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Step-by-step solution

Step-1-2-3-4

Cross the schematic diagram of the

Step-5-6

Check the exact temperature at node 1 by using the relation

$$\left\{\begin{array}{c}\frac{\partial T}{\partial x}\\ \frac{\partial T}{\partial y}\end{array}\right\}=\frac{\left[\begin{array}{cc}\cos\theta & -\sin\theta\\ \sin\theta & \cos\theta\end{array}\right]}{\left[\begin{array}{cc}\cos\theta & \sin\theta\\ -\sin\theta & \cos\theta\end{array}\right]}\left\{\begin{array}{c}\frac{\partial T}{\partial \xi}\\ \frac{\partial T}{\partial \eta}\end{array}\right\}$$

Here, ξ is internal coordinate, η is area, ξ is length, η is the transfer coefficient, ρ is the perimeter, T_∞ is the temperature, and θ is the angle of inclination of each line segment.

Substitute $\cos\theta=\frac{\Delta x}{L}$ for ξ, $\sin\theta=\frac{\Delta y}{L}$ for η, $\left(\frac{\partial T}{\partial \xi}\right)_{\xi=0}=\frac{\Delta T}{L}$ for η, $\left(\frac{\partial T}{\partial \eta}\right)_{\eta=0}=0$ and Δx for ξ, Δy for η in the equation

$$\left\{\begin{array}{c}\frac{\partial T}{\partial x}\\ \frac{\partial T}{\partial y}\end{array}\right\}=\frac{\left[\begin{array}{cc}\cos\theta & -\sin\theta\\ \sin\theta & \cos\theta\end{array}\right]}{\left[\begin{array}{cc}\cos\theta & \sin\theta\\ -\sin\theta & \cos\theta\end{array}\right]}\left\{\begin{array}{c}\frac{\Delta T}{L}\\ 0\end{array}\right\}$$

$$\left\{\begin{array}{c}\frac{\partial T}{\partial x}\\ \frac{\partial T}{\partial y}\end{array}\right\}=\left\{\begin{array}{c}\frac{\Delta T}{\Delta x}\\ \frac{\Delta T}{\Delta y}\end{array}\right\}$$

Step-7-8

Check the exact temperature at node 2 by using the relation

$$\left\{\begin{array}{c}\frac{\partial T}{\partial x}\\ \frac{\partial T}{\partial y}\end{array}\right\}=\frac{\left[\begin{array}{cc}\cos\theta & -\sin\theta\\ \sin\theta & \cos\theta\end{array}\right]}{\left[\begin{array}{cc}\cos\theta & \sin\theta\\ -\sin\theta & \cos\theta\end{array}\right]}\left\{\begin{array}{c}\frac{\partial T}{\partial \xi}\\ \frac{\partial T}{\partial \eta}\end{array}\right\}$$

Here, ξ is internal coordinate, η is area, ξ is length, η is the transfer coefficient, ρ is the perimeter, T_∞ is the temperature, and θ is the angle of inclination of each line segment.

Substitute $\cos\theta=\frac{\Delta x}{L}$ for ξ, $\sin\theta=\frac{\Delta y}{L}$ for η, $\left(\frac{\partial T}{\partial \xi}\right)_{\xi=0}=\frac{\Delta T}{L}$ for η, $\left(\frac{\partial T}{\partial \eta}\right)_{\eta=0}=0$ and Δx for ξ, Δy for η in the equation

$$\left\{\begin{array}{c}\frac{\partial T}{\partial x}\\ \frac{\partial T}{\partial y}\end{array}\right\}=\frac{\left[\begin{array}{cc}\cos\theta & -\sin\theta\\ \sin\theta & \cos\theta\end{array}\right]}{\left[\begin{array}{cc}\cos\theta & \sin\theta\\ -\sin\theta & \cos\theta\end{array}\right]}\left\{\begin{array}{c}\frac{\Delta T}{L}\\ 0\end{array}\right\}$$

$$\left\{\begin{array}{c}\frac{\partial T}{\partial x}\\ \frac{\partial T}{\partial y}\end{array}\right\}=\left\{\begin{array}{c}\frac{\Delta T}{\Delta x}\\ \frac{\Delta T}{\Delta y}\end{array}\right\}$$

Step-9-10

Check the exact temperature at node 3 by using the relation

$$\left\{\begin{array}{c}\frac{\partial T}{\partial x}\\ \frac{\partial T}{\partial y}\end{array}\right\}=\frac{\left[\begin{array}{cc}\cos\theta & -\sin\theta\\ \sin\theta & \cos\theta\end{array}\right]}{\left[\begin{array}{cc}\cos\theta & \sin\theta\\ -\sin\theta & \cos\theta\end{array}\right]}\left\{\begin{array}{c}\frac{\partial T}{\partial \xi}\\ \frac{\partial T}{\partial \eta}\end{array}\right\}$$

Here, ξ is internal coordinate, η is area, ξ is length, η is the transfer coefficient, ρ is the perimeter, T_∞ is the temperature, and θ is the angle of inclination of each line segment.

Substitute $\cos\theta=\frac{\Delta x}{L}$ for ξ, $\sin\theta=\frac{\Delta y}{L}$ for η, $\left(\frac{\partial T}{\partial \xi}\right)_{\xi=0}=\frac{\Delta T}{L}$ for η, $\left(\frac{\partial T}{\partial \eta}\right)_{\eta=0}=0$ and Δx for ξ, Δy for η in the equation

$$\left\{\begin{array}{c}\frac{\partial T}{\partial x}\\ \frac{\partial T}{\partial y}\end{array}\right\}=\frac{\left[\begin{array}{cc}\cos\theta & -\sin\theta\\ \sin\theta & \cos\theta\end{array}\right]}{\left[\begin{array}{cc}\cos\theta & \sin\theta\\ -\sin\theta & \cos\theta\end{array}\right]}\left\{\begin{array}{c}\frac{\Delta T}{L}\\ 0\end{array}\right\}$$

$$\left\{\begin{array}{c}\frac{\partial T}{\partial x}\\ \frac{\partial T}{\partial y}\end{array}\right\}=\left\{\begin{array}{c}\frac{\Delta T}{\Delta x}\\ \frac{\Delta T}{\Delta y}\end{array}\right\}$$

Step-11-12

Check the exact temperature at node 4 by using the relation

$$\left\{\begin{array}{c}\frac{\partial T}{\partial x}\\ \frac{\partial T}{\partial y}\end{array}\right\}=\frac{\left[\begin{array}{cc}\cos\theta & -\sin\theta\\ \sin\theta & \cos\theta\end{array}\right]}{\left[\begin{array}{cc}\cos\theta & \sin\theta\\ -\sin\theta & \cos\theta\end{array}\right]}\left\{\begin{array}{c}\frac{\partial T}{\partial \xi}\\ \frac{\partial T}{\partial \eta}\end{array}\right\}$$

Here, ξ is internal coordinate, η is area, ξ is length, η is the transfer coefficient, ρ is the perimeter, T_∞ is the temperature, and θ is the angle of inclination of each line segment.

