

CONDITIONS BEHIND OBLIQUE SHOCK WAVES FOR AIR IN DISSOCIATION EQUILIBRIUM

1. NOTATION AND UNITS

		<i>SI</i>	<i>British</i>
i	specific enthalpy	J/kg	ft lbf/slug
M	Mach number		
M'	Match number normal to shock		
p	static pressure	N/m ²	lbf/ft ²
R	gas constant, taken equal to 287.1 J/kg K, 3090 ft lbf/slug K	J/kg K	ft lbf/slug K
T	temperature	K	K
β	dimensionless enthalpy parameter, $i/(p/\rho)$		
γ	ratio of specific heat capacity at constant pressure to specific heat capacity at constant volume, taken as 1.4 for air		
δ	flow deflection angle	deg	deg
ζ	shock angle	deg	deg
ρ	density	kg/m ³	slug/ft ³

Subscript

1	denotes conditions in air ahead of shock assumed to be undissociated
2	denotes conditions in air ahead of shock assumed to be equilibrium

2. NOTES

Figure 1 gives flow deflection angle as a function of shock angle for various values of the density ratio across the shock. The deflection angle of the flow can only be determined directly when the shock wave angle is already known and for such a case the oblique shock may be treated as a normal shock with $M_1 = M_1'$; the conditions behind it can then be determined by the methods of Item No. Aero S.00.03.22.

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To obtain the solution of the more usual problem, *i.e.* where the flow deflection is known and the wave angle and conditions behind the shock are required, choose a range of values of ζ extending upwards from the Mach angle or the deflection angle whichever is the greater. For each value of ζ evaluate the Mach number normal to the shock, M_1' , and using the method and Notation of Item No. Aero S.00.03.22 determine ρ_2/ρ_1 for each value of M_1' . The curves of the present Item then give a value of δ appropriate to each value of ζ . It should be noted that if a large range of values of ζ is chosen, there will generally be two solutions. The solution corresponding to the smaller value of ζ represents the weak shock and is that which is found in practice. Plot ζ against δ and read off the shock angle corresponding to the given flow deflection.

It is assumed throughout that the air ahead of the shock wave is undissociated and acts as a perfect gas with $\gamma = 1.4$; this implies that $T_1 < 500$ K.

3. DERIVATION

1. WEAVER, A.K. Unpublished work.
DOMMETT, R.L.

4. EXAMPLE

Find the conditions behind the shock formed by a two-dimensional wedge that deflects the air flow 40° . The free-stream Mach number is 6, $T_1 = 300$ K and $p_1 = 10^{-4}$ atmospheres,

The Mach angle is given by $\sin^{-1} 1/M = 9.6^\circ$

The wedge angle is greater than this; therefore choose a range of ζ thus:—

ζ	40°	50°	60°	70°	80°
$M_1' = M_1 \sin \zeta$	3.857	4.596	5.196	5.638	5.909

Then, using the method and Notation of Item No. Aero S.00.03.22, replacing M_1 by M_1' :—

$F(M_1')$	0.900	0.835	0.802	0.783	0.775
$G(M_1')$	1.570	1.668	1.730	1.766	1.782
$i_2/R(K)$	4017	5291	6496	7467	8118
$\beta_2(\text{say})$	3.7	3.8	3.9	4.0	4.2
$p_2 \times 10^3$ atmospheres	1.741	2.478	3.192	3.773	4.178

From Figure 2 of Item No. Aero 00.01.06:—

β_2	3.69	3.78	3.87	3.98	4.06
so that ρ_2/ρ_1	4.79	5.30	5.70	6.03	6.23

From Figure 1 of the present Item:—

δ	30°	37.3°	42.9°	45.5°	37.6°
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