

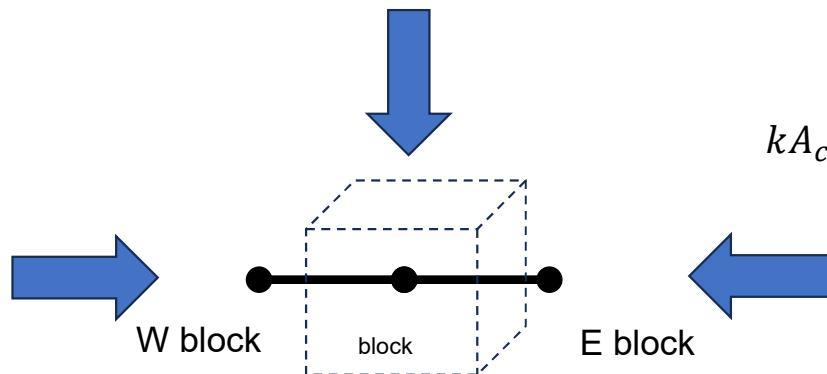
Today's Session Summary

- Time evolution
- Finite Volume Method
- Grid generation

Cell control volume – Non stationary

Heat Balance

$$hA_{convection}(T_\infty - T_{block}) = \dot{Q}_{convected}$$



$$kA_{conduction} \frac{T_{E\ block} - T_{block}}{Distance} = \dot{Q}_{E\ conducted}$$

$$kA_{conduction} \frac{T_{W\ block} - T_{block}}{Distance} = \dot{Q}_{W\ conducted}$$

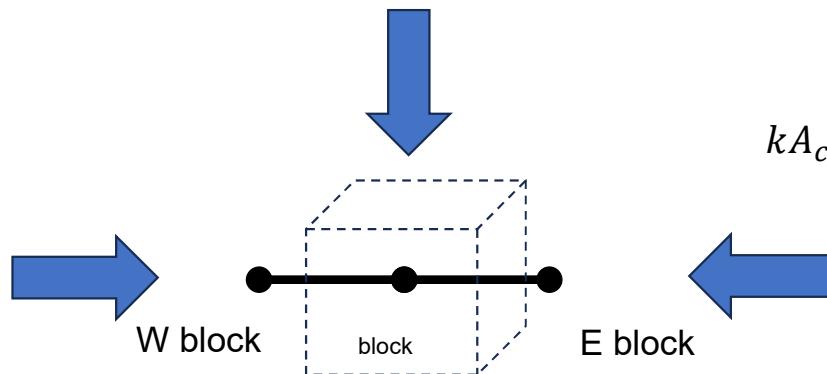
$$m_{block}C\dot{T}_{block} = \dot{Q}_{b\ stored}$$

$$kA_{conduction} \frac{T_{W\ block} - T_{block}}{Distance} + kA_{conduction} \frac{T_{E\ block} - T_{block}}{Distance} + hA_{convection}(T_{block} - T_\infty) = m_{block}C\dot{T}_{block}$$

Cell control volume – Non stationary – Forward Euler

Heat Balance

$$hA_{convection}(T_\infty - T_{block}) = \dot{Q}_{convected}$$



$$kA_{conduction} \frac{T_{E\ block} - T_{block}}{Distance} = \dot{Q}_{E\ conducted}$$

$$kA_{conduction} \frac{T_{W\ block} - T_{block}}{Distance} = \dot{Q}_{W\ conducted}$$

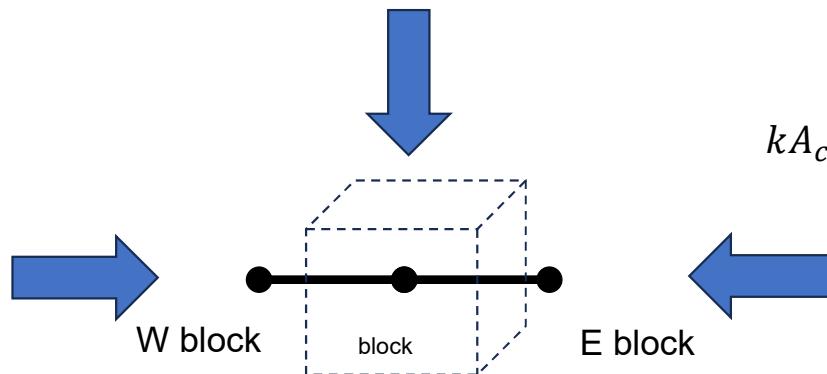
$$m_{block}C\dot{T}_{block} = \dot{Q}_{b\ stored}$$

$$kA_{conduction} \frac{T_{W\ block}^i - T_{block}^i}{Distance} + kA_{conduction} \frac{T_{E\ block}^i - T_{block}^i}{Distance} + hA_{convection}(T_\infty - T_{block}^i) = m_{block}C \frac{T_{block}^{i+1} - T_{block}^i}{\Delta t}$$

