Przybliżone metody rozwiązywania zagadnień początkowo-brzegowych

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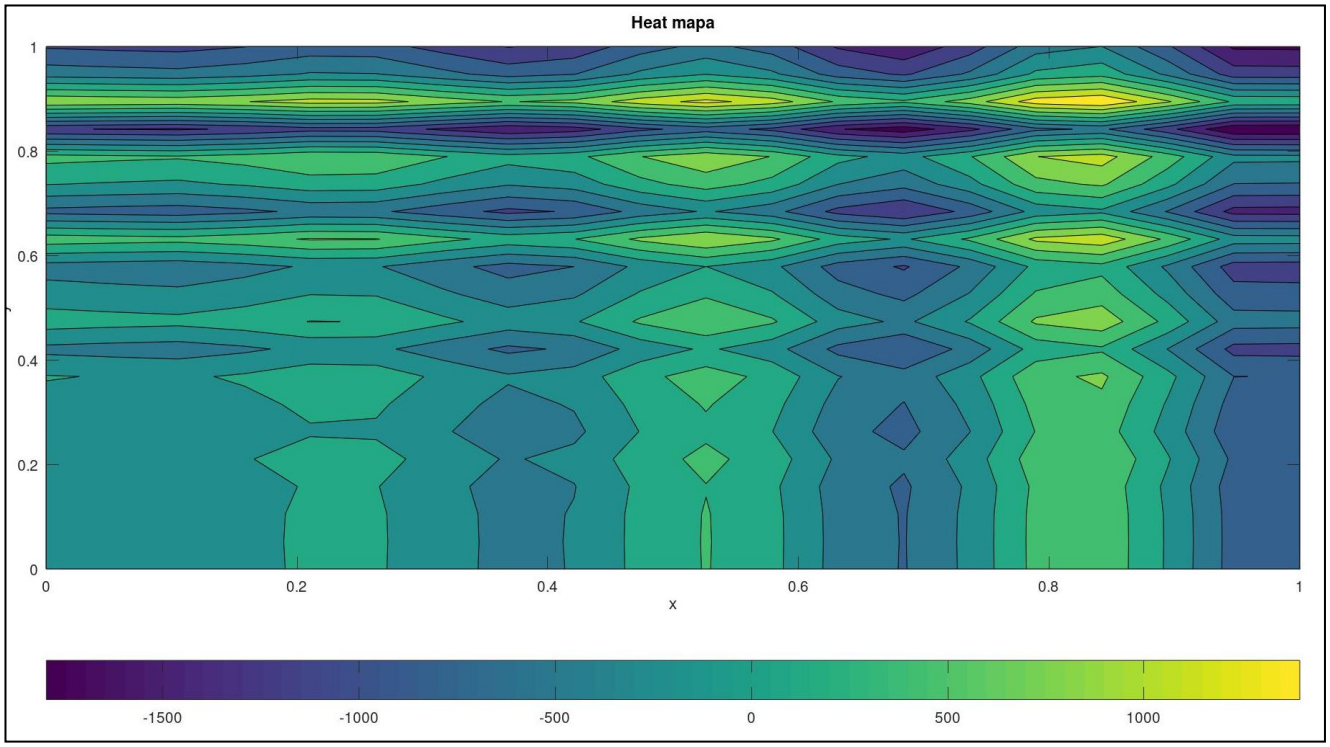
Informatyka, rok I, semestr II,

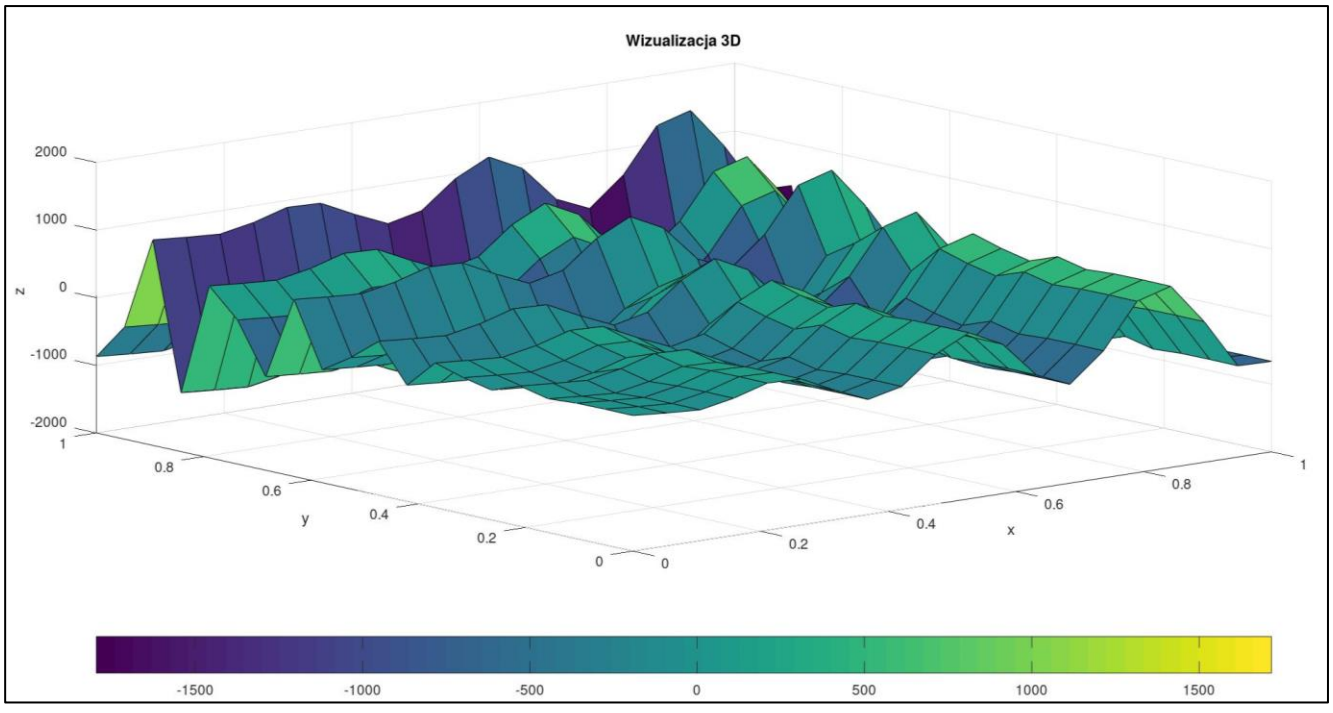
1.Wizualizacja danych w formie mapy 2D, kolory dla współrzędnej Z

Wizualizacje wykonałem w programie Octave na podstawie komend, które miałem na labolatoriach.

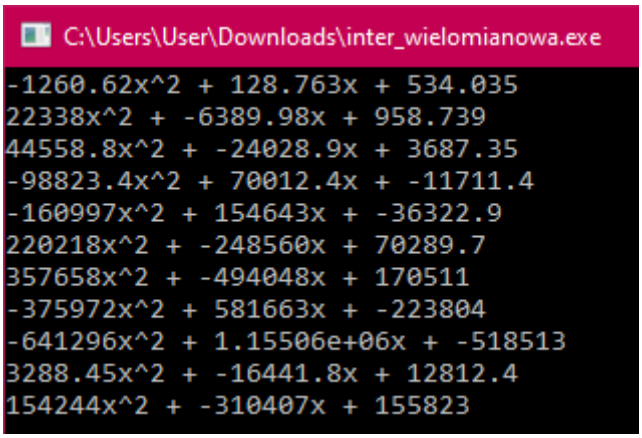


2.Wizualizacja danych w formie powierzchni 3D zbudowanej z trójkątów / kwadratów lub innej metody

Wizualizacje wykonałem w programie Octave na podstawie komend, które miałem na labolatoriach.



3.Wyznaczyć funkcje interpolacyjne dla wybranego wiersza lub kolumny z siatki.



