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Governing Equations and Sound Wave Formulas

Calculators! Examples! Conversions!

List of 18 Governing Equations and Sound Wave Formulas

Governing Equations and Sound Wave

1) Critical Density

Open Calculator

fx $$\rho_{cr} = \rho_o \cdot \left(\frac{2}{\gamma + 1}\right)^{\frac{1}{\gamma-1}}$$

ex $$0.773405\text{kg/m}^3 = 1.22\text{kg/m}^3 \cdot \left(\frac{2}{1.4 + 1}\right)^{\frac{1}{1.4-1}}$$

2) Critical Pressure

Open Calculator

fx $$p_{cr} = \left(\frac{2}{\gamma + 1}\right)^{\frac{\gamma}{\gamma-1}} \cdot P_0$$

ex $$2.641409\text{at} = \left(\frac{2}{1.4 + 1}\right)^{\frac{1.4}{1.4-1}} \cdot 5\text{at}$$

3) Critical Temperature

Open Calculator

fx $$T_{cr} = \frac{2 \cdot T_0}{\gamma + 1}$$

ex $$250\text{K} = \frac{2 \cdot 300\text{K}}{1.4 + 1}$$

4) Flow Velocity Downstream of Sound Wave

Open Calculator

fx $$u_2 = \sqrt{2 \cdot \left(\frac{a_1^2 - a_2^2}{\gamma - 1} + \frac{u_1^2}{2} \right)}$$

ex $$45.07716\text{m/s} = \sqrt{2 \cdot \left(\frac{(12\text{m/s})^2 - (31.90\text{m/s})^2}{1.4 - 1} + \frac{(80\text{m/s})^2}{2} \right)}$$

5) Flow Velocity Upstream of Sound Wave

Open Calculator

fx $$u_1 = \sqrt{2 \cdot \left(\frac{a_2^2 - a_1^2}{\gamma - 1} + \frac{u_2^2}{2} \right)}$$

ex $$79.95655\text{m/s} = \sqrt{2 \cdot \left(\frac{(31.90\text{m/s})^2 - (12\text{m/s})^2}{1.4 - 1} + \frac{(45\text{m/s})^2}{2} \right)}$$

6) Isentropic Change across Sound Wave

Open Calculator

fx $$dpd\rho = a^2$$

ex $$117649\text{m}^2/\text{s}^2 = (343\text{m/s})^2$$

7) Isentropic Compressibility for given Density and Speed of Sound

Open Calculator

fx $$\tau_s = \frac{1}{\rho \cdot a^2}$$

ex $$0.069387 \text{cm}^2/\text{N} = \frac{1}{1.225 \text{kg}/\text{m}^3 \cdot (343 \text{m}/\text{s})^2}$$

8) Mach Angle

Open Calculator

fx $$\mu = a\sin\left(\frac{1}{M}\right)$$

ex $$30^\circ = a\sin\left(\frac{1}{2}\right)$$

9) Mach Number

Open Calculator

fx $$M = \frac{V_b}{a}$$

ex $$2.040816 = \frac{700 \text{m}/\text{s}}{343 \text{m}/\text{s}}$$

10) Mayer's Formula

Open Calculator

fx $$R = C_p - C_v$$

ex $$273 \text{J}/(\text{kg*K}) = 1005 \text{J}/(\text{kg*K}) - 732 \text{J}/(\text{kg*K})$$

11) Ratio of Stagnation and Static Density

Open Calculator

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

ex $$4.346916 = \left(1 + \left(\frac{1.4 - 1}{2}\right) \cdot (2)^2\right)^{\frac{1}{1.4 - 1}}$$

12) Ratio of Stagnation and Static Pressure

Open Calculator

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

ex $$7.824449 = \left(1 + \left(\frac{1.4 - 1}{2}\right) \cdot (2)^2\right)^{\frac{1.4}{1.4 - 1}}$$

13) Ratio of Stagnation and Static Temperature

Open Calculator

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

ex $$1.8 = 1 + \left(\frac{1.4 - 1}{2}\right) \cdot (2)^2$$

14) Speed of Sound

Open Calculator

fx $$a = \sqrt{\gamma \cdot [\text{R-Dry-Air}] \cdot T_s}$$

ex $$344.9012\text{m/s} = \sqrt{1.4 \cdot [\text{R-Dry-Air}] \cdot 296\text{K}}$$

