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Basics of Gas Turbines Formulas

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List of 17 Basics of Gas Turbines Formulas

Basics of Gas Turbines

1) Diffuser Efficiency

$$fx \quad \eta_d = \frac{\Delta P}{\Delta P'}$$

Open Calculator 

$$ex \quad 0.625 = \frac{25Pa}{40Pa}$$

2) Diffuser Efficiency given Inlet and Exit Velocities

$$fx \quad \eta_d = \frac{\Delta P}{\frac{\rho}{2} \cdot (C_1^2 - C_2^2)}$$

Open Calculator 

$$ex \quad 1.678375 = \frac{25Pa}{\frac{1.293kg/m^3}{2} \cdot ((8m/s)^2 - (6.4m/s)^2)}$$

3) Enthalpy of Ideal Gas at given Temperature

$$fx \quad H = C_p \cdot T$$

Open Calculator 

$$ex \quad 301.5KJ = 1.005kJ/kg \cdot K \cdot 300K$$



4) Heat Capacity Ratio

$$fx \quad \gamma = \frac{C_p}{C_v}$$

[Open Calculator !\[\]\(cbe80b694ebd74fcfe136a095b608235_img.jpg\)](#)

$$ex \quad 1.34 = \frac{1.005 \text{kJ/kg} \cdot \text{K}}{0.75 \text{kJ/kg} \cdot \text{K}}$$

5) Internal Energy of Perfect Gas at given Temperature

$$fx \quad U = C_v \cdot T$$

[Open Calculator !\[\]\(3e2231b1ad3ca8da8658228c00dd08e0_img.jpg\)](#)

$$ex \quad 225 \text{KJ} = 0.75 \text{kJ/kg} \cdot \text{K} \cdot 300 \text{K}$$

6) Mach Angle

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

[Open Calculator !\[\]\(0d5ec72f61334709c3fc9450209b754f_img.jpg\)](#)

$$ex \quad 10.47568^\circ = a \sin\left(\frac{1}{5.5}\right)$$

7) Mach Number

$$fx \quad M = \frac{V_{\text{body}}}{c_{\text{speed}}}$$

[Open Calculator !\[\]\(b64b40baaee5acddc1eab8538ba84754_img.jpg\)](#)

$$ex \quad 0.055394 = \frac{19 \text{m/s}}{343 \text{m/s}}$$



8) Mass Flow Rate of Exhaust Gases 

$$fx \quad m = m_a + m_f$$

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


$$ex \quad 4.7\text{kg/s} = 3.5\text{kg/s} + 1.2\text{kg/s}$$

9) Mass Flow Rate of Exhaust Gases given Fuel Air Ratio 

$$fx \quad m = m_a \cdot (1 + f)$$

[Open Calculator !\[\]\(05be7c7a8995decd503647c99211f7c2_img.jpg\)](#)

$$ex \quad 9.45\text{kg/s} = 3.5\text{kg/s} \cdot (1 + 1.7)$$

10) Pressure Ratio 

$$fx \quad r_p = \frac{P_f}{P_i}$$

[Open Calculator !\[\]\(fe3aebe81acea8d45108cd2768939da7_img.jpg\)](#)

$$ex \quad 0.283538 = \frac{18.43\text{Pa}}{65\text{Pa}}$$

11) Shaft Work in Compressible Flow Machines 

$$fx \quad W_s = \left(h_1 + \frac{c_1^2}{2} \right) - \left(h_2 + \frac{c_2^2}{2} \right)$$

[Open Calculator !\[\]\(899d8b7697d64725bf017d3296cfcf1b_img.jpg\)](#)

$$ex \quad 35.99836\text{KJ} = \left(48\text{KJ} + \frac{(0.85\text{m/s})^2}{2} \right) - \left(12\text{KJ} + \frac{(2\text{m/s})^2}{2} \right)$$



12) Shaft Work in Compressible Flow Machines neglecting Inlet and Exit Velocities

$$\text{fx } W_s = h_1 - h_2$$

[Open Calculator !\[\]\(e2376d476d06eb31946dc01a69a4403a_img.jpg\)](#)

$$\text{ex } 36\text{KJ} = 48\text{KJ} - 12\text{KJ}$$

13) Speed of Sound

$$\text{fx } c_{\text{speed}} = \sqrt{k \cdot [\text{R-Dry-Air}] \cdot T_g}$$

[Open Calculator !\[\]\(0b5e7e25e8775f7e7e80906ada4f0021_img.jpg\)](#)

$$\text{ex } 332.4112\text{m/s} = \sqrt{1.41 \cdot [\text{R-Dry-Air}] \cdot 273\text{K}}$$