Kod programu:

```
#include <iostream>

#include <math.h>



long double x[20] = { 0, 0.0526316, 0.105263, 0.157895, 0.210526, 0.263158, 0.315789,
0.368421, 0.421053, 0.473684, 0.526316, 0.578947, 0.631579, 0.684211, 0.736842,
0.789474, 0.842105, 0.894737, 0.947368, 1 };

long double z[20][20] = {

4.1,7.38498,3.68669,-23.2389,73.5913,-80.2073,12.8567,138.986,-282.392,275.12,-59.3128,-
330.982,617.399,-616.6,130.887,542.012,-1129.78,1040.27,-342.569,-870.887,

-35.2535,-31.9686,-35.6668,-62.5925,34.2378,-119.561,-26.4968,99.6323,-321.746,235.767,-
98.6664,-370.336,578.045,-655.953,91.5334,502.659,-1169.14,1000.91,-381.923,-910.241,

-66.3381,-63.0531,-66.7514,-93.677,3.15324,-150.645,-57.5814,68.5477,-352.83,204.682,-
129.751,-401.42,546.961,-687.038,60.4488,471.574,-1200.22,969.829,-413.007,-941.325,

28.1257,31.4107,27.7124,0.786774,97.617,-56.1816,36.8824,163.011,-258.367,299.146,-
35.2871,-306.956,641.425,-592.574,154.913,566.038,-1105.76,1064.29,-318.544,-846.862,

175.262,178.547,174.849,147.924,244.754,90.9551,184.019,310.148,-
111.23,446.283,111.85,-159.82,788.561,-445.437,302.049,713.175,-958.622,1211.43,-
171.407,-699.725,

158.586,161.871,158.172,131.247,228.077,74.2784,167.342,293.471,-
127.907,429.606,95.1729,-176.496,771.885,-462.114,285.373,696.498,-975.298,1194.75,-
188.083,-716.402,
```

-82.6359,-79.3509,-83.0492,-109.975,-13.1446,-166.943,-73.8792,52.2499,-369.128,188.385,-146.049,-417.718,530.663,-703.335,44.151,455.276,-1216.52,953.531,-429.305,-957.623,

-298.115,-294.83,-298.529,-325.454,-228.624,-382.423,-289.359,-163.23,-584.608,-27.0949,-361.528,-633.197,315.184,-918.815,-171.328,239.797,-1432,738.051,-644.785,-1173.1,

-183.87,-180.585,-184.284,-211.209,-114.379,-268.178,-175.114,-48.9845,-470.363,87.1501,-247.283,-518.952,429.429,-804.57,-57.0834,354.042,-1317.75,852.296,-530.54,-1058.86,

211.05,214.335,210.637,183.711,280.542,126.743,219.807,345.936,-75.4419,482.071,147.638,-124.032,824.349,-409.649,337.837,748.963,-922.834,1247.22,-135.619,-663.937,

455.734,459.019,455.32,428.395,525.225,371.426,464.49,590.62,169.241,726.754,392.321,120.652,1069.03,-164.966,582.521,993.646,-678.15,1491.9,109.065,-419.254,

209.609,212.894,209.196,182.27,279.101,125.302,218.366,344.495,-76.883,480.63,146.196,-125.473,822.908,-411.09,336.396,747.521,-924.275,1245.78,-137.06,-665.378,

-321.745,-318.46,-322.158,-349.084,-252.253,-406.052,-312.988,-186.859,-608.237,-50.7243,-385.158,-656.827,291.554,-942.444,-194.958,216.168,-1455.63,714.422,-668.414,-1196.73,

-538.234,-534.949,-538.647,-565.573,-468.742,-622.541,-529.477,-403.348,-824.726,-267.213,-601.647,-873.316,75.0652,-1158.93,-411.447,-0.321527,-1672.12,497.933,-884.903,-1413.22,

-119.807,-116.522,-120.22,-147.146,-50.3158,-204.114,-111.05,15.0787,-406.299,151.213,-183.22,-454.889,493.492,-740.507,6.97981,418.105,-1253.69,916.359,-466.476,-994.794,

534.035,537.32,533.621,506.696,603.526,449.727,542.791,668.92,247.542,805.055,470.622,198.953,1147.33,-86.6649,660.822,1071.95,-599.849,1570.2,187.366,-340.953,

679.822,683.107,679.409,652.483,749.314,595.515,688.579,814.708,393.33,950.843,616.41,344.74,1293.12,59.1228,806.609,1217.73,-454.062,1715.99,333.153,-195.165,

78.1882,81.4732,77.7749,50.8493,147.68,-6.11905,86.9449,213.074,-208.304,349.209,14.7754,-256.894,691.487,-542.511,204.975,616.1,-1055.7,1114.35,-268.481,-796.799,

-651.863,-648.578,-652.276,-679.202,-582.371,-736.17,-643.106,-516.977,-938.355,-380.842,-715.275,-986.945,-38.5636,-1272.56,-525.076,-113.95,-1785.75,384.304,-998.532,-1526.85,

-662.641,-659.356,-663.054,-689.98,-593.149,-746.948,-653.884,-527.755,-949.133,-391.62,-726.054,-997.723,-49.3418,-1283.34,-535.854,-124.729,-1796.52,373.526,-1009.31,-1537.63

};

```
typedef struct {
    long double **mat;
    int m;
    int n;
} matrix_t;


void pamiecDel(matrix_t *b)
{
    for (int i = 0; i < b->m; ++i)
        delete []b->mat[i];


    delete []b->mat;
}
int pomnoz_macierz(matrix_t *c, matrix_t *a, matrix_t *b){
    for(int i = 0; i < a->m; i++){
        for(int j = 0; j < b->n; j++){
            double suma = 0;
            for(int s = 0; s < a->n; s++){
                suma += a->mat[i][s] * b->mat[s][j];
            }
            c->mat[i][j] = suma;
        }
    }
    return 0;
}
```

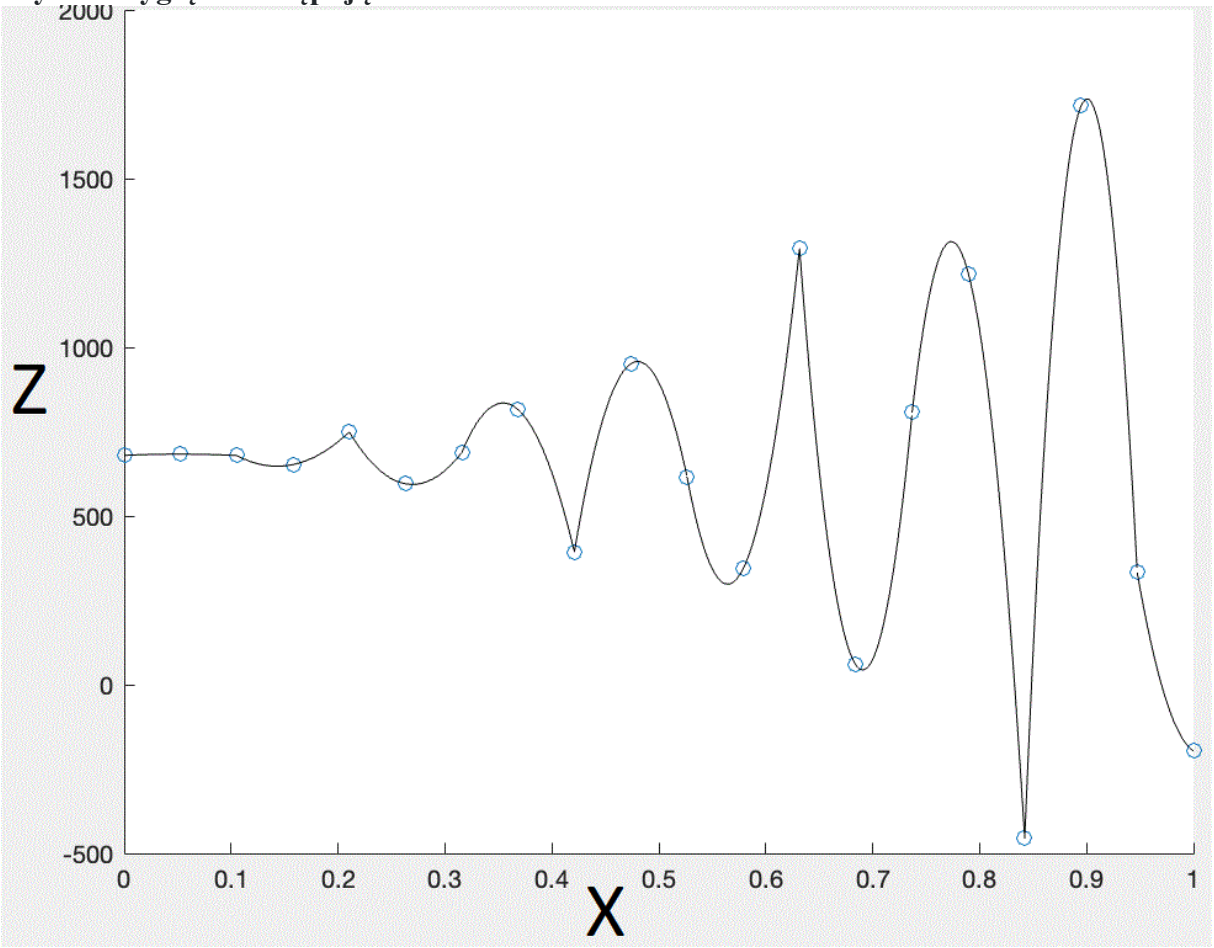
```
void pamiecNew(matrix_t *b, const int& m_, const int& n_)
{
    b->mat = new long double* [m_];
    for (int i = 0; i < m_; i++){
        b->mat[i] = new long double[n_];
    }
    b->m = m_;
    b->n = n_;
}

matrix_t odwroc_macierz(matrix_t *a){
    matrix_t b;
    pamiecNew(&b, a->m, a->n * 2);

    double c = 0;
    double d = 0;
    for(int i = 0; i < a->m; i++){
        for(int j = 0; j < a->n; j++){
            b.mat[i][j] = a->mat[i][j];
        }
    }
    for (int i = 0; i < a->n; i++)
    {
        for (int j = a->n; j < 2 * a->n; j++)
```

```
    {
        b.mat[i][j] = 0;
    }
}
for (int i = 0; i < a->n; i++)
{
    b.mat[i][i + a->n] = 1;
}
for (int s = 0; s < a->n; s++)
{
    c = b.mat[s][s];
    b.mat[s][s] = b.mat[s][s] - 1;
    for (int j = s + 1; j < 2 * a->n; j++)
    {
        d = (b.mat[s][j])/ c;
        for (int i = 0; i < a->n; i++)
        {
            b.mat[i][j] = b.mat[i][j] - (d * b.mat[i][s]);
        }
    }
}
matrix_t ret;
pamiecNew(&ret, a->n, a->n);
for(int i = 0; i < a->n; i++){
    for(int j = 0; j < a->n; j++){
```

```
            ret.mat[i][j] = b.mat[i][j + a->n];
        }
    }
    pamiecDel(&b);
    return ret;
}
void inter_wielomianowa(long double *x, long double *y){
    matrix_t Y;
    pamiecNew(&Y, 3, 1);
    matrix_t X;
    pamiecNew(&X, 3, 3);
    for(int i = 0; i < X.m; i++){
        for(int j = 0; j < X.n; j++){
            X.mat[i][j] = pow(x[i], j);
        }
    }
    for(int i = 0; i < Y.m; i++){
        for(int j = 0; j < Y.n; j++){
            Y.mat[i][j]= y[i];
        }
    }
    matrix_t X_rev = odwroc_macierz(&X);

    matrix_t F;
    pamiecNew(&F, 3, 1);
```

```
    pomnoz_macierz(&F, &X_rev, &Y);


    long double a = F.mat[2][0];
    long double b = F.mat[1][0];
    long double c = F.mat[0][0];


    std::cout << a << "x^2 + "  << b << "x + " << c << '\n';
    pamiecDel(&X);
    pamiecDel(&Y);
    pamiecDel(&X_rev);
    pamiecDel(&F);
}
int main(){
    long double *y = (long double * ) &z[15];
    for(int i = 0; i <= 18; i+=2){
        inter_wielomianowa(x + i, y + i);
    }
    inter_wielomianowa(x + 17, y + 17);
}
```

