIDENCE:
(IV) MACH NUMBER IN THE CONICAL FLOW FIELD

CONTENTS

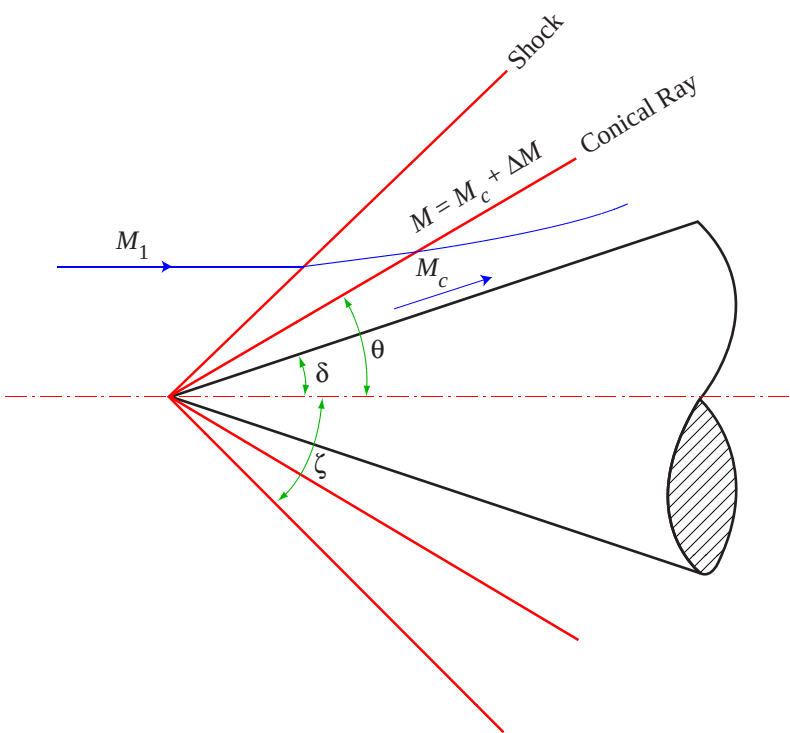
	Page
1. NOTATION AND UNITS	1
2. NOTES	2
3. DERIVATION AND REFERENCES	3
3.1 Derivation	3
3.2 References	3
4. EXAMPLE	4
Figures 1a to 2h	5-10

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INVISCID SUPERSONIC FLOW PAST CONES AT ZERO INCIDENCE:
(iv) MACH NUMBER IN THE CONICAL FLOW FIELD

1. NOTATION AND UNITS

		SI	British
M	Mach number in conical flow field		
M_c	Mach number at surface of cone		
M_1	Mach number in uniform flow upstream		
ΔM	Mach number increment, $M - M_c$		
γ	ratio of specific heat capacity at constant pressure to specific heat capacity at constant volume, taken as 1.4 for air		
δ	semi-vertex angle	deg	deg
ζ	shock angle	deg	deg
θ	conical ray angle	deg	deg



2. NOTES

Figures 1a and 1b present data for the Mach number, M_c , on the surface of a sharp-nosed right-circular cone at zero incidence in a uniform supersonic flow of air considered as a perfect gas ($\gamma = 1.4$). The flow is assumed to be inviscid throughout. The data are given for Mach numbers, M_1 , increasing from the shock detachment value (see also Item No. Aero S.00.03.16) to a value of 4 for cones with semi-vertex angles, δ , from zero to 50 degrees.

Figures 2a to 2h present data for the Mach number increment, ΔM , above the cone surface value, M_c , at any point in the conical flow field between the shock and the surface. The Mach number, M , constant along any given conical ray of angle θ , is therefore given by

$$M = M_c + \Delta M. \quad (2.1)$$

The variation of ΔM with θ in the range $\delta \leq \theta \leq \zeta$ is given for M_1 increasing from the shock detachment value to a value of 4 for cones with $\delta = 5, 10, 15, 20, 25, 30, 40$ and 50 degrees.

The short chain boundary shown on the Figures represents the upstream Mach number for shock detachment while the chain-dotted boundary represents the Mach number increment at the shock. The boundary for $M_c = 1$ (long chain) is also shown and it should be noted that the data below this Mach number apply only to infinite cones since conical flow cannot exist on a finite cone under conditions for which the surface Mach number is subsonic.

The data were derived from calculations made by Professor C.W. Jones of Imperial College for use in Derivation 2. These calculations were made in order to adjust the data given in Derivation 1 from $\gamma = 1.405$ to $\gamma = 1.4$.

In real flows viscosity causes a boundary layer on the cone surface which increases the effective vertex angle of the cone. Allowance for this effect, which is generally insignificant for Reynolds numbers greater than about 10^5 , may be made using the method of Reference 6.

The data presented in this Item are for cones at zero incidence in airflows with Mach numbers up to 4. For the effects of incidence, and Mach numbers up to 20, detailed tabulations are given in References 4, 5 and 7 while Reference 3 contains some useful graphical correlations.

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