Department of Energy Science and Engineering
Indian Institute of Technology Delhi
ESL 373: Computational Methods for Energy Systems (2024-2025 Sem II)
Course Project/Assignment

Date: 20/03/2025 Maximum marks: 10

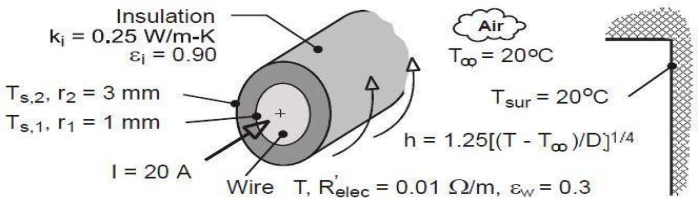
Please scan the hand-written parts to make a pdf. If you are able to type everything then also fine. Make a combined file with the scanned parts along with necessary plots. Include copies of the computer programs. The programs should not be added as screenshot or figures, but as texts. Clearly mention the programming language used and other relevant details. Please upload on Moodle by 24th April midnight (not on 25th April). Viva (possibly immediately after Major Exam to have sufficient time before grade moderation) will be taken to ascertain your genuine contribution and possible blind usage of AI tools. Viva has to be in-person. Otherwise marks will be deducted.

1. Consider the problem of 1D, constant property, steady-state, thermal diffusion, with heat generation. Set up the equations for solving 4 unknown temperatures. Expected final form to be AX=B. X is the array of unknown variables. A is the coefficient matrix. Write a computer programme to solve the unknown temperatures. Call a sub-routine/function for matrix inversion and solving for the unknown array. Draw the relevant flow-chart. Run the program for 8, 16, 64 and 128 CVs instead of 4 CVs and comment on the differences in the results. Compare the results from the computer program with the analytical result. Both faces assume Dirichlet boundary conditions.

1	2	3	4

2. Consider the problem of 2D, constant property, steady-state, thermal diffusion, with no heat generation. Set up the equations for solving the unknown temperatures. Assume left boundary cells have Neumann boundary condition. Assume the right boundary cells have Robin's boundary condition. Consider Dirichlet boundary conditions for the top and bottom boundary cells. Show the FVM discretization of the energy equation for the interior, the corner and the boundary cells.

3. We are dealing with a heat transfer problem considering both convection and radiation. An electrical wire with insulating cover on the outside is losing heat to ambient air and surroundings. An iterative procedure is needed to estimate the temperature of the outer surface of the covered wire, since there is a non-linear relation of temperature in the energy balance equation.



$$\dot{E}'_g = q' = q'_{conv} + q'_{rad} = \pi D h\left(T_{s,2} - T_\infty\right) + \pi D \varepsilon_i \sigma \left(T_{s,2}^4 - T_{sur}^4\right)$$

$$4\,W/m = 1.25\pi\left(0.006m\right)^{3/4}\left(T_{s,2} - 293\right)^{5/4} + \pi\left(0.006m\right)0.9\times 5.67\times 10^{-8}\,W/m^2\cdot K^4\left(T_{s,2}^4 - 293^4\right)K^4$$

Source: Solution manual of heat transfer book by Incropera et al. (7th Edition). The following equation is for the energy balance of electrical wire of unit length, with a non-linear relationship of outer surface temperature.
Write a program to solve for the unknown temperature. Plot the evolution of temperature estimates with iterations. Show how with change in initial guess and change in iteration procedure the convergence rate changes.