Substitute $\cos\theta=\frac{\Delta x}{L}$ for ξ, $\sin\theta=\frac{\Delta y}{L}$ for η, $\left(\frac{\partial T}{\partial \xi}\right)_{\xi=0}=\frac{\Delta T}{L}$ for η, $\left(\frac{\partial T}{\partial \eta}\right)_{\eta=0}=0$ and Δx for ξ, Δy for η in the equation

$$\left\{\begin{array}{c}\frac{\partial T}{\partial x}\\ \frac{\partial T}{\partial y}\end{array}\right\}=\frac{\left[\begin{array}{cc}\cos\theta & -\sin\theta\\ \sin\theta & \cos\theta\end{array}\right]}{\left[\begin{array}{cc}\cos\theta & \sin\theta\\ -\sin\theta & \cos\theta\end{array}\right]}\left\{\begin{array}{c}\frac{\Delta T}{L}\\ 0\end{array}\right\}$$

$$\left\{\begin{array}{c}\frac{\partial T}{\partial x}\\ \frac{\partial T}{\partial y}\end{array}\right\}=\left\{\begin{array}{c}\frac{\Delta T}{\Delta x}\\ \frac{\Delta T}{\Delta y}\end{array}\right\}$$

Step-13-14

Check the exact temperature at node 5 by using the relation

$$\left\{\begin{array}{c}\frac{\partial T}{\partial x}\\ \frac{\partial T}{\partial y}\end{array}\right\}=\frac{\left[\begin{array}{cc}\cos\theta & -\sin\theta\\ \sin\theta & \cos\theta\end{array}\right]}{\left[\begin{array}{cc}\cos\theta & \sin\theta\\ -\sin\theta & \cos\theta\end{array}\right]}\left\{\begin{array}{c}\frac{\partial T}{\partial \xi}\\ \frac{\partial T}{\partial \eta}\end{array}\right\}$$

Here, ξ is internal coordinate, η is area, ξ is length, η is the transfer coefficient, ρ is the perimeter, T_∞ is the temperature, and θ is the angle of inclination of each line segment.

Substitute $\cos\theta=\frac{\Delta x}{L}$ for ξ, $\sin\theta=\frac{\Delta y}{L}$ for η, $\left(\frac{\partial T}{\partial \xi}\right)_{\xi=0}=\frac{\Delta T}{L}$ for η, $\left(\frac{\partial T}{\partial \eta}\right)_{\eta=0}=0$ and Δx for ξ, Δy for η in the equation

$$\left\{\begin{array}{c}\frac{\partial T}{\partial x}\\ \frac{\partial T}{\partial y}\end{array}\right\}=\frac{\left[\begin{array}{cc}\cos\theta & -\sin\theta\\ \sin\theta & \cos\theta\end{array}\right]}{\left[\begin{array}{cc}\cos\theta & \sin\theta\\ -\sin\theta & \cos\theta\end{array}\right]}\left\{\begin{array}{c}\frac{\Delta T}{L}\\ 0\end{array}\right\}$$

$$\left\{\begin{array}{c}\frac{\partial T}{\partial x}\\ \frac{\partial T}{\partial y}\end{array}\right\}=\left\{\begin{array}{c}\frac{\Delta T}{\Delta x}\\ \frac{\Delta T}{\Delta y}\end{array}\right\}$$

Step-15-16

Check the exact temperature at node 6 by using the relation

$$\left\{\begin{array}{c}\frac{\partial T}{\partial x}\\ \frac{\partial T}{\partial y}\end{array}\right\}=\frac{\left[\begin{array}{cc}\cos\theta & -\sin\theta\\ \sin\theta & \cos\theta\end{array}\right]}{\left[\begin{array}{cc}\cos\theta & \sin\theta\\ -\sin\theta & \cos\theta\end{array}\right]}\left\{\begin{array}{c}\frac{\partial T}{\partial \xi}\\ \frac{\partial T}{\partial \eta}\end{array}\right\}$$

Here, ξ is internal coordinate, η is area, ξ is length, η is the transfer coefficient, ρ is the perimeter, T_∞ is the temperature, and θ is the angle of inclination of each line segment.

Substitute $\cos\theta=\frac{\Delta x}{L}$ for ξ, $\sin\theta=\frac{\Delta y}{L}$ for η, $\left(\frac{\partial T}{\partial \xi}\right)_{\xi=0}=\frac{\Delta T}{L}$ for η, $\left(\frac{\partial T}{\partial \eta}\right)_{\eta=0}=0$ and Δx for ξ, Δy for η in the equation

$$\left\{\begin{array}{c}\frac{\partial T}{\partial x}\\ \frac{\partial T}{\partial y}\end{array}\right\}=\frac{\left[\begin{array}{cc}\cos\theta & -\sin\theta\\ \sin\theta & \cos\theta\end{array}\right]}{\left[\begin{array}{cc}\cos\theta & \sin\theta\\ -\sin\theta & \cos\theta\end{array}\right]}\left\{\begin{array}{c}\frac{\Delta T}{L}\\ 0\end{array}\right\}$$

$$\left\{\begin{array}{c}\frac{\partial T}{\partial x}\\ \frac{\partial T}{\partial y}\end{array}\right\}=\left\{\begin{array}{c}\frac{\Delta T}{\Delta x}\\ \frac{\Delta T}{\Delta y}\end{array}\right\}$$

Step-17-18

Check the exact temperature at node 7 by using the relation

$$\left\{\begin{array}{c}\frac{\partial T}{\partial x}\\ \frac{\partial T}{\partial y}\end{array}\right\}=\frac{\left[\begin{array}{cc}\cos\theta & -\sin\theta\\ \sin\theta & \cos\theta\end{array}\right]}{\left[\begin{array}{cc}\cos\theta & \sin\theta\\ -\sin\theta & \cos\theta\end{array}\right]}\left\{\begin{array}{c}\frac{\partial T}{\partial \xi}\\ \frac{\partial T}{\partial \eta}\end{array}\right\}$$

Here, ξ is internal coordinate, η is area, ξ is length, η is the transfer coefficient, ρ is the perimeter, T_∞ is the temperature, and θ is the angle of inclination of each line segment.

