1

Wednesday, January 26, 2022 9:46 AM

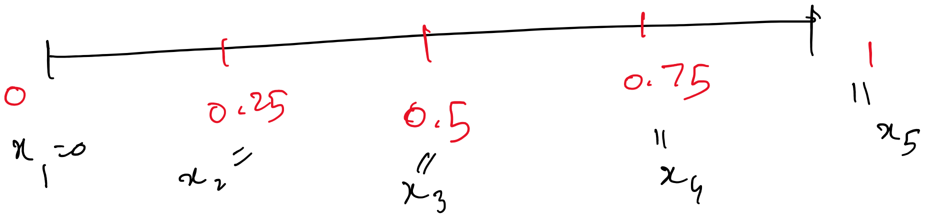
Given we have to partition into 4 equal intervals

from $[0, 1]$

$$l_{int} = \frac{l_{Tot}}{n_{int}} = \frac{1}{4} = 0.25 \qquad | \quad x_1 = 0$$

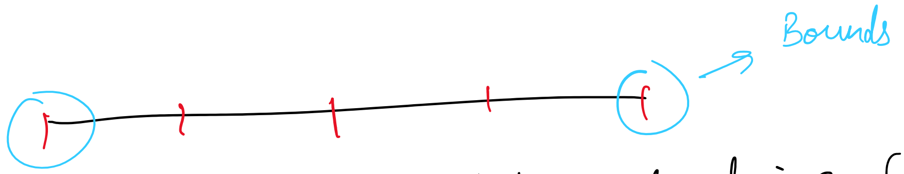
$\therefore$ interval every 0.25

$pts = x_1 + n(0.25)$, where $n = \{0, 1, \dots 4\}$



Hat functions :

The Domain we have



hat functions are partial at bounds i.e (only 1 part exists)

$x_a \ \forall \ a \in \{1, 2 \dots 5\}$ & hat functions are N_a at bounds.

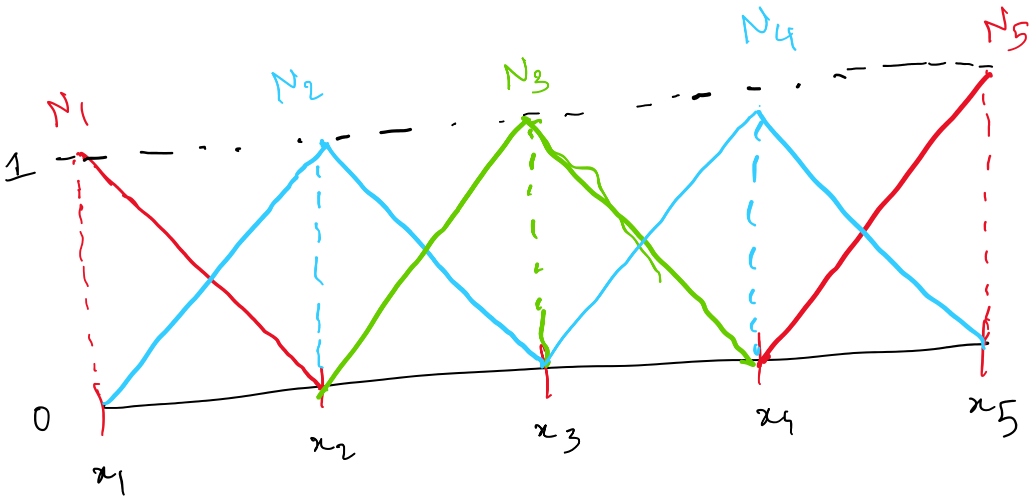
$$N_1 = \begin{cases} \dfrac{x - x_2}{x_1 - x_2} , & x_1 \leq x \leq x_2 \\ 0 , & x_2 < x \end{cases}$$

$$N_5 = \begin{cases} \dfrac{x - x_4}{x_5 - x_4} , & x_4 \leq x \leq x_5 \\ 0 , & x < x_4 \end{cases}$$

for internal nodes $a = \{2, 3, 4\}$

$$N_a = \begin{cases} 0 , & x < x_{a-1} \\ 0 , & x \geq x_{a+1} \\ \dfrac{x - x_{a-1}}{x_a - x_{a-1}} , & x_{a-1} \leq x < x_a \\ & x_a \leq x < x_{a+1} \end{cases}$$

$$\begin{cases} \dfrac{x - x_{a+1}}{x_a - x_{a+1}}, & x_a \le x < x_{a+1} \end{cases}$$



3

Wednesday, January 26, 2022 10:06 AM

The Problem we have is

$$u \in \mathcal{S} = \{ u : [0,1] \rightarrow \mathbb{R} \text{ smooth} \mid u(0) = 0 \}$$

$$\forall \quad w \in \mathcal{V} = \mathcal{S}$$

$$\therefore \quad u(0) = w(0) = 0$$

$$a(u,w) = l(w) \quad \text{where} \quad l(w) = \int_0^1 w x^2 \, dx + w(1)$$

$$a(u,w) = \int_0^1 (w_x u_x + \lambda w u) \, dx + w(1) u(1)$$

a is symmetric bi linear

we have $\quad m = n_{el} + 1 = 5$

From this we can build $\mathcal{S}_h$ & $\mathcal{V}_h$

$$\mathcal{W}_h = \text{span}(N_1, \dots N_5) \quad \text{given}$$

$$\mathcal{V}_h = \mathcal{S}_h = \{ v_h \in \mathcal{W}_h \mid v_h(0) = 0 \}$$

$$= \{ v_1 N_1 + v_2 N_2 \dots + v_5 N_5 \mid v_1, v_2 \dots v_5 \in \mathbb{R} \}$$

here $v_1 = 0$ as $u_h(0) = v_1 = 0$ from BC

$$\mathcal{V}_h, \mathcal{S}_h = \text{Span}(N_2, N_3, N_4, N_5)$$

$$\eta = \{2, \dots, 5\}$$

& $\eta_g = \{1\}$, $\eta_a = \{2, \ldots, 5\}$

finally Identifying $\bar{u}_a$

$u_h \in \mathcal{S}_h$ & from above $\mathcal{S}_h$

$$\bar{u}_1 = 0$$

$\therefore$ as $\bar{u}_h \in \mathcal{S}_h$ we can choose

$$\bar{u}_h = (0)N_1 = 0 \quad \text{or}$$

$$\bar{u}_h = (0)N_1 + N_2 = N_2$$

Galerkin of the problem :