14) Stagnation Temperature

$$\text{fx } T_0 = T_{\text{static}} + \frac{U_{\text{fluid}}^2}{2 \cdot C_p}$$

[Open Calculator !\[\]\(bd3b31712ad9bab5a241210fa6925cdd_img.jpg\)](#)

$$\text{ex } 350.1119\text{K} = 350\text{K} + \frac{(15\text{m/s})^2}{2 \cdot 1.005\text{kJ/kg}^*\text{K}}$$

15) Stagnation Velocity of Sound

$$\text{fx } a_o = \sqrt{\gamma \cdot [\text{R}] \cdot T_0}$$

[Open Calculator !\[\]\(7bc43b319a082987e20f7bf78f4bab80_img.jpg\)](#)

$$\text{ex } 34.11781\text{m/s} = \sqrt{1.4 \cdot [\text{R}] \cdot 100\text{K}}$$



16) Stagnation Velocity of Sound given Specific Heat at Constant Pressure

$$fx \quad a_o = \sqrt{(\gamma - 1) \cdot C_p \cdot T_0}$$

[Open Calculator](#)

$$ex \quad 200.4994\text{m/s} = \sqrt{(1.4 - 1) \cdot 1.005\text{kJ/kg}\cdot\text{K} \cdot 100\text{K}}$$

17) Stagnation Velocity of Sound given Stagnation Enthalpy

$$fx \quad a_o = \sqrt{(\gamma - 1) \cdot h_o}$$

[Open Calculator](#)

$$ex \quad 6.957011\text{m/s} = \sqrt{(1.4 - 1) \cdot 121\text{J/kg}}$$



Variables Used








- a_0 Stagnation Velocity of Sound (Meter per Second)
- c_1 Inlet Velocity (Meter per Second)
- C_1 Inlet Velocity to Diffuser (Meter per Second)
- c_2 Exit Velocity (Meter per Second)
- C_2 Exit Velocity To Diffuser (Meter per Second)
- C_p Specific Heat Capacity at Constant Pressure (Kilojoule per Kilogram per K)
- C_{speed} Speed of Sound (Meter per Second)
- C_v Specific Heat Capacity at Constant Volume (Kilojoule per Kilogram per K)
- f Fuel Air Ratio
- H Enthalpy (Kilojoule)
- h_1 Enthalpy at Inlet (Kilojoule)
- h_2 Enthalpy at Exit (Kilojoule)
- h_0 Stagnation Enthalpy (Joule per Kilogram)
- k Specific Heat Ratio
- m Mass Flow Rate (Kilogram per Second)
- M Mach Number
- m_a Air Flow Rate (Kilogram per Second)
- m_f Fuel Flow Rate (Kilogram per Second)
- P_f Final Pressure of System (Pascal)
- P_i Initial Pressure of System (Pascal)





- r_p Pressure Ratio
- T Temperature for Gas Turbines (Kelvin)
- T_0 Stagnation Temperature (Kelvin)
- T_g Temperature of Gas (Kelvin)
- T_{static} Static Temperature (Kelvin)
- U Internal Energy (Kilojoule)
- U_{fluid} Velocity of Fluid Flow (Meter per Second)
- V_{body} Speed of Body (Meter per Second)
- W_s Shaft Work (Kilojoule)
- γ Heat Capacity Ratio
- ΔP Static Pressure Rise in Actual (Pascal)
- $\Delta P'$ Static Pressure Rise in Isentropic Process (Pascal)
- η_d Diffuser Efficiency
- μ Mach Angle (Degree)
- ρ Density of Air (Kilogram per Cubic Meter)



Constants, Functions, Measurements used





- **Constant:** **[R-Dry-Air]**, 287.058 Joule / Kilogram * Kelvin
Specific Gas Constant for Dry Air
- **Constant:** **[R]**, 8.31446261815324 Joule / Kelvin * Mole
Universal gas constant
- **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 Pascal (Pa)
Pressure Unit Conversion 
- **Measurement:** **Speed** in Meter per Second (m/s)
Speed Unit Conversion 
- **Measurement:** **Energy** in Kilojoule (KJ)
Energy Unit Conversion 
- **Measurement:** **Angle** in Degree (°)
Angle Unit Conversion 
- **Measurement:** **Specific Heat Capacity** in Kilojoule per Kilogram per K (kJ/kg*K)
Specific Heat Capacity Unit Conversion 
- **Measurement:** **Mass Flow Rate** in Kilogram per Second (kg/s)
Mass Flow Rate Unit Conversion 



- **Measurement: Density** in Kilogram per Cubic Meter (kg/m^3)
Density Unit Conversion 
- **Measurement: Specific Energy** in Joule per Kilogram (J/kg)
Specific Energy Unit Conversion 



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