FORMULÁRIO

Balanço diferencial de energia térmica	
$$\frac{\partial T}{\partial t} + \vec{v} \cdot \vec{\nabla} T - \alpha \nabla^2 T - \frac{\dot{q}_V}{\rho \cdot Cp} = 0$$	Lei de Fourier: $\vec{q}'' = -k\vec{\nabla}T$ Lei de resf. de Newton: $q_{conv} = h.A_s(T_s - T_\infty)$ Difusividade térmica: $\alpha = \frac{k}{\rho \cdot Cp}$

Operadores diferenciais no espaço tridimensional

SC	Gradiente	Divergente	Laplaciano (divergente do gradiente)
1	$\vec{\nabla}s = \left(\frac{\partial s}{\partial x}, \frac{\partial s}{\partial y}, \frac{\partial s}{\partial z}\right)$	$\vec{\nabla} \cdot \vec{u} = \frac{\partial u_x}{\partial x} + \frac{\partial u_y}{\partial y} + \frac{\partial u_z}{\partial z}$	$\nabla^2 s = \frac{\partial^2 s}{\partial x^2} + \frac{\partial^2 s}{\partial y^2} + \frac{\partial^2 s}{\partial z^2}$
2	$\vec{\nabla}s = \left(\frac{\partial s}{\partial r}, \frac{1}{r}\frac{\partial s}{\partial \phi}, \frac{\partial s}{\partial z}\right)$	$\vec{\nabla} \cdot \vec{u} = \frac{1}{r}\frac{\partial}{\partial r}(r.u_r) + \frac{1}{r}\frac{\partial u_\phi}{\partial \phi} + \frac{\partial u_z}{\partial z}$	$\nabla^2 s = \frac{1}{r}\frac{\partial}{\partial r}\left(r\frac{\partial s}{\partial r}\right) + \frac{1}{r^2}\frac{\partial^2 s}{\partial \phi^2} + \frac{\partial^2 s}{\partial z^2}$
3	$\vec{\nabla}s = \left(\frac{\partial s}{\partial r}, \frac{1}{r}\frac{\partial s}{\partial \theta}, \frac{1}{r.\text{sen}\,\theta}\frac{\partial s}{\partial \phi}\right)$	$\vec{\nabla} \cdot \vec{u} = \frac{1}{r^2}\frac{\partial}{\partial r}(r^2.u_r) + \frac{1}{r.sen\theta}\frac{\partial}{\partial \theta}(u_\theta.sen\theta) + \frac{1}{r.sen\theta}\frac{\partial u_\phi}{\partial \phi}$	$\nabla^2 s = \frac{1}{r^2}\frac{\partial}{\partial r}\left(r^2\frac{\partial s}{\partial r}\right) + \frac{1}{r^2.sen\theta}\frac{\partial}{\partial \theta}\left(sen\theta.\frac{\partial s}{\partial \theta}\right) + \frac{1}{r^2.sen^2\theta}\frac{\partial^2 s}{\partial \phi^2}$

Tabela: *Perfis de temperatura e taxas de calor para aletas com área de seção transversal uniforme.*

Condição de contorno na ponta	Perfil de temperatura $\frac{\theta(x)}{\theta_b} = \frac{T(x) - T_\infty}{T_b - T_\infty}$	Taxa de calor para a aleta $q_a = -kA_x \left.\frac{dT}{dx}\right\|_{x=0}$
Convecção	$\frac{\cosh(m(L-x)) + \left(\frac{h}{mk}\right).\text{senh}(m(L-x))}{\cosh(mL) + \left(\frac{h}{mk}\right).\text{senh}(mL)}$	$M\,\frac{\text{senh}(mL) + \left(\frac{h}{mk}\right).\cosh(mL)}{\cosh(mL) + \left(\frac{h}{mk}\right).\text{senh}(mL)}$
Temperatura conhecida	$\frac{(\theta_L/\theta_b).\text{senh}(mx) + \text{senh}(m(L-x))}{\text{senh}(mL)}$	$M\,\frac{\text{senh}(mL) - (\theta_L/\theta_b)}{\text{senh}(mL)}$
Adiabática	$\frac{\cosh(m(L-x))}{\cosh(mL)}$	$M\tanh(mL)$
Aleta infinita L(m) $\gtrsim \frac{2,65}{m}$	e^{-mx}	M

Substituições: $m = \sqrt{\frac{hp}{kA_x}}$ $\quad M = k.A_x.m.\theta_b$ $\quad \theta_b = T_b - T_\infty$ $\quad \theta_L = T_L - T_\infty$

- Equações na tabela acima originadas a partir de $\frac{d^2T}{dx^2} = \frac{hp}{kA_x}(T - T_\infty)$ ou $\frac{d^2\theta}{dx^2} = m^2\theta$

Funções hiperbólicas:

$cosh(x) = \frac{e^x + e^{-x}}{2}$ $\quad senh(x) = \frac{e^x - e^{-x}}{2}$ $\quad tanh(x) = \frac{senh(x)}{cosh(x)}$