Find $u_h \in \mathcal{S}_h$ such that

$$a(u_h, v_h) = l(v_h) \quad \forall \quad v_h \in \mathcal{V}_h$$

where

$$a(u,v) = \int_0^1 (v_x u_x + \lambda u v)\, dx + v(1)\, u(1)$$

$$l(v) = \int_0^1 v x^2\, dx + v(1)$$

5

Wednesday, January 26, 2022 10:39 AM

Stiffness Matrix :

given $\lambda = 2$, $\eta_a = \{2, \dots, 5\}$, $\eta = \{1, \dots, 5\}$

$\eta_g = \{1\}$

$$a(u, v) = \int_0^1 (u_x v_x + 2uv)\, dx + u(1)\, v(1)$$

N_a & N_b are our hat functions

$$K_{ba} = a(N_a, N_b) = \int_0^1 (N_{a,x} N_{b,x} + 2 N_a N_b)\, dx + N_a(1)\, N_b(1)$$

$\forall \; a \in \eta_a$ & $b \in \eta$

And we also have

$K_{ab} = \delta_{ab} \quad \forall \quad a \in \eta_g$ & $b \in \eta$

Then we obtain K_{ab} as (shown in code)

6

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$$f_a = \ell(N_a) = \int_0^1 N_a \, x^2 \, dx + N_a(1) \quad \forall \, a \in \eta_a$$

$$f_a = \bar{u}_a = 0 \quad \forall \, a \in \eta_g$$

We get

$$\Rightarrow \quad f_a = \ell = \begin{bmatrix} 0 \\ 0.0182 \\ 0.0651 \\ 0.1432 \\ 1.1055 \end{bmatrix}$$

7

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The solution of system is

$$K u = f$$

$$u = K^{-1} f = \begin{bmatrix} 0 \\ 0.1044 \\ 0.2175 \\ 0.3417 \\ 0.4730 \end{bmatrix}$$

The galerkin approximati solution is

$$u_h = 0.1044 \, N_2 + 0.2175 \, N_3 + 0.3417 \, N_4 + 0.4730 \, N_5$$

5, 6, 7 code

28 January 2022 20:42

```
m = 5;
K = zeros(m, m);
L = zeros(m, 1);
syms x
N = [hatF.N1(x), hatF.N2(x), hatF.N3(x), hatF.N4(x), hatF.N5(x)];
N_1 = [hatF.N1(1), hatF.N2(1), hatF.N3(1), hatF.N4(1), hatF.N5(1)];
for a = 1:m
    for b = 1:m
        if a == 1
            L(a) = 0;
            if b == 1
                K(a, b) = 1;
            end
        else
            L(a) = alFuncOne.lV(x, N(a)) + N_1(a);
            K(a, b) = alFuncOne.aUV(N(a), N(b)) + N_1(a)*N_1(b);
        end
    end
end
K
L
%disp(K)
%disp(L)
Solution =  inv(K)*L;
Solution
```

```
K =

    1.0000         0         0         0         0
   -3.9167    8.3333   -3.9167         0         0
         0   -3.9167    8.3333   -3.9167         0
         0         0   -3.9167    8.3333   -3.9167
         0         0         0   -3.9167    5.1667


L =

         0
    0.0182
    0.0651
    0.1432
    1.1055


Solution =

         0
    0.1044
    0.2175
    0.3417
    0.4730
```

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Hat Function

28 January 2022 20:42

```
classdef    hatF
    methods     ( Static = true )
        function    outf = N1(x)
            outf = triangularPulse(-0.25, 0, 0.25, x);
            return
        end

        function    outf = N2(x)
            outf = triangularPulse(0, 0.25, 0.5, x);
            return
        end

        function    outf = N3(x)
            outf = triangularPulse(0.25, 0.5, 0.75, x);
            return
        end

        function    outf = N4(x)
            outf = triangularPulse(0.5, 0.75, 1.0, x);
            return
        end

        function    outf = N5(x)
            outf = triangularPulse(0.75, 1.0, 1.25, x);
            return
        end
    end
end
```

```
ans =

  hatF with no properties.
```

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a, l - functions

28 January 2022 20:43

```
classdef    alFuncOne
    methods     ( Static = true )
        function    outf = aUV(Na, Nb)
            outf = int((diff(Na)*diff(Nb) + 2*Na*Nb), 0, 1);
            return
        end

        function    outf = lV(x, Na)
            outf = int((Na* x^2), 0, 1);
            return
        end

    end
end
```

```
ans =

  alFuncOne with no properties.
```

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1a

Wednesday, January 26, 2022 12:26 PM

Given Mesh of Lagrange P_k - elements

$n_{el} = 3$, equal length in interval $[0, 3]$

given LG Map

$$LG = \begin{bmatrix} 1 & 2 & 3 \\ 1 & 2 & 3 \\ 1 & 2 & 3 \\ 1 & 2 & 3 \end{bmatrix}$$

from LG Map we can say we have 3 basis functions N_1, N_2, N_3 & 3 elements

for $k = 3$, $\mathbb{P}_k$ element $\Rightarrow$ we have 4 D.O.F
degree of freedom

So for 1^{st} element $\rightarrow \left.\begin{bmatrix} 1 \\ 1 \\ 1 \\ 1 \end{bmatrix}\right\}$ 4 DOF

If we split $[0, 1]$ into 3 parts

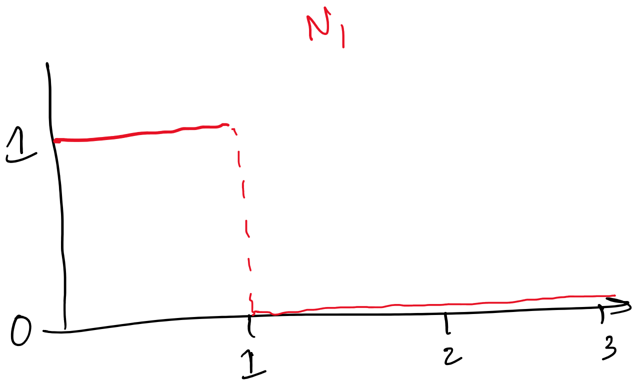
$N_1^1, N_2^1, N_3^1, N_4^1 \rightarrow$ All shape functions correspond to element 1 it self

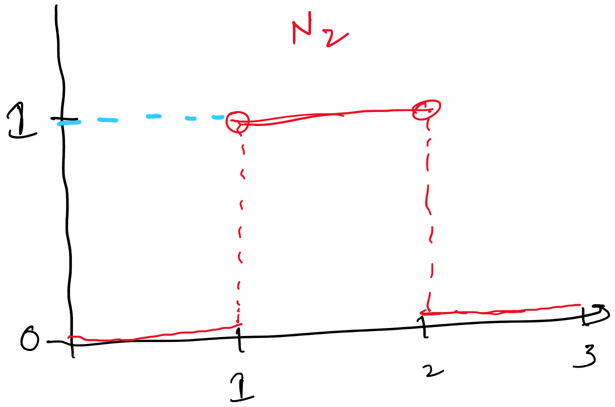
so $N_1^1 + N_2^1 + N_3^1 + N_4^1 = 1 \quad \forall x \in [0, 1]$

