

Computational Fluid Dynamics

Assignment Catalogue

AM5630 Assignment 1

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Contents

1	Problem statement	3
1.1	Boundary condition:	3
1.2	Initial condition:	3
2	Governing Equations	3
2.1	PDE	3
2.2	Finite difference formulation using FTCS scheme	3
3	Pseudo Code	3
4	Results	3
4.1	Case A	3
4.2	Case B	6
4.3	Case C	6
5	Appendix-Code	7
5.1	File - Assignment.m	7

1 Problem statement

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

1.1 Boundary condition:

$$T(0, t) = 0^\circ C \quad (1)$$

$$T(L, t) = 1^\circ C \quad (2)$$

1.2 Initial condition:

$$T(x, 0) = 0^\circ C \quad (3)$$

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

$$\frac{\delta T}{\delta t} = \alpha \frac{\delta^2 T}{\delta x^2} \quad (4)$$

2.2 Finite difference formulation using FTCS scheme

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

3 Pseudo Code

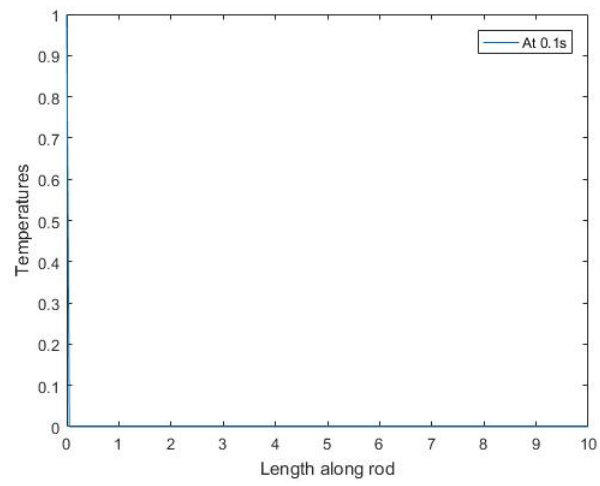
1. Initialize the variables $\alpha, \Delta t, T, \Delta x, N_x, L$.
(Note here T is a matrix with N_x columns, and $20/(\Delta T) = N_y$ rows)
2. For $n = 2$ to N_y execute the statements 3 and 4.
3. For $i = 2$ to $N_x - 1$ execute statement 4.
4. $T[i][n+1] = T[i][n] + \frac{\alpha \Delta t}{(\Delta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

