Computational Fluid Dynamics

Assignment Catalogue

AM5630 Assignment 1

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Contents

1 Problem statement

Given a rod of Length **L** ,with boundary conditions,initial conditions as follows:

1.1 Boundary condition:

$$T(0,t) = 0°C \tag{1}$$
$$T(L,t) = 1°C \tag{2}$$

1.2 Initial condition:

$$T(x,0) = 0°C \tag{3}$$

Compute the temperature for t = 0s to 20s for various values of $\Delta T = 0.1s, 0.01s, 0.001s$.

2 Governing Equations

2.1 PDE

$$\frac{\delta T}{\delta t} = \alpha \frac{\delta^2 T}{\delta x^2} \tag{4}$$

2.2 Finite difference formulation using FTCS scheme

$$T_i^{n+1} = T_i^n + \alpha \Delta t \frac{(T_{i+1}^n - 2T_i^n + T_{i-1}^n)}{(\Delta x)^2} \tag{5}$$

3 Pseudo Code

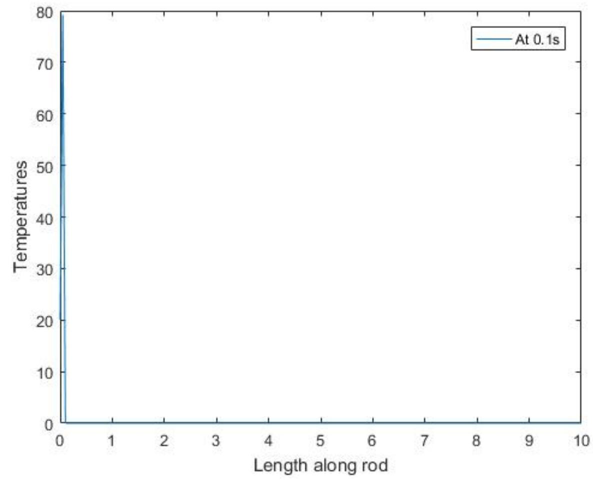
1. Initialize the variables $\alpha, \Delta t, T, \Delta x, N_x, L$.
   (Note here T is a matrix with N_x columns ,and $20/(\Delta t) + 1 = N_y$ rows)
2. For n = 2 to N_y execute the statements 3 and 4.
3. For i = 2 to $N_x - 1$ execute statement 4.
4. $T[i][n+1] = T[i][n] + \frac{\alpha \Delta t}{(\Delta x)^2}(T[i+1][n] - 2T[i][n] + T[i-1][n])$
5. end

