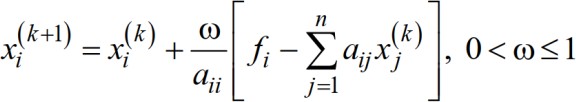
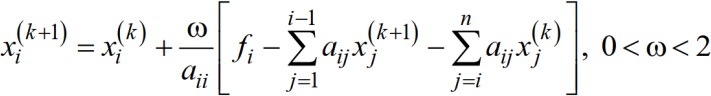
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| --- | --- | --- |
| Министерство науки и высшего образования  Российской Федерации | | |
| Федеральное государственное бюджетное  образовательное учреждение высшего образования | | |
| «Новосибирский государственный технический университет» | | |
|  | | |
| Кафедра прикладной математики | | |
|  | | |
| Практическое задание № 2 | | |
| по дисциплине «Численные методы» | | |
|  | | |
| **ИТЕРАЦИОННЫЕ МЕТОДЫ РЕШЕНИЯ СЛАУ** | | |
|  | | |
|  | Факультет: | ПМИ |
| Группа: | ПМ-71 |
| Студент: | Востриков Вячеслав |
| Вариант: | 11 |
| Преподаватели: | Патрушев И.И. |
|  | Задорожный А.Г. |
|  | Персова М.Г. |
|  |  |
|  | | |
| Новосибирск | | |
| 2020 | | |

1. **Цель работы**

Разработать программы решения СЛАУ методами Якоби, Гаусса-Зейделя с хранением матрицы в диагональном формате. Исследовать сходимость методов для различных тестовых матриц и её зависимость от параметра релаксации. Изучить возможность оценки порядка числа обусловленности матрицы путем вычислительного эксперимента.

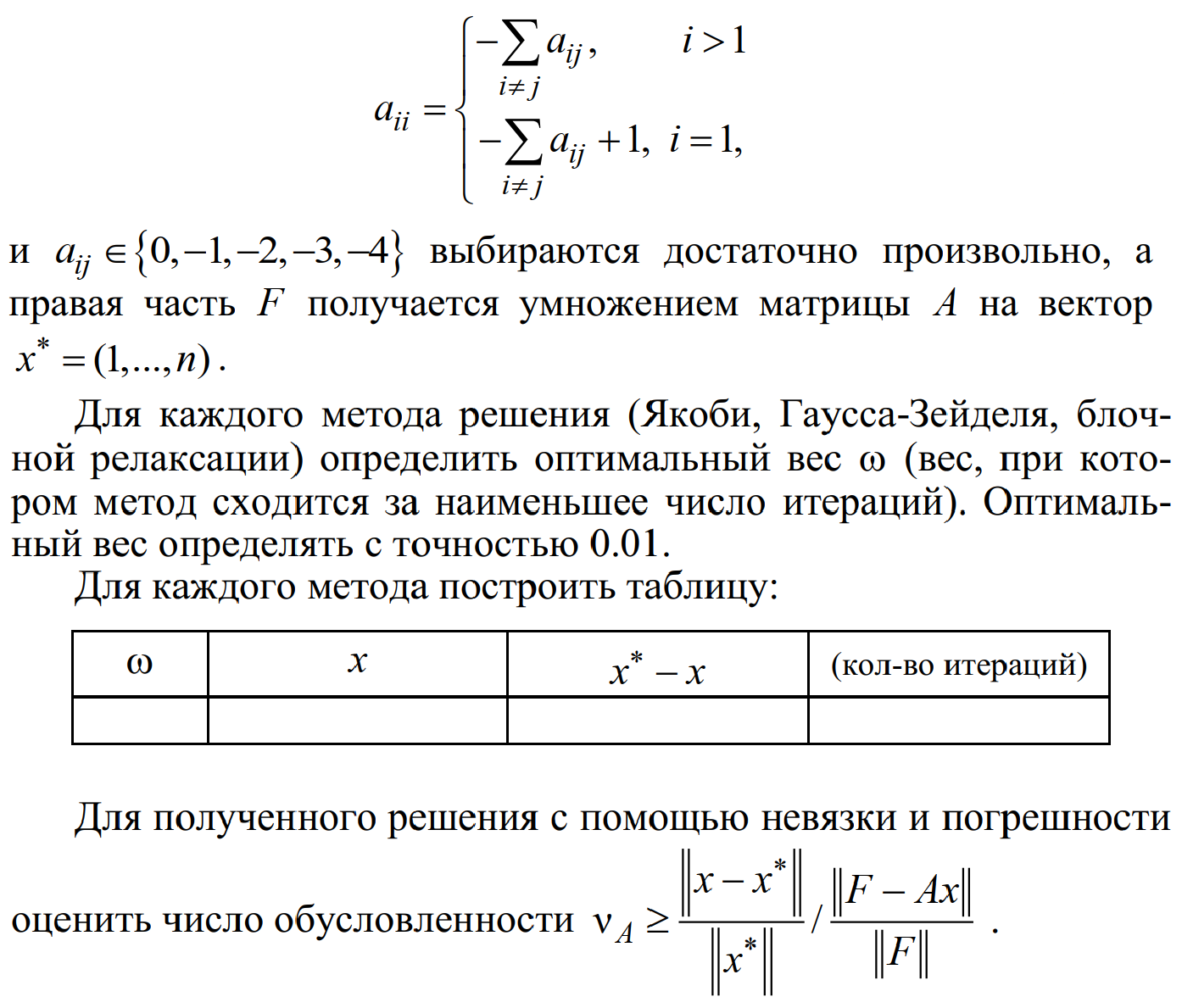
1. **Условие задачи** 
   1. Реализовать метод Якоби с параметром релаксации

