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Compressible Flow Formulas

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List of 25 Compressible Flow Formulas

Compressible Flow

1) Bulk Modulus for Velocity of Sound Wave

$$\text{fx } K = \rho_a \cdot C^2$$

[Open Calculator !\[\]\(a870788d6ed9b8fd294b7654a8c8526b_img.jpg\)](#)

$$\text{ex } 140481\text{N/m}^2 = 1.29\text{kg/m}^3 \cdot (330\text{m/s})^2$$

2) Mach Angle for Compressible Fluid Flow

$$\text{fx } \mu = a \sin\left(\frac{C}{V}\right)$$

[Open Calculator !\[\]\(c50c8b7b2cc2cf9ff925edec0ee94c0d_img.jpg\)](#)

$$\text{ex } 53.59848^\circ = a \sin\left(\frac{330\text{m/s}}{410\text{m/s}}\right)$$

3) Mach Number for Compressible Fluid Flow

$$\text{fx } M = \frac{V}{C}$$

[Open Calculator !\[\]\(f60b7a900783ac3fd531bfd9c111be6d_img.jpg\)](#)

$$\text{ex } 1.242424 = \frac{410\text{m/s}}{330\text{m/s}}$$



4) Pressure Ratio for Maximum Flow Rate through Nozzle

[Open Calculator !\[\]\(4729e517bc6a7cd81c8025b9646574fb_img.jpg\)](#)

$$\text{fx } r_p = \left(\frac{2}{\gamma + 1} \right)^{\frac{\gamma}{\gamma-1}}$$

$$\text{ex } 0.528282 = \left(\frac{2}{1.4 + 1} \right)^{\frac{1.4}{1.4-1}}$$

5) Temperature of Fluid for Stagnation Temperature considering Compressible Fluid Flow

[Open Calculator !\[\]\(e474458956c9a37fbf9586ddb60a7fa1_img.jpg\)](#)

$$\text{fx } T_1 = \frac{T_s}{1 + \frac{\gamma-1}{2} \cdot M^2}$$

$$\text{ex } 240.1493\text{K} = \frac{314\text{K}}{1 + \frac{1.4-1}{2} \cdot (1.24)^2}$$

6) Velocity at Outlet of Nozzle for Maximum Flow Rate of Fluid

[Open Calculator !\[\]\(4fe57c3593bf1b21d272ae7ac8dfaf77_img.jpg\)](#)

$$\text{fx } V_{f2} = \sqrt{\frac{2 \cdot \gamma \cdot P_1}{(\gamma + 1) \cdot \rho_a}}$$

$$\text{ex } 251.6098\text{m/s} = \sqrt{\frac{2 \cdot 1.4 \cdot 70000\text{N/m}^2}{(1.4 + 1) \cdot 1.29\text{kg/m}^3}}$$



7) Velocity of Projectile of Mach Cone in Compressible Fluid Flow

$$fx \quad V = \frac{C}{\sin(\mu)}$$

[Open Calculator !\[\]\(e78f798d4ea5c530c9db49e7d26e6b95_img.jpg\)](#)

$$ex \quad 409.992\text{m/s} = \frac{330\text{m/s}}{\sin(53.6^\circ)}$$

Absolute Temperature

8) Absolute Temperature for Velocity of Sound Wave in Isothermal Process

$$fx \quad T_{\text{abs}} = \frac{C^2}{R}$$

[Open Calculator !\[\]\(aa53ad6fea213b8b2226d3077e30533a_img.jpg\)](#)

$$ex \quad 379.2575\text{K} = \frac{(330\text{m/s})^2}{287.14\text{J}/(\text{kg}\cdot\text{K})}$$

9) Absolute Temperature for Velocity of Sound Wave using Adiabatic Process

$$fx \quad T_{\text{abs}} = \frac{C^2}{\gamma \cdot R}$$

[Open Calculator !\[\]\(626ce8ac21792b9405bfddfea8e0c96a_img.jpg\)](#)

$$ex \quad 270.8982\text{K} = \frac{(330\text{m/s})^2}{1.4 \cdot 287.14\text{J}/(\text{kg}\cdot\text{K})}$$



Pressure and Density

10) Density of Fluid considering Velocity at Outlet of Orifice

$$\text{fx } \rho_a = \frac{2 \cdot \gamma \cdot P_1}{V_{f2}^2 \cdot (\gamma + 1)}$$

[Open Calculator !\[\]\(74d4806277d7e73349d8e8c0897931e9_img.jpg\)](#)

$$\text{ex } 1.296276\text{kg/m}^3 = \frac{2 \cdot 1.4 \cdot 70000\text{N/m}^2}{(251\text{m/s})^2 \cdot (1.4 + 1)}$$