Cell control volume – Non stationary – Backward Euler

Heat Balance

$$hA_{convection}(T_\infty - T_{block}) = \dot{Q}_{convected}$$



$$kA_{conduction} \frac{T_{E\ block} - T_{block}}{\text{Distance}} = \dot{Q}_{E\ conducted}$$

$$kA_{conduction} \frac{T_{W\ block} - T_{block}}{\text{Distance}} = \dot{Q}_{W\ conducted}$$

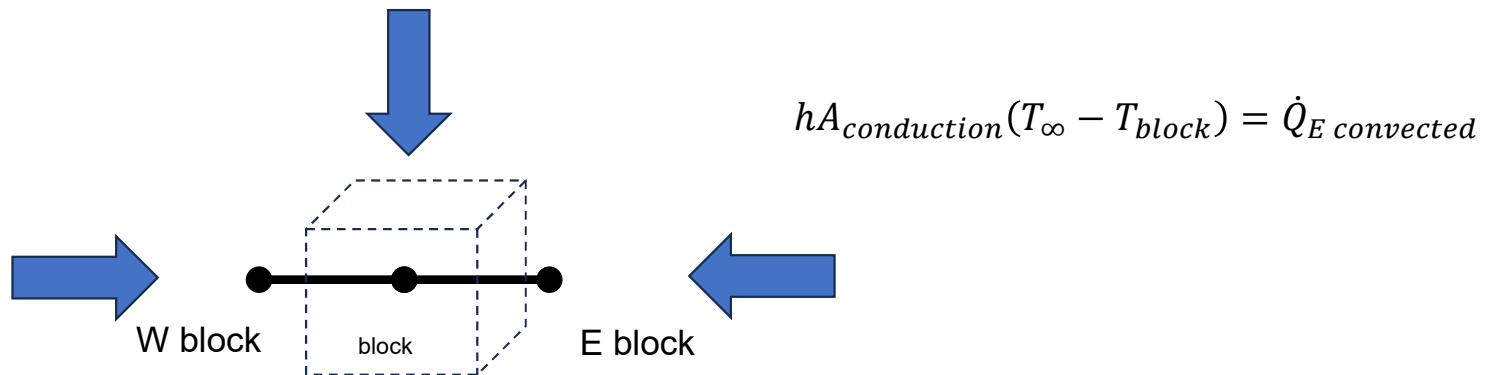
$$m_{block}C\dot{T}_{block} = \dot{Q}_{b\ stored}$$

$$kA_{conduction} \frac{T_{W\ block}^{i+1} - T_{block}^{i+1}}{\text{Distance}} + kA_{conduction} \frac{T_{E\ block}^{i+1} - T_{block}^{i+1}}{\text{Distance}} + hA_{convection}(T_\infty - T_{block}^{i+1}) = m_{block}C \frac{T_{block}^{i+1} - T_{block}^i}{\Delta t}$$

Cell control volume – Backward Euler

Heat Balance

$$hA_{convection}(T_\infty - T_{block}) = \dot{Q}_{convected}$$



$$kA_{conduction} \frac{T_{W\ block} - T_{block}}{Distance} = \dot{Q}_{W\ conducted}$$

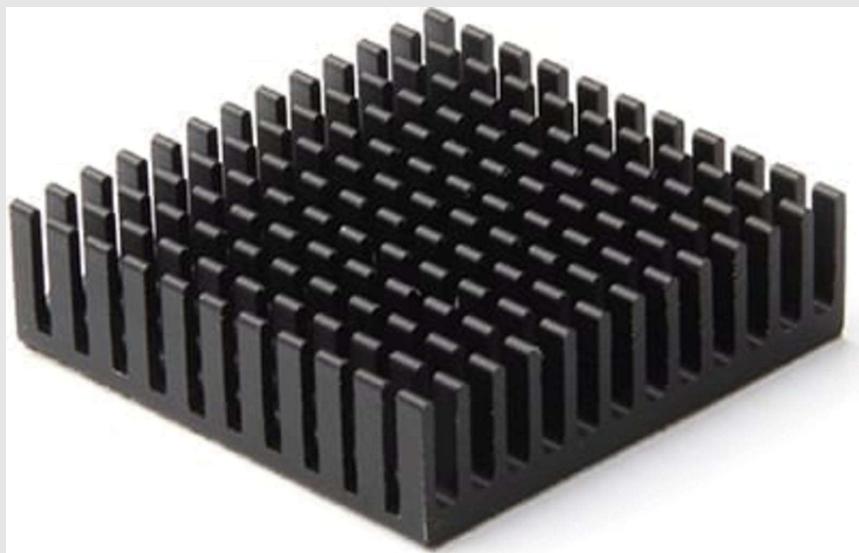
$$kA_{conduction} \frac{T_{W\ block} - T_{block}}{Distance} + h(A_{convection} + A_{conduction})(T_\infty - T_{block}) = m_{block}C \frac{T_{block}^{i+1} - T_{block}^i}{\Delta t}$$