Метод Гаусса-Зейделя с параметром релаксации



для указанной в варианте задания матрицы в диагональном формате с учетом следующих требований:

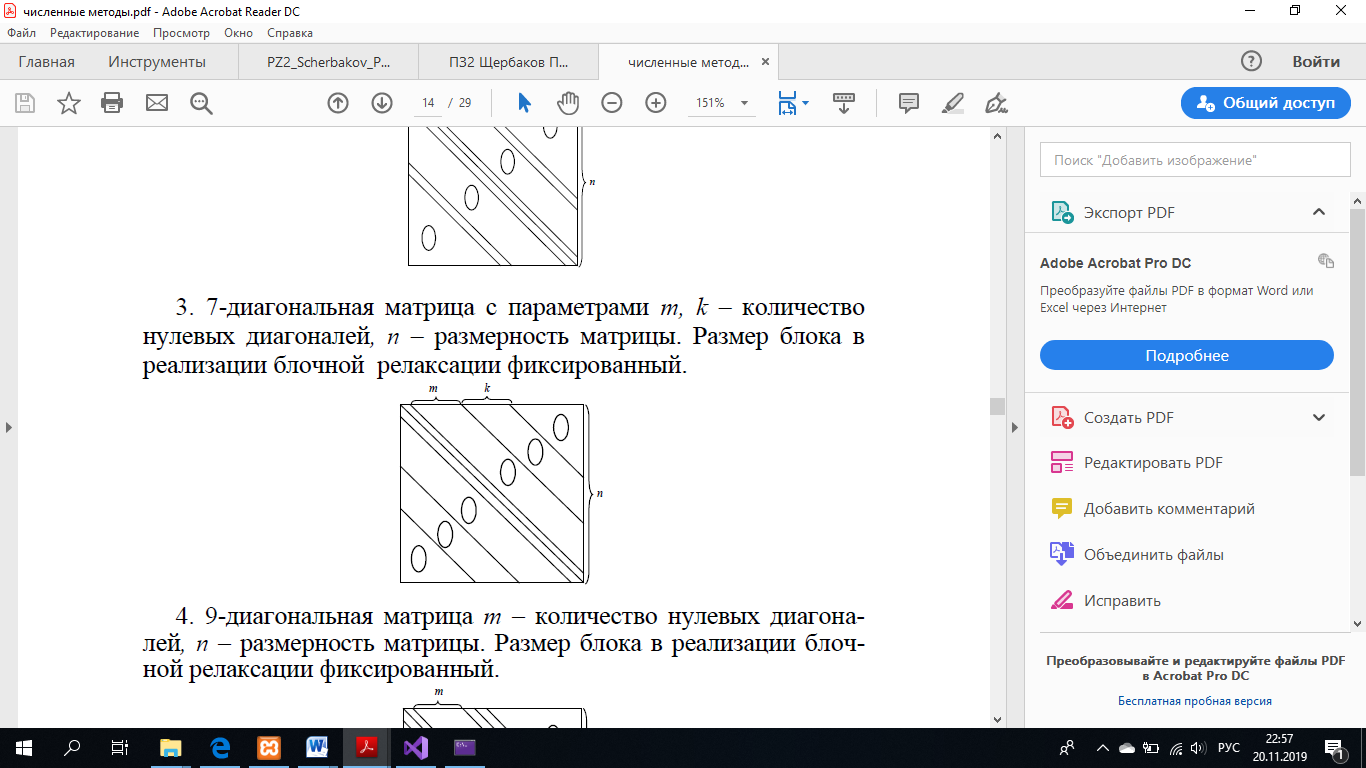
* + - размерность матрицы и её параметры, точность решения СЛАУ, максимальное количество итераций, элементы матрицы, вектор правой части и начальное приближение читать из файлов;
    - элементы матрицы должны храниться в диагональном формате соответственно варианту;
    - матрица должна обрабатываться в соответствии с форматом;
    - в реализации методов Якоби и Зейделя для итерационного шага использовать одну и ту же подпрограмму;
    - выход из итерационного процесса выполнять, если относительная невязка стала меньше заданного параметра;
    - предусмотреть аварийный выход из итерационного процесса при достижении максимального количества итерации;
    - результат записывать в файл в формате, соответствующем хранению начального приближения.
    - в процессе счета выдавать на экран сообщение о номере текущей итерации и относительную невязку.
  1. Протестировать разработанную программу.
  2. Провести исследование реализованных методов на матрице с диагональным преобладанием, построенной следующим образом:



* 1. Провести аналогичные исследования на матрице с обратным знаком внедиагональных элементов.

1. **Вариант задания**

Матрица из варианта 3. Размер блока в реализации блоч- ной релаксации переменный. Исследовать зависимость скорости сходимости от размеров блока. 7-диагональная матрица c параметрами *m, k –* количество нулевых диагоналей*, n –* размерность матрицы.



