INDIAN INSTITUTE OF TECHNOLOGY GANDHINAGAR

MA 202: MATHEMATICS - IV
Semester–II, Academic Year 2022-23

Tutorial Set -3
Question - 11

By

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➔ In question 11, we are asked to find the average concentration leaving the reactor over the 24hr period. I have used the Trapezoidal method to compute the average concentration. Here, the outflow concentration and outflow rate is given to us as shown below.

t (hr.)	0	1	5.5	10	12	14	16	18	20	24
c, (mg/l)	1	1.5	2.3	2.1	4	5	5.5	5	3	1.2

The outflow rate in m^3/s may be computed using the relation:

$$Q(t) = 20 + 10\sin\left\{\frac{2\pi}{24}(t-10)\right\}$$

The avg. concentration is defined as:

$$\bar{c} = \frac{\int_0^t dt' Q(t') c(t')}{\int_0^t dt' Q(t')}$$

- ➔ The idea behind the Trapezoidal method is to evaluate the area under the curves by dividing the total area into smaller trapezoids rather than using rectangles. This integration works by approximating the region under the graph of a function as a trapezoid, and it calculates the area.

- ➔ Here we can see that the interval lengths are not the same for two successive values so that we can not apply the trapezoidal rule directly for whole intervals. We need to apply the formula for each and every interval and then do summation to find the answer. I have done this in my code as shown below.

- ➔ I have taken input as n(number of iterations, order). We can find a more accurate answer by increasing the values of n. But here we are given maximum 10 data points so that we can maximum take the value of n as 9.

```matlab
% Submitted By Kush Patel [20110131]
% Tutorial-3
% Question-11

% Using the Trapezoidal method
function ans = T11_20110131(n)

t = [0, 1, 5.5, 10, 12, 14, 16, 18, 20, 24];  % Defining the data points of time as a matrix.
c = [1, 1.5, 2.3, 2.1, 4, 5, 5.5, 5, 3, 1.2]; % Defining the concentration matrix.
for i=1:n+1
    Q(i) = outflow_rate(t(i)); % This for loop assigns values to elements of matrix q(outflow rate at time t)
end
z1 = 0; % The final result (of denominator), using the Trapezoidal method.
for i=1:n
    z1 = z1 + (Q(i)+Q(i+1))*(t(i+1)-t(i))/2;
end
z2 = 0; % The final result (of numerator), using the Trapezoidal method.
for i=1:n
    z2 = z2 + ((Q(i)*c(i)) + (Q(i+1)*c(i+1)))*(t(i+1)-t(i))/2;
end

ans = z2/z1;
end

%% This function defines the outflow rate from the reactor. %%
function y = outflow_rate(t)
y = 20 + 10*(sin((2*pi)*(t-10)/24));
end
```

Code for this question

```
>> ans = T11_20110131(9)

ans =

   3.441355942222869

>>
```

Simulated output