Substitute $\cos\theta=\frac{\Delta x}{L}$ for ξ, $\sin\theta=\frac{\Delta y}{L}$ for η, $\left(\frac{\partial T}{\partial \xi}\right)_{\xi=0}=\frac{\Delta T}{L}$ for η, $\left(\frac{\partial T}{\partial \eta}\right)_{\eta=0}=0$ and Δx for ξ, Δy for η in the equation

$$\left\{\begin{array}{c}\frac{\partial T}{\partial x}\\ \frac{\partial T}{\partial y}\end{array}\right\}=\frac{\left[\begin{array}{cc}\cos\theta & -\sin\theta\\ \sin\theta & \cos\theta\end{array}\right]}{\left[\begin{array}{cc}\cos\theta & \sin\theta\\ -\sin\theta & \cos\theta\end{array}\right]}\left\{\begin{array}{c}\frac{\Delta T}{L}\\ 0\end{array}\right\}$$

$$\left\{\begin{array}{c}\frac{\partial T}{\partial x}\\ \frac{\partial T}{\partial y}\end{array}\right\}=\left\{\begin{array}{c}\frac{\Delta T}{\Delta x}\\ \frac{\Delta T}{\Delta y}\end{array}\right\}$$

Step-19-20

Check the exact temperature at node 8 by using the relation

$$\left\{\begin{array}{c}\frac{\partial T}{\partial x}\\ \frac{\partial T}{\partial y}\end{array}\right\}=\frac{\left[\begin{array}{cc}\cos\theta & -\sin\theta\\ \sin\theta & \cos\theta\end{array}\right]}{\left[\begin{array}{cc}\cos\theta & \sin\theta\\ -\sin\theta & \cos\theta\end{array}\right]}\left\{\begin{array}{c}\frac{\partial T}{\partial \xi}\\ \frac{\partial T}{\partial \eta}\end{array}\right\}$$

Here, ξ is internal coordinate, η is area, ξ is length, η is the transfer coefficient, ρ is the perimeter, T_∞ is the temperature, and θ is the angle of inclination of each line segment.

Substitute $\cos\theta=\frac{\Delta x}{L}$ for ξ, $\sin\theta=\frac{\Delta y}{L}$ for η, $\left(\frac{\partial T}{\partial \xi}\right)_{\xi=0}=\frac{\Delta T}{L}$ for η, $\left(\frac{\partial T}{\partial \eta}\right)_{\eta=0}=0$ and Δx for ξ, Δy for η in the equation

$$\left\{\begin{array}{c}\frac{\partial T}{\partial x}\\ \frac{\partial T}{\partial y}\end{array}\right\}=\frac{\left[\begin{array}{cc}\cos\theta & -\sin\theta\\ \sin\theta & \cos\theta\end{array}\right]}{\left[\begin{array}{cc}\cos\theta & \sin\theta\\ -\sin\theta & \cos\theta\end{array}\right]}\left\{\begin{array}{c}\frac{\Delta T}{L}\\ 0\end{array}\right\}$$

$$\left\{\begin{array}{c}\frac{\partial T}{\partial x}\\ \frac{\partial T}{\partial y}\end{array}\right\}=\left\{\begin{array}{c}\frac{\Delta T}{\Delta x}\\ \frac{\Delta T}{\Delta y}\end{array}\right\}$$

Step-21-22

Check the exact temperature at node 9 by using the relation

$$\left\{\begin{array}{c}\frac{\partial T}{\partial x}\\ \frac{\partial T}{\partial y}\end{array}\right\}=\frac{\left[\begin{array}{cc}\cos\theta & -\sin\theta\\ \sin\theta & \cos\theta\end{array}\right]}{\left[\begin{array}{cc}\cos\theta & \sin\theta\\ -\sin\theta & \cos\theta\end{array}\right]}\left\{\begin{array}{c}\frac{\partial T}{\partial \xi}\\ \frac{\partial T}{\partial \eta}\end{array}\right\}$$

Here, ξ is internal coordinate, η is area, ξ is length, η is the transfer coefficient, ρ is the perimeter, T_∞ is the temperature, and θ is the angle of inclination of each line segment.

Substitute $\cos\theta=\frac{\Delta x}{L}$ for ξ, $\sin\theta=\frac{\Delta y}{L}$ for η, $\left(\frac{\partial T}{\partial \xi}\right)_{\xi=0}=\frac{\Delta T}{L}$ for η, $\left(\frac{\partial T}{\partial \eta}\right)_{\eta=0}=0$ and Δx for ξ, Δy for η in the equation

$$\left\{\begin{array}{c}\frac{\partial T}{\partial x}\\ \frac{\partial T}{\partial y}\end{array}\right\}=\frac{\left[\begin{array}{cc}\cos\theta & -\sin\theta\\ \sin\theta & \cos\theta\end{array}\right]}{\left[\begin{array}{cc}\cos\theta & \sin\theta\\ -\sin\theta & \cos\theta\end{array}\right]}\left\{\begin{array}{c}\frac{\Delta T}{L}\\ 0\end{array}\right\}$$

$$\left\{\begin{array}{c}\frac{\partial T}{\partial x}\\ \frac{\partial T}{\partial y}\end{array}\right\}=\left\{\begin{array}{c}\frac{\Delta T}{\Delta x}\\ \frac{\Delta T}{\Delta y}\end{array}\right\}$$

Step-23-24

Check the exact temperature at node 10 by using the relation

$$\left\{\begin{array}{c}\frac{\partial T}{\partial x}\\ \frac{\partial T}{\partial y}\end{array}\right\}=\frac{\left[\begin{array}{cc}\cos\theta & -\sin\theta\\ \sin\theta & \cos\theta\end{array}\right]}{\left[\begin{array}{cc}\cos\theta & \sin\theta\\ -\sin\theta & \cos\theta\end{array}\right]}\left\{\begin{array}{c}\frac{\partial T}{\partial \xi}\\ \frac{\partial T}{\partial \eta}\end{array}\right\}$$

Here, ξ is internal coordinate, η is area, ξ is length, η is the transfer coefficient, ρ is the perimeter, T_∞ is the temperature, and θ is the angle of inclination of each line segment.

