Transient Conduction in a Slab, Cylinder or Sphere (One-Term Series)

Centre and surface temperatures and heat removed from a plane wall, long cylinder or sphere suddenly exposed to convection, by the one-term series solution.

Method: One-term approximation of the exact series solutions (Heisler charts in equation form)

Input parameters

Unit system: SI

Parameter	Value	Unit
Shape	Plane wall (L = half-thickness)	
Half-thickness or radius	50.000	mm
Thermal conductivity	40.000	W/(m·K)
Density	7,800.0	kg/m³
Specific heat	0.48000	kJ/(kg·K)
Surface heat transfer coefficient	300.00	W/(m²·K)
Initial uniform temperature	600.00	°C
Fluid temperature	30.000	°C
Time	30.000	min

Calculated results

Parameter	Value	Unit
Biot number hL/k	0.37500	
Fourier number αt/L²	7.6923	
First eigenvalue	0.57662	
First coefficient	1.0549	
Dimensionless centre temperature	0.081743	
Centre temperature	76.594	°C
Surface temperature	69.060	°C
Fraction of the maximum heat transferred	92.271	%

Notes for this case

- One-term approximation of the exact series: within about 2 % for Fo > 0.2.

Formula and method

$$\theta^* = \frac{T - T_\infty}{T_i - T_\infty} = C_1 e^{-\zeta_1^2 Fo} f(\zeta_1 x^*), \quad Bi = \frac{hL}{k}, \; Fo = \frac{\alpha t}{L^2}$$

$$\text{wall}: \; \zeta_1 \tan\zeta_1 = Bi, \quad \text{cylinder}: \; \zeta_1 \frac{J_1(\zeta_1)}{J_0(\zeta_1)} = Bi, \quad \text{sphere}: \; 1 - \zeta_1 \cot\zeta_1 = Bi$$

Variables

shape	Shape	-
L	Half-thickness or radius	m

k	Thermal conductivity	W/(m·K)
ρ	Density	kg/m³
c_p	Specific heat	J/(kg·K)
h	Surface heat transfer coefficient	W/(m²·K)
T_i	Initial uniform temperature	K
T_∞	Fluid temperature	K
t	Time	s
Bi	Biot number hL/k	-
Fo	Fourier number αt/L²	-
ζ_1	First eigenvalue	-
C_1	First coefficient	-
θ_0^*	Dimensionless centre temperature	-
T_0	Centre temperature	K
T_s	Surface temperature	K
Q/Q_0	Fraction of the maximum heat transferred	-

Method and standards

One-term series solution of transient conduction with convection at the surface.

Assumptions and limits

- Constant properties, uniform initial temperature, uniform h, no heat generation.

References

One-term approximation of the exact series solutions (Heisler charts in equation form)

Report details

Report reference	FCC-MJFZ-MPWY (the same inputs always give the same reference)
Generated	23 November 2026, 18:08 UTC
Calculator	Transient Conduction in a Slab, Cylinder or Sphere (One-Term Series)
Method last reviewed	17 November 2026
Software release	FireCAD Calc, release of 22 November 2026
Release checks	3 reference cases of this calculator, computed independently, are checked on every release

Results are for engineering estimation. Verify critical designs against the referenced standards and your own data.

This calculator online

https://calc.firecad.com/mechanical/heat-transfer/transient-conduction-one-term

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.