Important Thermodynamics and Governing Equations Formulas PDF

Formulas Examples with Units

List of 19 Important Thermodynamics and Governing Equations Formulas

1) Choked Mass Flow Rate Formula

Evaluate Formula

Formula

$$\dot{m}_{choke} = \frac{m \cdot \sqrt{C_p \cdot T}}{A_{throat} \cdot P_o}$$

Example with Units

$$1.279 = \frac{5\,\text{kg/s} \cdot \sqrt{1005\,\text{J/(kg*K)} \cdot 298.15\,\text{K}}}{21.4\,\text{m}^2 \cdot 100\,\text{Pa}}$$

2) Choked Mass Flow Rate given specific heat ratio Formula

Evaluate Formula

Formula

$$\dot{m}_{choke} = \left(\frac{\gamma}{\sqrt{\gamma - 1}}\right) \cdot \left(\frac{\gamma + 1}{2}\right)^{-\left(\frac{\gamma + 1}{2 \cdot \gamma - 2}\right)}$$

Example

$$1.281 = \left(\frac{1.4}{\sqrt{1.4 - 1}}\right) \cdot \left(\frac{1.4 + 1}{2}\right)^{-\left(\frac{1.4 + 1}{2 \cdot 1.4 - 2}\right)}$$

3) Efficiency of cycle Formula

Evaluate Formula

Formula

$$\eta_{cycle} = \frac{W_T - W_c}{Q}$$

Example with Units

$$0.4672 = \frac{600\,\text{KJ} - 315\,\text{KJ}}{610\,\text{KJ}}$$

4) Efficiency of Joule cycle Formula

Evaluate Formula

Formula

$$\eta_{joule\ cycle} = \frac{W_{Net}}{Q}$$

Example with Units

$$0.5 = \frac{305\,\text{KJ}}{610\,\text{KJ}}$$

5) Enthalpy of Ideal Gas at given Temperature Formula

Evaluate Formula

Formula

$$h = C_p \cdot T$$

Example with Units

$$299.6408\,\text{kJ/kg} = 1005\,\text{J/(kg*K)} \cdot 298.15\,\text{K}$$

6) Heat Capacity Ratio Formula

Evaluate Formula

Formula

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

Example with Units

$$1.34 = \frac{1005\,\mathrm{J/(kg*K)}}{750\,\mathrm{J/(kg*K)}}$$

7) Internal Energy of Perfect Gas at given Temperature Formula

Evaluate Formula

Formula

$$U = C_v \cdot T$$

Example with Units

$$223.6125\,\mathrm{kJ/kg} = 750\,\mathrm{J/(kg*K)} \cdot 298.15\,\mathrm{K}$$

8) Mach Angle Formula

Evaluate Formula

Formula

$$\mu = asin\left(\frac{1}{M}\right)$$

Example with Units

$$30° = asin\left(\frac{1}{2}\right)$$

9) Mach Number Formula

Evaluate Formula

Formula

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

Example with Units

$$2.0408 = \frac{700\,\mathrm{m/s}}{343\,\mathrm{m/s}}$$

10) Max work output in Brayton cycle Formula

Evaluate Formula

Formula

$$W_pmax = \left(1005 \cdot \frac{1}{\eta_c}\right) \cdot T_{B1} \cdot \left(\sqrt{\frac{T_{B3}}{T_{B1}} \cdot \eta_c \cdot \eta_{turbine}} - 1\right)^2$$

Example with Units

$$102.8266\,\mathrm{KJ} = \left(1005 \cdot \frac{1}{0.3}\right) \cdot 290\,\mathrm{K} \cdot \left(\sqrt{\frac{550\,\mathrm{K}}{290\,\mathrm{K}} \cdot 0.3 \cdot 0.8} - 1\right)^2$$

11) Pressure Ratio Formula

Evaluate Formula

Formula

$$P_R = \frac{P_f}{P_i}$$

Example with Units

$$3.9846 = \frac{259\,\mathrm{Pa}}{65\,\mathrm{Pa}}$$

12) Specific Heat of mixed out gas Formula

Evaluate Formula

Formula

$$C_{p,m} = \frac{C_{pe} + \beta \cdot C_{p,\beta}}{1 + \beta}$$

Example with Units

$$1043.3443\,\mathrm{J/(kg^*K)} = \frac{1244\,\mathrm{J/(kg^*K)} + 5.1 \cdot 1004\,\mathrm{J/(kg^*K)}}{1 + 5.1}$$

13) Speed of Sound Formula

Evaluate Formula

Formula

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

Example with Units

$$344.9012\,\mathrm{m/s} = \sqrt{1.4 \cdot 287.058 \cdot 296\,\mathrm{K}}$$

14) Stagnation enthalpy Formula

Evaluate Formula

Formula

$$h_0 = h + \frac{U_{fluid}^2}{2}$$

Example with Units

$$301.017\,\mathrm{kJ/kg} = 300\,\mathrm{kJ/kg} + \frac{45.1\,\mathrm{m/s}^2}{2}$$

