ME685A: Applied Numerical Methods
Assignment 4

23rd September 2020

1. A steel pellet, initially at a high temperature, cools in a large oil bath. Cooling is largely convective and the time constant of the cooling process is 10 seconds. (a) Starting from an analytical solution, find the time required for the pellet to cool to half the initial temperature difference. (b) Get numerical estimates of the time required in (a) using time steps of 1, 0.5, and 0.1 seconds. Time integration may be selected as explicit and implicit; tabulate your results for each approach.
2. In problem (a), the steel pellet cools in air where convective as well and radiative cooling are present. Set up a mathematical model of the cooling process and suggest a method of solution. Time integration may be selected independently as explicit and implicit.

Use implicit time differencing in the following examples.

3. A hot steel pellet cools as it moves vertically downwards in a large reservoir. Set up the equation of motion as well as that of cooling of the pellet. Assume drag resistance of the pellet to be proportional to velocity while the cooling is convective. Develop an algorithm that will determine the temperature of the pellet as a function of its position.
4. Set up a mathematical model for a tank-emptying process in a tank-and-tube system and derive an expression for the time constant of the system. Discuss the extent to which the tank would empty in a time period of one, two and ten time constants.
5. State the mathematical model for a process that contains a tank-tube pair in series (two tanks and two tubes) with suitable initial conditions. Describe a numerical method that can be used to obtain water levels in the reservoirs. Extend the formulation to a problem where the relative water levels in the reservoirs are not known in advance and the flow direction has to be obtained as a part of the solution.