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Unsteady State Heat Conduction Formulas

Calculators! Examples! Conversions!

List of 18 Unsteady State Heat Conduction Formulas

Unsteady State Heat Conduction

1) Biot Number given Characteristic Dimension and Fourier Number

Open Calculator

fx $$\mathrm{Bi} = \frac{h \cdot \tau}{\rho_B \cdot c \cdot s \cdot F_o}$$

ex $$110.0234 = \frac{10\mathrm{W/m^2{*}K} \cdot 1937\mathrm{s}}{15\mathrm{kg/m^3} \cdot 1.5\mathrm{J/(kg{*}K)} \cdot 6.9\mathrm{m} \cdot 1.134}$$

2) Biot Number given Heat Transfer Coefficient and Time Constant

Open Calculator

fx $$\mathrm{Bi} = \frac{h \cdot A_c \cdot \tau}{\rho_B \cdot c \cdot V \cdot F_o}$$

ex $$0.911086 = \frac{10\mathrm{W/m^2{*}K} \cdot 0.00785\mathrm{m^2} \cdot 1937\mathrm{s}}{15\mathrm{kg/m^3} \cdot 1.5\mathrm{J/(kg{*}K)} \cdot 6.541\mathrm{m^3} \cdot 1.134}$$

3) Biot Number using Fourier Number

Open Calculator

fx $$\mathrm{Bi} = \left(-\frac{1}{F_o}\right) \cdot \ln\left(\frac{T - T_\infty}{T_0 - T_\infty}\right)$$

ex $$0.765119 = \left(-\frac{1}{1.134}\right) \cdot \ln\left(\frac{589\mathrm{K} - 373\mathrm{K}}{887.36\mathrm{K} - 373\mathrm{K}}\right)$$

4) Biot Number using Heat Transfer Coefficient

Open Calculator

fx $$\mathrm{Bi} = \frac{h \cdot \ell}{k}$$

ex $$23.16279 = \frac{10\mathrm{W/m^2{*}K} \cdot 4.98\mathrm{m}}{2.15\mathrm{W/(m{*}K)}}$$

5) Capacitance of Thermal System by Lumped Heat Capacity Method

Open Calculator

fx $$C_{Th} = \rho_B \cdot c \cdot V$$

ex $$147.1725\mathrm{J/K} = 15\mathrm{kg/m^3} \cdot 1.5\mathrm{J/(kg{*}K)} \cdot 6.541\mathrm{m^3}$$

6) Fourier Number

Open Calculator

fx $F_o = \frac{\alpha \cdot \tau_c}{s^2}$

ex $0.293006 = \frac{5.58\text{m}^2/\text{s} \cdot 2.5\text{s}}{(6.9\text{m})^2}$

7) Fourier Number given Characteristic Dimension and Biot Number

Open Calculator

fx $F_o = \frac{h \cdot \tau}{\rho_B \cdot c \cdot s \cdot Bi}$

ex $4.595451 = \frac{10\text{W/m}^2\text{*K} \cdot 1937\text{s}}{15\text{kg/m}^3 \cdot 1.5\text{J/(kg*K)} \cdot 6.9\text{m} \cdot 27.15}$

8) Fourier Number given Heat Transfer Coefficient and Time Constant

Open Calculator

fx $F_o = \frac{h \cdot A_c \cdot \tau}{\rho_B \cdot c \cdot V \cdot Bi}$

ex $0.038054 = \frac{10\text{W/m}^2\text{*K} \cdot 0.00785\text{m}^2 \cdot 1937\text{s}}{15\text{kg/m}^3 \cdot 1.5\text{J/(kg*K)} \cdot 6.541\text{m}^3 \cdot 27.15}$

9) Fourier Number using Biot Number

Open Calculator

fx $F_o = \left(-\frac{1}{Bi}\right) \cdot \ln\left(\frac{T - T_\infty}{T_0 - T_\infty}\right)$

ex $0.031957 = \left(-\frac{1}{27.15}\right) \cdot \ln\left(\frac{589\text{K} - 373\text{K}}{887.36\text{K} - 373\text{K}}\right)$

