Normal Shock Wave Relations for a Perfect Gas

Downstream Mach number, pressure, temperature, density and stagnation-pressure loss across a normal shock in a perfect gas, with the pitot pressure.

Method: Rankine–Hugoniot normal shock relations for a perfect gas

Input parameters

Unit system: SI

Parameter	Value	Unit
Upstream Mach number	2.0000	
Ratio of specific heats	1.4000	
Upstream static pressure	50.000	kPa
Upstream static temperature	250.00	K

Calculated results

Parameter	Value	Unit
Downstream Mach number	0.57735	
Downstream static pressure	225.00	kPa
Downstream temperature	421.87	K
Density ratio	2.6667	
Stagnation pressure ratio	0.72087	
Stagnation (pitot) pressure behind the shock	282.02	kPa
Entropy rise over the gas constant	0.32729	

Notes for this case

• Rankine–Hugoniot relations for a calorically perfect gas. A pitot tube in supersonic flow reads p_{02}, the stagnation pressure behind the bow shock (Rayleigh pitot formula).

Formula and method

$$M_2^2 = \frac{1 + \frac{\gamma-1}{2} M_1^2}{\gamma M_1^2 - \frac{\gamma-1}{2}}, \quad \frac{p_2}{p_1} = 1 + \frac{2\gamma}{\gamma+1}(M_1^2 - 1), \quad \frac{\rho_2}{\rho_1} = \frac{(\gamma+1)M_1^2}{2 + (\gamma-1)M_1^2}$$

$$\frac{p_{02}}{p_{01}} = \left(\frac{\rho_2}{\rho_1}\right)^{\gamma/(\gamma-1)} \left(\frac{\gamma+1}{2\gamma M_1^2 - (\gamma-1)}\right)^{1/(\gamma-1)}$$

Variables

M_1	Upstream Mach number	-
γ	Ratio of specific heats	-
p_1	Upstream static pressure	Pa
T_1	Upstream static temperature	K
M_2	Downstream Mach number	-
p_2	Downstream static pressure	Pa
T_2	Downstream temperature	K
ρ_2/ρ_1	Density ratio	-
p_{02}/p_{01}	Stagnation pressure ratio	-
p_{02}	Stagnation (pitot) pressure behind the shock	Pa

$\Delta s/R$	Entropy rise over the gas constant	-

Method and standards

Normal shock relations.

Assumptions and limits

- Calorically perfect gas, adiabatic, one-dimensional, steady.

References

Rankine–Hugoniot normal shock relations for a perfect gas

Report details

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This calculator online

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