Substitute $\cos\theta=\frac{\Delta x}{L}$ for ξ, $\sin\theta=\frac{\Delta y}{L}$ for η, $\left(\frac{\partial T}{\partial \xi}\right)_{\xi=0}=\frac{\Delta T}{L}$ for η, $\left(\frac{\partial T}{\partial \eta}\right)_{\eta=0}=0$ and Δx for ξ, Δy for η in the equation

$$\left\{\begin{array}{c}\frac{\partial T}{\partial x}\\ \frac{\partial T}{\partial y}\end{array}\right\}=\frac{\left[\begin{array}{cc}\cos\theta & -\sin\theta\\ \sin\theta & \cos\theta\end{array}\right]}{\left[\begin{array}{cc}\cos\theta & \sin\theta\\ -\sin\theta & \cos\theta\end{array}\right]}\left\{\begin{array}{c}\frac{\Delta T}{L}\\ 0\end{array}\right\}$$

$$\left\{\begin{array}{c}\frac{\partial T}{\partial x}\\ \frac{\partial T}{\partial y}\end{array}\right\}=\left\{\begin{array}{c}\frac{\Delta T}{\Delta x}\\ \frac{\Delta T}{\Delta y}\end{array}\right\}$$

Step-25-26

Check the exact temperature at node 11 by using the relation

$$\left\{\begin{array}{c}\frac{\partial T}{\partial x}\\ \frac{\partial T}{\partial y}\end{array}\right\}=\frac{\left[\begin{array}{cc}\cos\theta & -\sin\theta\\ \sin\theta & \cos\theta\end{array}\right]}{\left[\begin{array}{cc}\cos\theta & \sin\theta\\ -\sin\theta & \cos\theta\end{array}\right]}\left\{\begin{array}{c}\frac{\partial T}{\partial \xi}\\ \frac{\partial T}{\partial \eta}\end{array}\right\}$$

Here, ξ is internal coordinate, η is area, ξ is length, η is the transfer coefficient, ρ is the perimeter, T_∞ is the temperature, and θ is the angle of inclination of each line segment.

Substitute $\cos\theta=\frac{\Delta x}{L}$ for ξ, $\sin\theta=\frac{\Delta y}{L}$ for η, $\left(\frac{\partial T}{\partial \xi}\right)_{\xi=0}=\frac{\Delta T}{L}$ for η, $\left(\frac{\partial T}{\partial \eta}\right)_{\eta=0}=0$ and Δx for ξ, Δy for η in the equation

$$\left\{\begin{array}{c}\frac{\partial T}{\partial x}\\ \frac{\partial T}{\partial y}\end{array}\right\}=\frac{\left[\begin{array}{cc}\cos\theta & -\sin\theta\\ \sin\theta & \cos\theta\end{array}\right]}{\left[\begin{array}{cc}\cos\theta & \sin\theta\\ -\sin\theta & \cos\theta\end{array}\right]}\left\{\begin{array}{c}\frac{\Delta T}{L}\\ 0\end{array}\right\}$$

$$\left\{\begin{array}{c}\frac{\partial T}{\partial x}\\ \frac{\partial T}{\partial y}\end{array}\right\}=\left\{\begin{array}{c}\frac{\Delta T}{\Delta x}\\ \frac{\Delta T}{\Delta y}\end{array}\right\}$$

Step-27-28

Check the exact temperature at node 12 by using the relation

$$\left\{\begin{array}{c}\frac{\partial T}{\partial x}\\ \frac{\partial T}{\partial y}\end{array}\right\}=\frac{\left[\begin{array}{cc}\cos\theta & -\sin\theta\\ \sin\theta & \cos\theta\end{array}\right]}{\left[\begin{array}{cc}\cos\theta & \sin\theta\\ -\sin\theta & \cos\theta\end{array}\right]}\left\{\begin{array}{c}\frac{\partial T}{\partial \xi}\\ \frac{\partial T}{\partial \eta}\end{array}\right\}$$

Here, ξ is internal coordinate, η is area, ξ is length, η is the transfer coefficient, ρ is the perimeter, T_∞ is the temperature, and θ is the angle of inclination of each line segment.

Substitute $\cos\theta=\frac{\Delta x}{L}$ for ξ, $\sin\theta=\frac{\Delta y}{L}$ for η, $\left(\frac{\partial T}{\partial \xi}\right)_{\xi=0}=\frac{\Delta T}{L}$ for η, $\left(\frac{\partial T}{\partial \eta}\right)_{\eta=0}=0$ and Δx for ξ, Δy for η in the equation

$$\left\{\begin{array}{c}\frac{\partial T}{\partial x}\\ \frac{\partial T}{\partial y}\end{array}\right\}=\frac{\left[\begin{array}{cc}\cos\theta & -\sin\theta\\ \sin\theta & \cos\theta\end{array}\right]}{\left[\begin{array}{cc}\cos\theta & \sin\theta\\ -\sin\theta & \cos\theta\end{array}\right]}\left\{\begin{array}{c}\frac{\Delta T}{L}\\ 0\end{array}\right\}$$

$$\left\{\begin{array}{c}\frac{\partial T}{\partial x}\\ \frac{\partial T}{\partial y}\end{array}\right\}=\left\{\begin{array}{c}\frac{\Delta T}{\Delta x}\\ \frac{\Delta T}{\Delta y}\end{array}\right\}$$

Step-29-30

Check the exact temperature at node 13 by using the relation

$$\left\{\begin{array}{c}\frac{\partial T}{\partial x}\\ \frac{\partial T}{\partial y}\end{array}\right\}=\frac{\left[\begin{array}{cc}\cos\theta & -\sin\theta\\ \sin\theta & \cos\theta\end{array}\right]}{\left[\begin{array}{cc}\cos\theta & \sin\theta\\ -\sin\theta & \cos\theta\end{array}\right]}\left\{\begin{array}{c}\frac{\partial T}{\partial \xi}\\ \frac{\partial T}{\partial \eta}\end{array}\right\}$$

Here, ξ is internal coordinate, η is area, ξ is length, η is the transfer coefficient, ρ is the perimeter, T_∞ is the temperature, and θ is the angle of inclination of each line segment.

