Important Convection Heat Transfer Formulas PDF

Formulas
Examples
with Units

List of 31
Important Convection Heat Transfer Formulas

1) Correlation for Local Nusselt Number for Laminar Flow on Isothermal Flat Plate Formula

Evaluate Formula

Formula

$$Nu_x = \frac{0.3387 \cdot \left(Re_l^{\frac{1}{2}}\right) \cdot \left(Pr^{\frac{1}{3}}\right)}{\left(1 + \left(\left(\frac{0.0468}{Pr}\right)^{\frac{2}{3}}\right)\right)^{\frac{1}{4}}}$$

Example

$$0.4829 = \frac{0.3387 \cdot \left(0.55^{\frac{1}{2}}\right) \cdot \left(7.29^{\frac{1}{3}}\right)}{\left(1 + \left(\left(\frac{0.0468}{7.29}\right)^{\frac{2}{3}}\right)\right)^{\frac{1}{4}}}$$

2) Correlation for Nusselt Number for Constant Heat Flux Formula

Evaluate Formula

Formula

$$Nu_x = \frac{0.4637 \cdot \left(Re_l^{\frac{1}{2}}\right) \cdot \left(Pr^{\frac{1}{3}}\right)}{\left(1 + \left(\left(\frac{0.0207}{Pr}\right)^{\frac{2}{3}}\right)\right)^{\frac{1}{4}}}$$

Example

$$0.6635 = \frac{0.4637 \cdot \left(0.55^{\frac{1}{2}}\right) \cdot \left(7.29^{\frac{1}{3}}\right)}{\left(1 + \left(\left(\frac{0.0207}{7.29}\right)^{\frac{2}{3}}\right)\right)^{\frac{1}{4}}}$$

3) Drag Coefficient for Bluff Bodies Formula

Evaluate Formula

Formula

$$C_D = \frac{2 \cdot F_D}{A \cdot \rho_{Fluid} \cdot \left(u_\infty^2\right)}$$

Example with Units

$$0.4043 = \frac{2 \cdot 80\,\text{N}}{2.67\,\text{m}^2 \cdot 1.225\,\text{kg/m}^3 \cdot \left(11\,\text{m/s}^2\right)}$$

4) Drag Force for Bluff Bodies Formula

Evaluate Formula

Formula

$$F_D = \frac{C_D \cdot A \cdot \rho_{Fluid} \cdot \left(u_\infty^2\right)}{2}$$

Example with Units

$$79.9437\,\text{N} = \frac{0.404 \cdot 2.67\,\text{m}^2 \cdot 1.225\,\text{kg/m}^3 \cdot \left(11\,\text{m/s}^2\right)}{2}$$

5) Friction Coefficient given Shear Stress at Wall Formula

Evaluate Formula

Formula

$$C_f = \frac{\tau_w \cdot 2}{\rho_{Fluid} \cdot \left(u_\infty^2 \right)}$$

Example with Units

$$0.0742 = \frac{5.5\,\text{Pa} \cdot 2}{1.225\,\text{kg/m}^3 \cdot \left(11\,\text{m/s}^2 \right)}$$

6) Friction Factor given Reynolds Number for Flow in Smooth Tubes Formula

Evaluate Formula

Formula

$$f = \frac{0.316}{\left(Re_d \right)^{\frac{1}{4}}}$$

Example

$$0.0461 = \frac{0.316}{\left(2200 \right)^{\frac{1}{4}}}$$

7) Friction Factor given Stanton Number for Turbulent Flow in Tube Formula

Evaluate Formula

Formula

$$f = 8 \cdot St$$

Example

$$0.045 = 8 \cdot 0.005625$$

8) Local Friction Coefficient given Local Reynolds Number Formula

Evaluate Formula

Formula

$$C_{fx} = 2 \cdot 0.332 \cdot \left(Re_l^{-0.5} \right)$$

Example

$$0.8953 = 2 \cdot 0.332 \cdot \left(0.55^{-0.5} \right)$$

9) Local Nusselt Number for Constant Heat Flux given Prandtl Number Formula

Evaluate Formula

Formula

$$Nu_x = 0.453 \cdot \left(Re_l^{\frac{1}{2}} \right) \cdot \left(Pr^{\frac{1}{3}} \right)$$

Example

$$0.6514 = 0.453 \cdot \left(0.55^{\frac{1}{2}} \right) \cdot \left(7.29^{\frac{1}{3}} \right)$$

10) Local Nusselt Number for Plate Heated over its Entire Length Formula

Evaluate Formula

Formula

$$Nu_x = 0.332 \cdot \left(Pr^{\frac{1}{3}} \right) \cdot \left(Re_l^{\frac{1}{2}} \right)$$

Example

$$0.4774 = 0.332 \cdot \left(7.29^{\frac{1}{3}} \right) \cdot \left(0.55^{\frac{1}{2}} \right)$$

