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Convection Heat Transfer Formulas

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List of 31 Convection Heat Transfer Formulas

Convection Heat Transfer

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

$$\text{fx } Nu_x = \frac{0.3387 \cdot \left(Re_1^{\frac{1}{2}}\right) \cdot \left(Pr^{\frac{1}{3}}\right)}{\left(1 + \left(\left(\frac{0.0468}{Pr}\right)^{\frac{2}{3}}\right)\right)^{\frac{1}{4}}}$$

[Open Calculator !\[\]\(a870788d6ed9b8fd294b7654a8c8526b_img.jpg\)](#)

$$\text{ex } 0.482931 = \frac{0.3387 \cdot \left((0.55)^{\frac{1}{2}}\right) \cdot \left((7.29)^{\frac{1}{3}}\right)}{\left(1 + \left(\left(\frac{0.0468}{7.29}\right)^{\frac{2}{3}}\right)\right)^{\frac{1}{4}}}$$

2) Correlation for Nusselt Number for Constant Heat Flux

$$\text{fx } Nu_x = \frac{0.4637 \cdot \left(Re_1^{\frac{1}{2}}\right) \cdot \left(Pr^{\frac{1}{3}}\right)}{\left(1 + \left(\left(\frac{0.0207}{Pr}\right)^{\frac{2}{3}}\right)\right)^{\frac{1}{4}}}$$

[Open Calculator !\[\]\(c50c8b7b2cc2cf9ff925edec0ee94c0d_img.jpg\)](#)

$$\text{ex } 0.663497 = \frac{0.4637 \cdot \left((0.55)^{\frac{1}{2}}\right) \cdot \left((7.29)^{\frac{1}{3}}\right)}{\left(1 + \left(\left(\frac{0.0207}{7.29}\right)^{\frac{2}{3}}\right)\right)^{\frac{1}{4}}}$$



3) Drag Coefficient for Bluff Bodies

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

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

$$ex \quad 0.404285 = \frac{2 \cdot 80N}{2.67m^2 \cdot 1.225kg/m^3 \cdot ((11m/s)^2)}$$

4) Drag Force for Bluff Bodies

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

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

$$ex \quad 79.94367N = \frac{0.404 \cdot 2.67m^2 \cdot 1.225kg/m^3 \cdot ((11m/s)^2)}{2}$$


5) Friction Coefficient given Shear Stress at Wall

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

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

$$ex \quad 0.074212 = \frac{5.5Pa \cdot 2}{1.225kg/m^3 \cdot ((11m/s)^2)}$$



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

$$f_x = \frac{0.316}{(\text{Re}_d)^{\frac{1}{4}}}$$

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

$$\text{ex } 0.04614 = \frac{0.316}{(2200)^{\frac{1}{4}}}$$

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

$$f_x = 8 \cdot \text{St}$$

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

$$\text{ex } 0.045 = 8 \cdot 0.005625$$

8) Local Friction Coefficient given Local Reynolds Number 

$$f_x C_{fx} = 2 \cdot 0.332 \cdot (\text{Re}_1^{-0.5})$$

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

$$\text{ex } 0.895337 = 2 \cdot 0.332 \cdot ((0.55)^{-0.5})$$

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

$$f_x \text{Nu}_x = 0.453 \cdot (\text{Re}_1^{\frac{1}{2}}) \cdot (\text{Pr}^{\frac{1}{3}})$$

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

$$\text{ex } 0.651411 = 0.453 \cdot ((0.55)^{\frac{1}{2}}) \cdot ((7.29)^{\frac{1}{3}})$$



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

$$fx \quad Nu_x = 0.332 \cdot \left(Pr^{\frac{1}{3}} \right) \cdot \left(Re_1^{\frac{1}{2}} \right)$$

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

$$ex \quad 0.477414 = 0.332 \cdot \left((7.29)^{\frac{1}{3}} \right) \cdot \left((0.55)^{\frac{1}{2}} \right)$$

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

$$fx \quad C_{fx} = 0.0592 \cdot \left(Re_1^{-\frac{1}{5}} \right)$$

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

$$ex \quad 0.066719 = 0.0592 \cdot \left((0.55)^{-\frac{1}{5}} \right)$$

12) Local Stanton Number

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

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

$$ex \quad 2.378574 = \frac{40W/m^2 \cdot K}{1.225kg/m^3 \cdot 1.248J/(kg \cdot K) \cdot 11m/s}$$

13) Local Stanton Number given Local Friction Coefficient

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

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

$$ex \quad 0.103732 = \frac{0.78}{2 \cdot \left((7.29)^{\frac{2}{3}} \right)}$$



14) Local Stanton Number given Prandtl Number

$$\text{fx } St_x = \frac{0.332 \cdot \left(Re_1^{\frac{1}{2}} \right)}{Pr^{\frac{2}{3}}}$$