**4. Текст программы:**

// Файл DiagonalFormat.h #ifndef DIAGONALFORMAT\_H #define DIAGONALFORMAT\_H

#include <fstream> #include <vector>

template <typename T> class DiagonalFormat

{

public:

int n;

int diagonalsCount;

DiagonalFormat(int n, int diagonalsCount); std::vector<std::vector<T>> diagonals; std::vector<int> offsets;

void multByVector(std::vector<T> vector, std::vector<T>& resultVector); void load(std::string filename);

};

#include "DiagonalFormat.cpp" #endif DIAGONALFORMAT\_H

// Файл DiagonalFormat.cpp #ifndef DIAGONALFORMAT\_CPP #define DIAGONALFORMAT\_CPP

#include "DiagonalFormat.h" using namespace std;

template <typename T>

DiagonalFormat<T>::DiagonalFormat(int n, int diagonalsCount)

{

this->n = n;

this->diagonalsCount = diagonalsCount;

this->offsets = std::vector<int>(diagonalsCount);

this->diagonals = std::vector<std::vector<T>>(diagonalsCount, vector<T>(n));

}

template <typename T>

void DiagonalFormat<T>::multByVector(std::vector<T> vector, std::vector<T> &resultVector)

{

for (int i = 0; i < this->n; i++)

{

T sum = 0;

for (int diagonalIndex = 0; diagonalIndex < this->diagonalsCount; diagonalIndex++)

{

int offset = this->offsets[diagonalIndex]; int j = i + offset;

if (j < 0 || j >= this->n) continue;

sum += this->diagonals[diagonalIndex][i] \* vector[j];

}

resultVector[i] = sum;

}

}

template <typename T>

void DiagonalFormat<T>::load(std::string filename)

{

std::ifstream file(filename);

for (int diagonalIndex = 0; diagonalIndex < this->diagonalsCount; diagonalIndex++)

{

file >> this->offsets[diagonalIndex];

for (int elementIndex = 0; elementIndex < this->n; elementIndex++)

file >> this->diagonals[diagonalIndex][elementIndex];

}

}

#endif

// Файл SLE.h #ifndef SLE\_H #define SLE\_H

#include "DiagonalFormat.h" #include "VectorOperations.h" #include <iostream>

template <typename T> class SLE

{

private:

int n;

int diagonalsCount; int maxIter;

double epsilon; double omega;

DiagonalFormat<T> matrix; std::vector<T> f;

void iteration(std::vector<T> &x0, std::vector<T> &x); double calculateResidual(std::vector<T>& x);

public:

SLE(int maxIter, double epsilon, double omega, DiagonalFormat<T> &matrix, std::vector<T> &f);

void Jacobi(std::vector<T> &x0);

void GaussSeidel(std::vector<T>& x0, std::vector<T>& x);

double calculateCondNum(std::vector<T>& x, std::vector<T>& x\_exact);

};

#include "SLE.cpp" #endif SLE\_H

// // Файл SLE.cpp #ifndef SLE\_CPP #define SLE\_CPP #include "SLE.h" #include <iomanip>

template <typename T>

SLE<T>::SLE(int maxIter, double epsilon, double omega, DiagonalFormat<T> &matrix, std::vector<T> &f)

:matrix(matrix), f(f)

{

this->n = matrix.n;

this->diagonalsCount = matrix.diagonalsCount; this->maxIter = maxIter;

this->epsilon = epsilon; this->omega = omega;

}

template <typename T>

void SLE<T>::iteration(std::vector<T>& x0, std::vector<T>& x)

{

0);

// Найдем вектор главной диагонали

auto mainDiagonalOffsetIter = std::find(matrix.offsets.begin(), matrix.offsets.end(),

int mainDiagonalOffsetIndex = std::distance(matrix.offsets.begin(),

mainDiagonalOffsetIter);

for (int i = 0; i < this->n; i++)

{

T sum = 0;

for (int diagonalIndex = 0; diagonalIndex < this->diagonalsCount; diagonalIndex++)

{

x0[j]);

int offset = this->matrix.offsets[diagonalIndex]; int j = i + offset;

if (j < 0 || j >= this->n) continue;

sum += this->matrix.diagonals[diagonalIndex][i] \* (j <= i ? x[j] :

}

T mainDiagonalElement = this->matrix.diagonals[mainDiagonalOffsetIndex][i]; x[i] = x0[i] + this->omega / mainDiagonalElement \* (f[i] - sum);

}

x0 = x;

}

template <typename T>

double SLE<T>::calculateResidual(std::vector<T>& x)

{

std::vector<T> newF(this->n);

this->matrix.multByVector(x, newF);

auto fSubNewF = subtract<T>(this->f, newF); double fSubNewFNorm = EuclideanNorm<T>(fSubNewF); double fNorm = EuclideanNorm<T>(f);

double residual = fSubNewFNorm / fNorm; return residual;

}

template <typename T>

double SLE<T>::calculateCondNum(std::vector<T>& x, std::vector<T>& x\_exact)

{

auto xSubXExact = subtract<T>(x, x\_exact);

double xSubXExactNorm = EuclideanNorm<T>(xSubXExact); double xExactNorm = EuclideanNorm<T>(x\_exact);

double residual = this->calculateResidual(x);

double condNum = xSubXExactNorm / xExactNorm / residual;

return condNum;

}

template <typename T>

void SLE<T>::Jacobi(std::vector<T> &x0)

{

double residual = numeric\_limits<double>::infinity(); int i;

for (i = 0; i < this->maxIter && residual > this->epsilon; i++)

{

this->iteration(x0, x0);

residual = this->calculateResidual(x0);

