# AE 675

Coding Assignment

Group Members

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**Case 1**

**Part (a)**

One of the diagonals of the square was used to divide the square into 2 equal triangular elements.

The element-wise terms of the 2D heat conduction equation were calculated (in general) by hand and then implemented in the code file. The determination of the natural coordinates and subsequent calculation of the Jacobian and required matrices were done through code.

The final equation was brought into the form of AX = B so that X = B\A can be directly obtained.

Q0 = 1000 * 0.01 to divide the 1KW power provided throughout the thickness (1cm) of the sheet

Result :

[298, 298, 914/3, 934/3]

**Part (b)**

Each triangular element had one side of the square as its base and the opposite vertex at the centre of the square, which coincides with the application of the point heat source.

The element-wise terms of the PDE were calculated and implemented. Matrices were formed for the shape functions and cartesian coordinates of the nodes. All calculations were done on MATLAB through corresponding matrix operations.

Individual terms for each element were coded separately and then assembled at the end.

Result :

298

298

303

303

303

**Part (c)**

The pattern identified by writing the PDE for parts (a) and (b) led to a generalisation where a loop is run for each element and the similar terms were added to a larger sum

These sums of terms were then used to generate the assembly equation. Simplification due to known nodal temperatures and forming of AX = B equation followed.

Result :

| | | | |
|---|---|---|---|
| 298.0000 | 302.5575 | 303.1770 | 301.0088 |
| 298.0000 | 302.6460 | 302.6460 | 303.9735 |
| 301.0088 | 303.1770 | 302.5575 | |

**Part (d)**

The same code and logic implemented in part (c) was used in part (d) too with minor changes. The number of elements was increased to 100 and number of nodes to 101.

Plotting the contours and line plots for each case, it is easily seen that as the number of elements is increased, the curve is smoother and more realistic (temperature gradients are expected to be smooth in real life). The difference between adjacent nodal temperatures also decreases drastically as the number of elements is increased.

Result : (split into columns for better visualisation)

| | | | | |
|---|---|---|---|---|
| 298.0000 | 298.0000 | 300.5548 | 302.6420 | 303.2224 |
| 298.0000 | 298.0000 | 300.8606 | 302.6207 | 303.2018 |
| 298.0000 | 298.0000 | 301.1452 | 302.5916 | 303.1715 |
| 298.0000 | 298.0000 | 301.4067 | 302.6743 | 303.1323 |
| 298.0000 | 298.0000 | 301.6434 | 302.7539 | 303.0848 |
| 298.0000 | 298.0000 | 301.8539 | 302.8300 | 303.0300 |
| 298.0000 | 298.0000 | 302.0375 | 302.9018 | 302.9687 |
| 298.0000 | 298.0000 | 302.1944 | 302.9687 | 302.9018 |
| 298.0000 | 298.0000 | 302.3251 | 303.0300 | 302.8300 |
| 298.0000 | 298.0000 | 302.4309 | 303.0848 | 302.7539 |
| 298.0000 | 298.3965 | 302.5135 | 303.1323 | 302.6743 |
| 298.0000 | 298.7851 | 302.5751 | 303.1715 | 302.5916 |
| 298.0000 | 299.1644 | 302.6178 | 303.2018 | 302.6207 |
| 298.0000 | 299.5329 | 302.6438 | 303.2224 | 302.6420 |
| 298.0000 | 299.8888 | 302.6552 | 303.2328 | 302.6540 |
| 298.0000 | 300.2302 | 302.6540 | 303.2328 | 302.6552 |

| | | | | |
|---|---|---|---|---|
| 302.6438 | 302.3251 | 301.4067 | 299.8888 | 304.0509 |
| 302.6178 | 302.1944 | 301.1452 | 299.5329 | |
| 302.5751 | 302.0375 | 300.8606 | 299.1644 | |
| 302.5135 | 301.8539 | 300.5548 | 298.7851 | |
| 302.4309 | 301.6434 | 300.2302 | 298.3965 | |

**Case 2**

The matrix equations and code-building procedure followed in parts (c), (d) of Case 1 was followed. The only change was in the equation, which introduced an additional term due to the heat convection through one of the sides. Another change is the absence of known nodal temperatures. As such, Case 1 involved giving Dirichlet BCs, while Case 2 provided Neumann BCs.

Result : (split into columns for better visualisation)

| | | | | |
|---|---|---|---|---|
| 295.7903 | 298.0058 | 296.2450 | 299.3430 | 301.5253 |
| 295.9102 | 298.0765 | 296.0619 | 299.6965 | 301.5576 |
| 296.0619 | 298.0765 | 295.9102 | 300.0213 | 301.5718 |
| 296.2450 | 298.0058 | 295.7903 | 300.3152 | 301.5703 |
| 296.4569 | 297.8704 | 296.2828 | 300.5766 | 301.5554 |
| 296.6930 | 297.6817 | 296.7654 | 300.8047 | 301.5290 |
| 296.9455 | 297.4542 | 297.2365 | 300.9994 | 301.4928 |
| 297.2037 | 297.2037 | 297.6941 | 301.1618 | 301.5955 |
| 297.4542 | 296.9455 | 298.1361 | 301.2932 | 301.6944 |
| 297.6817 | 296.6930 | 298.5601 | 301.3959 | 301.7888 |
| 297.8704 | 296.4569 | 298.9633 | 301.4723 | 301.8780 |

| | |
|---|---|
| 301.9612 | 301.5703 |
| 302.0373 | 301.5718 |
| 302.1053 | 301.5576 |
| 302.1643 | 301.5253 |
| 302.2130 | 301.4723 |
| 302.2506 | 301.3959 |
| 302.2761 | 301.2932 |
| 302.2891 | 301.1618 |
| 302.2891 | 300.9994 |
| 302.2761 | 300.8047 |
| 302.2506 | 300.5766 |
| 302.2130 | 300.3152 |
| 302.1643 | 300.0213 |
| 302.1053 | 299.6965 |
| 302.0373 | 299.3430 |
| 301.9612 | 298.9633 |
| 301.8780 | 298.5601 |
| 301.7888 | 298.1361 |
| 301.6944 | 297.6941 |
| 301.5955 | 297.2365 |
| 301.4928 | 296.7654 |
| 301.5290 | 296.2828 |
| 301.5554 | 303.3052 |