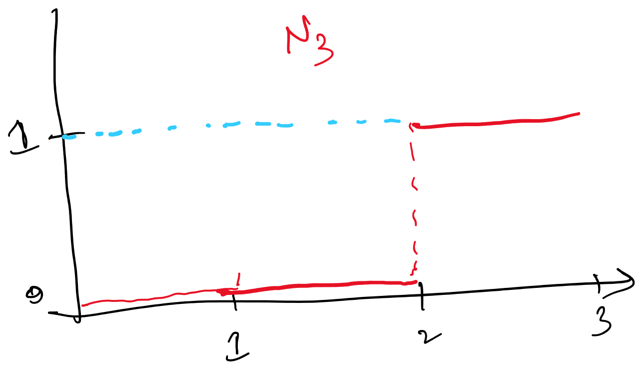
similarly for 2 & 3

$N_2 = 1 \quad \forall x \in [1, 2]$

$$N_3 = 1 \quad \forall \quad x \in [2, 3]$$







1b

Wednesday, January 26, 2022 12:41 PM

$$LG = \begin{bmatrix} 1 & 1 & 1 \\ 2 & 2 & 2 \\ 3 & 3 & 4 \\ 5 & 6 & 6 \end{bmatrix}$$

0 to 1   1 to 2   2 to 3

from 0 to 1 we have (each element has 3 DOF)

$N_1^1, N_2^1, N_3^1, N_5^1$

consider equal-interval x from left to right

$x_1^1 = 0$, $x_2^1 = 0.333$, $x_3^1 = 0.667$, $x_5^1 = 1$

$$\left.\begin{aligned}
N_1^1(x) &= \frac{(x - x_2^1)(x - x_3^1)(x - x_5^1)}{(x_1^1 - x_2^1)(x_1^1 - x_3^1)(x_1^1 - x_5^1)} \\
N_2^1(x) &= \frac{(x - x_1^1)(x - x_3^1)(x - x_5^1)}{(x_2^1 - x_1^1)(x_2^1 - x_3^1)(x_2^1 - x_5^1)} \\
N_3^1(x) &= \frac{(x - x_1^1)(x - x_2^1)(x - x_5^1)}{(x_3^1 - x_1^1)(x_3^1 - x_2^1)(x_3^1 - x_5^1)} \\
N_5^1(x) &= \frac{(x - x_1^1)(x - x_2^1)(x - x_3^1)}{(x_5^1 - x_1^1)(x_5^1 - x_2^1)(x_5^1 - x_3^1)}
\end{aligned}\right\} \forall x \in [0,1]$$

Sum of all 4 functions should be $= 1$

Plots included in matlab file

Similarly $N_i^2(x)$ & $N_j^3(x)$ can be

Similarly $N_i^2(x)$ & $N_j^?(x)$ can be calculated

(a) when $n_{el} = 3$ ⊳ P_3 elements → 4 DOF each

Each basis function zero in minimum no. of elements

1 possible way is when moving from 1 element to another the function should continue i.e correspond to same basis

$$\begin{bmatrix} 1 & 4 & 7 \\ 2 & 5 & 8 \\ 3 & 6 & 9 \\ 4 & 7 & 10 \end{bmatrix}$$

here $\{1, 2, 3, 5, 6, 8, 9, 10\}$ are zero in 2 elements

$\{4, 7\}$ are zero in 1 element.

(b) for P_4 elements 5 DOF in each element

$$LG = \begin{bmatrix} 1 & 5 & 9 \\ 2 & 6 & 10 \\ 3 & 7 & 11 \\ 4 & 8 & 12 \\ 5 & 9 & 13 \end{bmatrix}$$

or

$$LG = \begin{bmatrix} 1 & 5 & 1 \\ 2 & 4 & 2 \\ 3 & 3 & 3 \\ 4 & 2 & 4 \end{bmatrix}$$

→ if ordered properly all basis functions will be present in all elements

$$\begin{bmatrix} 4 & 2 & 4 \\ 5 & 1 & 5 \end{bmatrix}$$

0 – 1   1 – 2   2 – 3

$N_5^1 = N_5^2 = 1$ at $x = 1$

$N_4^1 = N_4^2 = 0$ at $x = 1$

& so on

But there can still be sharp corners on the function

3

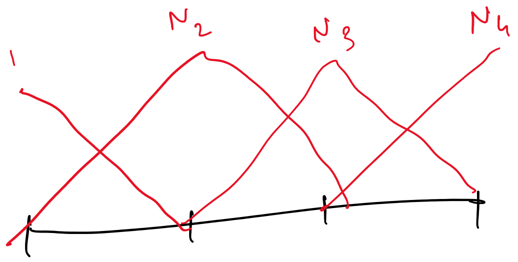
Wednesday, January 26, 2022 2:44 PM

Solutions for both $\mathbb{P}_3$ & $\mathbb{P}_4$ are published in Matlab.

4

Friday, January 28, 2022 4:12 PM

Given $k = 1$, $n_{el} = 3$ & $u(0) = u(3)$



$N_1 = N_1^1 \longrightarrow \frac{x-1}{-1} = 1-x$

$N_2 = N_2^1$ & N_1^2

$N_2^1 = \frac{x-0}{1-0} = x$

$N_1^2 = \frac{x-2}{-1} = 2-x$

$N_3 = N_2^2$ & N_1^3

$N_2^2 = \frac{x-1}{1} = x-1$

$N_4 = N_2^3$

$N_1^3 = \frac{x-3}{-1} = 3-x$

$N_2^3 = \frac{x-2}{1} = x-2$

let us say $u = \sum_{i=1}^{4} c_i N_i$

$= c_1 N_1 + c_2 N_2 + c_3 N_3 + c_4 N_4$

$u(0) = c_1 + 0$, $u(3) = c_4$

$u(0) = u(3) \Rightarrow c_1 = c_4$

$u = c_1(N_1 + N_4)$ & $c_2 N_2$ & $c_3 N_3$

By this we can group N_1 & N_4 in 1 basis function

So $N_1 = N_1^1 + N_2^3$

& our L-G Map will be

$$\begin{bmatrix} 1 & 2 & 3 \\ 2 & 3 & 4 \end{bmatrix} \longrightarrow \begin{bmatrix} 1 & 2 & 3 \\ 2 & 3 & 1 \end{bmatrix}$$

$$\begin{bmatrix} 1 & 2 & 3 \\ 2 & 3 & 4 \end{bmatrix} \longrightarrow \begin{bmatrix} 2 & 3 & 1 \end{bmatrix}$$

as $4 = 1$

here we assumed continuous ~~fcn~~ functions

dimension of the space $= 3$

as $m = 3 \rightarrow N_1, N_2, N_3$

5

Friday, January 28, 2022 4:43 PM

given P_3 elements so

$$N_1^e(x) = \frac{(x - x_2^e)(x - x_3^e)(x - x_4^e)}{(x_1^e - x_2^e)(x_1^e - x_3^e)(x_1^e - x_4^e)}$$

this is the form of our basis functions in each element.