}

cout << std::fixed << std::scientific << setprecision(16) << "iter " << i << " residual " << residual << endl;

}

template <typename T>

void SLE<T>::GaussSeidel(std::vector<T>& x0, std::vector<T>& x)

{

double residual = numeric\_limits<double>::infinity(); int i;

for (i = 0; i < this->maxIter && residual > this->epsilon; i++)

{

this->iteration(x0, x);

residual = this->calculateResidual(x);

}

cout << "iter " << i << " residual " << residual << endl;

}

#endif

//Файл VectorOperations.h #ifndef VECTOROPERATIONS\_H #define VECTOROPERATIONS\_H

#include <vector>

template <typename T>

double EuclideanNorm(std::vector<T> vector)

{

double norm = 0;

for (int i = 0; i < vector.size(); i++)

{

norm += vector[i] \* vector[i];

}

norm = sqrt(norm); return norm;

}

template <typename T>

std::vector<T> subtract(std::vector<T> vector1, std::vector<T> vector2)

{

for (int i = 0; i < vector1.size(); i++)

{

vector1[i] -= vector2[i];

}

return vector1;

}

#endif

**5. Исследования**

5.1. Проведем исследование по поиску оптимального параметра релаксации на матрицах с диагональным преобладанием

A=

Начальное приближение – нулевой вектор.