4 Results

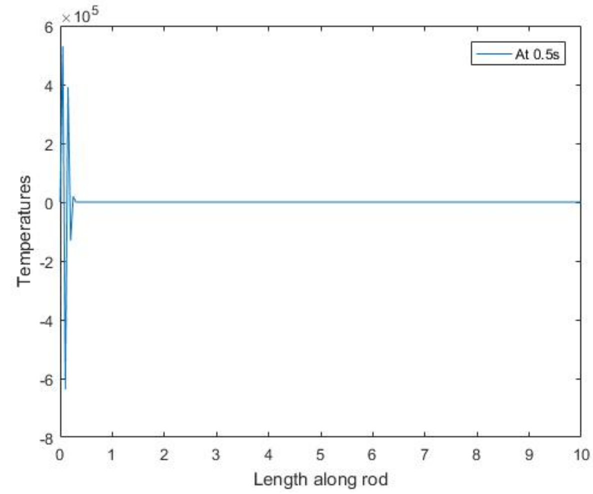
4.1 Case A

Assumptions : $N_x = 200, \Delta t = 0.1s$

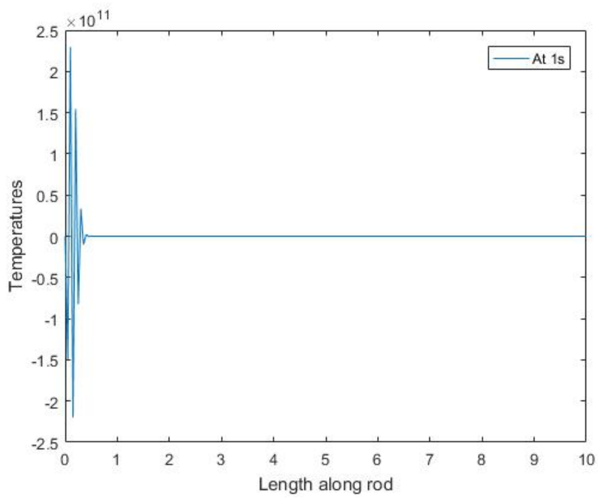
1. At 0.1s



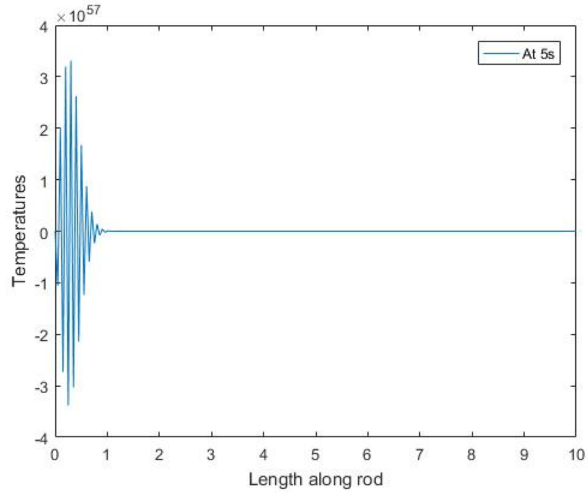
2. At 0.5s



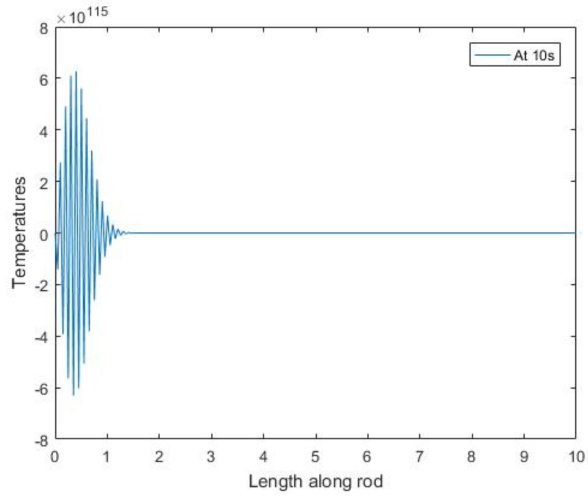