Substitute $\cos\theta=\frac{\Delta x}{L}$ for ξ, $\sin\theta=\frac{\Delta y}{L}$ for η, $\left(\frac{\partial T}{\partial \xi}\right)_{\xi=0}=\frac{\Delta T}{L}$ for η, $\left(\frac{\partial T}{\partial \eta}\right)_{\eta=0}=0$ and Δx for ξ, Δy for η in the equation

$$\left\{\begin{array}{c}\frac{\partial T}{\partial x}\\ \frac{\partial T}{\partial y}\end{array}\right\}=\frac{\left[\begin{array}{cc}\cos\theta & -\sin\theta\\ \sin\theta & \cos\theta\end{array}\right]}{\left[\begin{array}{cc}\cos\theta & \sin\theta\\ -\sin\theta & \cos\theta\end{array}\right]}\left\{\begin{array}{c}\frac{\Delta T}{L}\\ 0\end{array}\right\}$$

$$\left\{\begin{array}{c}\frac{\partial T}{\partial x}\\ \frac{\partial T}{\partial y}\end{array}\right\}=\left\{\begin{array}{c}\frac{\Delta T}{\Delta x}\\ \frac{\Delta T}{\Delta y}\end{array}\right\}$$

Step-31-32

Check the exact temperature at node 14 by using the relation

$$\left\{\begin{array}{c}\frac{\partial T}{\partial x}\\ \frac{\partial T}{\partial y}\end{array}\right\}=\frac{\left[\begin{array}{cc}\cos\theta & -\sin\theta\\ \sin\theta & \cos\theta\end{array}\right]}{\left[\begin{array}{cc}\cos\theta & \sin\theta\\ -\sin\theta & \cos\theta\end{array}\right]}\left\{\begin{array}{c}\frac{\partial T}{\partial \xi}\\ \frac{\partial T}{\partial \eta}\end{array}\right\}$$

Here, ξ is internal coordinate, η is area, ξ is length, η is the transfer coefficient, ρ is the perimeter, T_∞ is the temperature, and θ is the angle of inclination of each line segment.

Substitute $\cos\theta=\frac{\Delta x}{L}$ for ξ, $\sin\theta=\frac{\Delta y}{L}$ for η, $\left(\frac{\partial T}{\partial \xi}\right)_{\xi=0}=\frac{\Delta T}{L}$ for η, $\left(\frac{\partial T}{\partial \eta}\right)_{\eta=0}=0$ and Δx for ξ, Δy for η in the equation

$$\left\{\begin{array}{c}\frac{\partial T}{\partial x}\\ \frac{\partial T}{\partial y}\end{array}\right\}=\frac{\left[\begin{array}{cc}\cos\theta & -\sin\theta\\ \sin\theta & \cos\theta\end{array}\right]}{\left[\begin{array}{cc}\cos\theta & \sin\theta\\ -\sin\theta & \cos\theta\end{array}\right]}\left\{\begin{array}{c}\frac{\Delta T}{L}\\ 0\end{array}\right\}$$

$$\left\{\begin{array}{c}\frac{\partial T}{\partial x}\\ \frac{\partial T}{\partial y}\end{array}\right\}=\left\{\begin{array}{c}\frac{\Delta T}{\Delta x}\\ \frac{\Delta T}{\Delta y}\end{array}\right\}$$

Step-33-34

Check the exact temperature at node 15 by using the relation

$$\left\{\begin{array}{c}\frac{\partial T}{\partial x}\\ \frac{\partial T}{\partial y}\end{array}\right\}=\frac{\left[\begin{array}{cc}\cos\theta & -\sin\theta\\ \sin\theta & \cos\theta\end{array}\right]}{\left[\begin{array}{cc}\cos\theta & \sin\theta\\ -\sin\theta & \cos\theta\end{array}\right]}\left\{\begin{array}{c}\frac{\partial T}{\partial \xi}\\ \frac{\partial T}{\partial \eta}\end{array}\right\}$$

Here, ξ is internal coordinate, η is area, ξ is length, η is the transfer coefficient, ρ is the perimeter, T_∞ is the temperature, and θ is the angle of inclination of each line segment.

Substitute $\cos\theta=\frac{\Delta x}{L}$ for ξ, $\sin\theta=\frac{\Delta y}{L}$ for η, $\left(\frac{\partial T}{\partial \xi}\right)_{\xi=0}=\frac{\Delta T}{L}$ for η, $\left(\frac{\partial T}{\partial \eta}\right)_{\eta=0}=0$ and Δx for ξ, Δy for η in the equation

$$\left\{\begin{array}{c}\frac{\partial T}{\partial x}\\ \frac{\partial T}{\partial y}\end{array}\right\}=\frac{\left[\begin{array}{cc}\cos\theta & -\sin\theta\\ \sin\theta & \cos\theta\end{array}\right]}{\left[\begin{array}{cc}\cos\theta & \sin\theta\\ -\sin\theta & \cos\theta\end{array}\right]}\left\{\begin{array}{c}\frac{\Delta T}{L}\\ 0\end{array}\right\}$$

$$\left\{\begin{array}{c}\frac{\partial T}{\partial x}\\ \frac{\partial T}{\partial y}\end{array}\right\}=\left\{\begin{array}{c}\frac{\Delta T}{\Delta x}\\ \frac{\Delta T}{\Delta y}\end{array}\right\}$$

Step-35-36

Check the exact temperature at node 16 by using the relation

$$\left\{\begin{array}{c}\frac{\partial T}{\partial x}\\ \frac{\partial T}{\partial y}\end{array}\right\}=\frac{\left[\begin{array}{cc}\cos\theta & -\sin\theta\\ \sin\theta & \cos\theta\end{array}\right]}{\left[\begin{array}{cc}\cos\theta & \sin\theta\\ -\sin\theta & \cos\theta\end{array}\right]}\left\{\begin{array}{c}\frac{\partial T}{\partial \xi}\\ \frac{\partial T}{\partial \eta}\end{array}\right\}$$

Here, ξ is internal coordinate, η is area, ξ is length, η is the transfer coefficient, ρ is the perimeter, T_∞ is the temperature, and θ is the angle of inclination of each line segment.