if we take a LG Map of

$$\begin{bmatrix} 1 & 4 & 7 \\ 2 & 5 & 8 \\ 3 & 6 & 9 \\ 4 & 7 & 10 \end{bmatrix}$$

$$f(x) = \sum_{i=1}^{10} c_i N_i$$

at each local node of element the equation should satisfy

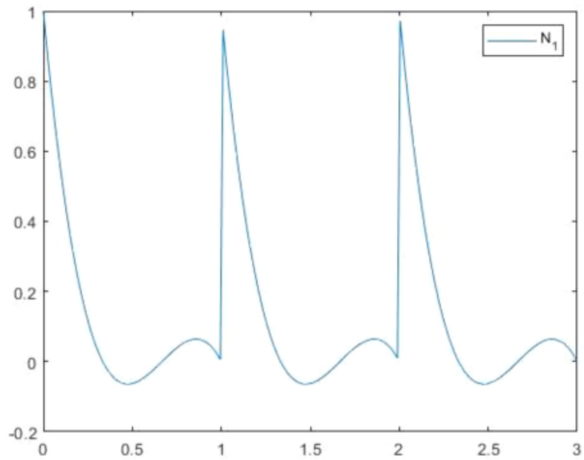
All elements = [0, 0.33, 0.66, 1, 1.33, 1.66, 2, 2.33, 2.66, 3]

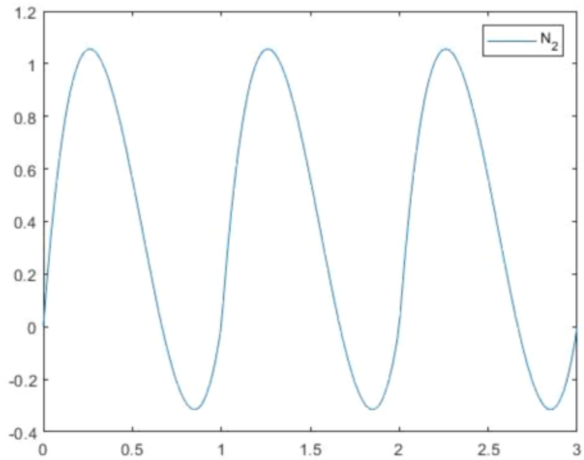
Code in Matlab

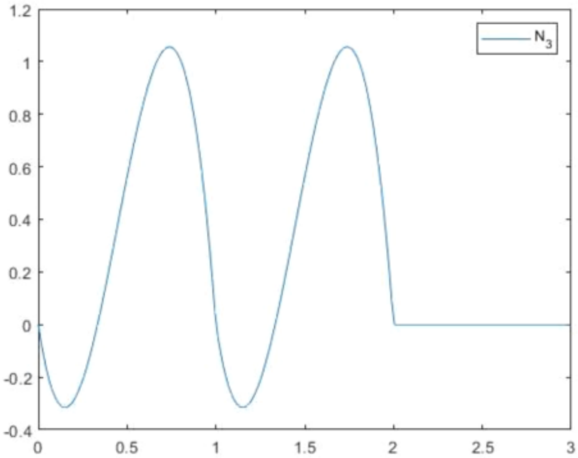
1b code

28 January 2022 20:36

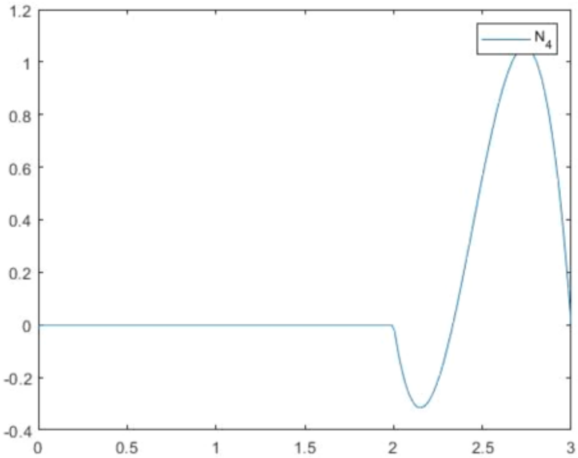
```
y_1 = linspace(0, 1, 4);
y_2 = linspace(1, 2, 4);
y_3 = linspace(2, 3, 4);

x_a = linspace(0, 3, 200);

N1 = P3_func(x_a, y_1(1), y_1(2), y_1(3), y_1(4), 1) + P3_func(x_a, y_2(1), y_2(2), y_2(3), y_2(4), 2) + P3_func(x_a, y_3(1), y_3(2), y_3(3), y_3(4), 3);
N2 = P3_func(x_a, y_1(2), y_1(1), y_1(3), y_1(4), 1) + P3_func(x_a, y_2(2), y_2(1), y_2(3), y_2(4), 2) + P3_func(x_a, y_3(2), y_3(1), y_3(3), y_3(4), 3);
N3 = P3_func(x_a, y_1(3), y_1(2), y_1(1), y_1(4), 1) + P3_func(x_a, y_2(3), y_2(2), y_2(1), y_2(4), 2);
N4 = P3_func(x_a, y_3(3), y_3(2), y_3(1), y_3(4), 3);
N5 = P3_func(x_a, y_1(4), y_1(2), y_1(3), y_1(1), 1);
N6 = P3_func(x_a, y_2(4), y_2(2), y_2(3), y_2(1), 2) + P3_func(x_a, y_3(4), y_3(2), y_3(3), y_3(1), 3);


figure(1);
plot(x_a,N1, 'DisplayName','N_1', 'LineStyle','-')
legend
figure(2);
plot(x_a,N2, 'DisplayName','N_2', 'LineStyle','-')
legend
figure(3);
plot(x_a,N3, 'DisplayName','N_3', 'LineStyle','-')
legend
figure(4);
plot(x_a,N4, 'DisplayName','N_4', 'LineStyle','-')
legend
figure(5);
plot(x_a,N5, 'DisplayName','N_5', 'LineStyle','-')
legend
figure(6);
plot(x_a,N6, 'DisplayName','N_6', 'LineStyle','-')
legend
```