3. At 1s



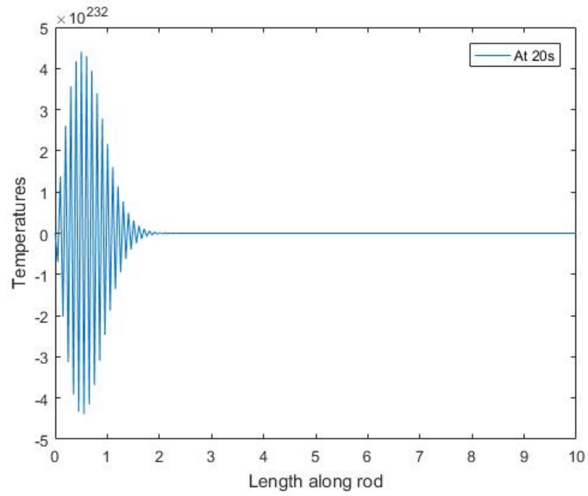
4. At 5s



5. At 10s

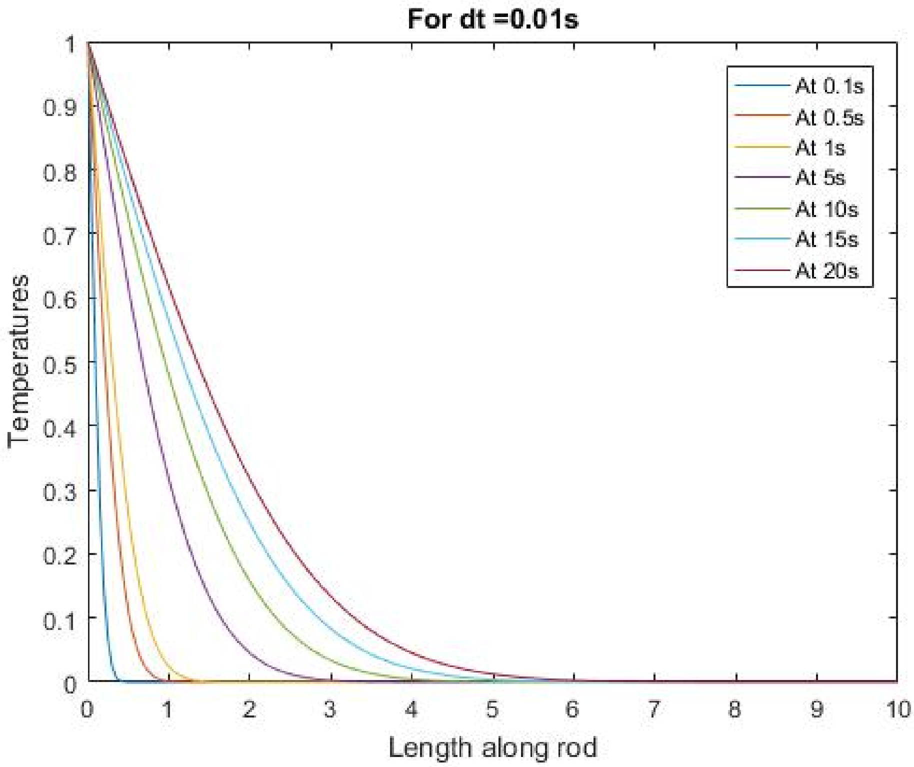


6. At 20s



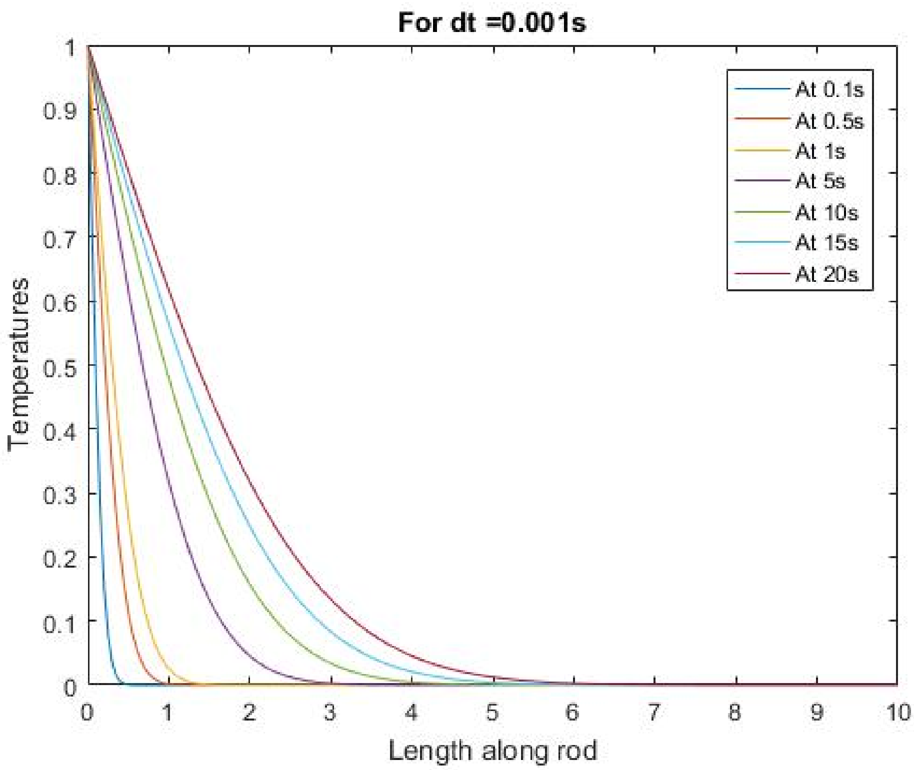
4.2 Case B

Assumptions : $N_x = 200, \Delta t = 0.01s$
Results:



4.3 Case C

Assumptions : $N_x = 200, \Delta t = 0.001s$
Results:



5 Appendix A-Code

5.1 File - ME14B149_ Input.m

Input Variables

```
L = 10 ; % Length of rod in meters
t = 2000;  % Max time of observation in seconds
alpha = .1; % SI units

Nx = 200; % No of grid points in space
dt = .01; % Time differential in seconds
dx = (L/(Nx-1)); % Distance differential in m
```

5.2 File - ME14B149_ Assignment.m

Contents

- CFD Assignment -Intro
- Variable initialization -1
- CSFT scheme
- Plotting data for t = 0.1,0.5,1,5,10,15,20 s

CFD Assignment -Intro

One dimentional unsteady heat conduction equation

```
close ;
clear ;
clc;
```

Variable initialization

```
ME14B149_Input  % Running input file

m = round(t/dt + 1); % No of grid points in time
T = zeros(m,Nx); % Grid generation ,Initial condition

T(:,1) = 1;  %Boundary condition
T(:,Nx) = 0; %Boundary condition
```

CSFT scheme

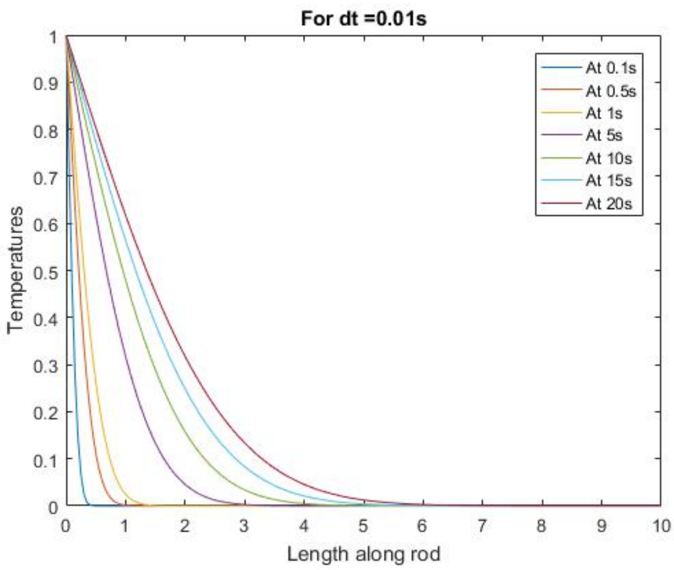
dT/dt = alpha d2T/d2x Tn+1(i) = Tn(i) + alpha*dt(Tn(i+1)+2*Tn(i)+Tn(i-1))/dx2

```
for n = 2:m
    for i = 2:(Nx-1)
     T(n,i) =  T(n-1,i) + alpha*dt*(T(n-1,i+1)-2*T(n-1,i)+T(n-1,i-1))/dx/dx;
     %pause;
    end
end
```

Plotting data for t = 0.1,0.5,1,5,10,15,20 s

```
total = 20;
step = 5;
j = (0:step:total)/dt;
plot(0:dx:L , T(0.1/dt+1,:),0:dx:L , T(0.5/dt+1,:),0:dx:L , T(1/dt+1,:), ...
0:dx:L , T(5/dt+1,:), 0:dx:L, T(10/dt+1,:),0:dx:L , T(15/dt+1,:),0:dx:L , T(20/dt+1,:));
xlabel('Length along rod')
ylabel('Temperatures')
legend('At 0.1s','At 0.5s','At 1s','At 5s','At 10s','At 15s','At 20s');
s1 = num2str(dt);
s2 = 'For dt =' ;
s3 = strcat(s2,s1,'s');
title(s3);
```

Sample Result



6 Appendix B - Code Links

Matlab Code : https://github.com/RAAKASH/Intro-to-CFD-.git