15) Stagnation Temperature Formula

Evaluate Formula

Formula

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

Example with Units

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

16) Stagnation Velocity of Sound Formula

Evaluate Formula

Formula

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

Example with Units

$$59.0938\,\mathrm{m/s} = \sqrt{1.4 \cdot 8.3145 \cdot 300\,\mathrm{K}}$$

17) Stagnation Velocity of Sound given Specific Heat at Constant Pressure Formula

Evaluate Formula

Formula

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

Example with Units

$$347.2751\,\mathrm{m/s} = \sqrt{(1.4 - 1) \cdot 1005\,\mathrm{J/(kg^*K)} \cdot 300\,\mathrm{K}}$$

18) Stagnation Velocity of Sound given Stagnation Enthalpy Formula

Evaluate Formula

Formula

$$a_o = \sqrt{(\gamma - 1) \cdot h_0}$$

Example with Units

$$346.987\,\mathrm{m/s} = \sqrt{(1.4 - 1) \cdot 301\,\mathrm{kJ/kg}}$$

19) Work ratio in practical cycle Formula

Evaluate Formula

Formula

$$W = 1 - \left(\frac{W_c}{W_T}\right)$$

Example with Units

$$0.475 = 1 - \left(\frac{315\,\mathrm{KJ}}{600\,\mathrm{KJ}}\right)$$

Variables used in list of Thermodynamics and Governing Equations Formulas above

- **a** Speed of Sound *(Meter per Second)*
- a_o Stagnation Velocity of Sound *(Meter per Second)*
- A_{throat} Nozzle Throat Area *(Square Meter)*
- C_p Specific Heat Capacity at Constant Pressure *(Joule per Kilogram per K)*
- $C_{p,m}$ Specific Heat of Mixed Gas *(Joule per Kilogram per K)*
- $C_{p,\beta}$ Specific Heat of Bypass Air *(Joule per Kilogram per K)*
- C_{pe} Specific Heat of Core Gas *(Joule per Kilogram per K)*
- C_v Specific Heat Capacity at Constant Volume *(Joule per Kilogram per K)*
- **h** Enthalpy *(Kilojoule per Kilogram)*
- h_0 Stagnation Enthalpy *(Kilojoule per Kilogram)*
- **m** Mass Flow Rate *(Kilogram per Second)*
- **M** Mach Number
- $\dot{m}_{choke}$ Choked Mass Flow Rate
- P_f Final Pressure *(Pascal)*
- P_i Initial Pressure *(Pascal)*
- P_o Throat Pressure *(Pascal)*
- P_R Pressure Ratio
- **Q** Heat *(Kilojoule)*
- **T** Temperature *(Kelvin)*
- T_0 Stagnation Temperature *(Kelvin)*
- T_{B1} Temperature at Inlet of Compressor in Brayton *(Kelvin)*
- T_{B3} Temperature at Inlet to Turbine in Brayton Cycle *(Kelvin)*
- T_s Static Temperature *(Kelvin)*
- **U** Internal Energy *(Kilojoule per Kilogram)*
- U_{fluid} Velocity of Fluid Flow *(Meter per Second)*

Constants, Functions, Measurements used in list of Thermodynamics and Governing Equations Formulas above

- constant(s): **[R-Dry-Air]**, 287.058
  Specific Gas Constant for Dry Air
- constant(s): **[R]**, 8.31446261815324
  Universal gas constant
- Functions: **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.
- Functions: **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.
- Functions: **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: **Area** in Square Meter (m²)
  Area 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 Joule per Kilogram per K (J/(kg*K))
  Specific Heat Capacity Unit Conversion
- Measurement: **Mass Flow Rate** in Kilogram per Second (kg/s)
  Mass Flow Rate Unit Conversion
- Measurement: **Specific Energy** in Kilojoule per Kilogram (kJ/kg)
  Specific Energy Unit Conversion

- **V_b** Speed of Object *(Meter per Second)*
- **W** Work Ratio
- **W_c** Compressor Work *(Kilojoule)*
- **W_{Net}** Net Work Output *(Kilojoule)*
- **$W_p max$** Maximum Work done in Brayton Cycle *(Kilojoule)*
- **W_T** Turbine Work *(Kilojoule)*
- **β** Bypass Ratio
- **γ** Specific Heat Ratio
- **η_c** Compressor Efficiency
- **η_{cycle}** Efficiency of Cycle
- **$\eta_{joule\ cycle}$** Efficiency of Joule Cycle
- **$\eta_{turbine}$** Turbine Efficiency
- **μ** Mach Angle *(Degree)*

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