Practice

Develop model to evaluate a heat sink thermal behavior.

Analyze heat sink power dissipation capability for a limit temperature of 60C with an environment temperature range from -20C to 45C.

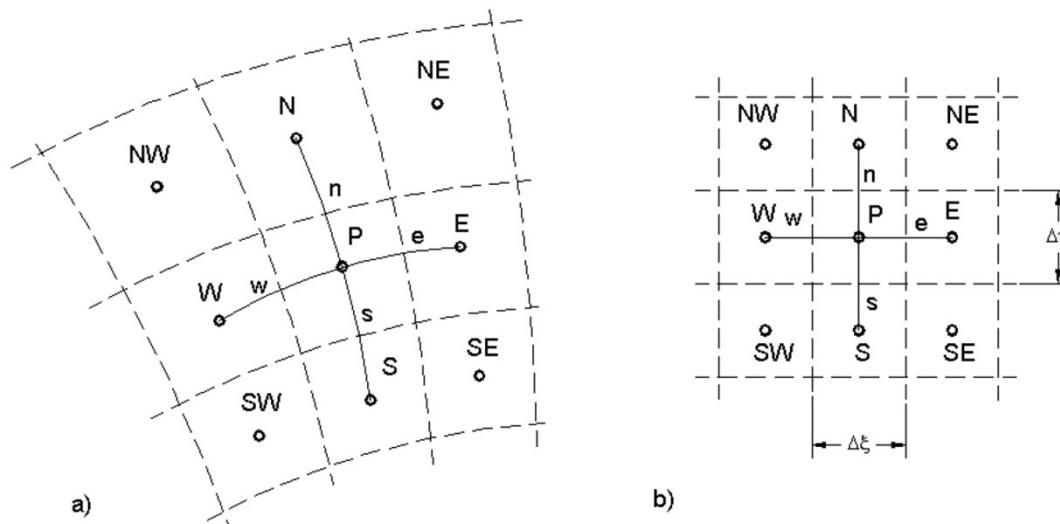
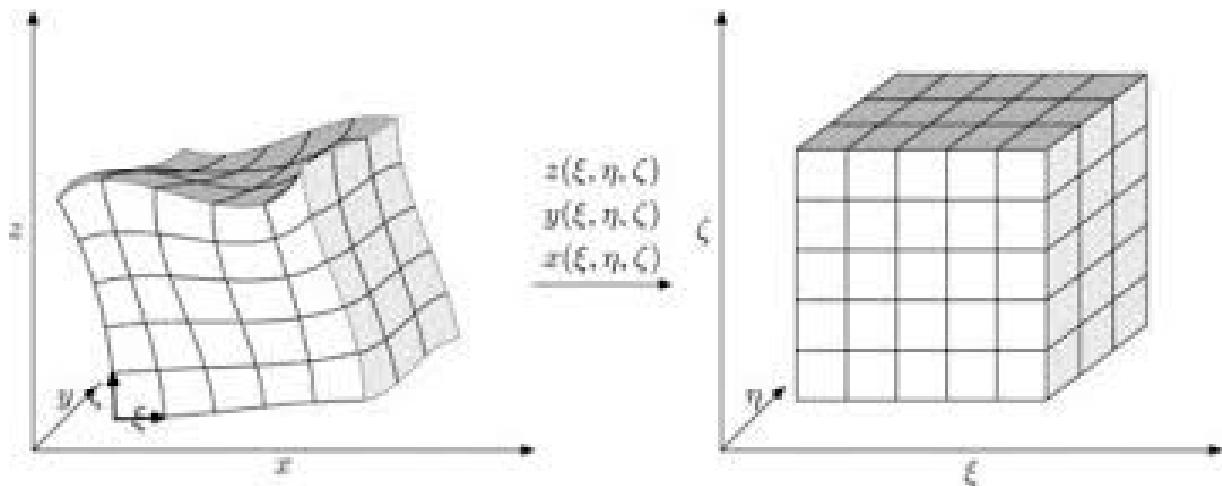
Determine time 90% of steady state temperature