10) Fourier Number using Thermal Conductivity

Open Calculator

fx $F_o = \left(\frac{k \cdot \tau_c}{\rho_B \cdot c \cdot (s^2)}\right)$

ex $0.005018 = \left(\frac{2.15\text{W/(m*K)} \cdot 2.5\text{s}}{15\text{kg/m}^3 \cdot 1.5\text{J/(kg*K)} \cdot \left((6.9\text{m})^2\right)}\right)$

11) Initial Internal Energy Content of Body in Reference to Environment Temperature

Open Calculator

fx $Q_o = \rho_B \cdot c \cdot V \cdot (T_i - T_{amb})$

ex $21781.53\text{J} = 15\text{kg/m}^3 \cdot 1.5\text{J/(kg*K)} \cdot 6.541\text{m}^3 \cdot (600\text{K} - 452\text{K})$

12) Initial Temperature of Body by Lumped Heat Capacity Method

Open Calculator

fx $$T_0 = \frac{T - T_\infty}{\exp\left(\frac{-h \cdot A_c \cdot \tau}{\rho_B \cdot c \cdot V}\right)} + T_\infty$$

ex $$979.9524K = \frac{589K - 373K}{\exp\left(\frac{-10W/m^2*K \cdot 0.00785m^2 \cdot 1937s}{15kg/m^3 \cdot 1.5J/(kg*K) \cdot 6.541m^3}\right)} + 373K$$

13) Temperature of Body by Lumped Heat Capacity Method

Open Calculator

fx $$T = \left(\exp\left(\frac{-h \cdot A_c \cdot \tau}{\rho_B \cdot c \cdot V}\right)\right) \cdot (T_0 - T_\infty) + T_\infty$$

ex $$556.0486K = \left(\exp\left(\frac{-10W/m^2*K \cdot 0.00785m^2 \cdot 1937s}{15kg/m^3 \cdot 1.5J/(kg*K) \cdot 6.541m^3}\right)\right) \cdot (887.36K - 373K) + 373K$$

14) Temperature Response of Instantaneous Energy Pulse in Semi Infinite Solid

Open Calculator

fx $$T = T_i + \left(\frac{Q}{A \cdot \rho_B \cdot c \cdot (\pi \cdot \alpha \cdot \tau)^{0.5}}\right) \cdot \exp\left(\frac{-x^2}{4 \cdot \alpha \cdot \tau}\right)$$

ex $$600.0201K = 600K + \left(\frac{4200J}{50.3m^2 \cdot 15kg/m^3 \cdot 1.5J/(kg*K) \cdot (\pi \cdot 5.58m^2/s \cdot 1937s)^{0.5}}\right) \cdot \exp\left(\frac{-(0.02m)^2}{4 \cdot 5.58m^2/s \cdot 193'}\right.$$

15) Temperature Response of Instantaneous Energy Pulse in Semi Infinite Solid at Surface

Open Calculator

fx $$T = T_i + \left(\frac{Q}{A \cdot \rho_B \cdot c \cdot (\pi \cdot \alpha \cdot \tau)^{0.5}}\right)$$

ex $$600.0201K = 600K + \left(\frac{4200J}{50.3m^2 \cdot 15kg/m^3 \cdot 1.5J/(kg*K) \cdot (\pi \cdot 5.58m^2/s \cdot 1937s)^{0.5}}\right)$$

16) Thermal Conductivity given Biot Number

Open Calculator

fx $$k = \frac{h \cdot \ell}{Bi}$$

ex $$1.834254W/(m*K) = \frac{10W/m^2*K \cdot 4.98m}{27.15}$$

17) Time Constant of Thermal System

Open Calculator

fx $$\tau = \frac{\rho_B \cdot c \cdot V}{h \cdot A_c}$$

ex $$1874.809s = \frac{15kg/m^3 \cdot 1.5J/(kg^*K) \cdot 6.541m^3}{10W/m^2{}^*K \cdot 0.00785m^2}$$