Substitute $\cos\theta=\frac{\Delta x}{L}$ for ξ, $\sin\theta=\frac{\Delta y}{L}$ for η, $\left(\frac{\partial T}{\partial \xi}\right)_{\xi=0}=\frac{\Delta T}{L}$ for η, $\left(\frac{\partial T}{\partial \eta}\right)_{\eta=0}=0$ and Δx for ξ, Δy for η in the equation

$$\left\{\begin{array}{c}\frac{\partial T}{\partial x}\\ \frac{\partial T}{\partial y}\end{array}\right\}=\frac{\left[\begin{array}{cc}\cos\theta & -\sin\theta\\ \sin\theta & \cos\theta\end{array}\right]}{\left[\begin{array}{cc}\cos\theta & \sin\theta\\ -\sin\theta & \cos\theta\end{array}\right]}\left\{\begin{array}{c}\frac{\Delta T}{L}\\ 0\end{array}\right\}$$

$$\left\{\begin{array}{c}\frac{\partial T}{\partial x}\\ \frac{\partial T}{\partial y}\end{array}\right\}=\left\{\begin{array}{c}\frac{\Delta T}{\Delta x}\\ \frac{\Delta T}{\Delta y}\end{array}\right\}$$

$$\begin{bmatrix} \frac{\partial N_1}{\partial x} & \frac{\partial N_2}{\partial x} & \frac{\partial N_3}{\partial x} & \frac{\partial N_4}{\partial x} \\ \frac{\partial N_1}{\partial y} & \frac{\partial N_2}{\partial y} & \frac{\partial N_3}{\partial y} & \frac{\partial N_4}{\partial y} \end{bmatrix} = \begin{bmatrix} -1 & 1 & 0 & 0 \\ -1 & -1 & 1 & 0 \end{bmatrix}$$

$$\{\epsilon\} = [B]\{\delta\}$$

Comment

Step 17 of 17

Obtain the axial heat flux from the relation

$$q = \left[\frac{\partial N}{\partial x}\right]^T \text{cond} \left[\frac{\partial N}{\partial x}\right] \{\delta\} \cdot \{\epsilon\}$$

Here, q is the heat conductivity, cond is heat, $\{\epsilon\}$ is the nodal temperature, δ is the strain, $\frac{\partial N}{\partial x}$ is the shape function, $\{\delta\}$ is the nodal displacement.

Substitute $\frac{\partial N}{\partial x} = \begin{bmatrix} -1 & 1 & 0 & 0 \end{bmatrix}$, $\text{cond} = 200 \frac{W}{m \cdot K}$, $\{\epsilon\} = \begin{bmatrix} 0 & 0 & 0 & 0 \end{bmatrix}^T$, $\{\delta\} = \begin{bmatrix} 0 & 0 & 0 & 0 \end{bmatrix}^T$ in

$$q = \left[\frac{\partial N}{\partial x}\right]^T \text{cond} \left[\frac{\partial N}{\partial x}\right] \{\delta\} \cdot \{\epsilon\}$$

$$= \begin{bmatrix} -1 \\ 1 \\ 0 \\ 0 \end{bmatrix} 200 \begin{bmatrix} -1 & 1 & 0 & 0 \end{bmatrix} \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \end{bmatrix} \cdot \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}$$

$$= \begin{bmatrix} 200 & -200 & 0 & 0 \\ -200 & 200 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix} \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix} \cdot \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}$$

$$= 0 \text{ W/m}^2$$

Therefore, the axial heat flux from the fin is $\boxed{0 \text{ W/m}^2}$.

Comment

Step 16 of 17

Obtain the force matrix of element $\text{elem}^{(1)}$, $\{\epsilon\}$, $\{\delta\}$ from the relation.

$$\rho = \frac{\partial N}{\partial x} \{\epsilon\}$$

Substitute $\{\epsilon\} = \begin{bmatrix} 0 & 0 & 0 & 0 \end{bmatrix}^T$, $\{\delta\} = \begin{bmatrix} 0 & 0 & 0 & 0 \end{bmatrix}^T$ in $\rho = \frac{\partial N}{\partial x} \{\epsilon\}$ to $\{\epsilon\}$.

$$\rho = \frac{\partial N}{\partial x} \{\epsilon\}$$

$$= \begin{bmatrix} -1 & 1 & 0 & 0 \\ -1 & -1 & 1 & 0 \end{bmatrix} \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}$$

$$= \begin{bmatrix} 0 \\ 0 \end{bmatrix}$$

Comment

Step 15 of 17

Obtain the force matrix of element $\text{elem}^{(1)}$, $\{\epsilon\}$, $\{\delta\}$ from the relation.

$$\rho = \frac{\partial N}{\partial x} \{\epsilon\}$$

Substitute $\{\epsilon\} = \begin{bmatrix} 0 & 0 & 0 & 0 \end{bmatrix}^T$, $\{\delta\} = \begin{bmatrix} 0 & 0 & 0 & 0 \end{bmatrix}^T$ in $\rho = \frac{\partial N}{\partial x} \{\epsilon\}$ to $\{\epsilon\}$.

$$\rho = \frac{\partial N}{\partial x} \{\epsilon\}$$

$$= \begin{bmatrix} -1 & 1 & 0 & 0 \\ -1 & -1 & 1 & 0 \end{bmatrix} \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}$$

$$= \begin{bmatrix} 0 \\ 0 \end{bmatrix}$$

Comment

Step 14 of 17

Obtain the force matrix of element $\text{elem}^{(1)}$, $\{\epsilon\}$, $\{\delta\}$ from the relation.

$$\rho = \frac{\partial N}{\partial x} \{\epsilon\}$$

Substitute $\{\epsilon\} = \begin{bmatrix} 0 & 0 & 0 & 0 \end{bmatrix}^T$, $\{\delta\} = \begin{bmatrix} 0 & 0 & 0 & 0 \end{bmatrix}^T$ in $\rho = \frac{\partial N}{\partial x} \{\epsilon\}$ to $\{\epsilon\}$.

$$\rho = \frac{\partial N}{\partial x} \{\epsilon\}$$

$$= \begin{bmatrix} -1 & 1 & 0 & 0 \\ -1 & -1 & 1 & 0 \end{bmatrix} \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}$$

$$= \begin{bmatrix} 0 \\ 0 \end{bmatrix}$$

Comment

Step 13 of 17

Obtain the force matrix of element $\text{elem}^{(1)}$, $\{\epsilon\}$, $\{\delta\}$ from the relation.

$$\rho = \frac{\partial N}{\partial x} \{\epsilon\}$$

Substitute $\{\epsilon\} = \begin{bmatrix} 0 & 0 & 0 & 0 \end{bmatrix}^T$, $\{\delta\} = \begin{bmatrix} 0 & 0 & 0 & 0 \end{bmatrix}^T$ in $\rho = \frac{\partial N}{\partial x} \{\epsilon\}$ to $\{\epsilon\}$.

$$\rho = \frac{\partial N}{\partial x} \{\epsilon\}$$

$$= \begin{bmatrix} -1 & 1 & 0 & 0 \\ -1 & -1 & 1 & 0 \end{bmatrix} \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}$$

$$= \begin{bmatrix} 0 \\ 0 \end{bmatrix}$$

Comment

Step 12 of 17

Obtain the global force matrix by assembling the element force matrices.