Wykres wygląda następująco:



4.Wyznaczyć funkcje aproksymacyjne dla wybranego wiersza lub kolumny z siatki.
-240.746 * x + 605.823
Kod programu:

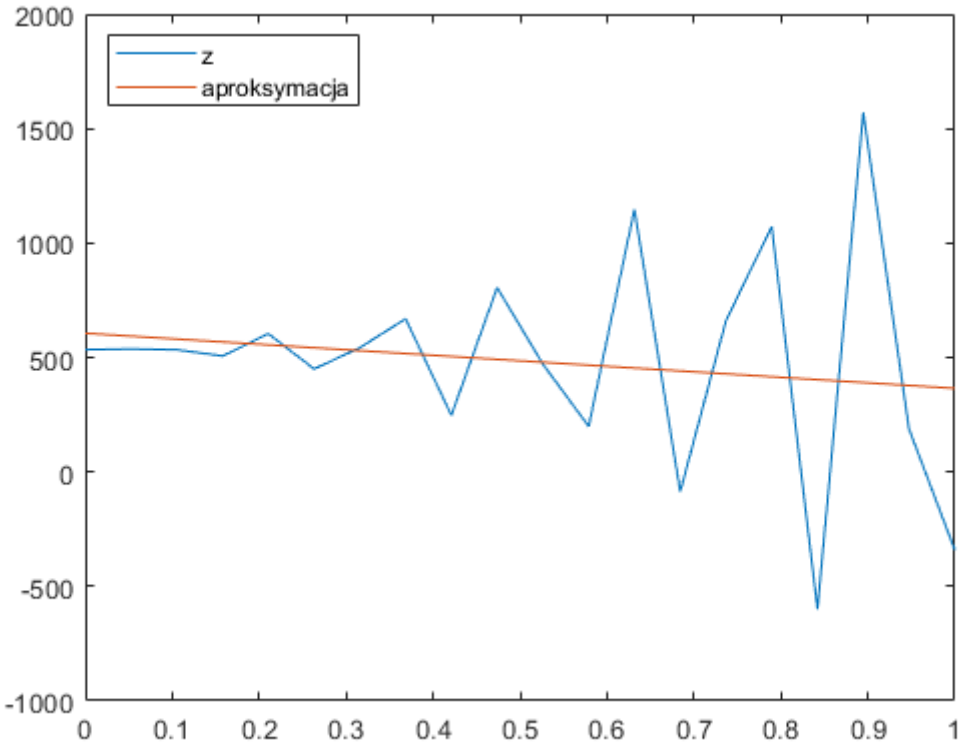
```
#include <iostream>

#include <math.h>

using namespace std;



long double f(long double a, long double b, long double x)

{

return a*x + b;

}

int main()

{
```

```
const int m = 20;

int z = 2;

long double Y[m] =
{534.035,537.32,533.621,506.696,603.526,449.727,542.791,668.92,247.542,805.055,470.622
,198.953,1147.33,-86.6649,660.822,1071.95,-599.849,1570.2,187.366,-340.953};

long double X[m] =

{0,0.0526316,0.105263,0.157895,0.210526,0.263158,0.315789,0.368421,0.421053,0.473684,
0.526316,0.578947,0.631579,0.684211,0.736842,0.789474,0.842105,0.894737,0.947368,1};

long double B[z][z+1];

long double p[z][1];

long double suma_x = 0;

long double suma_x2 = 0;

long double suma_y = 0;

long double suma_xy = 0;

B[0][0]= m;

for(int i = 0; i < m; i++)

{

suma_x += X[i];

suma_y += Y[i];

suma_x2 += X[i]*X[i];

suma_xy += X[i]*Y[i];

}

B[0][1] = suma_x;

B[1][0] = suma_x;

B[1][1] = suma_x2;

B[0][2] = suma_y;

B[1][2] = suma_xy;
```

```
for(int s = 0; s <= z-1 ; s++)
{
for(int i = s+1; i < z; i++)
{
for(int j = s+1; j <= z+1; j++)
{
B[i][j]=B[i][j] - B[i][s]/B[s][s] * B[s][j];
}
}
}
p[z-1][0] = B[z-1][z]/B[z-1][z-1];
for(int i = z - 2; i >= 0; i--){
long double suma = 0.0;
for(int s = i + 1; s < z; s++){
suma += B[i][s] * p[s][0];
}
p[i][0] = (B[i][z] - suma) / B[i][i];
}
cout << "Wspolczynniki funkcji aproksymacyjnej: " << endl;
cout << "a = " << p[1][0] <<endl;
cout << "b = " << p[0][0] << '\n' << endl;
cout << "Kolejne punkty: " << endl;
for(int i = 0; i < m; i++)
{
cout << "f(" << i << ") = " << f(p[1][0], p[0][0], X[i]) << endl;
```

```
}

return 0;

}
```

Wykres wygląda następująco:



5.Wyznaczyć średnią, medianę, odchylenie standardowe.

```
"C:\Users\User\Desktop\Projekt Metody Numeryczne\programy\projekt1\main.exe"
mediana = -56.6325
srednia = -69.8837
odchylenie = 594.622
```

