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Governing Equations and Sound Wave Formulas

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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 $$\text{dpd}\rho = a^2$$

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

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

10) Mayer's Formula

Open Calculator

fx $$R = C_p - C_v$$

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

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 $$a = \sqrt{dp d\rho}$$

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 $$T_0 = T_s + \frac{U_{fluid}^2}{2 \cdot C_p}$$

ex $$297.0119\text{K} = 296\text{K} + \frac{(45.1\text{m/s})^2}{2 \cdot 1005\text{J/(kg*K)}}$$

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)*
- U_{fluid} Velocity of Fluid Flow *(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 (cm²/N)
  Compressibility Unit Conversion

Check other formula lists

- **Governing Equations and Sound Wave Formulas**
- **Normal Shock Wave Formulas**
- **Oblique Shock and Expansion Waves Formulas**

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