$$F = \begin{bmatrix} 0 \\ 0 \\ 0.075 \times 0.075 \\ 0.075 \times 0.075 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0.075 \\ 0.075 \\ 0.075 \\ 0.075 \\ 0.075 \\ 0.075 \\ 0.075 \\ 0.075 \end{bmatrix}$$

Obtain the temperature by using the equations.

$$[K]\{T\} = \{F\}$$

$$\begin{bmatrix} 200 & -200 & 0 & 0 & 0 & 0 & 0 & 0 \\ -200 & 200 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1000 & -1000 & 0 & 0 & 0 & 0 \\ 0 & 0 & -1000 & 1000 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1000 & -1000 & 0 & 0 \\ 0 & 0 & 0 & 0 & -1000 & 1000 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 200 & -200 \\ 0 & 0 & 0 & 0 & 0 & 0 & -200 & 200 \end{bmatrix} \begin{bmatrix} T_1 \\ T_2 \\ T_3 \\ T_4 \\ T_5 \\ T_6 \\ T_7 \\ T_8 \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ 0.075 \times 0.075 \\ 0.075 \times 0.075 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0.075 \\ 0.075 \\ 0.075 \\ 0.075 \\ 0.075 \\ 0.075 \\ 0.075 \\ 0.075 \end{bmatrix}$$

Therefore, the temperatures at the nodes are

$$\begin{bmatrix} T_1 \\ T_2 \\ T_3 \\ T_4 \\ T_5 \\ T_6 \\ T_7 \\ T_8 \end{bmatrix} = \begin{bmatrix} 0.0 \text{ °C} \\ 0.0 \text{ °C} \\ 0.0 \text{ °C} \\ 0.0 \text{ °C} \\ 0.0 \text{ °C} \\ 0.0 \text{ °C} \\ 0.0 \text{ °C} \\ 0.0 \text{ °C} \end{bmatrix}$$

Comment

Step 11 of 17

Obtain the heat flux from the element by using the relation.

$$q^{(1)} = \text{cond}\left[\frac{\partial N}{\partial x}\right]^T \{\delta\}$$

Here, q is heat, $\{\delta\}$ is the heat flux, cond is the conductivity, $\frac{\partial N}{\partial x}$ is the temperature.

Substitute $\{\delta\} = \begin{bmatrix} 0 & 0 & 0 & 0 \end{bmatrix}^T$, $\text{cond} = 200 \frac{W}{m \cdot K}$, $\frac{\partial N}{\partial x} = \begin{bmatrix} -1 & 1 & 0 & 0 \end{bmatrix}$ in $q^{(1)} = \text{cond}\left[\frac{\partial N}{\partial x}\right]^T \{\delta\}$.

$$q^{(1)} = \text{cond}\left[\frac{\partial N}{\partial x}\right]^T \{\delta\}$$

$$= 200 \begin{bmatrix} -1 \\ 1 \\ 0 \\ 0 \end{bmatrix} \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}$$

$$= 0 \text{ W/m}^2$$

Comment

Step 10 of 17

Obtain the heat flux from the element by using the relation.

$$q^{(1)} = \text{cond}\left[\frac{\partial N}{\partial x}\right]^T \{\delta\}$$

Substitute $\{\delta\} = \begin{bmatrix} 0 & 0 & 0 & 0 \end{bmatrix}^T$, $\text{cond} = 200 \frac{W}{m \cdot K}$, $\frac{\partial N}{\partial x} = \begin{bmatrix} -1 & 1 & 0 & 0 \end{bmatrix}$ in $q^{(1)} = \text{cond}\left[\frac{\partial N}{\partial x}\right]^T \{\delta\}$.

$$q^{(1)} = \text{cond}\left[\frac{\partial N}{\partial x}\right]^T \{\delta\}$$

$$= 200 \begin{bmatrix} -1 \\ 1 \\ 0 \\ 0 \end{bmatrix} \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}$$

$$= 0 \text{ W/m}^2$$

Comment

Step 9 of 17

Obtain the heat flux from the element by using the relation.

$$q^{(1)} = \text{cond}\left[\frac{\partial N}{\partial x}\right]^T \{\delta\}$$

Substitute $\{\delta\} = \begin{bmatrix} 0 & 0 & 0 & 0 \end{bmatrix}^T$, $\text{cond} = 200 \frac{W}{m \cdot K}$, $\frac{\partial N}{\partial x} = \begin{bmatrix} -1 & 1 & 0 & 0 \end{bmatrix}$ in $q^{(1)} = \text{cond}\left[\frac{\partial N}{\partial x}\right]^T \{\delta\}$.

$$q^{(1)} = \text{cond}\left[\frac{\partial N}{\partial x}\right]^T \{\delta\}$$

$$= 200 \begin{bmatrix} -1 \\ 1 \\ 0 \\ 0 \end{bmatrix} \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}$$

$$= 0 \text{ W/m}^2$$

Comment

Step 8 of 17

Obtain the heat flux from the element by using the relation.

$$q^{(1)} = \text{cond}\left[\frac{\partial N}{\partial x}\right]^T \{\delta\}$$

Substitute $\{\delta\} = \begin{bmatrix} 0 & 0 & 0 & 0 \end{bmatrix}^T$, $\text{cond} = 200 \frac{W}{m \cdot K}$, $\frac{\partial N}{\partial x} = \begin{bmatrix} -1 & 1 & 0 & 0 \end{bmatrix}$ in $q^{(1)} = \text{cond}\left[\frac{\partial N}{\partial x}\right]^T \{\delta\}$.

$$q^{(1)} = \text{cond}\left[\frac{\partial N}{\partial x}\right]^T \{\delta\}$$

$$= 200 \begin{bmatrix} -1 \\ 1 \\ 0 \\ 0 \end{bmatrix} \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}$$

$$= 0 \text{ W/m}^2$$

Comment

Step 7 of 17

Obtain the heat flux from the element by using the relation.

$$q^{(1)} = \text{cond}\left[\frac{\partial N}{\partial x}\right]^T \{\delta\}$$

Substitute $\{\delta\} = \begin{bmatrix} 0 & 0 & 0 & 0 \end{bmatrix}^T$, $\text{cond} = 200 \frac{W}{m \cdot K}$, $\frac{\partial N}{\partial x} = \begin{bmatrix} -1 & 1 & 0 & 0 \end{bmatrix}$ in $q^{(1)} = \text{cond}\left[\frac{\partial N}{\partial x}\right]^T \{\delta\}$.