Średnia, mediana i odchylenie standardowe zostały obliczone dzięki programowi „projekt1.cpp”, którego kod wstawiam poniżej:

```
#include <iostream>

#include <cmath>



using namespace std;
```

```
int main()

{

    int n = 400;

    double tab [n] = {

4.1,7.38498,3.68669,-23.2389,73.5913,-80.2073,12.8567,138.986,-282.392,275.12,-59.3128,-
330.982,617.399,-616.6,130.887,542.012,-1129.78,1040.27,-342.569,-870.887,

-35.2535,-31.9686,-35.6668,-62.5925,34.2378,-119.561,-26.4968,99.6323,-321.746,235.767,-
98.6664,-370.336,578.045,-655.953,91.5334,502.659,-1169.14,1000.91,-381.923,-910.241,

-66.3381,-63.0531,-66.7514,-93.677,3.15324,-150.645,-57.5814,68.5477,-352.83,204.682,-129.751,-
401.42,546.961,-687.038,60.4488,471.574,-1200.22,969.829,-413.007,-941.325,

28.1257,31.4107,27.7124,0.786774,97.617,-56.1816,36.8824,163.011,-258.367,299.146,-35.2871,-
306.956,641.425,-592.574,154.913,566.038,-1105.76,1064.29,-318.544,-846.862,

175.262,178.547,174.849,147.924,244.754,90.9551,184.019,310.148,-111.23,446.283,111.85,-
159.82,788.561,-445.437,302.049,713.175,-958.622,1211.43,-171.407,-699.725,

158.586,161.871,158.172,131.247,228.077,74.2784,167.342,293.471,-127.907,429.606,95.1729,-
176.496,771.885,-462.114,285.373,696.498,-975.298,1194.75,-188.083,-716.402,

-82.6359,-79.3509,-83.0492,-109.975,-13.1446,-166.943,-73.8792,52.2499,-369.128,188.385,-
146.049,-417.718,530.663,-703.335,44.151,455.276,-1216.52,953.531,-429.305,-957.623,

-298.115,-294.83,-298.529,-325.454,-228.624,-382.423,-289.359,-163.23,-584.608,-27.0949,-
361.528,-633.197,315.184,-918.815,-171.328,239.797,-1432,738.051,-644.785,-1173.1,

-183.87,-180.585,-184.284,-211.209,-114.379,-268.178,-175.114,-48.9845,-470.363,87.1501,-
247.283,-518.952,429.429,-804.57,-57.0834,354.042,-1317.75,852.296,-530.54,-1058.86,

211.05,214.335,210.637,183.711,280.542,126.743,219.807,345.936,-75.4419,482.071,147.638,-
124.032,824.349,-409.649,337.837,748.963,-922.834,1247.22,-135.619,-663.937,

455.734,459.019,455.32,428.395,525.225,371.426,464.49,590.62,169.241,726.754,392.321,120.652,1
069.03,-164.966,582.521,993.646,-678.15,1491.9,109.065,-419.254,

209.609,212.894,209.196,182.27,279.101,125.302,218.366,344.495,-76.883,480.63,146.196,-
125.473,822.908,-411.09,336.396,747.521,-924.275,1245.78,-137.06,-665.378,

-321.745,-318.46,-322.158,-349.084,-252.253,-406.052,-312.988,-186.859,-608.237,-50.7243,-
385.158,-656.827,291.554,-942.444,-194.958,216.168,-1455.63,714.422,-668.414,-1196.73,

-538.234,-534.949,-538.647,-565.573,-468.742,-622.541,-529.477,-403.348,-824.726,-267.213,-
601.647,-873.316,75.0652,-1158.93,-411.447,-0.321527,-1672.12,497.933,-884.903,-1413.22,

-119.807,-116.522,-120.22,-147.146,-50.3158,-204.114,-111.05,15.0787,-406.299,151.213,-183.22,-
454.889,493.492,-740.507,6.97981,418.105,-1253.69,916.359,-466.476,-994.794,
```

534.035,537.32,533.621,506.696,603.526,449.727,542.791,668.92,247.542,805.055,470.622,198.953,1147.33,-86.6649,660.822,1071.95,-599.849,1570.2,187.366,-340.953,

679.822,683.107,679.409,652.483,749.314,595.515,688.579,814.708,393.33,950.843,616.41,344.74,1293.12,59.1228,806.609,1217.73,-454.062,1715.99,333.153,-195.165,

78.1882,81.4732,77.7749,50.8493,147.68,-6.11905,86.9449,213.074,-208.304,349.209,14.7754,-256.894,691.487,-542.511,204.975,616.1,-1055.7,1114.35,-268.481,-796.799,

-651.863,-648.578,-652.276,-679.202,-582.371,-736.17,-643.106,-516.977,-938.355,-380.842,-715.275,-986.945,-38.5636,-1272.56,-525.076,-113.95,-1785.75,384.304,-998.532,-1526.85,

-662.641,-659.356,-663.054,-689.98,-593.149,-746.948,-653.884,-527.755,-949.133,-391.62,-726.054,-997.723,-49.3418,-1283.34,-535.854,-124.729,-1796.52,373.526,-1009.31,-1537.63,

};

```
double var = tab[0];

for(int j = 0; j < n; j++){

        var = tab[0];

    for(int i = 1; i < n; i++)

    {

        if(var > tab[i])

        {

            tab[i-1] = tab[i];

            tab[i] = var;

        }

        else if(var < tab[i])

        {

            var = tab[i];

        }

    }

}



double mediana = 0;
```

```
int srodek = n/2;
if(srodek % 2 == 0)
{
    mediana = (tab[srodek] + tab[srodek-1])/2;
}
else
{
    mediana = tab[srodek+1];
}
cout << "mediana = " << mediana << endl;
double sumaS = 0;
double srednia = 0;
for(int i = 0; i < n; i++)
{
    sumaS += tab[i];
}
srednia = sumaS/n;
cout << "srednia = " << srednia << endl;
double sumaO = 0;
double odchylenie = 0;
for(int i = 0; i < n; i++)
{
    sumaO += (tab[i] - srednia)*(tab[i] - srednia);
}
odchylenie = sqrt(sumaO/n);
cout << "odchylenie = " << odchylenie << endl;
```

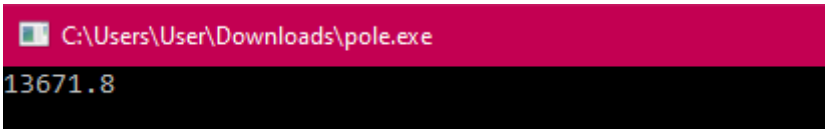
```
const int m = 20;

double tabx [m][m] = {

{4.1,7.38498,3.68669,-23.2389,73.5913,-80.2073,12.8567,138.986,-282.392,275.12,-59.3128,-
330.982,617.399,-616.6,130.887,542.012,-1129.78,1040.27,-342.569,-870.887},

{-35.2535,-31.9686,-35.6668,-62.5925,34.2378,-119.561,-26.4968,99.6323,-321.746,235.767,-
98.6664,-370.336,578.045,-655.953,91.5334,502.659,-1169.14,1000.91,-381.923,-910.241},

{-66.3381,-63.0531,-66.7514,-93.677,3.15324,-150.645,-57.5814,68.5477,-352.83,204.682,-129.751,-
401.42,546.961,-687.038,60.4488,471.574,-1200.22,969.829,-413.007,-941.325},

{28.1257,31.4107,27.7124,0.786774,97.617,-56.1816,36.8824,163.011,-258.367,299.146,-35.2871,-
306.956,641.425,-592.574,154.913,566.038,-1105.76,1064.29,-318.544,-846.862},

{175.262,178.547,174.849,147.924,244.754,90.9551,184.019,310.148,-111.23,446.283,111.85,-
159.82,788.561,-445.437,302.049,713.175,-958.622,1211.43,-171.407,-699.725},

{158.586,161.871,158.172,131.247,228.077,74.2784,167.342,293.471,-127.907,429.606,95.1729,-
176.496,771.885,-462.114,285.373,696.498,-975.298,1194.75,-188.083,-716.402},

{-82.6359,-79.3509,-83.0492,-109.975,-13.1446,-166.943,-73.8792,52.2499,-369.128,188.385,-
146.049,-417.718,530.663,-703.335,44.151,455.276,-1216.52,953.531,-429.305,-957.623},

{-298.115,-294.83,-298.529,-325.454,-228.624,-382.423,-289.359,-163.23,-584.608,-27.0949,-
361.528,-633.197,315.184,-918.815,-171.328,239.797,-1432,738.051,-644.785,-1173.1},

{-183.87,-180.585,-184.284,-211.209,-114.379,-268.178,-175.114,-48.9845,-470.363,87.1501,-
247.283,-518.952,429.429,-804.57,-57.0834,354.042,-1317.75,852.296,-530.54,-1058.86},

{211.05,214.335,210.637,183.711,280.542,126.743,219.807,345.936,-75.4419,482.071,147.638,-
124.032,824.349,-409.649,337.837,748.963,-922.834,1247.22,-135.619,-663.937},

{455.734,459.019,455.32,428.395,525.225,371.426,464.49,590.62,169.241,726.754,392.321,120.652,
1069.03,-164.966,582.521,993.646,-678.15,1491.9,109.065,-419.254},

{209.609,212.894,209.196,182.27,279.101,125.302,218.366,344.495,-76.883,480.63,146.196,-
125.473,822.908,-411.09,336.396,747.521,-924.275,1245.78,-137.06,-665.378},

{-321.745,-318.46,-322.158,-349.084,-252.253,-406.052,-312.988,-186.859,-608.237,-50.7243,-
385.158,-656.827,291.554,-942.444,-194.958,216.168,-1455.63,714.422,-668.414,-1196.73},

{-538.234,-534.949,-538.647,-565.573,-468.742,-622.541,-529.477,-403.348,-824.726,-267.213,-
601.647,-873.316,75.0652,-1158.93,-411.447,-0.321527,-1672.12,497.933,-884.903,-1413.22},

{-119.807,-116.522,-120.22,-147.146,-50.3158,-204.114,-111.05,15.0787,-406.299,151.213,-183.22,-
454.889,493.492,-740.507,6.97981,418.105,-1253.69,916.359,-466.476,-994.794},

{534.035,537.32,533.621,506.696,603.526,449.727,542.791,668.92,247.542,805.055,470.622,198.953
,1147.33,-86.6649,660.822,1071.95,-599.849,1570.2,187.366,-340.953},
```

```
{679.822,683.107,679.409,652.483,749.314,595.515,688.579,814.708,393.33,950.843,616.41,344.74,
1293.12,59.1228,806.609,1217.73,-454.062,1715.99,333.153,-195.165},

{78.1882,81.4732,77.7749,50.8493,147.68,-6.11905,86.9449,213.074,-208.304,349.209,14.7754,-
256.894,691.487,-542.511,204.975,616.1,-1055.7,1114.35,-268.481,-796.799},

{-651.863,-648.578,-652.276,-679.202,-582.371,-736.17,-643.106,-516.977,-938.355,-380.842,-
715.275,-986.945,-38.5636,-1272.56,-525.076,-113.95,-1785.75,384.304,-998.532,-1526.85},

{-662.641,-659.356,-663.054,-689.98,-593.149,-746.948,-653.884,-527.755,-949.133,-391.62,-
726.054,-997.723,-49.3418,-1283.34,-535.854,-124.729,-1796.52,373.526,-1009.31,-1537.63}

};

int z = 2;

long double X[m] = {71.8237,119.777,90.8386,-65.1875,0.585689,286.255,233.286,-185.554,-
192.383,355.266,475.602,-173.517,-446.913,273.465,742.997,5.91143,-
677.902,26.9053,945.018,344.09};

long double Y[m] =
{0,0.0526316,0.105263,0.157895,0.210526,0.263158,0.315789,0.368421,0.421053,0.473684,0.52631
6,0.578947,0.631579,0.684211,0.736842,0.789474,0.842105,0.894737,0.947368,1};

long double B[z][z+1];

long double p[z][1];

long double suma_x = 0;

    long double suma_x2 = 0;

    long double suma_y = 0;

    long double suma_xy = 0;

    B[0][0]= m;

    for(int i = 0; i < m; i++)

    {

        suma_x += X[i];

        suma_y += Y[i];

        suma_x2 = suma_x2 + (X[i]*X[i]);

        suma_xy += X[i]*Y[i];

    }

    B[0][1] = suma_x;
```

```
    B[1][0] = suma_x;
    B[1][1] = suma_x2;
    B[0][2] = suma_y;
    B[1][2] = suma_xy;
for(int s = 0; s <= z-1 ; s++)
    {
        for(int i = s+1; i < z; i++)
        {
            for(int j = s+1; j <= z+1; j++)
            {
                B[i][j]=B[i][j] - B[i][s]/B[s][s] * B[s][j];
            }
        }
    }

    p[z-1][0] = B[z-1][z]/B[z-1][z-1];

    for(int i = z - 2; i >= 0; i--){
                        double suma = 0.0;
                        for(int s = i + 1; s < z; s++){
                                suma += B[i][s] * p[s][0];
                        }
                        p[i][0] = (B[i][z] - suma) / B[i][i];
            }

    for(int i = 0; i < z; i++)
```

```
    {
        cout << "p"<< i << " = " << p[i][0] <<endl;
    }
    double funkcja = 0;
    for(int i = 0; i < m; i++)
    {
        funkcja = i*p[0][0] + p[1][0];
        cout << /*"x" << i << " = " <<*/ funkcja << endl;
    }
    return 0;
}
```