11) Local Skin Friction Coefficient for Turbulent Flow on Flat Plates Formula

Evaluate Formula

Formula

$$C_{fx} = 0.0592 \cdot \left(Re_l^{-\frac{1}{5}} \right)$$

Example

$$0.0667 = 0.0592 \cdot \left(0.55^{-\frac{1}{5}} \right)$$

12) Local Stanton Number Formula

Evaluate Formula

Formula

$$St_x = \frac{h_x}{\rho_{Fluid} \cdot C_p \cdot u_\infty}$$

Example with Units

$$2.3786 = \frac{40\,\text{W/m}^2\text{*K}}{1.225\,\text{kg/m}^3 \cdot 1.248\,\text{J/(kg*K)} \cdot 11\,\text{m/s}}$$

13) Local Stanton Number given Local Friction Coefficient Formula

Evaluate Formula

Formula

$$St_x = \frac{C_{fx}}{2 \cdot \left(Pr^{\frac{2}{3}} \right)}$$

Example

$$0.1037 = \frac{0.78}{2 \cdot \left(7.29^{\frac{2}{3}} \right)}$$

14) Local Stanton Number given Prandtl Number Formula

Evaluate Formula

Formula

$$St_x = \frac{0.332 \cdot \left(Re_l^{\frac{1}{2}} \right)}{Pr^{\frac{2}{3}}}$$

Example

$$0.0655 = \frac{0.332 \cdot \left(0.55^{\frac{1}{2}} \right)}{7.29^{\frac{2}{3}}}$$

15) Local Velocity of Sound Formula

Evaluate Formula

Formula

$$a = \sqrt{\left(\gamma \cdot [R] \cdot T_m \right)}$$

Example with Units

$$201.0181 \text{ m/s} = \sqrt{\left(16.2 \cdot 8.3145 \cdot 300 \text{ K} \right)}$$

16) Local Velocity of Sound when Air Behaves as Ideal Gas Formula

Evaluate Formula

Formula

$$a = 20.045 \cdot \sqrt{\left(T_m \right)}$$

Example with Units

$$347.1896 \text{ m/s} = 20.045 \cdot \sqrt{\left(300 \text{ K} \right)}$$

17) Mass Flow Rate from Continuity Relation for One Dimensional Flow in Tube Formula

Evaluate Formula

Formula

$$\dot{m} = \rho_{Fluid} \cdot A_T \cdot u_m$$

Example with Units

$$133.7455 \text{ kg/s} = 1.225 \text{ kg/m}^3 \cdot 10.3 \text{ m}^2 \cdot 10.6 \text{ m/s}$$

18) Mass Flow Rate given Mass Velocity Formula

Evaluate Formula

Formula

$$\dot{m} = G \cdot A_T$$

Example with Units

$$133.9 \text{ kg/s} = 13 \text{ kg/s/m}^2 \cdot 10.3 \text{ m}^2$$

19) Mass Velocity Formula

Evaluate Formula

Formula

$$G = \frac{\dot{m}}{A_T}$$

Example with Units

$$13 \text{ kg/s/m}^2 = \frac{133.9 \text{ kg/s}}{10.3 \text{ m}^2}$$

20) Mass Velocity given Mean Velocity Formula

Evaluate Formula

Formula

$$G = \rho_{Fluid} \cdot u_m$$

Example with Units

$$12.985 \text{ kg/s/m}^2 = 1.225 \text{ kg/m}^3 \cdot 10.6 \text{ m/s}$$

21) Mass Velocity given Reynolds Number Formula

Evaluate Formula

Formula

$$G = \frac{Re_d \cdot \mu}{d}$$

Example with Units

$$13.5802\,\text{kg/s/m}^2 = \frac{2200 \cdot 0.6\,\text{P}}{9.72\,\text{m}}$$

22) Nusselt Number for Plate heated over its Entire Length Formula

Evaluate Formula

Formula

$$Nu_L = 0.664 \cdot \left(\left(Re_L \right)^{\frac{1}{2}} \right) \cdot \left(Pr^{\frac{1}{3}} \right)$$

Example

$$5.7578 = 0.664 \cdot \left(\left(20 \right)^{\frac{1}{2}} \right) \cdot \left(7.29^{\frac{1}{3}} \right)$$

23) Nusselt Number for Turbulent Flow in Smooth Tube Formula

Evaluate Formula

Formula

$$Nu_d = 0.023 \cdot \left(Re_d^{0.8} \right) \cdot \left(Pr^{0.4} \right)$$

Example

$$24.0302 = 0.023 \cdot \left(2200^{0.8} \right) \cdot \left(7.29^{0.4} \right)$$

24) Prandtl Number given Recovery Factor for Gases for Laminar Flow Formula

Evaluate Formula

Formula

$$Pr = \left(r^2 \right)$$

Example

$$6.25 = \left(2.5^2 \right)$$

25) Recovery Factor Formula

Evaluate Formula

Formula

$$r = \left(\frac{T_{aw} - T_\infty}{T_o - T_\infty} \right)$$

Example with Units

$$1.8889 = \left(\frac{410\,\text{K} - 325\,\text{K}}{370\,\text{K} - 325\,\text{K}} \right)$$