Максимальное число итераций – 1000000

Целевая относительная невязка – 1.0E-14

Якоби:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | x |  |  | Количество итераций |
| 0.1 | 9.99999999961036e-001 | 3.896e-011 | 6.005e+001 | 27912 |
| 1.99999999995649e+000 | 4.351e-011 |
| 2.99999999995400e+000 | 4.600e-011 |
| 3.99999999995406e+000 | 4.594e-011 |
| 4.99999999995438e+000 | 4.562e-011 |
| 5.99999999995563e+000 | 4.437e-011 |
| 6.99999999995973e+000 | 4.027e-011 |
| 7.99999999995634e+000 | 4.366e-011 |
| 8.99999999995562e+000 | 4.438e-011 |
| 9.99999999995509e+000 | 4.491e-011 |
| 1.09999999999542e+001 | 4.582e-011 |
| 1.19999999999540e+001 | 4.598e-011 |
| 0.2 | 9.99999999961111e-001 | 3.889e-011 | 6.000e+001 | 13949 |
| 1.99999999995657e+000 | 4.343e-011 |
| 2.99999999995409e+000 | 4.591e-011 |
| 3.99999999995415e+000 | 4.585e-011 |
| 4.99999999995447e+000 | 4.553e-011 |
| 5.99999999995572e+000 | 4.428e-011 |
| 6.99999999995980e+000 | 4.020e-011 |
| 7.99999999995642e+000 | 4.358e-011 |
| 8.99999999995571e+000 | 4.429e-011 |
| 9.99999999995518e+000 | 4.482e-011 |
| 1.09999999999543e+001 | 4.573e-011 |
| 1.19999999999541e+001 | 4.588e-011 |
| 0.3 | 9.99999999961049e-001 | 3.895e-011 | 6.002e+001 | 9294 |
| 1.99999999995650e+000 | 4.350e-011 |
| 2.99999999995402e+000 | 4.598e-011 |
| 3.99999999995407e+000 | 4.593e-011 |
| 4.99999999995439e+000 | 4.561e-011 |
| 5.99999999995565e+000 | 4.435e-011 |
| 6.99999999995974e+000 | 4.026e-011 |
| 7.99999999995635e+000 | 4.365e-011 |
| 8.99999999995564e+000 | 4.436e-011 |
| 9.99999999995511e+000 | 4.489e-011 |
| 1.09999999999542e+001 | 4.580e-011 |
| 1.19999999999540e+001 | 4.596e-011 |
| 0.4 | 9.99999999961049e-001 | 3.895e-011 | 6.001e+001 | 6967 |
| 1.99999999995650e+000 | 4.350e-011 |
| 2.99999999995402e+000 | 4.598e-011 |
| 3.99999999995408e+000 | 4.592e-011 |
| 4.99999999995440e+000 | 4.560e-011 |
| 5.99999999995565e+000 | 4.435e-011 |
| 6.99999999995974e+000 | 4.026e-011 |
| 7.99999999995635e+000 | 4.365e-011 |
| 8.99999999995564e+000 | 4.436e-011 |
| 9.99999999995511e+000 | 4.489e-011 |
| 1.09999999999542e+001 | 4.580e-011 |
| 1.19999999999540e+001 | 4.596e-011 |
| 0.5 | 9.99999999961080e-001 | 3.892e-011 | 6.001e+001 | 5571 |
| 1.99999999995654e+000 | 4.346e-011 |
| 2.99999999995405e+000 | 4.595e-011 |
| 3.99999999995411e+000 | 4.589e-011 |
| 4.99999999995443e+000 | 4.557e-011 |
| 5.99999999995569e+000 | 4.431e-011 |
| 6.99999999995977e+000 | 4.023e-011 |
| 7.99999999995639e+000 | 4.361e-011 |
| 8.99999999995567e+000 | 4.433e-011 |
| 9.99999999995515e+000 | 4.485e-011 |
| 1.09999999999542e+001 | 4.577e-011 |
| 1.19999999999541e+001 | 4.592e-011 |
| 0.6 | 9.99999999961255e-001 | 3.875e-011 | 6.002e+001 | 4641 |
| 1.99999999995673e+000 | 4.327e-011 |
| 2.99999999995426e+000 | 4.574e-011 |
| 3.99999999995432e+000 | 4.568e-011 |
| 4.99999999995464e+000 | 4.536e-011 |
| 5.99999999995588e+000 | 4.412e-011 |
| 6.99999999995995e+000 | 4.005e-011 |
| 7.99999999995658e+000 | 4.342e-011 |
| 8.99999999995587e+000 | 4.413e-011 |
| 9.99999999995535e+000 | 4.465e-011 |
| 1.09999999999544e+001 | 4.556e-011 |
| 1.19999999999543e+001 | 4.571e-011 |
| 0.7 | 9.99999999961252e-001 | 3.875e-011 | 6.001e+001 | 3976 |
| 1.99999999995673e+000 | 4.327e-011 |
| 2.99999999995426e+000 | 4.574e-011 |
| 3.99999999995431e+000 | 4.569e-011 |
| 4.99999999995463e+000 | 4.537e-011 |
| 5.99999999995588e+000 | 4.412e-011 |
| 6.99999999995995e+000 | 4.005e-011 |
| 7.99999999995658e+000 | 4.342e-011 |
| 8.99999999995587e+000 | 4.413e-011 |
| 9.99999999995534e+000 | 4.466e-011 |