6.Obliczyć pole powierzchni.



Pole powierzchni zostało obliczone dzięki programowi „pole.cpp”, którego kod wstawiam poniżej:

```
#include <iostream>

#include <cmath>

long double x[20] = { 0, 0.0526316, 0.105263, 0.157895, 0.210526, 0.263158, 0.315789, 0.368421,
0.421053, 0.473684, 0.526316, 0.578947, 0.631579, 0.684211, 0.736842, 0.789474, 0.842105,
0.894737, 0.947368, 1 };

long double y[20] = { 0, 0.0526316, 0.105263, 0.157895, 0.210526, 0.263158, 0.315789, 0.368421,
0.421053, 0.473684, 0.526316, 0.578947, 0.631579, 0.684211, 0.736842, 0.789474, 0.842105,
0.894737, 0.947368, 1 };

long double z[20][20] = {

4.1,7.38498,3.68669,-23.2389,73.5913,-80.2073,12.8567,138.986,-282.392,275.12,-59.3128,-
330.982,617.399,-616.6,130.887,542.012,-1129.78,1040.27,-342.569,-870.887,

-35.2535,-31.9686,-35.6668,-62.5925,34.2378,-119.561,-26.4968,99.6323,-321.746,235.767,-
98.6664,-370.336,578.045,-655.953,91.5334,502.659,-1169.14,1000.91,-381.923,-910.241,
```

-66.3381,-63.0531,-66.7514,-93.677,3.15324,-150.645,-57.5814,68.5477,-352.83,204.682,-129.751,-401.42,546.961,-687.038,60.4488,471.574,-1200.22,969.829,-413.007,-941.325,

28.1257,31.4107,27.7124,0.786774,97.617,-56.1816,36.8824,163.011,-258.367,299.146,-35.2871,-306.956,641.425,-592.574,154.913,566.038,-1105.76,1064.29,-318.544,-846.862,

175.262,178.547,174.849,147.924,244.754,90.9551,184.019,310.148,-111.23,446.283,111.85,-159.82,788.561,-445.437,302.049,713.175,-958.622,1211.43,-171.407,-699.725,

158.586,161.871,158.172,131.247,228.077,74.2784,167.342,293.471,-127.907,429.606,95.1729,-176.496,771.885,-462.114,285.373,696.498,-975.298,1194.75,-188.083,-716.402,

-82.6359,-79.3509,-83.0492,-109.975,-13.1446,-166.943,-73.8792,52.2499,-369.128,188.385,-146.049,-417.718,530.663,-703.335,44.151,455.276,-1216.52,953.531,-429.305,-957.623,

-298.115,-294.83,-298.529,-325.454,-228.624,-382.423,-289.359,-163.23,-584.608,-27.0949,-361.528,-633.197,315.184,-918.815,-171.328,239.797,-1432,738.051,-644.785,-1173.1,

-183.87,-180.585,-184.284,-211.209,-114.379,-268.178,-175.114,-48.9845,-470.363,87.1501,-247.283,-518.952,429.429,-804.57,-57.0834,354.042,-1317.75,852.296,-530.54,-1058.86,

211.05,214.335,210.637,183.711,280.542,126.743,219.807,345.936,-75.4419,482.071,147.638,-124.032,824.349,-409.649,337.837,748.963,-922.834,1247.22,-135.619,-663.937,

455.734,459.019,455.32,428.395,525.225,371.426,464.49,590.62,169.241,726.754,392.321,120.652,1069.03,-164.966,582.521,993.646,-678.15,1491.9,109.065,-419.254,

209.609,212.894,209.196,182.27,279.101,125.302,218.366,344.495,-76.883,480.63,146.196,-125.473,822.908,-411.09,336.396,747.521,-924.275,1245.78,-137.06,-665.378,

-321.745,-318.46,-322.158,-349.084,-252.253,-406.052,-312.988,-186.859,-608.237,-50.7243,-385.158,-656.827,291.554,-942.444,-194.958,216.168,-1455.63,714.422,-668.414,-1196.73,

-538.234,-534.949,-538.647,-565.573,-468.742,-622.541,-529.477,-403.348,-824.726,-267.213,-601.647,-873.316,75.0652,-1158.93,-411.447,-0.321527,-1672.12,497.933,-884.903,-1413.22,

-119.807,-116.522,-120.22,-147.146,-50.3158,-204.114,-111.05,15.0787,-406.299,151.213,-183.22,-454.889,493.492,-740.507,6.97981,418.105,-1253.69,916.359,-466.476,-994.794,

534.035,537.32,533.621,506.696,603.526,449.727,542.791,668.92,247.542,805.055,470.622,198.953,1147.33,-86.6649,660.822,1071.95,-599.849,1570.2,187.366,-340.953,

679.822,683.107,679.409,652.483,749.314,595.515,688.579,814.708,393.33,950.843,616.41,344.74,1293.12,59.1228,806.609,1217.73,-454.062,1715.99,333.153,-195.165,

78.1882,81.4732,77.7749,50.8493,147.68,-6.11905,86.9449,213.074,-208.304,349.209,14.7754,-256.894,691.487,-542.511,204.975,616.1,-1055.7,1114.35,-268.481,-796.799,

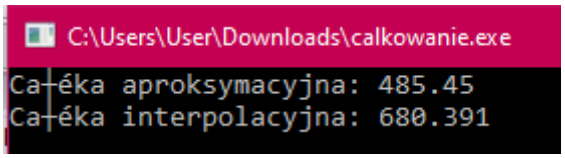
-651.863,-648.578,-652.276,-679.202,-582.371,-736.17,-643.106,-516.977,-938.355,-380.842,-715.275,-986.945,-38.5636,-1272.56,-525.076,-113.95,-1785.75,384.304,-998.532,-1526.85,