15) Speed of Sound Downstream of Sound Wave

Open Calculator

fx $$a_2 = \sqrt{(\gamma - 1) \cdot \left(\frac{u_1^2 - u_2^2}{2} + \frac{a_1^2}{\gamma - 1}\right)}$$

ex $$31.92178\text{m/s} = \sqrt{(1.4 - 1) \cdot \left(\frac{(80\text{m/s})^2 - (45\text{m/s})^2}{2} + \frac{(12\text{m/s})^2}{1.4 - 1}\right)}$$

16) Speed of Sound given Isentropic Change

Open Calculator

fx $$a = \sqrt{\text{dpd}\rho}$$

ex $$343\text{m/s} = \sqrt{117649\text{m}^2/\text{s}^2}$$

17) Speed of Sound Upstream of Sound Wave

Open Calculator

fx $$a_1 = \sqrt{(\gamma - 1) \cdot \left(\frac{u_2^2 - u_1^2}{2} + \frac{a_2^2}{\gamma - 1} \right)}$$

ex $$11.94194\text{m/s} = \sqrt{(1.4 - 1) \cdot \left(\frac{(45\text{m/s})^2 - (80\text{m/s})^2}{2} + \frac{(31.90\text{m/s})^2}{1.4 - 1} \right)}$$

18) Stagnation Temperature

Open Calculator

fx $$T_0 = T_s + \frac{u_2^2}{2 \cdot C_p}$$

ex $$297.0075\text{K} = 296\text{K} + \frac{(45\text{m/s})^2}{2 \cdot 1005\text{J/(kg*K)}}$$

Variables Used

- **a** Speed of Sound *(Meter per Second)*
- **a_1** Sound Speed Upstream *(Meter per Second)*
- **a_2** Sound Speed Downstream *(Meter per Second)*
- **C_p** Specific Heat Capacity at Constant Pressure *(Joule per Kilogram per K)*
- **C_v** Specific Heat Capacity at Constant Volume *(Joule per Kilogram per K)*
- **dpdρ** Isentropic Change *(Square Meter per Square Second)*
- **M** Mach Number
- **P_0** Stagnation Pressure *(Atmosphere Technical)*
- **p_{cr}** Critical Pressure *(Atmosphere Technical)*
- **P_r** Stagnation to Static Pressure
- **R** Specific Gas Constant *(Joule per Kilogram per K)*
- **T_0** Stagnation Temperature *(Kelvin)*
- **T_{cr}** Critical Temperature *(Kelvin)*
- **T_r** Stagnation to Static Temperature
- **T_s** Static Temperature *(Kelvin)*
- **u_1** Flow Velocity Upstream of Sound *(Meter per Second)*
- **u_2** Flow Velocity Downstream of Sound *(Meter per Second)*
- **V_b** Speed of Object *(Meter per Second)*
- **γ** Specific Heat Ratio
- **μ** Mach Angle *(Degree)*
- **ρ** Density *(Kilogram per Cubic Meter)*
- **ρ_{cr}** Critical Density *(Kilogram per Cubic Meter)*

- ρ_o Stagnation Density *(Kilogram per Cubic Meter)*
- ρ_r Stagnation to Static Density
- τ_s Isentropic Compressibility *(Square Centimeter per Newton)*

Constants, Functions, Measurements used

- Constant: **[R-Dry-Air]**, 287.058
  Specific Gas Constant for Dry Air
- Function: **asin**, asin(Number)
  The inverse sine function, is a trigonometric function that takes a ratio of two sides of a right triangle and outputs the angle opposite the side with the given ratio.
- Function: **sin**, sin(Angle)
  Sine is a trigonometric function that describes the ratio of the length of the opposite side of a right triangle to the length of the hypotenuse.
- Function: **sqrt**, sqrt(Number)
  A square root function is a function that takes a non-negative number as an input and returns the square root of the given input number.
- Measurement: **Temperature** in Kelvin (K)
  Temperature Unit Conversion
- Measurement: **Pressure** in Atmosphere Technical (at)
  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
- Measurement: **Specific Energy** in Square Meter per Square Second (m²/s²)

Specific Energy Unit Conversion

- Measurement: **Compressibility** in Square Centimeter per Newton (cm^2/N)
  Compressibility Unit Conversion

Check other formula lists

- **Governing Equations and Sound Wave Formulas**
- **Normal Shock Wave Formulas**

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