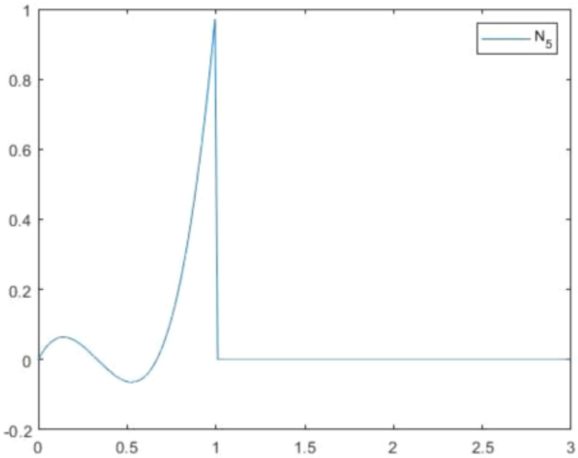


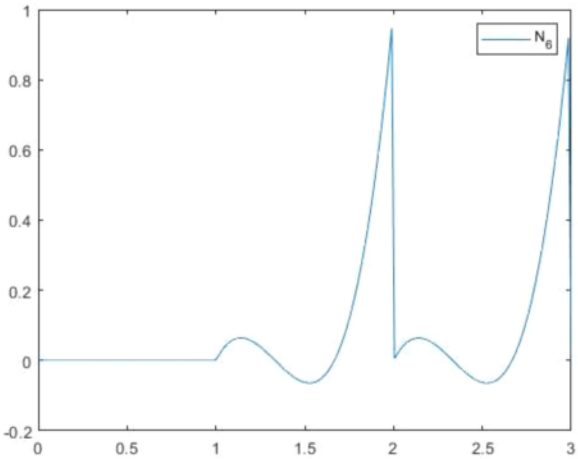


N3



N4





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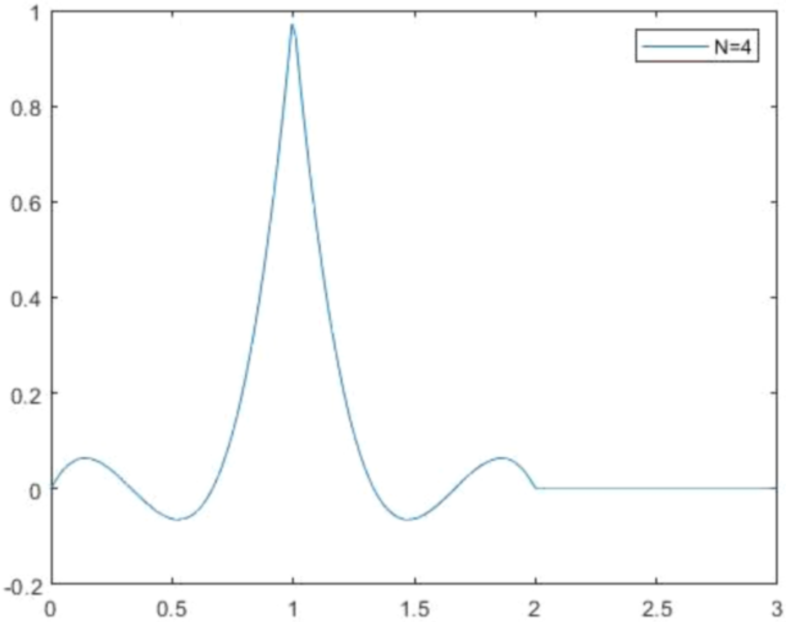
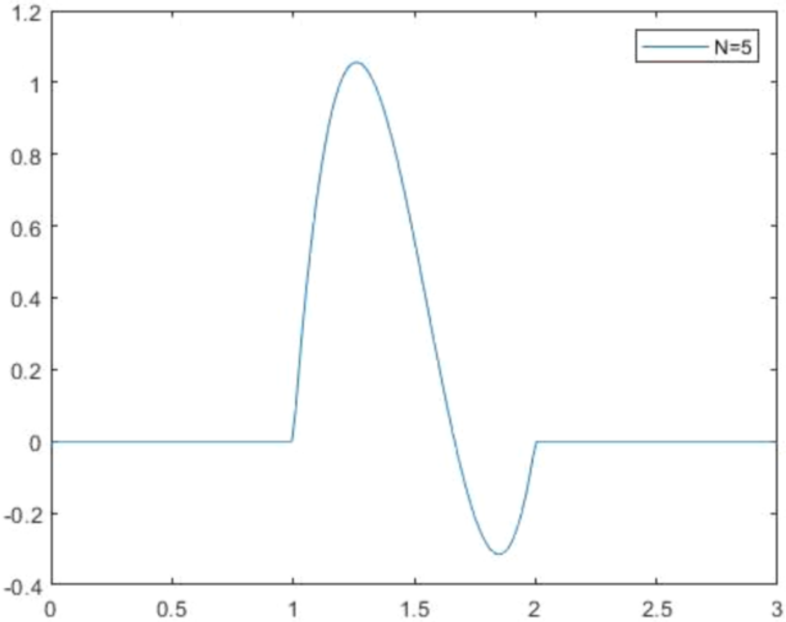
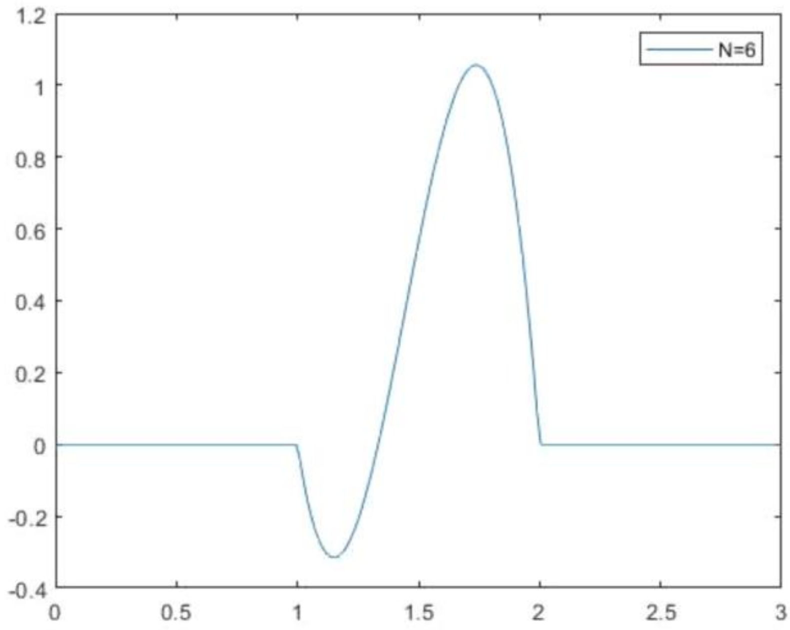
3 P3