-662.641,-659.356,-663.054,-689.98,-593.149,-746.948,-653.884,-527.755,-949.133,-391.62,-726.054,-997.723,-49.3418,-1283.34,-535.854,-124.729,-1796.52,373.526,-1009.31,-1537.63

```
};
struct punkt {
    double x;
    double y;
    double z;
};
long double pole_trk(double a, double b, double c){
    double p = (a + b + c) / 2;
    long double pole = sqrt(p * (p - a)*(p - b)*(p - c));
    return pole;
}
long double pole(punkt &a, punkt &b, punkt &c, punkt &d){
    double e = sqrt(pow(a.x - b.x,2) + pow(a.z - b.z,2));
    double f = sqrt(pow(c.y - a.y,2) + pow(c.z - a.z, 2));
    double pod = sqrt(pow(b.x - a.x,2) + pow(a.y - c.y, 2));
    double g = sqrt(pow(c.z - b.z,2) + pow(pod,2));
    double pole_r = pole_trk(e, f, g);
    e = sqrt(pow(c.x - d.x,2) + pow(c.z - d.z,2));
    f = sqrt(pow(d.y - b.y, 2) + pow(d.z - b.z, 2));
    pole_r += pole_trk(e, f, g);
    return pole_r;
}
int main(){
    double polecal = 0.0;
    for(int i = 0; i < 19; i++){
       for(int j = 0; j < 19; j++){
```

```
            punkt a = {x[i], y[j], z[i][j]};
            punkt b = {x[i + 1], y[j], z[i + 1][j]};
            punkt c = {x[i], y[j + 1], z[i][j + 1]};
            punkt d = {x[i + 1], y[j + 1], z[i + 1][j + 1]};
            polecal += pole(a,b,c,d);
        }
    }
    std::cout << polecal << '\n';
}
```

7.Obliczyć całkę z funkcji interpolacyjnych i aproksymacyjnych.



Kod programu:

```
#include <iostream>
#include <cmath>


int n = 19;
double a = 0;
double b = 1;
double h = 0.0526316;
double f(double x){
            return -240.746 * x + 605.823;
}
long double g(long double x, int i){
    if(i >= 0 && i <= 1)
```

```
        return -1260.44 * x * x + 128.754 * x + 697.822;
    if(i >= 2 && i <= 3)
        return 22338.3 * x * x - 6390.1 * x + 1104.53;
    if(i >= 4 && i <= 5)
        return 44558.8 * x * x -24028.9 * x + 3833.13;
    if(i >= 6 && i <= 7)
        return -98823.4 * x * x + 70012.4 * x - 11565.6;
    if(i >= 8 && i <= 9)
        return - 160997 * x * x + 154643 * x - 36177.1;
    if(i >= 10 && i <= 11)
        return 220219 * x * x - 248561 * x + 70435.7;
    if(i >= 12 && i <= 13)
        return 357658 * x * x - 494049 * x + 170657;
    if(i >= 14 && i <= 15)
        return -375969 * x * x + 581659 * x - 223657;
    if(i >= 16 && i <= 17)
        return -641297 * x * x +1155060 * x - 518368;
    if(i >= 18 && i <= 19)
        return 154244 * x * x - 310409 * x + 155969;
    return 0;
}
int main(){
    double x_l, x_p, x_s;
            double calka = 0.0;
            for(int i = 0 ; i < n ; i++){
```

```
            x_l = a + i * h;
            x_p = a + i * h + h;
            x_s = a + i * h + (h/2);
            calka += (h / 6) * (f(x_l) + 4 * f(x_s) + f(x_p));
        }
        std::cout << "Całka aproksymacyjna: " << calka << '\n';
        calka = 0.0;
        for(int i = 0 ; i < n ; i++){
            x_l = a + i * h;
            x_p = a + i * h + h;
            x_s = a + i * h + (h/2);
            calka += (h / 6) * (g(x_l, i) + 4 * g(x_s, i) + g(x_p, i));
        }
        std::cout << "Całka interpolacyjna: " << calka << '\n';
}
```

8.Wyznaczyć pochodne cząstkowe.

Pochodna cząstkowa – dla danej funkcji wielu zmiennych pochodna względem jednej z jej zmiennych przy ustaleniu pozostałych. Pochodne cząstkowe znajdują zastosowanie np. w rachunku wektorowym oraz geometrii różniczkowej.

Do wyznaczenia pochodnej cząstkowej użyłem programu, którego kod wygląda następująco:

```
#include <iostream>
#include <fstream>
long double x[20] = { 0, 0.0526316, 0.105263, 0.157895, 0.210526, 0.263158, 0.315789, 0.368421, 0.421053, 0.473684, 0.526316, 0.578947, 0.631579, 0.684211, 0.736842, 0.789474, 0.842105, 0.894737, 0.947368, 1 };
long double y[20] = { 0, 0.0526316, 0.105263, 0.157895, 0.210526, 0.263158, 0.315789, 0.368421, 0.421053, 0.473684, 0.526316, 0.578947, 0.631579, 0.684211, 0.736842, 0.789474, 0.842105, 0.894737, 0.947368, 1 };
```

```
long double d[20][20] = {

        4.1,7.38498,3.68669,-23.2389,73.5913,-80.2073,12.8567,138.986,-282.392,275.12,-59.3128,-
330.982,617.399,-616.6,130.887,542.012,-1129.78,1040.27,-342.569,-870.887,

-35.2535,-31.9686,-35.6668,-62.5925,34.2378,-119.561,-26.4968,99.6323,-321.746,235.767,-
98.6664,-370.336,578.045,-655.953,91.5334,502.659,-1169.14,1000.91,-381.923,-910.241,

-66.3381,-63.0531,-66.7514,-93.677,3.15324,-150.645,-57.5814,68.5477,-352.83,204.682,-129.751,-
401.42,546.961,-687.038,60.4488,471.574,-1200.22,969.829,-413.007,-941.325,

28.1257,31.4107,27.7124,0.786774,97.617,-56.1816,36.8824,163.011,-258.367,299.146,-35.2871,-
306.956,641.425,-592.574,154.913,566.038,-1105.76,1064.29,-318.544,-846.862,

175.262,178.547,174.849,147.924,244.754,90.9551,184.019,310.148,-111.23,446.283,111.85,-
159.82,788.561,-445.437,302.049,713.175,-958.622,1211.43,-171.407,-699.725,

158.586,161.871,158.172,131.247,228.077,74.2784,167.342,293.471,-127.907,429.606,95.1729,-
176.496,771.885,-462.114,285.373,696.498,-975.298,1194.75,-188.083,-716.402,

-82.6359,-79.3509,-83.0492,-109.975,-13.1446,-166.943,-73.8792,52.2499,-369.128,188.385,-
146.049,-417.718,530.663,-703.335,44.151,455.276,-1216.52,953.531,-429.305,-957.623,

-298.115,-294.83,-298.529,-325.454,-228.624,-382.423,-289.359,-163.23,-584.608,-27.0949,-
361.528,-633.197,315.184,-918.815,-171.328,239.797,-1432,738.051,-644.785,-1173.1,

-183.87,-180.585,-184.284,-211.209,-114.379,-268.178,-175.114,-48.9845,-470.363,87.1501,-
247.283,-518.952,429.429,-804.57,-57.0834,354.042,-1317.75,852.296,-530.54,-1058.86,

211.05,214.335,210.637,183.711,280.542,126.743,219.807,345.936,-75.4419,482.071,147.638,-
124.032,824.349,-409.649,337.837,748.963,-922.834,1247.22,-135.619,-663.937,

455.734,459.019,455.32,428.395,525.225,371.426,464.49,590.62,169.241,726.754,392.321,120.652,1
069.03,-164.966,582.521,993.646,-678.15,1491.9,109.065,-419.254,

209.609,212.894,209.196,182.27,279.101,125.302,218.366,344.495,-76.883,480.63,146.196,-
125.473,822.908,-411.09,336.396,747.521,-924.275,1245.78,-137.06,-665.378,

-321.745,-318.46,-322.158,-349.084,-252.253,-406.052,-312.988,-186.859,-608.237,-50.7243,-
385.158,-656.827,291.554,-942.444,-194.958,216.168,-1455.63,714.422,-668.414,-1196.73,

-538.234,-534.949,-538.647,-565.573,-468.742,-622.541,-529.477,-403.348,-824.726,-267.213,-
601.647,-873.316,75.0652,-1158.93,-411.447,-0.321527,-1672.12,497.933,-884.903,-1413.22,

-119.807,-116.522,-120.22,-147.146,-50.3158,-204.114,-111.05,15.0787,-406.299,151.213,-183.22,-
454.889,493.492,-740.507,6.97981,418.105,-1253.69,916.359,-466.476,-994.794,

534.035,537.32,533.621,506.696,603.526,449.727,542.791,668.92,247.542,805.055,470.622,198.953,
1147.33,-86.6649,660.822,1071.95,-599.849,1570.2,187.366,-340.953,

679.822,683.107,679.409,652.483,749.314,595.515,688.579,814.708,393.33,950.843,616.41,344.74,1
293.12,59.1228,806.609,1217.73,-454.062,1715.99,333.153,-195.165,
```

```
78.1882,81.4732,77.7749,50.8493,147.68,-6.11905,86.9449,213.074,-208.304,349.209,14.7754,-256.894,691.487,-542.511,204.975,616.1,-1055.7,1114.35,-268.481,-796.799,

-651.863,-648.578,-652.276,-679.202,-582.371,-736.17,-643.106,-516.977,-938.355,-380.842,-715.275,-986.945,-38.5636,-1272.56,-525.076,-113.95,-1785.75,384.304,-998.532,-1526.85,

-662.641,-659.356,-663.054,-689.98,-593.149,-746.948,-653.884,-527.755,-949.133,-391.62,-726.054,-997.723,-49.3418,-1283.34,-535.854,-124.729,-1796.52,373.526,-1009.31,-1537.63

};

long double Px[20][20];

long double Py[20][20];

long double h = 0.0526316;



int main() {

    for (int i = 1; i < 19; i++) {

        for (int j = 1; j < 19; j++) {

            Px[i][j] = (d[i + 1][j] - d[i - 1][j]) / (2 * h);

            Py[i][j] = (d[i][j + 1] - d[i][j - 1]) / (2 * h);

        }

    }

    std::ofstream plik_out;

    plik_out.open("px.txt");

    for (int i = 1; i < 19; i++) {

        for (int j = 1; j < 19; j++) {

            plik_out << Px[i][j] << ' ';

        }

        plik_out << '\n';

    }

    plik_out.close();

    plik_out.open("py.txt");
```

```
for (int i = 1; i < 19; i++) {
    for (int j = 1; j < 19; j++) {
        plik_out << Py[i][j] << ' ';
    }
    plik_out << '\n';
}
plik_out.close();
plik_out.open("mon_x.txt");
for (int i = 1; i < 19; i++) {
    for (int j = 1; j < 19; j++) {
        if (Px[i][j] < 0) {
            plik_out << -1 << ' ';
        } else {
            plik_out << 1 << ' ';
        }
    }
    plik_out << '\n';
}
plik_out.close();
plik_out.open("mon_y.txt");
for (int i = 1; i < 19; i++) {
    for (int j = 1; j < 19; j++) {
        if (Py[i][j] < 0) {
            plik_out << -1 << ' ';
        }
        else {
```

```
            plik_out << 1 << ' ';

          }

        }

        plik_out << '\n';

    }

    plik_out.close();

}
```