18) Time Taken by Object for Heating or Cooling by Lumped Heat Capacity Method

Open Calculator

fx $$\tau = \left(\frac{-\rho_B \cdot c \cdot V}{h \cdot A_c}\right) \cdot \ln\left(\frac{T - T_\infty}{T_0 - T_\infty}\right)$$

ex $$1626.669s = \left(\frac{-15kg/m^3 \cdot 1.5J/(kg^*K) \cdot 6.541m^3}{10W/m^2{}^*K \cdot 0.00785m^2}\right) \cdot \ln\left(\frac{589K - 373K}{887.36K - 373K}\right)$$

Variables Used

- **A** Area *(Square Meter)*
- **A_c** Surface Area for Convection *(Square Meter)*
- **Bi** Biot Number
- **c** Specific Heat Capacity *(Joule per Kilogram per K)*
- **C_{Th}** Capacitance of Thermal System *(Joule per Kelvin)*
- **F_o** Fourier Number
- **h** Heat Transfer Coefficient *(Watt per Square Meter per Kelvin)*
- **k** Thermal Conductivity *(Watt per Meter per K)*
- **Q** Heat Energy *(Joule)*
- **Q_o** Initial Energy Content *(Joule)*
- **s** Characteristic Dimension *(Meter)*
- **T** Temperature at Any Time T *(Kelvin)*
- **T_0** Initial Temperature of Object *(Kelvin)*
- **T_∞** Temperature of Bulk Fluid *(Kelvin)*
- **T_{amb}** Ambient Temperature *(Kelvin)*
- **T_i** Initial Temperature of Solid *(Kelvin)*
- **V** Volume of Object *(Cubic Meter)*
- **x** Depth of Semi Infinite Solid *(Meter)*
- **α** Thermal Diffusivity *(Square Meter Per Second)*
- **ρ_B** Density of Body *(Kilogram per Cubic Meter)*
- **ℓ** Thickness of Wall *(Meter)*
- **τ** Time Constant *(Second)*
- **τ_c** Characteristic Time *(Second)*

Constants, Functions, Measurements used

- Constant: **pi**, 3.14159265358979323846264338327950288
  Archimedes' constant
- Function: **exp**, exp(Number)
  Exponential function
- Function: **ln**, ln(Number)
  Natural logarithm function (base e)
- Measurement: **Length** in Meter (m)
  Length Unit Conversion
- Measurement: **Time** in Second (s)
  Time Unit Conversion
- Measurement: **Temperature** in Kelvin (K)
  Temperature Unit Conversion
- Measurement: **Volume** in Cubic Meter (m^3)
  Volume Unit Conversion
- Measurement: **Area** in Square Meter (m^2)
  Area Unit Conversion
- Measurement: **Energy** in Joule (J)
  Energy Unit Conversion
- Measurement: **Thermal Conductivity** in Watt per Meter per K (W/(m*K))
  Thermal Conductivity Unit Conversion
- Measurement: **Specific Heat Capacity** in Joule per Kilogram per K (J/(kg*K))
  Specific Heat Capacity Unit Conversion
- Measurement: **Heat Transfer Coefficient** in Watt per Square Meter per Kelvin (W/m^2*K)
  Heat Transfer Coefficient Unit Conversion
- Measurement: **Density** in Kilogram per Cubic Meter (kg/m^3)
  Density Unit Conversion
- Measurement: **Diffusivity** in Square Meter Per Second (m^2/s)
  Diffusivity Unit Conversion
- Measurement: **Entropy** in Joule per Kelvin (J/K)
  Entropy Unit Conversion

Check other formula lists

- Basics of Heat Transfer Formulas
- Co-Relation of Dimensionless Numbers Formulas
- Heat Exchanger Formulas
- Heat Exchanger and its Effectiveness Formulas
- Heat Transfer from Extended Surfaces (Fins) Formulas
- Heat Transfer from Extended Surfaces (Fins), Critical Thickness of Insulation and Thermal Resistance Formulas
- Thermal Resistance Formulas
- Unsteady State Heat Conduction Formulas

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