$$q^{(1)} = \text{cond}\left[\frac{\partial N}{\partial x}\right]^T \{\delta\}$$

$$= 200 \begin{bmatrix} -1 \\ 1 \\ 0 \\ 0 \end{bmatrix} \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}$$

$$= 0 \text{ W/m}^2$$

Comment

Step 6 of 17

Obtain the heat flux from the element by using the relation.

$$q^{(1)} = \text{cond}\left[\frac{\partial N}{\partial x}\right]^T \{\delta\}$$

Substitute $\{\delta\} = \begin{bmatrix} 0 & 0 & 0 & 0 \end{bmatrix}^T$, $\text{cond} = 200 \frac{W}{m \cdot K}$, $\frac{\partial N}{\partial x} = \begin{bmatrix} -1 & 1 & 0 & 0 \end{bmatrix}$ in $q^{(1)} = \text{cond}\left[\frac{\partial N}{\partial x}\right]^T \{\delta\}$.

$$q^{(1)} = \text{cond}\left[\frac{\partial N}{\partial x}\right]^T \{\delta\}$$

$$= 200 \begin{bmatrix} -1 \\ 1 \\ 0 \\ 0 \end{bmatrix} \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}$$

$$= 0 \text{ W/m}^2$$

Comment

Step 5 of 17

Obtain the heat flux from the element by using the relation.

$$q^{(1)} = \text{cond}\left[\frac{\partial N}{\partial x}\right]^T \{\delta\}$$

Substitute $\{\delta\} = \begin{bmatrix} 0 & 0 & 0 & 0 \end{bmatrix}^T$, $\text{cond} = 200 \frac{W}{m \cdot K}$, $\frac{\partial N}{\partial x} = \begin{bmatrix} -1 & 1 & 0 & 0 \end{bmatrix}$ in $q^{(1)} = \text{cond}\left[\frac{\partial N}{\partial x}\right]^T \{\delta\}$.

$$q^{(1)} = \text{cond}\left[\frac{\partial N}{\partial x}\right]^T \{\delta\}$$

$$= 200 \begin{bmatrix} -1 \\ 1 \\ 0 \\ 0 \end{bmatrix} \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}$$

$$= 0 \text{ W/m}^2$$

Comment

Step 4 of 17

Obtain the heat flux from the element by using the relation.

$$q^{(1)} = \text{cond}\left[\frac{\partial N}{\partial x}\right]^T \{\delta\}$$

Substitute $\{\delta\} = \begin{bmatrix} 0 & 0 & 0 & 0 \end{bmatrix}^T$, $\text{cond} = 200 \frac{W}{m \cdot K}$, $\frac{\partial N}{\partial x} = \begin{bmatrix} -1 & 1 & 0 & 0 \end{bmatrix}$ in $q^{(1)} = \text{cond}\left[\frac{\partial N}{\partial x}\right]^T \{\delta\}$.

$$q^{(1)} = \text{cond}\left[\frac{\partial N}{\partial x}\right]^T \{\delta\}$$

$$= 200 \begin{bmatrix} -1 \\ 1 \\ 0 \\ 0 \end{bmatrix} \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}$$

$$= 0 \text{ W/m}^2$$

Comment

Step 3 of 17

Obtain the heat flux from the element by using the relation.

$$q^{(1)} = \text{cond}\left[\frac{\partial N}{\partial x}\right]^T \{\delta\}$$

Substitute $\{\delta\} = \begin{bmatrix} 0 & 0 & 0 & 0 \end{bmatrix}^T$, $\text{cond} = 200 \frac{W}{m \cdot K}$, $\frac{\partial N}{\partial x} = \begin{bmatrix} -1 & 1 & 0 & 0 \end{bmatrix}$ in $q^{(1)} = \text{cond}\left[\frac{\partial N}{\partial x}\right]^T \{\delta\}$.

$$q^{(1)} = \text{cond}\left[\frac{\partial N}{\partial x}\right]^T \{\delta\}$$

$$= 200 \begin{bmatrix} -1 \\ 1 \\ 0 \\ 0 \end{bmatrix} \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}$$

$$= 0 \text{ W/m}^2$$

Comment

Step 2 of 17

Obtain the heat flux from the element by using the relation.

$$q^{(1)} = \text{cond}\left[\frac{\partial N}{\partial x}\right]^T \{\delta\}$$

Substitute $\{\delta\} = \begin{bmatrix} 0 & 0 & 0 & 0 \end{bmatrix}^T$, $\text{cond} = 200 \frac{W}{m \cdot K}$, $\frac{\partial N}{\partial x} = \begin{bmatrix} -1 & 1 & 0 & 0 \end{bmatrix}$ in $q^{(1)} = \text{cond}\left[\frac{\partial N}{\partial x}\right]^T \{\delta\}$.

$$q^{(1)} = \text{cond}\left[\frac{\partial N}{\partial x}\right]^T \{\delta\}$$

$$= 200 \begin{bmatrix} -1 \\ 1 \\ 0 \\ 0 \end{bmatrix} \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}$$

$$= 0 \text{ W/m}^2$$

Comment

Step 1 of 17

Obtain the axial heat flux from the fin by substituting the heat flux from the elements $q^{(1)}$, $q^{(2)}$, $q^{(3)}$, $q^{(4)}$, $q^{(5)}$, $q^{(6)}$, $q^{(7)}$, $q^{(8)}$ in $q = \sum_{i=1}^{8} q^{(i)}$ and $q^{(1)} = q^{(2)} = q^{(3)} = q^{(4)} = q^{(5)} = q^{(6)} = q^{(7)} = q^{(8)} = 0$.

$$q = \sum_{i=1}^{8} q^{(i)}$$

$$= q^{(1)} + q^{(2)} + q^{(3)} + q^{(4)} + q^{(5)} + q^{(6)} + q^{(7)} + q^{(8)}$$

$$= 0 + 0 + 0 + 0 + 0 + 0 + 0 + 0$$

$$= 0 \text{ W/m}^2$$

The axial heat flux from the fin is $\boxed{0 \text{ W/m}^2}$.

Comment

Obtain the nodal temperatures from the relation $\{T\} = [K]^{-1}\{F\}$.

Node	Exact temperature (elem 1, $\xi = 0$) °C	Calculated temperature (elem 1, $\xi = 0$) °C	Exact temperature (elem 1, $\xi = 1$) °C	Calculated temperature (elem 1, $\xi = 1$) °C
1	100	100	100	100
2	62.50	62.50	62.50	62.50
3	45.47	45.24	32.50	32.72
4	37.97	37.50	20.72	20.00
5	27.50	27.50	10.42	10.25
6	18.42	18.72	5.25	4.47

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