Wyniki prezentują się następująco:
***dla X:**

-669.161 -669.162 -669.162 -669.161 -669.158 -669.162 -669.164 -669.161 -669.161 -669.163 -669.161 -669.161 -669.161 -669.163 -669.161 -669.18 -669.189 -669.161

602.103 602.102 602.103 602.102 602.104 602.102 602.097 602.1 602.1 602.103 602.11 602.11 602.1 602.106 602.1 602.11 602.11 602.1

2295.2 2295.2 2295.21 2295.21 2295.2 2295.2 2295.2 2295.2 2295.21 2295.21 2295.2 2295.2 2295.21 2295.2 2295.21 2295.18 2295.21 2295.2

1239.37 1239.37 1239.37 1239.37 1239.37 1239.37 1239.37 1239.37 1239.37 1239.37 1239.37 1239.37 1239.37 1239.37 1239.37 1239.39 1239.37 1239.38

-2450.03 -2450.03 -2450.04 -2450.04 -2450.03 -2450.03 -2450.03 -2450.03 -2450.03 -2450.04 -2450.03 -2450.03 -2450.03 -2450.03 -2450.04 -2450.03 -2450.04 -2450.03

-4338.66 -4338.66 -4338.66 -4338.66 -4338.66 -4338.66 -4338.66 -4338.66 -4338.66 -4338.66 -4338.66 -4338.66 -4338.66 -4338.66 -4338.66 -4338.67 -4338.64 -4338.67

-961.724 -961.73 -961.723 -961.726 -961.732 -961.73 -961.726 -961.732 -961.731 -961.723 -961.723 -961.723 -961.732 -961.726 -961.723 -961.685 -961.732 -961.732

4837.07 4837.08 4837.07 4837.08 4837.08 4837.08 4837.08 4837.08 4837.07 4837.08 4837.07 4837.07 4837.08 4837.07 4837.08 4837.08 4837.1 4837.08

6076.24 6076.24 6076.24 6076.24 6076.24 6076.24 6076.24 6076.24 6076.23 6076.24 6076.24 6076.21 6076.24 6076.24 6076.24 6076.2 6076.24 6076.25

-13.6895 -13.6895 -13.6895 -13.6895 -13.6895 -13.6895 -13.6895 -13.6904 -13.6895 -13.699 -13.6895 -13.6895 -13.6895 -13.6895 -13.699 -13.6895 -13.68 -13.6895

-7386.05 -7386.04 -7386.05 -7386.04 -7386.04 -7386.04 -7386.05 -7386.04 -7386.04 -7386.05 -7386.05 -7386.02 -7386.04 -7386.05 -7386.04 -7386.06 -7386.04 -7386.05

-7104.51 -7104.51 -7104.51 -7104.51 -7104.51 -7104.51 -7104.51 -7104.51 -7104.51 -7104.51 -7104.51 -7104.5 -7104.48 -7104.51 -7104.5 -7104.52 -7104.54 -7104.51

1918.41 1918.41 1918.41 1918.4 1918.41 1918.41 1918.41 1918.41 1918.4 1918.41 1918.41 1918.41 1918.4 1918.41 1918.4 1918.43 1918.4 1918.41

10186.6 10186.5 10186.6 10186.5 10186.5 10186.5 10186.5 10186.5 10186.5 10186.6 10186.6 10186.5 10186.5 10186.6 10186.6 10186.6 10186.5 10186.6

7596.47 7596.47 7596.47 7596.48 7596.47 7596.47 7596.48 7596.47 7596.48 7596.48 7596.47 7596.46 7596.48 7596.47 7596.43 7596.46 7596.49 7596.47

-4330.54 -4330.54 -4330.54 -4330.54 -4330.54 -4330.54 -4330.54 -4330.54 -4330.54 -4330.54 -4330.54 -4330.51 -4330.54 -4330.54 -4330.57 -4330.58 -4330.57 -4330.54

-12651 -12651 -12651 -12651 -12651 -12651 -12651 -12651 -12651 -12651 -12651 -12651 -12651 -12651 -12651 -12651 -12651 -12651

-7037.87 -7037.87 -7037.88 -7037.87 -7037.87 -7037.87 -7037.87 -7037.87 -7037.87 -7037.88 -7037.87 -7037.87 -7037.87 -7037.87 -7037.87 -7037.79 -7037.83 -7037.87

***dla Y**

-3.92635 -290.927 664.093 -541.201 -576.978 2082.34 -2804.87 1293.28 2119.26 -5757.98 6428.76 -2713.36 -4621.86 11006.8 -11976.4 4733.38 7478.56 -18155.9

-3.92635 -290.927 664.094 -541.196 -576.979 2082.33 -2804.86 1293.28 2119.25 -5757.97 6428.76 -2713.37 -4621.86 11006.8 -11976.3 4733.42 7478.52 -18156

-3.92635 -290.927 664.093 -541.199 -576.978 2082.33 -2804.87 1293.28 2119.26 -5757.97 6428.76 -2713.37 -4621.86 11006.8 -11976.4 4733.39 7478.55 -18155.9

-3.9235 -290.918 664.097 -541.204 -576.982 2082.33 -2804.86 1293.28 2119.26 -5757.98 6428.75 -2713.36 -4621.86 11006.8 -11976.4 4733.42 7478.54 -18156

-3.933 -290.928 664.097 -541.201 -576.982 2082.33 -2804.86 1293.28 2119.26 -5757.97 6428.76 -2713.37 -4621.86 11006.8 -11976.4 4733.39 7478.54 -18155.9

-3.92635 -290.929 664.093 -541.196 -576.978 2082.33 -2804.86 1293.28 2119.25 -5757.98 6428.76 -2713.36 -4621.86 11006.8 -11976.4 4733.42 7478.54 -18156

-3.933 -290.928 664.097 -541.205 -576.982 2082.33 -2804.86 1293.28 2119.26 -5757.97 6428.76 -2713.37 -4621.86 11006.8 -11976.4 4733.41 7478.54 -18155.9

