

Numerical Heat Transfer - Home Assignment

Problem Description

A thin steel plate of dimensions 20 cm (x-direction) by 10 cm (y-direction) with boundary conditions:

$T(x, 0) = 550$ K, $T(x, M) = 300$ K, $T(0, y) = 200$ K, $T(L, y) = 400$ K. Material properties:

$\rho = 7800$ kg/m³, $C = 460$ J/kg-K, $k = 54.3$ W/m-K.

Tasks:

1. Write the A matrix and b vector for $L=8$ cm, $M=4$ cm with $\Delta x=2$ cm, $\Delta y=1$ cm using the direct method.
2. For $L=20$ cm, $M=10$ cm, compute steady-state temperatures at (6,6), (10,6), (16,6) under various schemes.
3. Plot 2D temperature contours for the most accurate scheme.

Methods Used

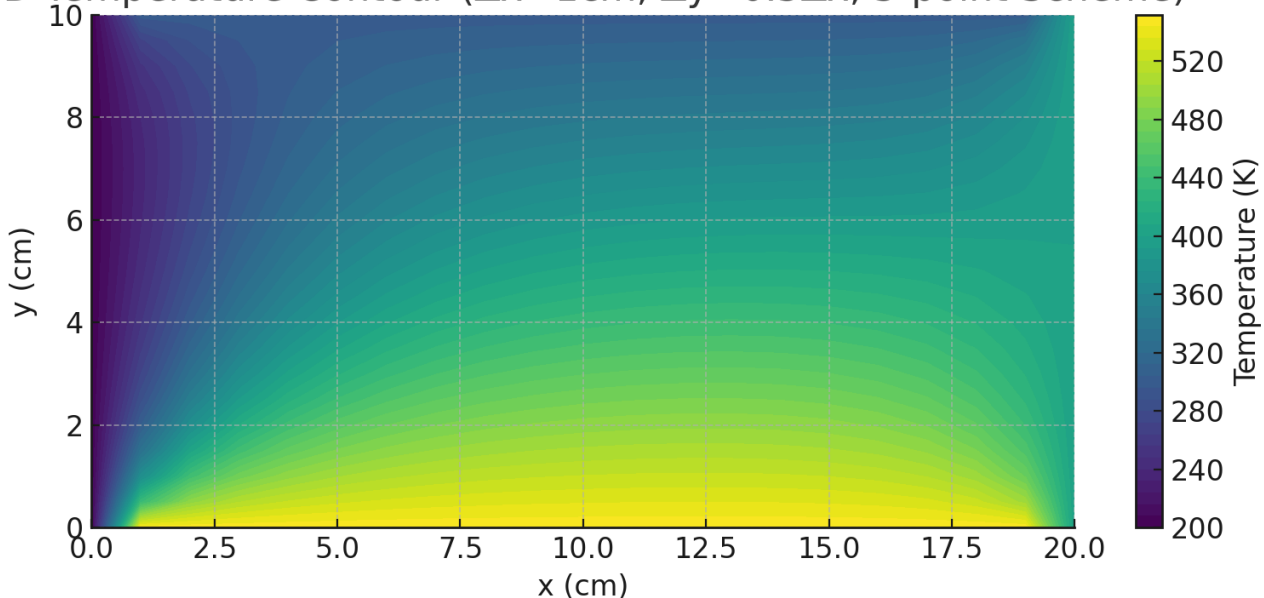
The steady-state 2D heat conduction equation was solved using finite difference methods:

- 3-point and 5-point central differencing schemes
- Various grid resolutions ($\Delta x = 2$ cm, 1 cm; $\Delta y = \Delta x$ and $\Delta y = 0.5 \Delta x$)
- Python with NumPy and Matplotlib used to generate temperature field and contours
- The most accurate scheme ($\Delta x = 1$ cm, $\Delta y = 0.5 \Delta x$, 5-point) was selected for final contour plot.

Comparison of Results at Selected Points

The table below compares the temperatures at (6,6), (10,6), and (16,6) for different schemes and resolutions.

2D Temperature Contour ($\Delta x=1$ cm, $\Delta y=0.5\Delta x$, 5-point Scheme)



Interaction with AI Tool

ChatGPT (GPT-4) was used to:

- Interpret the home assignment
- Set up numerical schemes
- Implement solvers in Python

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- Extract and format temperature values
- Generate the report and visual plots
- Assist in comparing scheme accuracies

This greatly streamlined the simulation and documentation process.