Programming Assignment to solve 1-D Transient Heat Transfer Problem using Finite Difference Numerical Method

Submitted for Core Course MM204

For the requirements of the MEMS B.Tech. Program

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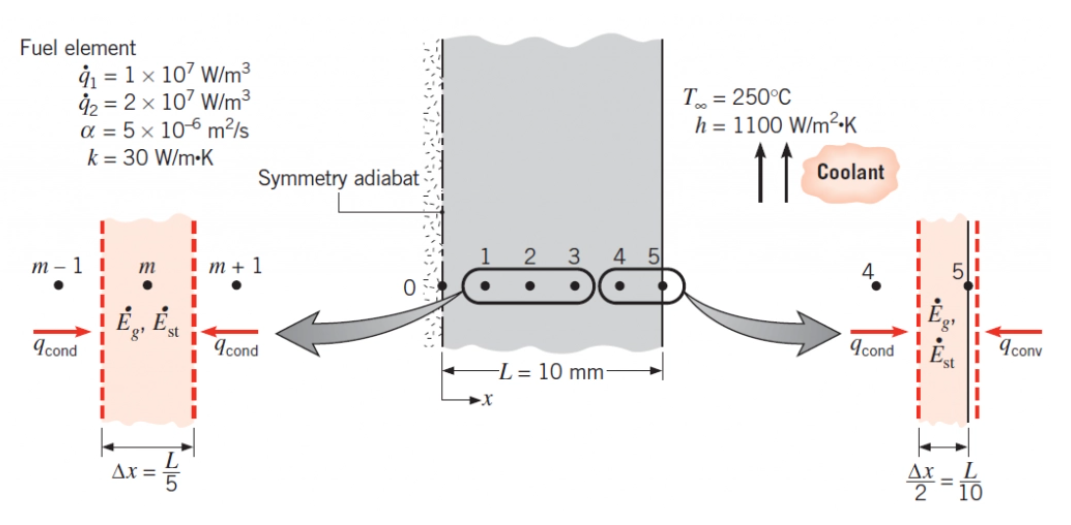
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PROBLEM STATEMENT

A fuel element of a nuclear reactor is in the shape of a plane wall of thickness 2L = 20 mm and is convectively cooled at both surfaces, with h = 1100W/m2.K and T∞ = 250oC. At normal operating power, heat is generated uniformly within the element at a volumetric rate of q1 = 107 W/m3. A departure from the steady-state conditions associated with normal operation will occur if there is a change in the generation rate. Consider a sudden change to , and use the explicit finite-difference method to determine the fuel element temperature distribution after 1.5 s. The fuel element thermal properties are k = 30 W/m.K and α = 5 x 10^-6 m^2/s



Known: Conditions associated with heat generation in a rectangular fuel element with surface cooling.

Find: Temperature distribution 1.5 s after a change in operating power.

Assumptions:

1. One-dimensional conduction in x.

2. Uniform generation.

3. Constant properties.

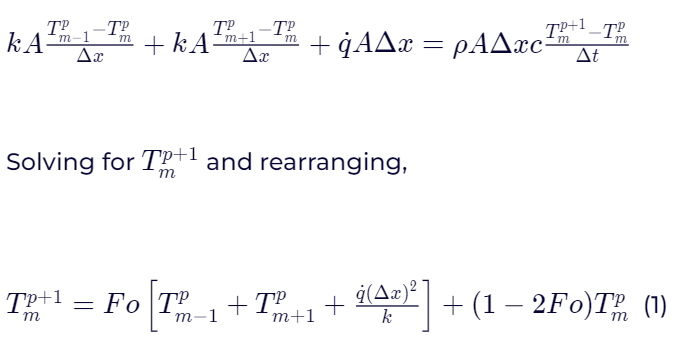
PROBLEM SOLVING APPROACH

**ANALYSIS**:

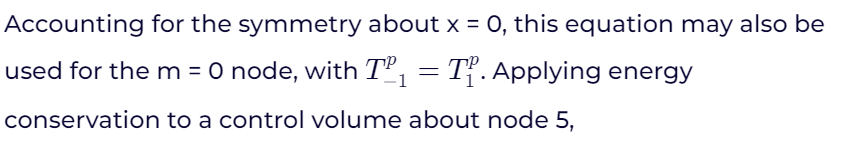
A numerical solution will be obtained using a space increment of

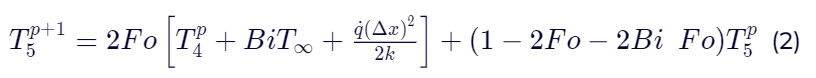
Δ*x=2mm*. Since there is symmetry about the midplane, the nodal network yields 6unknown nodal temperatures. Using the energy balance method, Equation 5.84, an explicit finite-difference equation may be derived for any interior node m.

**HEAT TRANSFER EQUATION FOR INTERMEDIATE NODES**



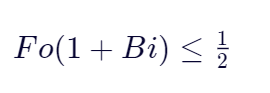
**HEAT TRANSFER EQUATION FOR SURFACE NODE**

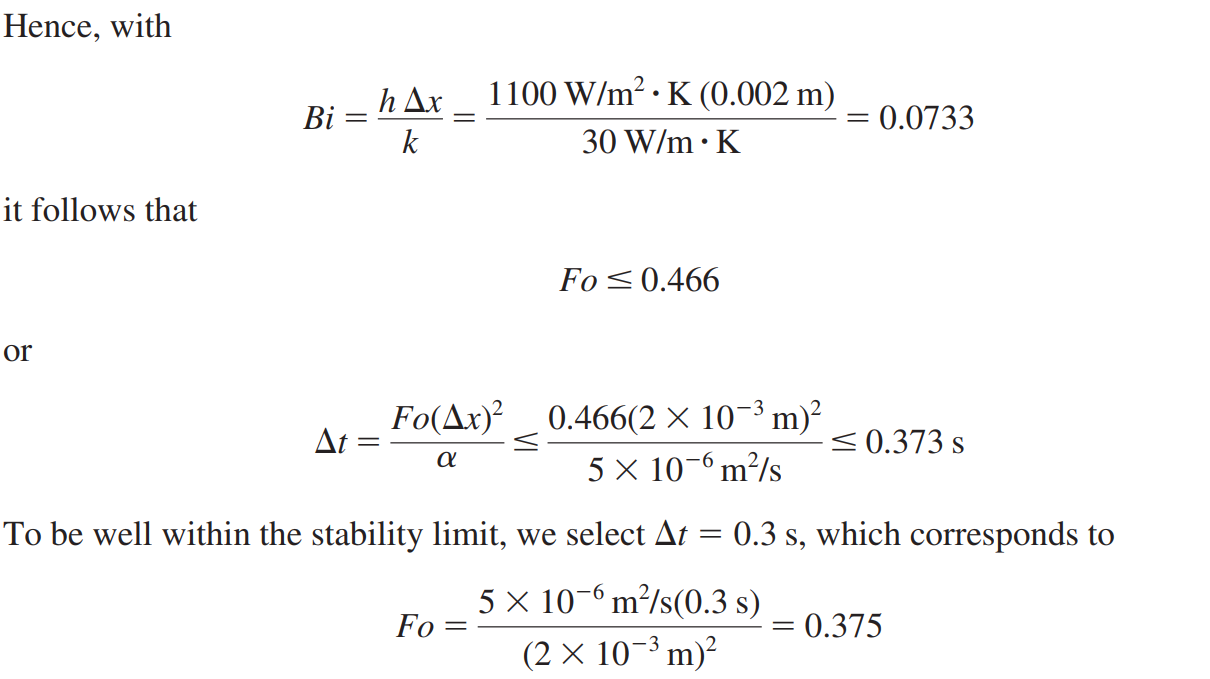


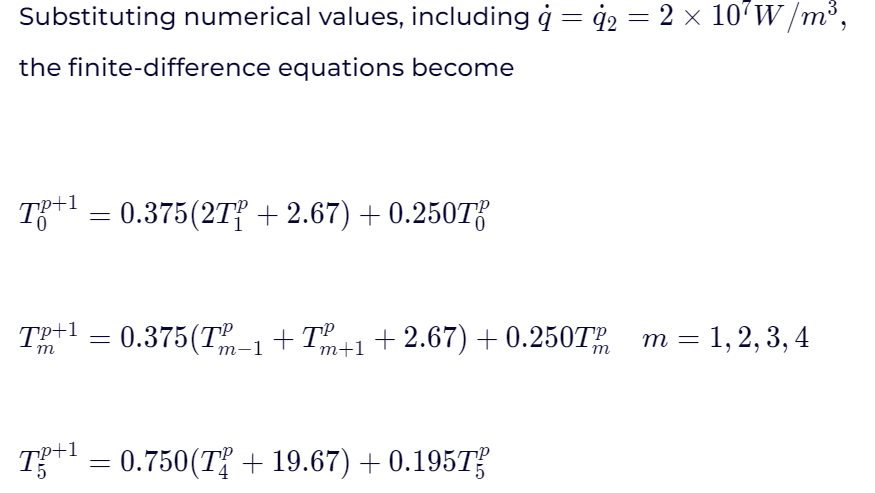


**STABILITY CRITERION**

Since the most restrictive stability criterion is associated with Equation 2, we select Fo from the requirement that



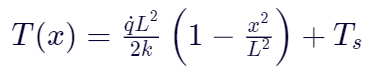




**INITIAL CONDITION (t=0)**

Using equations derived for plane walls at steady state with heat generation at the center (here q = q1 ).





Initial temperatures for the nodal points are shown in the first row of the accompanying table.

**RESULTS**

Using the finite-difference equations, the nodal temperatures may be sequentially calculated with a time increment of 0.3 s until the desired final time is reached.