11) Density of Fluid for Stagnation considering Compressible Fluid Flow

$$\text{fx } \rho_a = \frac{\rho_s}{\left(1 + \frac{\gamma-1}{2} \cdot M^2\right)^{\frac{1}{\gamma-1}}}$$

[Open Calculator !\[\]\(8bba887393ca45b761e5cb49e755e762_img.jpg\)](#)

$$\text{ex } 1.289079\text{kg/m}^3 = \frac{2.52\text{kg/m}^3}{\left(1 + \frac{1.4-1}{2} \cdot (1.24)^2\right)^{\frac{1}{1.4-1}}}$$

12) Pressure at Inlet considering Maximum Flow Rate of Fluid

$$\text{fx } P_1 = \frac{\gamma + 1}{2 \cdot \gamma} \cdot \rho_a \cdot V_{f2}^2$$

[Open Calculator !\[\]\(0fb13ad0bfa3d86868cdd3883e5665b3_img.jpg\)](#)

$$\text{ex } 69661.11\text{N/m}^2 = \frac{1.4 + 1}{2 \cdot 1.4} \cdot 1.29\text{kg/m}^3 \cdot (251\text{m/s})^2$$



13) Pressure at Inlet of Tank or Vessel considering Compressible Fluid Flow

$$\text{fx } P_a = \frac{P_s}{\left(1 + \frac{\gamma-1}{2} \cdot M^2\right)^{\frac{\gamma}{\gamma-1}}}$$

[Open Calculator !\[\]\(d3fb9f94af8b26d1c844efa9a98805b0_img.jpg\)](#)

$$\text{ex } 47729.91\text{N/m}^2 = \frac{1.22\text{E}5\text{N/m}^2}{\left(1 + \frac{1.4-1}{2} \cdot (1.24)^2\right)^{\frac{1.4}{1.4-1}}}$$

Stagnation Density

14) Stagnation Density considering other Stagnation Properties of Fluid

$$\text{fx } \rho_s = \frac{P_s}{R \cdot T_s}$$

[Open Calculator !\[\]\(73002692dd5e7a64e60946be3158e719_img.jpg\)](#)

$$\text{ex } 1.353121\text{kg/m}^3 = \frac{1.22\text{E}5\text{N/m}^2}{287.14\text{J}/(\text{kg}\cdot\text{K}) \cdot 314\text{K}}$$

15) Stagnation Density given Compressible Fluid Flow

$$\text{fx } \rho_s = \rho_a \cdot \left(1 + \frac{\gamma-1}{2} \cdot M^2\right)^{\frac{1}{\gamma-1}}$$

[Open Calculator !\[\]\(104fbf564e2e5a8fbd84f31656d114c7_img.jpg\)](#)

$$\text{ex } 2.5218\text{kg/m}^3 = 1.29\text{kg/m}^3 \cdot \left(1 + \frac{1.4-1}{2} \cdot (1.24)^2\right)^{\frac{1}{1.4-1}}$$



Stagnation Pressure

16) Stagnation Pressure considering other Stagnation Properties of Fluid

$$fx \quad p_s = T_s \cdot R \cdot \rho_s$$

[Open Calculator !\[\]\(83f22ed94ec5517769dd76d702c6bfd8_img.jpg\)](#)

$$ex \quad 227208.1 \text{N/m}^2 = 314 \text{K} \cdot 287.14 \text{J}/(\text{kg} \cdot \text{K}) \cdot 2.52 \text{kg/m}^3$$

17) Stagnation Pressure for Compressible Fluid Flow

$$fx \quad p_s = P_a \cdot \left(1 + \frac{\gamma - 1}{2} \cdot M^2 \right)^{\frac{\gamma}{\gamma - 1}}$$

[Open Calculator !\[\]\(3cb60d42b10e53f9522bb0b392c1c4cd_img.jpg\)](#)

$$ex \quad 122179.1 \text{N/m}^2 = 4.78 \text{E}4 \text{N/m}^2 \cdot \left(1 + \frac{1.4 - 1}{2} \cdot (1.24)^2 \right)^{\frac{1.4}{1.4 - 1}}$$

Stagnation Temperature

18) Stagnation Temperature considering Compressible Fluid Flow

$$fx \quad T_s = T_1 \cdot \left(1 + \frac{\gamma - 1}{2} \cdot M^2 \right)$$

[Open Calculator !\[\]\(274fd520e03b61c1b9ffc861754cacdc_img.jpg\)](#)

$$ex \quad 313.8048 \text{K} = 240 \text{K} \cdot \left(1 + \frac{1.4 - 1}{2} \cdot (1.24)^2 \right)$$