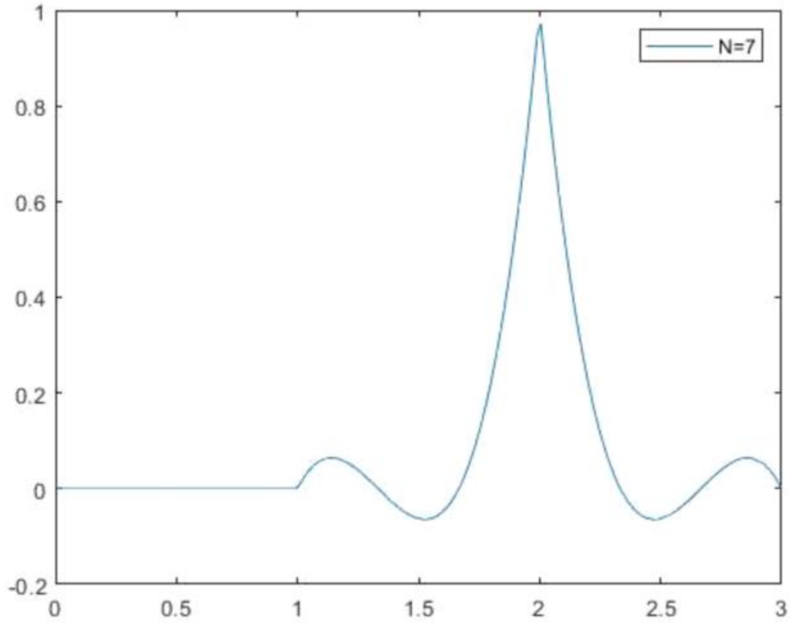
28 January 2022 20:38

```
y_1 = linspace(0, 1, 4);
y_2 = linspace(1, 2, 4);
y_3 = linspace(2, 3, 4);

x_a = linspace(0, 3, 200);

N_all = zeros([4, 200]);

N_all(1,:) = P3_func(x_a, y_1(4), y_1(2), y_1(3), y_1(1), 1) + P3_func(x_a, y_2(1), y_2(2), y_2(3), y_2(4), 2);

N_all(2,:) = P3_func(x_a, y_2(2), y_2(1), y_2(3), y_2(4), 2);

N_all(3,:) = P3_func(x_a, y_2(3), y_2(2), y_2(1), y_2(4), 2);

N_all(4,:) = P3_func(x_a, y_2(4), y_2(2), y_2(3), y_2(1), 2) + P3_func(x_a, y_3(1), y_3(4), y_3(3), y_3(2), 3);

for jj = 1:4
    figure(jj);
    plot(x_a,N_all(jj,:), 'DisplayName',strcat('N=',num2str(jj+3)), 'LineStyle','-')
    legend
end
```


N=4
1
0.8
0.6
0.4
0.2
0
-0.2
0
0.5
1
1.5
2
2.5
3


N=5
1.2
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
0
0.5
1
1.5
2
2.5
3





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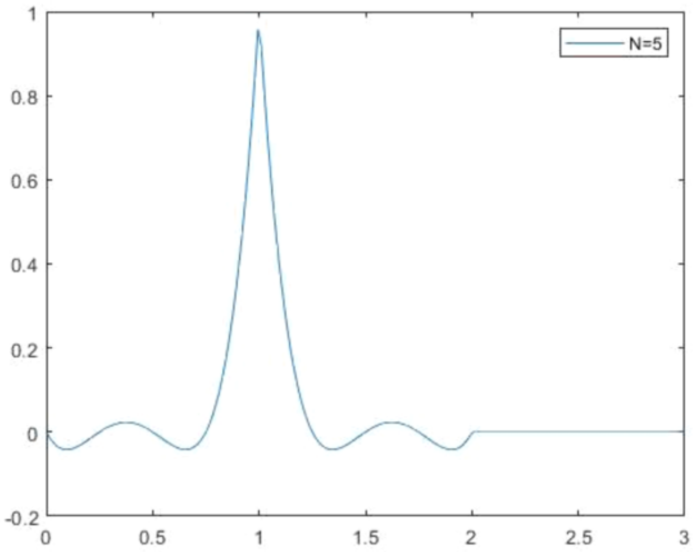
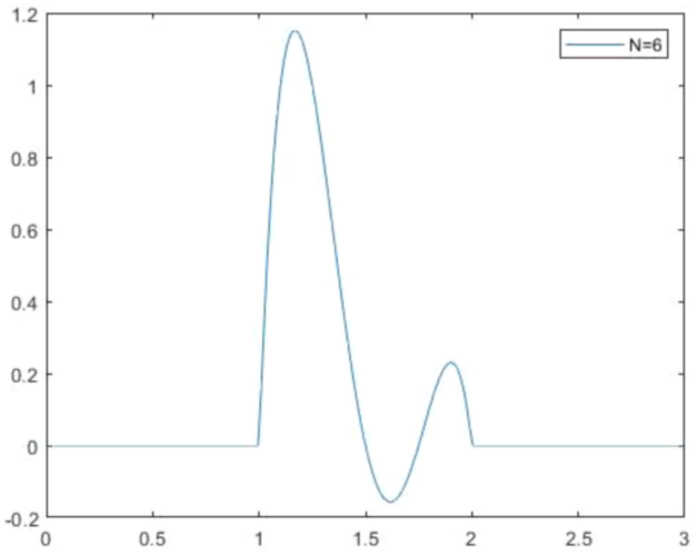
3 P4

28 January 2022 20:39

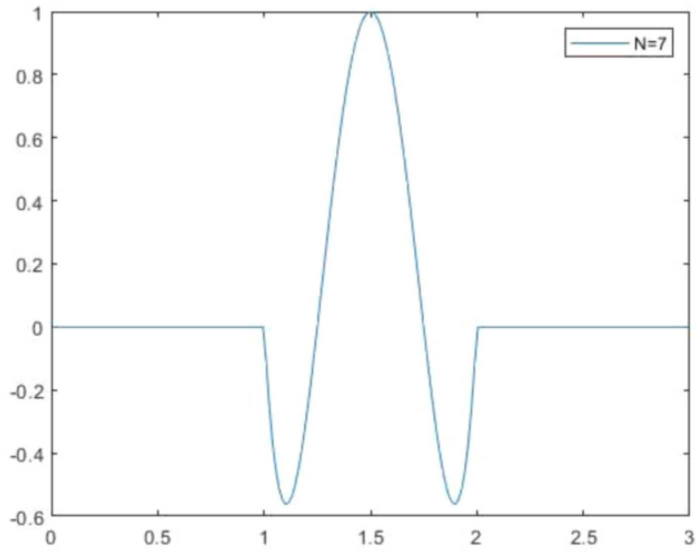
```
y_1 = linspace(0, 1, 5);
y_2 = linspace(1, 2, 5);
y_3 = linspace(2, 3, 5);

x_a = linspace(0, 3, 200);

N_all = zeros([5, 200]);

N_all(1,:) = P4_func(x_a, y_1(5), y_1(2), y_1(3), y_1(1), y_1(4), 1) + P4_func(x_a, y_2(1), y_2(2), y_2(3), y_2(4), y_2(5), 2);

N_all(2,:) = P4_func(x_a, y_2(2), y_2(1), y_2(3), y_2(4), y_2(5), 2);

N_all(3,:) = P4_func(x_a, y_2(3), y_2(2), y_2(1), y_2(4), y_2(5), 2);

N_all(4,:) = P4_func(x_a, y_2(4), y_2(2), y_2(1), y_2(3), y_2(5), 2);

N_all(5,:) = P4_func(x_a, y_2(5), y_2(2), y_2(1), y_2(3), y_2(4), 2) + P4_func(x_a, y_3(1), y_3(4), y_3(3), y_3(2), y_3(5), 3);

for jj = 1:5
    figure(jj);
    plot(x_a,N_all(jj,:), 'DisplayName',strcat('N=',num2str(jj+4)), 'LineStyle','-')
    legend
end
```

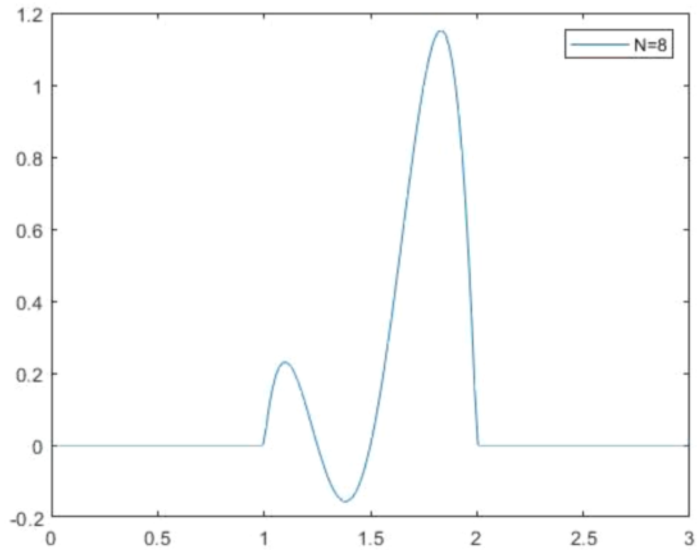


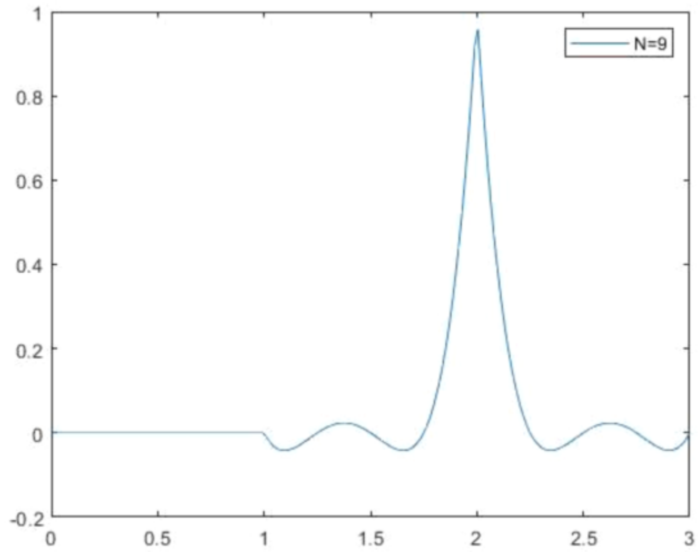
N=5
1
0.8
0.6
0.4
0.2
0
-0.2
0
0.5
1
1.5
2
2.5
3



N=6
1.2
1
0.8
0.6
0.4
0.2
0
-0.2
0
0.5
1
1.5
2
2.5
3


N=7
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
0
0.5
1
1.5
2
2.5
3


N=8
1.2
1
0.8
0.6
0.4
0.2
0
-0.2
0
0.5
1
1.5
2
2.5
3



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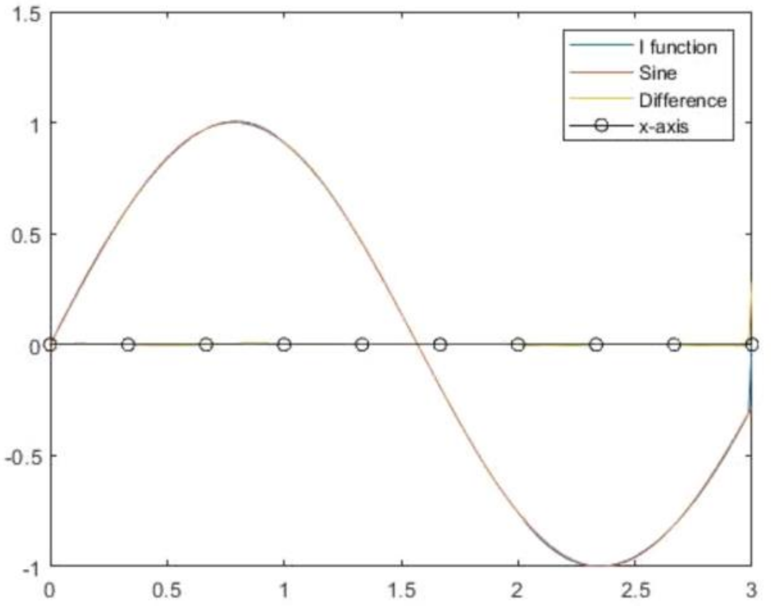
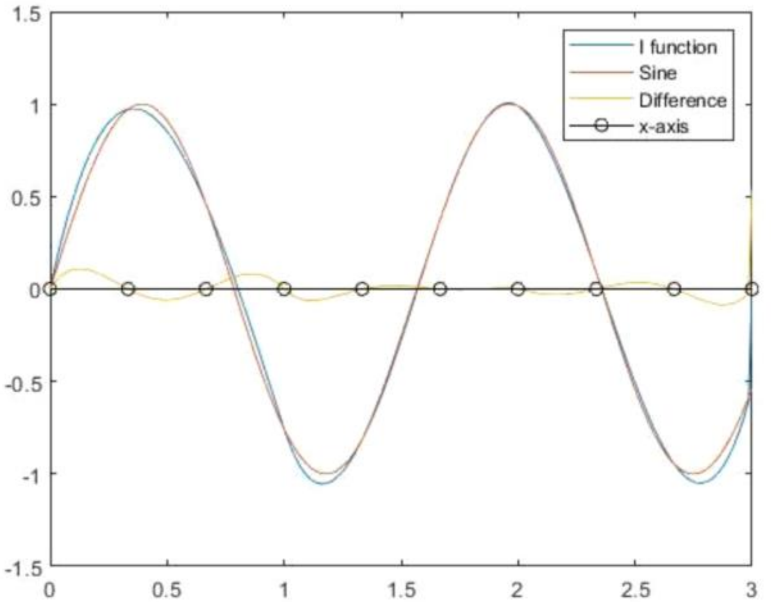
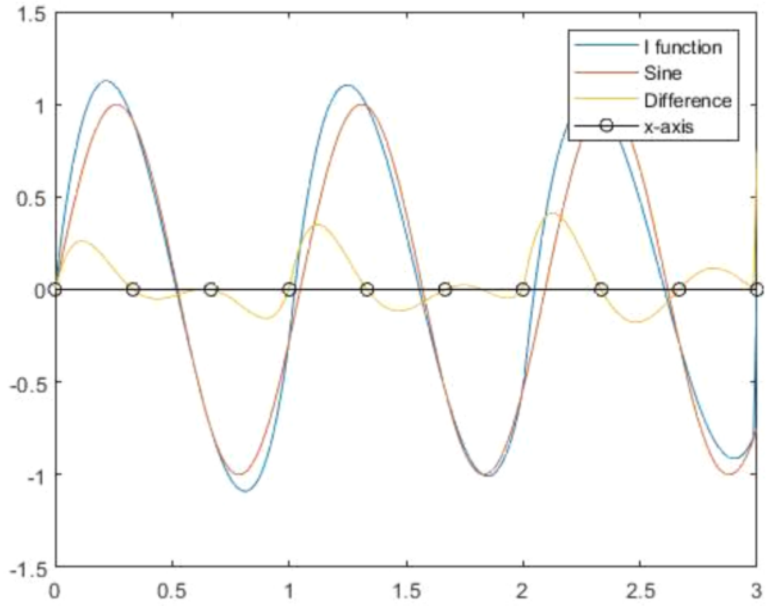
5 code