| 1.09999999999544e+001 | 4.557e-011 |
| 1.19999999999543e+001 | 4.572e-011 |
| 0.8 | 9.99999999961176e-001 | 3.882e-011 | 5.992e+001 | 3477 |
| 1.99999999995665e+000 | 4.335e-011 |
| 2.99999999995417e+000 | 4.583e-011 |
| 3.99999999995423e+000 | 4.577e-011 |
| 4.99999999995454e+000 | 4.546e-011 |
| 5.99999999995580e+000 | 4.420e-011 |
| 6.99999999995987e+000 | 4.013e-011 |
| 7.99999999995650e+000 | 4.350e-011 |
| 8.99999999995578e+000 | 4.422e-011 |
| 9.99999999995526e+000 | 4.474e-011 |
| 1.09999999999543e+001 | 4.565e-011 |
| 1.19999999999542e+001 | 4.581e-011 |
| 0.9 | 9.99999999961136e-001 | 3.886e-011 | 6.001e+001 | 3089 |
| 1.99999999995660e+000 | 4.340e-011 |
| 2.99999999995412e+000 | 4.588e-011 |
| 3.99999999995418e+000 | 4.582e-011 |
| 4.99999999995450e+000 | 4.550e-011 |
| 5.99999999995575e+000 | 4.425e-011 |
| 6.99999999995983e+000 | 4.017e-011 |
| 7.99999999995645e+000 | 4.355e-011 |
| 8.99999999995574e+000 | 4.426e-011 |
| 9.99999999995521e+000 | 4.479e-011 |
| 1.09999999999543e+001 | 4.570e-011 |
| 1.19999999999541e+001 | 4.585e-011 |
| 1 | 9.99999999961240e-001 | 3.876e-011 | 6.000e+001 | 2779 |
| 1.99999999995672e+000 | 4.328e-011 |
| 2.99999999995424e+000 | 4.576e-011 |
| 3.99999999995430e+000 | 4.570e-011 |
| 4.99999999995462e+000 | 4.538e-011 |
| 5.99999999995587e+000 | 4.413e-011 |
| 6.99999999995994e+000 | 4.006e-011 |
| 7.99999999995657e+000 | 4.343e-011 |
| 8.99999999995586e+000 | 4.414e-011 |
| 9.99999999995533e+000 | 4.467e-011 |
| 1.09999999999544e+001 | 4.558e-011 |
| 1.19999999999543e+001 | 4.573e-011 |
| 1,01 | 9.99999999961113e-001 | 3.889e-011 | 6.001e+001 | 2751 |
| 1.99999999995658e+000 | 4.342e-011 |
| 2.99999999995409e+000 | 4.591e-011 |
| 3.99999999995415e+000 | 4.585e-011 |
| 4.99999999995447e+000 | 4.553e-011 |
| 5.99999999995572e+000 | 4.428e-011 |
| 6.99999999995981e+000 | 4.019e-011 |
| 7.99999999995642e+000 | 4.358e-011 |
| 8.99999999995571e+000 | 4.429e-011 |
| 9.99999999995518e+000 | 4.482e-011 |
| 1.09999999999543e+001 | 4.573e-011 |
| 1.19999999999541e+001 | 4.588e-011 |
| 1,02 | 9.99999999961152e-001 | 3.885e-011 | 5.991e+001 | 2724 |
| 1.99999999995662e+000 | 4.338e-011 |
| 2.99999999995414e+000 | 4.586e-011 |
| 3.99999999995420e+000 | 4.580e-011 |
| 4.99999999995452e+000 | 4.548e-011 |
| 5.99999999995577e+000 | 4.423e-011 |
| 6.99999999995985e+000 | 4.015e-011 |
| 7.99999999995647e+000 | 4.353e-011 |
| 8.99999999995576e+000 | 4.424e-011 |
| 9.99999999995523e+000 | 4.477e-011 |
| 1.09999999999543e+001 | 4.568e-011 |
| 1.19999999999542e+001 | 4.584e-011 |
| 1,03 | 9.99999999961368e-001 | 3.863e-011 | 6.004e+001 | 2698 |
| 1.99999999995686e+000 | 4.314e-011 |
| 2.99999999995439e+000 | 4.561e-011 |
| 3.99999999995445e+000 | 4.555e-011 |
| 4.99999999995477e+000 | 4.523e-011 |
| 5.99999999995601e+000 | 4.399e-011 |
| 6.99999999996006e+000 | 3.994e-011 |
| 7.99999999995671e+000 | 4.329e-011 |
| 8.99999999995600e+000 | 4.400e-011 |
| 9.99999999995548e+000 | 4.452e-011 |
| 1.09999999999546e+001 | 4.543e-011 |
| 1.19999999999544e+001 | 4.558e-011 |
| 1,04 | 3.33825589749613e+152 | 3.338e+152 |  |  |
| -3.69050910850507e+152 | 3.691e+152 |
| 2.47793096356326e+152 | 2.478e+152 |
| -2.03231323255623e+152 | 2.032e+152 |
| 1.09731554174125e+152 | 1.097e+152 |
| 3.36990383770929e+151 | 3.370e+151 |
| -3.69950226247949e+152 | 3.700e+152 |
| 3.78147105361777e+152 | 3.781e+152 |
| -3.12296838823344e+152 | 3.123e+152 |
| 3.27727342182276e+152 | 3.277e+152 |
| -2.14381965887900e+152 | 2.144e+152 |
| 1.66571048431634e+152 | 1.666e+152 |