[Open Calculator !\[\]\(d3fb9f94af8b26d1c844efa9a98805b0_img.jpg\)](#)

$$\text{ex } 0.065489 = \frac{0.332 \cdot \left((0.55)^{\frac{1}{2}} \right)}{(7.29)^{\frac{2}{3}}}$$

15) Local Velocity of Sound

$$\text{fx } a = \sqrt{(\gamma \cdot [R] \cdot T_m)}$$

[Open Calculator !\[\]\(e1d6102fe77919492c04879c8450f1f5_img.jpg\)](#)

$$\text{ex } 201.0181\text{m/s} = \sqrt{(16.2 \cdot [R] \cdot 300\text{K})}$$

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

$$\text{fx } a = 20.045 \cdot \sqrt{(T_m)}$$

[Open Calculator !\[\]\(ab4e2b3fc7e7887b7a72f548aa6f5e60_img.jpg\)](#)

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


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

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

[Open Calculator !\[\]\(5abce1a84a655b073239ab33e1199487_img.jpg\)](#)

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



18) Mass Flow Rate given Mass Velocity 

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

[Open Calculator !\[\]\(9dfdaff1d86ba3c1f8353b4d1b61b8c5_img.jpg\)](#)


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

19) Mass Velocity 

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

[Open Calculator !\[\]\(2b376d1a92330ab09dad2665d2f89bf5_img.jpg\)](#)


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

20) Mass Velocity given Mean Velocity 

$$fx \quad G = \rho_{\text{Fluid}} \cdot u_m$$

[Open Calculator !\[\]\(c444627dab9fee9a1550c053ffaaaae2_img.jpg\)](#)

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

21) Mass Velocity given Reynolds Number 

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

[Open Calculator !\[\]\(06a315363e7801bba8c7489a6694af19_img.jpg\)](#)

$$ex \quad 13.58025\text{kg/s/m}^2 = \frac{2200 \cdot 0.6\text{P}}{9.72\text{m}}$$



22) Nusselt Number for Plate heated over its Entire Length

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

[Open Calculator !\[\]\(6605b201d6f14d9b3bcb8ab5f274d107_img.jpg\)](#)

$$ex \quad 5.757831 = 0.664 \cdot \left((20)^{\frac{1}{2}} \right) \cdot \left((7.29)^{\frac{1}{3}} \right)$$

23) Nusselt Number for Turbulent Flow in Smooth Tube

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

[Open Calculator !\[\]\(e8fb589d58dad1692debababa5e928b6_img.jpg\)](#)

$$ex \quad 24.03018 = 0.023 \cdot \left((2200)^{0.8} \right) \cdot \left((7.29)^{0.4} \right)$$

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

$$fx \quad Pr = (r^2)$$

[Open Calculator !\[\]\(4688aadfd656ded00cd6bdfae55089a9_img.jpg\)](#)

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

25) Recovery Factor

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

[Open Calculator !\[\]\(4146d17f71dced09c6ad789cacceaa6d_img.jpg\)](#)

$$ex \quad 1.888889 = \left(\frac{410K - 325K}{370K - 325K} \right)$$



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

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

[Open Calculator !\[\]\(c3d993ca47bfe2a953c700506ce31fa0_img.jpg\)](#)

$$ex \quad 2.7 = (7.29)^{\frac{1}{2}}$$

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

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

[Open Calculator !\[\]\(17413706fd4997a1a4bdf85c6864eee1_img.jpg\)](#)

$$ex \quad 1.938991 = (7.29)^{\frac{1}{3}}$$

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

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

[Open Calculator !\[\]\(4b7a79268f6ba26c1471d4232fffa85a_img.jpg\)](#)

$$ex \quad 2431.634 = \left(\frac{0.316}{0.045} \right)^4$$

29) Reynolds Number given Mass Velocity

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

[Open Calculator !\[\]\(3342c215b2a8b663596a81468d5dc314_img.jpg\)](#)

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



30) Shear Stress at Wall given Friction Coefficient

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

[Open Calculator !\[\]\(0f848bbd71cef6b345273b16f905912a_img.jpg\)](#)

$$\text{ex } 5.484325 \text{ Pa} = \frac{0.074 \cdot 1.225 \text{ kg/m}^3 \cdot ((11 \text{ m/s})^2)}{2}$$

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

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

[Open Calculator !\[\]\(3211b5d1d968fc1665909b34f9f16010_img.jpg\)](#)

$$\text{ex } 0.005625 = \frac{0.045}{8}$$



Variables Used











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



Constants, Functions, Measurements used

- **Constant:** [R], 8.31446261815324 Joule / Kelvin * Mole
Universal gas constant
- **Function:** sqrt, sqrt(Number)
Square root function
- **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 



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- [Basics of Modes of Heat Transfer Formulas](#) 
- [Convection Heat Transfer Formulas](#) 

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