28 January 2022 20:39

```
y_1 = linspace(0, 1, 4);
y_2 = linspace(1, 2, 4);
y_3 = linspace(2, 3, 4);
for jj = 1:3
    x_a = linspace(0, 3, 10);
    n = jj*2;
    func = sin(n*x_a);

    x_a = linspace(0, 3, 200);
    N_all = zeros([10, 200]);

    N_all(1,:) = P3_func(x_a, y_1(1), y_1(2), y_1(3), y_1(4), 1);
    N_all(2,:) = P3_func(x_a, y_1(2), y_1(1), y_1(3), y_1(4), 1);
    N_all(3,:) = P3_func(x_a, y_1(3), y_1(1), y_1(2), y_1(4), 1);
    N_all(4,:) = P3_func(x_a, y_1(4), y_1(1), y_1(3), y_1(2), 1) + P3_func(x_a, y_2(1), y_2(4), y_2(3), y_2(2), 2);

    %N_all(1,:) + N_all(2,:) + N_all(3,:) + N_all(4,:);

    N_all(5,:) = P3_func(x_a, y_2(2), y_2(4), y_2(3), y_2(1), 2);
    N_all(6,:) = P3_func(x_a, y_2(3), y_2(4), y_2(2), y_2(1), 2);
    N_all(7,:) = P3_func(x_a, y_2(4), y_2(2), y_2(3), y_2(1), 2) + P3_func(x_a, y_3(1), y_3(2), y_3(3), y_3(4), 3);

    N_all(8,:) = P3_func(x_a, y_3(2), y_3(1), y_3(3), y_3(4), 3);
    N_all(9,:) = P3_func(x_a, y_3(3), y_3(1), y_3(2), y_3(4), 3);
    N_all(10,:) = P3_func(x_a, y_3(4), y_3(1), y_3(3), y_3(2), 3);

    Ifunc = zeros([1, 200]);
    for ii = 1:10
        Ifunc = Ifunc + func(ii)*N_all(ii,:);
    end
    y_true = zeros([1, 10]);
    figure(jj);
    plot(x_a,Ifunc, 'DisplayName','I function', 'LineStyle','-')
    hold on
    func = sin(n*x_a);
    plot(x_a,func, 'DisplayName','Sine', 'LineStyle','-')
    hold on
    plot(x_a,-func + Ifunc, 'DisplayName','Difference', 'LineStyle','-')
    hold on
    x_line = linspace(0, 3, 10);
    plot(x_line,y_true, 'DisplayName','x-axis', 'LineStyle','-', 'Marker','o','Color', 'k')
    legend
end
```


I function
Sine
Difference
x-axis
1.5
1
0.5
0
-0.5
-1
0
0.5
1
1.5
2
2.5
3


I function
Sine
Difference
x-axis
1.5
1
0.5
0
-0.5
-1
-1.5
0
0.5
1
1.5
2
2.5
3



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P3 elements code

28 January 2022 20:40

```
function [outcome] = P3_func(x, x1, x2, x3, x4, ele)
    sz = size(x);
    outcome = zeros(sz);
    if ele==1
        for ii = 1:sz(2)
            if x(1, ii) < 1
                outcome(1, ii) = ((x(1, ii)-x2)*(x(1, ii)-x3)*(x(1, ii)-x4))/(((x1-x2)*(x1-x3)*(x1-x4)));
                %disp(outcome(1, ii))
            end
        end
    elseif ele==2
        for ii = 1:sz(2)
            if x(1, ii) < 2  && x(1, ii) > 1
                outcome(1, ii) = ((x(1, ii)-x2)*(x(1, ii)-x3)*(x(1, ii)-x4))/(((x1-x2)*(x1-x3)*(x1-x4)));
                %disp(outcome(1, ii))
            end
        end
    else
        for ii = 1:sz(2)
            if x(1, ii) < 3  && x(1, ii) > 2
                outcome(1, ii) = ((x(1, ii)-x2)*(x(1, ii)-x3)*(x(1, ii)-x4))/(((x1-x2)*(x1-x3)*(x1-x4)));
                %disp(outcome(1, ii))
            end
        end
    end
    return
end
```

```
Not enough input arguments.

Error in P3_func (line 2)
    sz = size(x);
```

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P4 elements code

28 January 2022 20:41

```
function [outcome] = P4_func(x, x1, x2, x3, x4, x5, ele)
    sz = size(x);
    outcome = zeros(sz);
    if ele==1
        for ii = 1:sz(2)
            if x(1, ii) < 1
                outcome(1, ii) = ((x(1, ii)-x2)*(x(1, ii)-x3)*(x(1, ii)-x4)*(x(1, ii)-x5))/(((x1-x2)*(x1-x3)*(x1-x4)*(x1-x5)));
                %disp(outcome(1, ii))
            end
        end
    elseif ele==2
        for ii = 1:sz(2)
            if x(1, ii) < 2  && x(1, ii) > 1
                outcome(1, ii) = ((x(1, ii)-x2)*(x(1, ii)-x3)*(x(1, ii)-x4)*(x(1, ii)-x5))/(((x1-x2)*(x1-x3)*(x1-x4)*(x1-x5)));
                %disp(outcome(1, ii))
            end
        end
    elseif ele==3
        for ii = 1:sz(2)
            if x(1, ii) < 3  && x(1, ii) > 2
                outcome(1, ii) = ((x(1, ii)-x2)*(x(1, ii)-x3)*(x(1, ii)-x4)*(x(1, ii)-x5))/(((x1-x2)*(x1-x3)*(x1-x4)*(x1-x5)));
                %disp(outcome(1, ii))
            end
        end
    else
        for ii = 1:sz(2)
            if x(1, ii) < 4  && x(1, ii) > 3
                outcome(1, ii) = ((x(1, ii)-x2)*(x(1, ii)-x3)*(x(1, ii)-x4)*(x(1, ii)-x5))/(((x1-x2)*(x1-x3)*(x1-x4)*(x1-x5)));
                %disp(outcome(1, ii))
            end
        end
    end
    return
end
```

```
Not enough input arguments.

Error in P4_func (line 2)
    sz = size(x);
```

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