# Гаус-зейделя:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | x |  |  | Количество итераций |
| 0.1 | 9.99999999961165e-001 | 3.883e-011 | 5.982e+001 | 26531,00 |
| 1.99999999995665e+000 | 4.335e-011 |
| 2.99999999995416e+000 | 4.584e-011 |
| 3.99999999995422e+000 | 4.578e-011 |
| 4.99999999995454e+000 | 4.546e-011 |
| 5.99999999995580e+000 | 4.420e-011 |
| 6.99999999995988e+000 | 4.012e-011 |
| 7.99999999995651e+000 | 4.349e-011 |
| 8.99999999995579e+000 | 4.421e-011 |
| 9.99999999995528e+000 | 4.472e-011 |
| 1.09999999999544e+001 | 4.563e-011 |
| 1.19999999999542e+001 | 4.578e-011 |
| 0.2 | 9.99999999961318e-001 | 3.868e-011 | 5.953e+001 | 12567,00 |
| 1.99999999995684e+000 | 4.316e-011 |
| 2.99999999995436e+000 | 4.564e-011 |
| 3.99999999995441e+000 | 4.559e-011 |
| 4.99999999995474e+000 | 4.526e-011 |
| 5.99999999995600e+000 | 4.400e-011 |
| 6.99999999996005e+000 | 3.995e-011 |
| 7.99999999995671e+000 | 4.329e-011 |
| 8.99999999995600e+000 | 4.400e-011 |
| 9.99999999995551e+000 | 4.449e-011 |
| 1.09999999999546e+001 | 4.539e-011 |
| 1.19999999999545e+001 | 4.554e-011 |
| 0.3 | 9.99999999961657e-001 | 3.834e-011 | 5.898e+001 | 7914,00 |
| 1.99999999995724e+000 | 4.276e-011 |
| 2.99999999995477e+000 | 4.523e-011 |
| 3.99999999995482e+000 | 4.518e-011 |
| 4.99999999995515e+000 | 4.485e-011 |
| 5.99999999995640e+000 | 4.360e-011 |
| 6.99999999996042e+000 | 3.958e-011 |
| 7.99999999995712e+000 | 4.288e-011 |
| 8.99999999995642e+000 | 4.358e-011 |
| 9.99999999995596e+000 | 4.404e-011 |
| 1.09999999999551e+001 | 4.494e-011 |
| 1.19999999999549e+001 | 4.509e-011 |
| 0.4 | 9.99999999962144e-001 | 3.786e-011 | 5.832e+001 | 5588,00 |
| 1.99999999995781e+000 | 4.219e-011 |
| 2.99999999995536e+000 | 4.464e-011 |
| 3.99999999995541e+000 | 4.459e-011 |
| 4.99999999995574e+000 | 4.426e-011 |
| 5.99999999995698e+000 | 4.302e-011 |
| 6.99999999996095e+000 | 3.905e-011 |
| 7.99999999995771e+000 | 4.229e-011 |
| 8.99999999995701e+000 | 4.299e-011 |
| 9.99999999995658e+000 | 4.342e-011 |
| 1.09999999999557e+001 | 4.430e-011 |
| 1.19999999999555e+001 | 4.445e-011 |
| 0.5 | 9.99999999962880e-001 | 3.712e-011 | 5.730e+001 | 4193,00 |
| 1.99999999995866e+000 | 4.134e-011 |
| 2.99999999995625e+000 | 4.375e-011 |
| 3.99999999995629e+000 | 4.371e-011 |
| 4.99999999995662e+000 | 4.338e-011 |
| 5.99999999995785e+000 | 4.215e-011 |
| 6.99999999996173e+000 | 3.827e-011 |
| 7.99999999995857e+000 | 4.143e-011 |
| 8.99999999995789e+000 | 4.211e-011 |
| 9.99999999995749e+000 | 4.251e-011 |
| 1.09999999999566e+001 | 4.337e-011 |
| 1.19999999999565e+001 | 4.352e-011 |
| 0.6 | 9.99999999963477e-001 | 3.652e-011 | 5.603e+001 | 3262,00 |
| 1.99999999995935e+000 | 4.065e-011 |
| 2.99999999995697e+000 | 4.303e-011 |
| 3.99999999995701e+000 | 4.299e-011 |
| 4.99999999995734e+000 | 4.266e-011 |
| 5.99999999995856e+000 | 4.144e-011 |
| 6.99999999996237e+000 | 3.763e-011 |
| 7.99999999995928e+000 | 4.072e-011 |
| 8.99999999995861e+000 | 4.139e-011 |
| 9.99999999995825e+000 | 4.175e-011 |
| 1.09999999999574e+001 | 4.260e-011 |
| 1.19999999999573e+001 | 4.274e-011 |
| 0.7 | 9.99999999964945e-001 | 3.505e-011 | 5.425e+001 | 2599,00 |
| 1.99999999996102e+000 | 3.898e-011 |
| 2.99999999995872e+000 | 4.128e-011 |
| 3.99999999995876e+000 | 4.124e-011 |
| 4.99999999995908e+000 | 4.092e-011 |
| 5.99999999996026e+000 | 3.974e-011 |
| 6.99999999996392e+000 | 3.608e-011 |
| 7.99999999996097e+000 | 3.903e-011 |
| 8.99999999996033e+000 | 3.967e-011 |
| 9.99999999996001e+000 | 3.999e-011 |
| 1.09999999999592e+001 | 4.080e-011 |
| 1.19999999999591e+001 | 4.094e-011 |
| 0.8 | 9.99999999965964e-001 | 3.404e-011 | 5.209e+001 | 2100,00 |
| 1.99999999996219e+000 | 3.781e-011 |
| 2.99999999995995e+000 | 4.005e-011 |
| 3.99999999995998e+000 | 4.002e-011 |
| 4.99999999996030e+000 | 3.970e-011 |
| 5.99999999996145e+000 | 3.855e-011 |
| 6.99999999996500e+000 | 3.500e-011 |
| 7.99999999996217e+000 | 3.783e-011 |
| 8.99999999996154e+000 | 3.846e-011 |
| 9.99999999996127e+000 | 3.873e-011 |
| 1.09999999999605e+001 | 3.951e-011 |
| 1.19999999999604e+001 | 3.965e-011 |
| 0.9 | 9.99999999967818e-001 | 3.218e-011 | 4.936e+001 | 1713,00 |
| 1.99999999996429e+000 | 3.571e-011 |
| 2.99999999996216e+000 | 3.784e-011 |
| 3.99999999996218e+000 | 3.782e-011 |
| 4.99999999996250e+000 | 3.750e-011 |
| 5.99999999996360e+000 | 3.640e-011 |
| 6.99999999996695e+000 | 3.305e-011 |
| 7.99999999996429e+000 | 3.571e-011 |
| 8.99999999996370e+000 | 3.630e-011 |
| 9.99999999996349e+000 | 3.651e-011 |
| 1.09999999999627e+001 | 3.725e-011 |
| 1.19999999999626e+001 | 3.738e-011 |
| 1.0 | 9.99999999969876e-001 | 3.012e-011 | 4.606e+001 | 1403,00 |
| 1.99999999996662e+000 | 3.338e-011 |
| 2.99999999996461e+000 | 3.539e-011 |
| 3.99999999996462e+000 | 3.538e-011 |
| 4.99999999996493e+000 | 3.507e-011 |