26) Recovery Factor for Gases with Prandtl Number near Unity under Laminar Flow Formula

Evaluate Formula

Formula

$$r = Pr^{\frac{1}{2}}$$

Example

$$2.7 = 7.29^{\frac{1}{2}}$$

27) Recovery Factor for Gases with Prandtl Number near Unity under Turbulent Flow Formula

Evaluate Formula

Formula

$$r = Pr^{\frac{1}{3}}$$

Example

$$1.939 = 7.29^{\frac{1}{3}}$$

28) Reynolds Number given Friction Factor for Flow in Smooth Tubes Formula

Evaluate Formula

Formula

$$Re_d = \left(\frac{0.316}{f}\right)^4$$

Example

$$2431.6344 = \left(\frac{0.316}{0.045}\right)^4$$

29) Reynolds Number given Mass Velocity Formula

Evaluate Formula

Formula

$$Re_d = \frac{G \cdot d}{\mu}$$

Example with Units

$$2106 = \frac{13\,\text{kg/s/m}^2 \cdot 9.72\,\text{m}}{0.6\,\text{P}}$$

30) Shear Stress at Wall given Friction Coefficient Formula

Evaluate Formula

Formula

$$\tau_w = \frac{C_f \cdot \rho_{Fluid} \cdot \left(u_\infty^{\,2}\right)}{2}$$

Example with Units

$$5.4843\,\text{Pa} = \frac{0.074 \cdot 1.225\,\text{kg/m}^3 \cdot \left(11\,\text{m/s}^{\,2}\right)}{2}$$

31) Stanton Number given Friction Factor for Turbulent Flow in Tube Formula

Evaluate Formula

Formula

$$St = \frac{f}{8}$$

Example

$$0.0056 = \frac{0.045}{8}$$

Variables used in list of Convection Heat Transfer Formulas above

- **a** Local Velocity of Sound *(Meter per Second)*
- **A** Frontal Area *(Square Meter)*
- A_T Cross Sectional Area *(Square Meter)*
- C_D Drag Coefficient
- C_f Friction Coefficient
- C_{fx} Local Friction Coefficient
- C_p Specific Heat at Constant Pressure *(Joule per Kilogram per K)*
- **d** Diameter of Tube *(Meter)*
- **f** Fanning Friction Factor
- F_D Drag Force *(Newton)*
- **G** Mass Velocity *(Kilogram per Second per Square Meter)*
- h_x Local Heat Transfer Coefficient *(Watt per Square Meter per Kelvin)*
- $\dot{m}$ Mass Flow Rate *(Kilogram per Second)*
- Nu_d Nusselt Number
- Nu_L Nusselt Number at Location L
- Nu_x Local Nusselt number
- **Pr** Prandtl Number
- **r** Recovery Factor
- Re_d Reynolds Number in Tube
- Re_l Local Reynolds Number
- Re_L Reynolds Number
- **St** Stanton Number
- St_x Local Stanton Number
- T_∞ Static Temperature of Free Stream *(Kelvin)*
- T_{aw} Adiabatic Wall Temperature *(Kelvin)*
- T_m Temperature of Medium *(Kelvin)*
- T_o Stagnation Temperature *(Kelvin)*
- u_∞ Free Stream Velocity *(Meter per Second)*
- u_m Mean velocity *(Meter per Second)*
- **γ** Ratio of Specific Heat Capacities

Constants, Functions, Measurements used in list of Convection Heat Transfer Formulas above

- constant(s): **[R]**, 8.31446261815324
  Universal gas constant
- 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: **Length** in Meter (m)
  Length Unit Conversion
- Measurement: **Temperature** in Kelvin (K)
  Temperature Unit Conversion
- Measurement: **Area** in Square Meter (m²)
  Area Unit Conversion
- Measurement: **Speed** in Meter per Second (m/s)
  Speed Unit Conversion
- Measurement: **Force** in Newton (N)
  Force 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: **Heat Transfer Coefficient** in Watt per Square Meter per Kelvin (W/m²*K)
  Heat Transfer Coefficient Unit Conversion
- Measurement: **Dynamic Viscosity** in Poise (P)
  Dynamic Viscosity Unit Conversion
- Measurement: **Density** in Kilogram per Cubic Meter (kg/m³)
  Density Unit Conversion
- Measurement: **Mass Velocity** in Kilogram per Second per Square Meter (kg/s/m²)
  Mass Velocity Unit Conversion
- Measurement: **Stress** in Pascal (Pa)
  Stress Unit Conversion

- **μ** Dynamic Viscosity *(Poise)*
- ρ_{Fluid} Density of Fluid *(Kilogram per Cubic Meter)*
- τ_w Shear Stress *(Pascal)*

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