4 Results

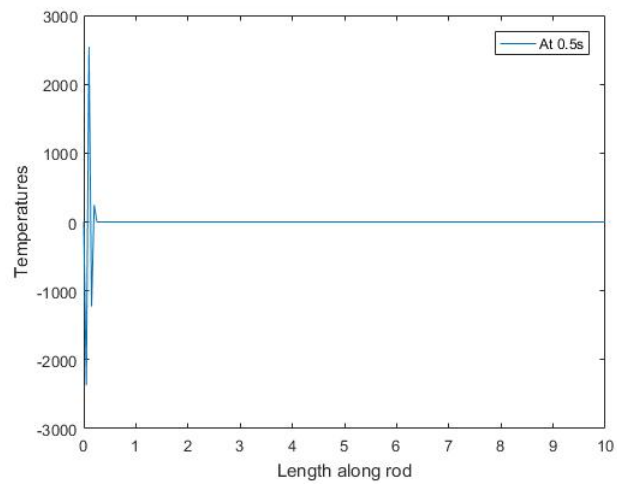
4.1 Case A

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

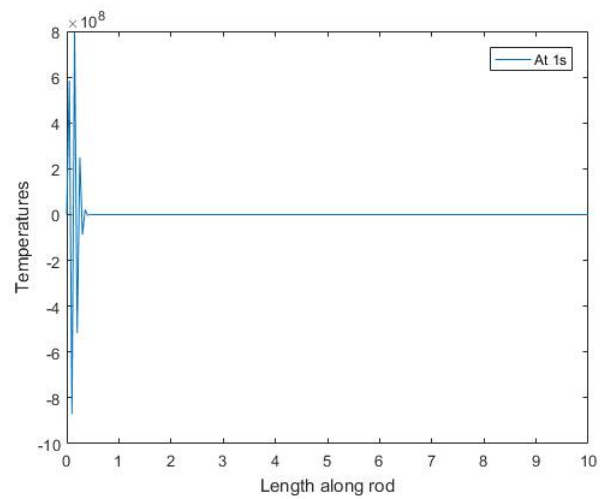
1. At $0.1s$



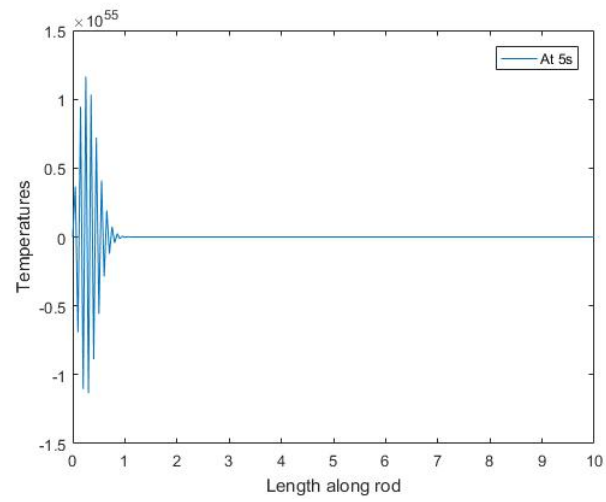
2. At 0.5s



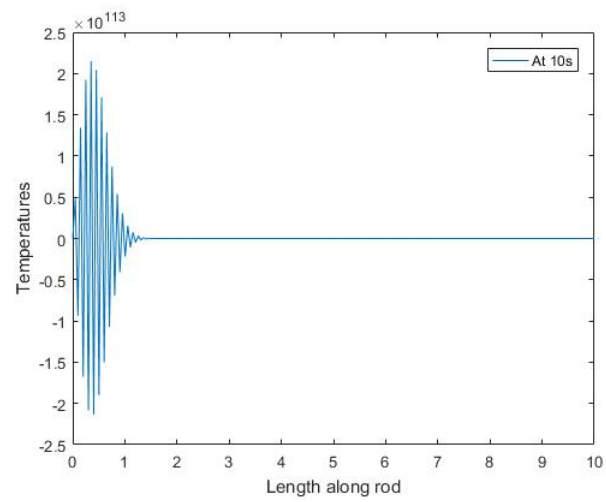
3. At 1s



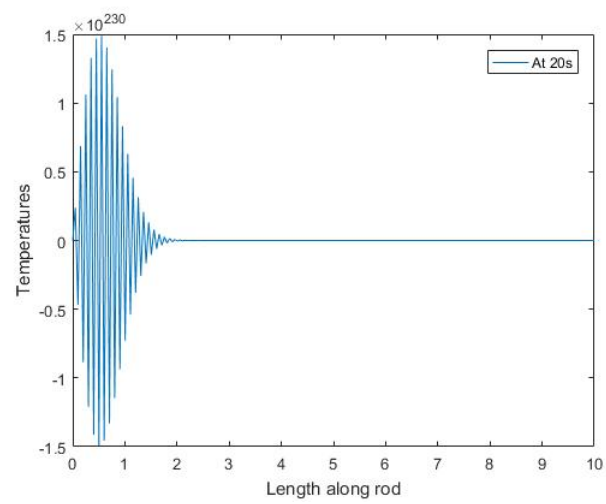
4. At 5s



5. At 10s



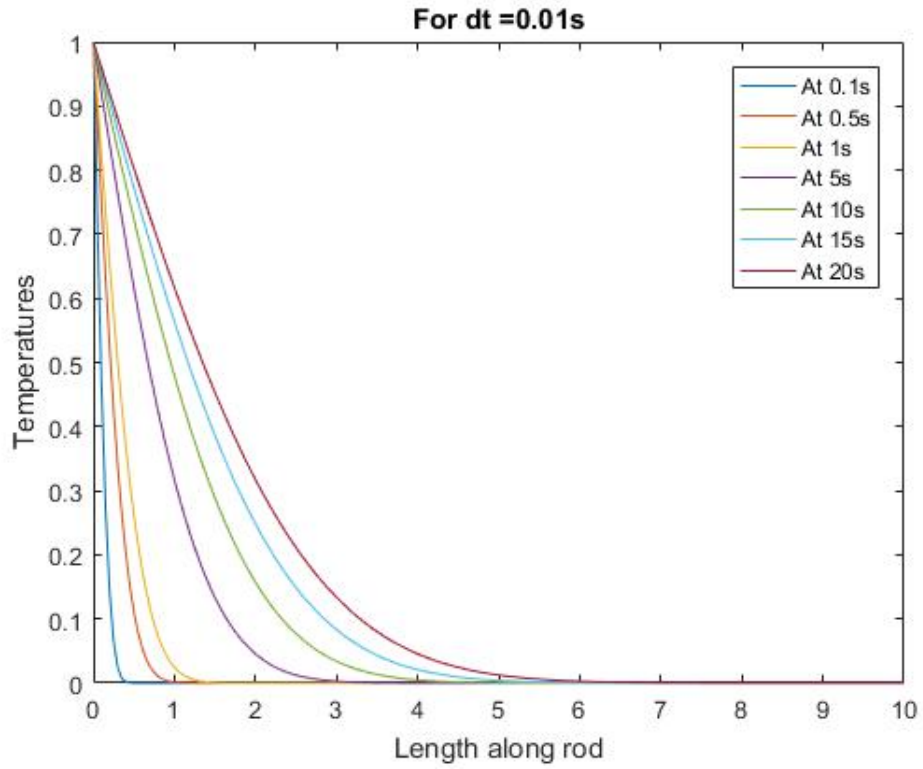
6. At 20s



4.2 Case B

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

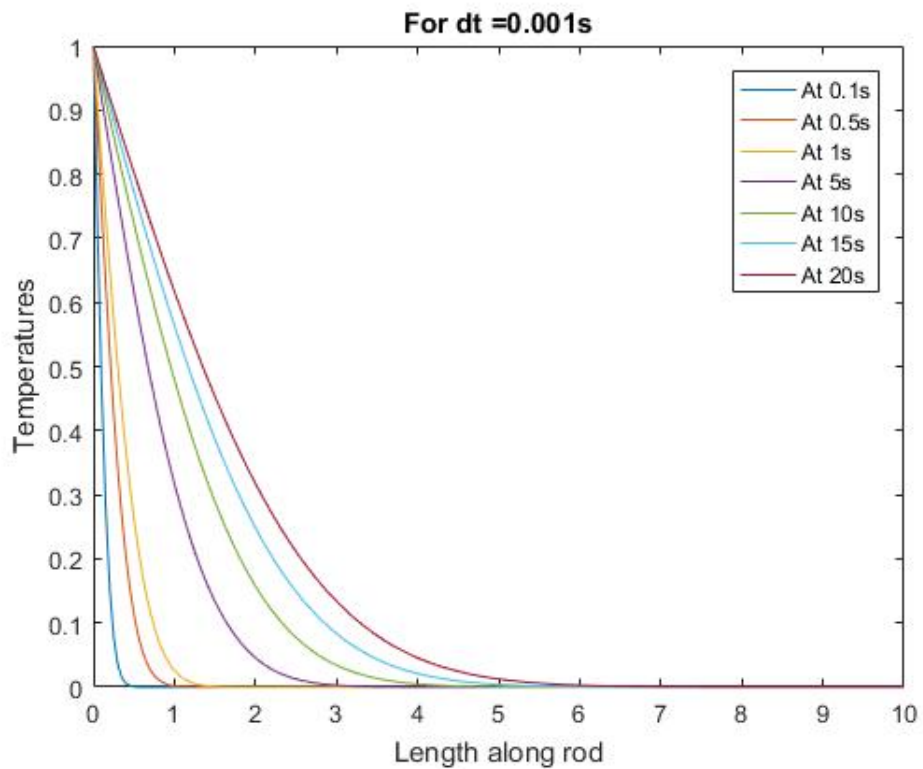
Results:



4.3 Case C

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

Results:



5 Appendix-Code

5.1 File - 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 - 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 dimensional unsteady heat conduction equation

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

Variable initialization

```
Input % Running input file
```

```
m = round(t/dt); % 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

$dT/dt = \alpha d^2T/dx^2$ $T_{n+1}(i) = T_n(i) + \alpha * dt (T_n(i+1) + 2 * T_n(i) + T_n(i-1)) / dx^2$

```
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,:),0:dx:L , T(0.5/dt,:),0:dx:L , T(1/dt,:),0:dx:L , T(5/dt,:), ...
0:dx:L, T(10/dt,:),0:dx:L , T(15/dt,:),0:dx:L , T(20/dt,:));
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

