Ground Temperature at Depth through the Year (Kusuda)

Undisturbed ground temperature at a depth and day of the year from the annual mean and swing at the surface and the soil diffusivity, with damping and time lag.

Method: Kusuda–Achenbach periodic ground temperature

Input parameters

Unit system: SI

Parameter	Value	Unit
Mean annual surface temperature	26.000	°C
Annual surface temperature amplitude	8.0000	K
Soil thermal diffusivity	5.0000e-07	m²/s
Depth	2.0000	m
Day of the year	180.00	
Day of minimum surface temperature	15.000	

Calculated results

Parameter	Value	Unit
Ground temperature	27.206	°C
Annual amplitude at the depth	3.2763	K
Time lag behind the surface (days)	51.860	
Damping depth √(αP/π)	2.2403	m
Minimum temperature at the depth	22.724	°C
Maximum temperature at the depth	29.276	°C

Notes for this case

• Periodic conduction into a semi-infinite solid: T = T_m − A_s e^(−z/d) cos[2π(t − t₀)/365 − z/d], d = √(αP/π) with P one year. Snow, vegetation, groundwater flow and moisture changes are not modelled.

Formula and method

$$T(z,t) = T_m - A_s e^{-z/d} \cos\left[\frac{2\pi(t-t_0)}{365} - \frac{z}{d}\right], \quad d = \sqrt{\frac{\alpha P}{\pi}}$$

Variables

T_m	Mean annual surface temperature	K
A_s	Annual surface temperature amplitude	K
α	Soil thermal diffusivity	m²/s
z	Depth	m
t	Day of the year	-
t_0	Day of minimum surface temperature	-
$T(z,t)$	Ground temperature	K
A_z	Annual amplitude at the depth	K
Δt	Time lag behind the surface (days)	-
d	Damping depth √(αP/π)	m
T_{min}	Minimum temperature at the depth	K
T_{max}	Maximum temperature at the depth	K

Method and standards

Periodic heat conduction in the ground.

Assumptions and limits

- Homogeneous soil; sinusoidal annual surface temperature.

References

Kusuda–Achenbach periodic ground temperature

Report details

Report reference	FCC-EQ3T-F457 (the same inputs always give the same reference)
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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/environmental/geothermal-ocean/ground-temperature-depth-season

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.