-3.933 -290.928 664.097 -541.205 -576.982 2082.34 -2804.86 1293.28 2119.26 -5757.97 6428.76 -2713.37 -4621.87 11006.8 -11976.3 4733.41 7478.49 -18156

-3.9235 -290.928 664.097 -541.196 -576.982 2082.33 -2804.86 1293.28 2119.26 -5757.98 6428.75 -2713.36 -4621.86 11006.8 -11976.4 4733.44 7478.54 -18156

-3.933 -290.928 664.097 -541.205 -576.982 2082.34 -2804.86 1293.27 2119.26 -5757.97 6428.73 -2713.37 -4621.83 11006.8 -11976.4 4733.41 7478.54 -18156

-3.9235 -290.928 664.097 -541.196 -576.982 2082.33 -2804.86 1293.28 2119.25 -5757.98 6428.76 -2713.36 -4621.86 11006.8 -11976.4 4733.46 7478.54 -18156

-3.9235 -290.928 664.097 -541.196 -576.982 2082.33 -2804.86 1293.28 2119.25 -5757.97 6428.76 -2713.36 -4621.86 11006.8 -11976.4 4733.41 7478.55 -18155.9

-3.9235 -290.928 664.097 -541.196 -576.982 2082.33 -2804.86 1293.28 2119.25 -5757.98 6428.76 -2713.33 -4621.86 11006.8 -11976.4 4733.42 7478.56 -18155.9

-3.9235 -290.928 664.09 -541.196 -576.975 2082.33 -2804.86 1293.28 2119.25 -5757.97 6428.76 -2713.37 -4621.86 11006.8 -11976.4 4733.41 7478.53 -18155.9

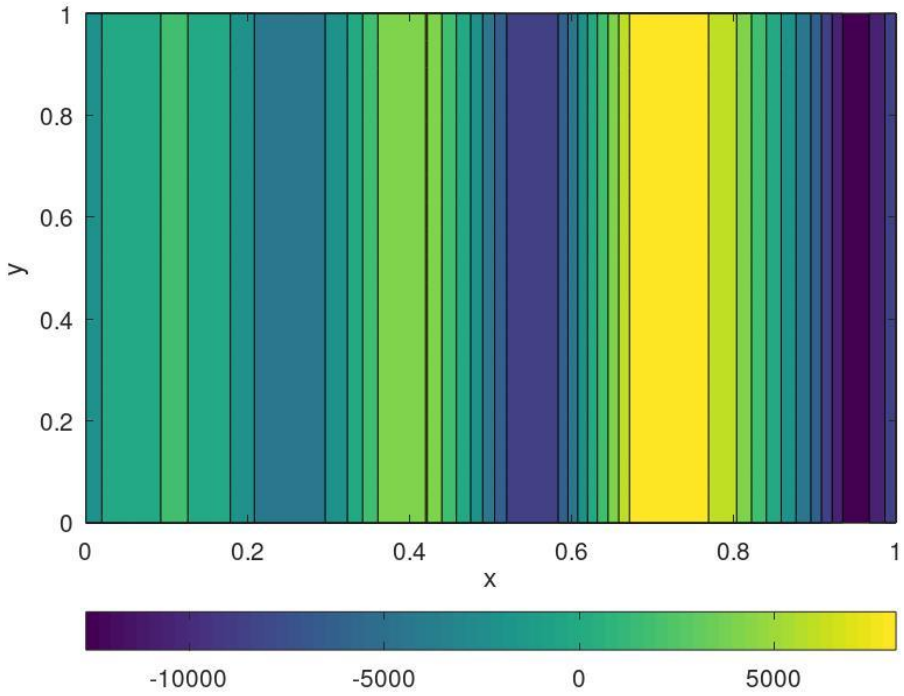
-3.933 -290.928 664.097 -541.205 -576.982 2082.33 -2804.86 1293.28 2119.26 -5757.97 6428.72 -2713.37 -4621.82 11006.8 -11976.4 4733.37 7478.54 -18155.9

-3.9235 -290.928 664.097 -541.196 -576.982 2082.33 -2804.86 1293.28 2119.26 -5757.98 6428.74 -2713.36 -4621.85 11006.8 -11976.4 4733.47 7478.54 -18156

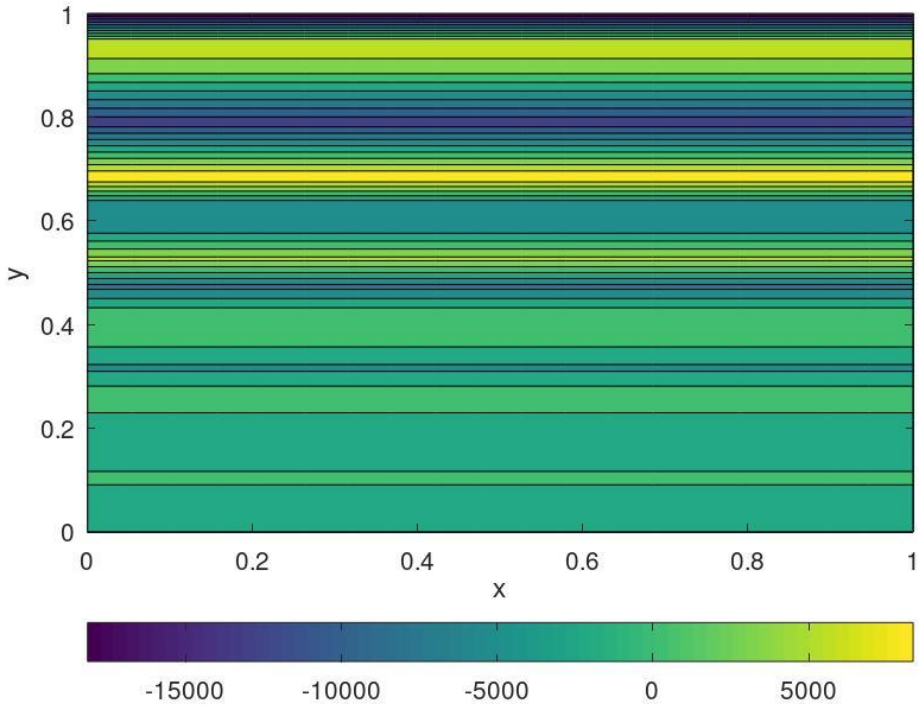
-3.92635 -290.927 664.098 -541.199 -576.983 2082.33 -2804.86 1293.28 2119.25 -5757.98 6428.76 -2713.36 -4621.86 11006.8 -11976.4 4733.37 7478.58 -18155.9

-3.9235 -290.928 664.097 -541.196 -576.982 2082.33 -2804.86 1293.28 2119.26 -5757.98 6428.76 -2713.34 -4621.87 11006.8 -11976.4 4733.41 7478.57 -18156

Heatmapa pochodnej X:

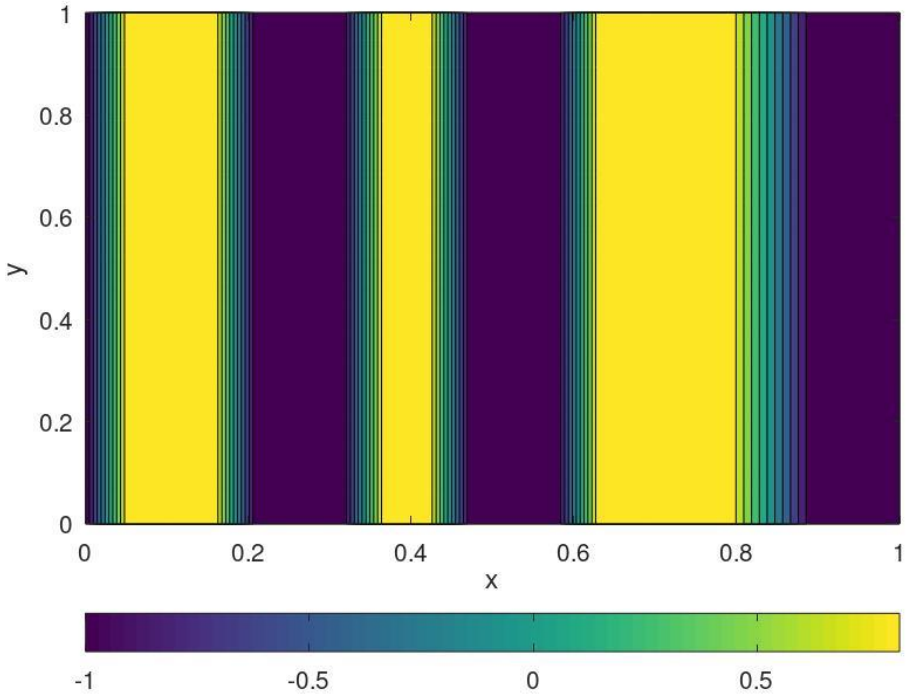


Heatmapa pochodnej Y:



9.Określić monotoniczność.

Monotoniczność X:



Monotoniczność Y: