Prandtl–Meyer Expansion Fan: Turning Angle and Mach Number

Downstream Mach number and pressure and temperature ratios after a supersonic flow turns through an expansion corner, from the Prandtl–Meyer function.

Method: Prandtl–Meyer function for isentropic centred expansions

Input parameters

Unit system: SI

Parameter	Value	Unit
Upstream Mach number	1.8000	
Turning angle	15.000	°
Ratio of specific heats	1.4000	

Calculated results

Parameter	Value	Unit
Prandtl–Meyer angle upstream	20.725	°
Prandtl–Meyer angle downstream	35.725	°
Downstream Mach number	2.3581	
Mach angle of the leading wave	33.749	°
Mach angle of the trailing wave	25.092	°
Static pressure ratio	0.41959	
Temperature ratio	0.78025	
Maximum turning from M = 1	130.45	°

Notes for this case

- Isentropic centred expansion: $\nu(M_2) = \nu(M_1) + \theta$, with pressure and temperature from the isentropic relations at constant stagnation conditions.

Formula and method

$$\nu(M) = \sqrt{\frac{\gamma+1}{\gamma-1}}\tan^{-1}\sqrt{\frac{\gamma-1}{\gamma+1}(M^2-1)} - \tan^{-1}\sqrt{M^2-1}, \quad \nu(M_2) = \nu(M_1) + \theta$$

Variables

M_1	Upstream Mach number	-
θ	Turning angle	rad
γ	Ratio of specific heats	-
$\nu(M_1)$	Prandtl–Meyer angle upstream	rad
$\nu(M_2)$	Prandtl–Meyer angle downstream	rad
M_2	Downstream Mach number	-
μ_1	Mach angle of the leading wave	rad
μ_2	Mach angle of the trailing wave	rad
p_2/p_1	Static pressure ratio	-
T_2/T_1	Temperature ratio	-
ν_{max}	Maximum turning from M = 1	rad

Method and standards

Prandtl–Meyer expansion theory.

Assumptions and limits

- Calorically perfect gas, two-dimensional, isentropic.

References

Prandtl–Meyer function for isentropic centred expansions

Report details

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Results are for engineering estimation. Verify critical designs against the referenced standards and your own data.

This calculator online

https://calc.firecad.com/mechanical/fluid-mechanics/prandtl-meyer-expansion

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