143 Fins. Aluminium Heatsink Cooling Module
Fins: 2.5(L) x 1mm(W) x 10mm(H)
Module: 40mm(L) x 40mm(W) x 11mm(H)

Planar Grids Creation

- Mapped grid
- Boundary's
- Refinement
- Coordinate transformation



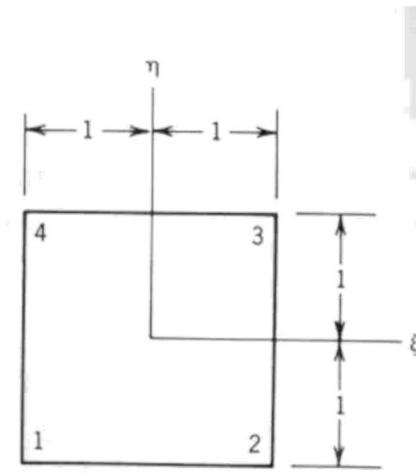
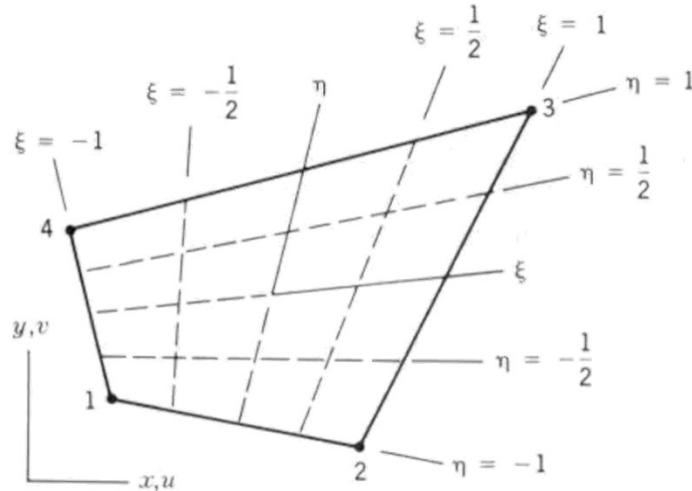
From Equations to Innovation:
Modeling and Optimization in Engineering

Planar Grids Creation

- Coordinate transformation

$$x(\xi, \eta) = \sum_i N(\xi, \eta)_i x_i$$

$$y(\xi, \eta) = \sum_i N(\xi, \eta)_i y_i$$



	$i = 5$	$i = 6$	$i = 7$	$i = 8$	$i = 9$
$N_1 = \frac{1}{4}(1 - \xi)(1 - \eta)$	$-\frac{1}{2}N_5$			$-\frac{1}{2}N_8$	$-\frac{1}{4}N_9$
$N_2 = \frac{1}{4}(1 + \xi)(1 - \eta)$	$-\frac{1}{2}N_5$	$-\frac{1}{2}N_6$			$-\frac{1}{4}N_9$
$N_3 = \frac{1}{4}(1 + \xi)(1 + \eta)$		$-\frac{1}{2}N_6$	$-\frac{1}{2}N_7$		$-\frac{1}{4}N_9$
$N_4 = \frac{1}{4}(1 - \xi)(1 + \eta)$			$-\frac{1}{2}N_7$	$-\frac{1}{2}N_8$	$-\frac{1}{4}N_9$
$N_5 = \frac{1}{2}(1 - \xi^2)(1 - \eta)$					$-\frac{1}{2}N_9$
$N_6 = \frac{1}{2}(1 + \xi^2)(1 - \eta^2)$					$-\frac{1}{2}N_9$
$N_7 = \frac{1}{2}(1 - \xi^2)(1 + \eta)$					$-\frac{1}{2}N_9$
$N_8 = \frac{1}{2}(1 + \xi^2)(1 - \eta^2)$					$-\frac{1}{2}N_9$
$N_9 = (1 - \xi^2)(1 - \eta^2)$					

From Equations to Innovation:
Modeling and Optimization in Engineering

Practice

Build the grid matrixes using provided code

(<https://colab.research.google.com/drive/13HZCLAIwhNo9fiVaw3Om9N-DbKbT8-FE?usp=sharing>)

Nodes

Neighbors

Areas

Volumes

End Session 21