19) Stagnation Temperature considering other Stagnation Properties of Fluid

$$fx \quad T_s = \frac{p_s}{R \cdot \rho_s}$$

[Open Calculator !\[\]\(6605b201d6f14d9b3bcb8ab5f274d107_img.jpg\)](#)

$$ex \quad 168.6031K = \frac{1.22E5N/m^2}{287.14J/(kg \cdot K) \cdot 2.52kg/m^3}$$

Velocity of Sound Wave

20) Sonic Velocity

$$fx \quad C = \sqrt{\frac{K}{\rho_a}}$$

[Open Calculator !\[\]\(f95dab70c751fda7d824b8b03650f7aa_img.jpg\)](#)

$$ex \quad 332.9455m/s = \sqrt{\frac{1.43E5N/m^2}{1.29kg/m^3}}$$

21) Velocity of Sound Wave considering Mach Angle in Compressible Fluid Flow

$$fx \quad C = V \cdot \sin(\mu)$$

[Open Calculator !\[\]\(e9474ce1d70442456f8fe9c393ea149c_img.jpg\)](#)

$$ex \quad 330.0065m/s = 410m/s \cdot \sin(53.6^\circ)$$



22) Velocity of Sound Wave given Bulk Modulus

[Open Calculator !\[\]\(666e09182d4cd268646ea700ea60dcdf_img.jpg\)](#)

$$fx \quad C = \sqrt{\frac{K}{\rho_a}}$$

$$ex \quad 332.9455m/s = \sqrt{\frac{1.43E5N/m^2}{1.29kg/m^3}}$$

23) Velocity of Sound Wave given Mach Number for Compressible Fluid Flow

[Open Calculator !\[\]\(003082e50e3009141f59bd5df831749f_img.jpg\)](#)

$$fx \quad C = \frac{V}{M}$$

$$ex \quad 330.6452m/s = \frac{410m/s}{1.24}$$

24) Velocity of Sound Wave using Adiabatic Process

[Open Calculator !\[\]\(d3102649f02e825ddb76dc3de0190154_img.jpg\)](#)

$$fx \quad C = \sqrt{\gamma \cdot R \cdot T_{abs}}$$

$$ex \quad 331.3687m/s = \sqrt{1.4 \cdot 287.14J/(kg \cdot K) \cdot 273.15K}$$

25) Velocity of Sound Wave using Isothermal Process

[Open Calculator !\[\]\(4f6bf54ae7e4144a72d78316053e412d_img.jpg\)](#)

$$fx \quad C = \sqrt{R \cdot T_{abs}}$$

$$ex \quad 280.0577m/s = \sqrt{287.14J/(kg \cdot K) \cdot 273.15K}$$









Variables Used

- **C** Velocity of Sound in Medium (*Meter per Second*)
- **K** Bulk Modulus of Sound Medium (*Newton per Square Meter*)
- **M** Mach Number for Compressible Flow
- **P₁** Pressure at Nozzle Inlet (*Newton per Square Meter*)
- **P_a** Pressure of Still Air (*Newton per Square Meter*)
- **p_s** Stagnation Pressure in Compressible Flow (*Newton per Square Meter*)
- **R** Gas Constant in Compressible Flow (*Joule per Kilogram per K*)
- **r_p** Pressure Ratio for Flow through Nozzle
- **T₁** Temperature of Still Air (*Kelvin*)
- **T_{abs}** Absolute Temperature (*Kelvin*)
- **T_s** Stagnation Temperature in Compressible Flow (*Kelvin*)
- **V** Projectile Velocity of Mach Cone (*Meter per Second*)
- **V_{f2}** Velocity of Flow at Nozzle Outlet (*Meter per Second*)
- **γ** Specific Heat Ratio
- **μ** Mach Angle in Compressible Flow (*Degree*)
- **ρ_a** Density of Air Medium (*Kilogram per Cubic Meter*)
- **ρ_s** Stagnation Density in Compressible Flow (*Kilogram per Cubic Meter*)



Constants, Functions, Measurements used

- **Function:** **asin**, asin(Number)
Inverse trigonometric sine function
- **Function:** **sin**, sin(Angle)
Trigonometric sine function
- **Function:** **sqrt**, sqrt(Number)
Square root function
- **Measurement:** **Temperature** in Kelvin (K)
Temperature Unit Conversion 
- **Measurement:** **Pressure** in Newton per Square Meter (N/m²)
Pressure Unit Conversion 
- **Measurement:** **Speed** in Meter per Second (m/s)
Speed Unit Conversion 
- **Measurement:** **Angle** in Degree (°)
Angle Unit Conversion 
- **Measurement:** **Specific Heat Capacity** in Joule per Kilogram per K (J/(kg*K))
Specific Heat Capacity Unit Conversion 
- **Measurement:** **Density** in Kilogram per Cubic Meter (kg/m³)
Density Unit Conversion 



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