| 5.99999999996598e+000 | 3.402e-011 |
| 6.99999999996911e+000 | 3.089e-011 |
| 7.99999999996665e+000 | 3.335e-011 |
| 8.99999999996610e+000 | 3.390e-011 |
| 9.99999999996594e+000 | 3.406e-011 |
| 1.09999999999653e+001 | 3.475e-011 |
| 1.19999999999651e+001 | 3.486e-011 |
| 1,10 | 9.99999999972882e-001 | 2.712e-011 | 4.214e+001 | 1150,00 |
| 1.99999999997001e+000 | 2.999e-011 |
| 2.99999999996818e+000 | 3.182e-011 |
| 3.99999999996818e+000 | 3.182e-011 |
| 4.99999999996847e+000 | 3.153e-011 |
| 5.99999999996943e+000 | 3.057e-011 |
| 6.99999999997224e+000 | 2.776e-011 |
| 7.99999999997006e+000 | 2.994e-011 |
| 8.99999999996956e+000 | 3.044e-011 |
| 9.99999999996947e+000 | 3.053e-011 |
| 1.09999999999689e+001 | 3.114e-011 |
| 1.19999999999687e+001 | 3.125e-011 |
| 1,20 | 9.99999999975790e-001 | 2.421e-011 | 3.771e+001 | 938,00 |
| 1.99999999997328e+000 | 2.672e-011 |
| 2.99999999997163e+000 | 2.837e-011 |
| 3.99999999997163e+000 | 2.837e-011 |
| 4.99999999997190e+000 | 2.810e-011 |
| 5.99999999997277e+000 | 2.723e-011 |
| 6.99999999997527e+000 | 2.473e-011 |
| 7.99999999997336e+000 | 2.664e-011 |
| 8.99999999997292e+000 | 2.708e-011 |
| 9.99999999997290e+000 | 2.710e-011 |
| 1.09999999999724e+001 | 2.765e-011 |
| 1.19999999999723e+001 | 2.775e-011 |
| 1,30 | 9.99999999978407e-001 | 2.159e-011 | 3.281e+001 | 757,00 |
| 1.99999999997624e+000 | 2.376e-011 |
| 2.99999999997474e+000 | 2.526e-011 |
| 3.99999999997473e+000 | 2.527e-011 |
| 4.99999999997499e+000 | 2.501e-011 |
| 5.99999999997579e+000 | 2.421e-011 |
| 6.99999999997801e+000 | 2.199e-011 |
| 7.99999999997635e+000 | 2.365e-011 |
| 8.99999999997596e+000 | 2.404e-011 |
| 9.99999999997600e+000 | 2.400e-011 |
| 1.09999999999755e+001 | 2.449e-011 |
| 1.19999999999754e+001 | 2.457e-011 |
| 1,40 | 9.99999999982390e-001 | 1.761e-011 | 2.757e+001 | 602,00 |
| 1.99999999998070e+000 | 1.930e-011 |
| 2.99999999997945e+000 | 2.055e-011 |
| 3.99999999997943e+000 | 2.057e-011 |
| 4.99999999997966e+000 | 2.034e-011 |
| 5.99999999998033e+000 | 1.967e-011 |
| 6.99999999998214e+000 | 1.786e-011 |
| 7.99999999998083e+000 | 1.917e-011 |
| 8.99999999998051e+000 | 1.949e-011 |
| 9.99999999998062e+000 | 1.938e-011 |
| 1.09999999999802e+001 | 1.977e-011 |
| 1.19999999999802e+001 | 1.984e-011 |
| 1,50 | 9.99999999985924e-001 | 1.408e-011 | 2.223e+001 | 465,00 |
| 1.99999999998466e+000 | 1.534e-011 |
| 2.99999999998363e+000 | 1.637e-011 |
| 3.99999999998361e+000 | 1.639e-011 |
| 4.99999999998381e+000 | 1.619e-011 |
| 5.99999999998437e+000 | 1.563e-011 |
| 6.99999999998581e+000 | 1.419e-011 |
| 7.99999999998481e+000 | 1.519e-011 |
| 8.99999999998456e+000 | 1.544e-011 |
| 9.99999999998472e+000 | 1.528e-011 |
| 1.09999999999844e+001 | 1.558e-011 |
| 1.19999999999844e+001 | 1.564e-011 |
| 1,57 | 9.99999999987936e-001 | 1.206e-011 | 1.838e+001 | 377,00 |
| 1.99999999998693e+000 | 1.307e-011 |
| 2.99999999998602e+000 | 1.398e-011 |
| 3.99999999998599e+000 | 1.401e-011 |
| 4.99999999998618e+000 | 1.382e-011 |
| 5.99999999998668e+000 | 1.332e-011 |
| 6.99999999998791e+000 | 1.209e-011 |
| 7.99999999998711e+000 | 1.289e-011 |
| 8.99999999998688e+000 | 1.312e-011 |
| 9.99999999998710e+000 | 1.290e-011 |
| 1.09999999999868e+001 | 1.316e-011 |
| 1.19999999999868e+001 | 1.321e-011 |
| 1,58 | 9.99999999988328e-001 | 1.167e-011 | 1.784e+001 | 365,00 |
| 1.99999999998737e+000 | 1.263e-011 |
| 2.99999999998648e+000 | 1.352e-011 |
| 3.99999999998645e+000 | 1.355e-011 |
| 4.99999999998664e+000 | 1.336e-011 |
| 5.99999999998713e+000 | 1.287e-011 |
| 6.99999999998831e+000 | 1.169e-011 |
| 7.99999999998754e+000 | 1.246e-011 |
| 8.99999999998733e+000 | 1.267e-011 |
| 9.99999999998755e+000 | 1.245e-011 |
| 1.09999999999873e+001 | 1.270e-011 |
| 1.19999999999873e+001 | 1.275e-011 |
| 1,59 | 9.99999999988636e-001 | 1.136e-011 | 1.724e+001 | 353,00 |
| 1.99999999998773e+000 | 1.227e-011 |
| 2.99999999998685e+000 | 1.315e-011 |
| 3.99999999998682e+000 | 1.318e-011 |
| 4.99999999998700e+000 | 1.300e-011 |
| 5.99999999998750e+000 | 1.250e-011 |
| 6.99999999998862e+000 | 1.138e-011 |
| 7.99999999998790e+000 | 1.210e-011 |
| 8.99999999998769e+000 | 1.231e-011 |
| 9.99999999998792e+000 | 1.208e-011 |
| 1.09999999999877e+001 | 1.233e-011 |
| 1.19999999999876e+001 | 1.237e-011 |
| 1,60 | 9.99999999998287e-001 | 1.713e-012 | 2.611e+000 | 365,00 |
| 1.99999999999869e+000 | 1.311e-012 |
| 2.99999999999788e+000 | 2.122e-012 |
| 3.99999999999825e+000 | 1.750e-012 |
| 4.99999999999839e+000 | 1.608e-012 |
| 5.99999999999863e+000 | 1.375e-012 |
| 6.99999999999762e+000 | 2.378e-012 |
| 7.99999999999932e+000 | 6.777e-013 |
| 8.99999999999809e+000 | 1.915e-012 |
| 9.99999999999776e+000 | 2.238e-012 |
| 1.09999999999982e+001 | 1.831e-012 |
| 1.19999999999984e+001 | 1.593e-012 |
| 1,61 | 1.00000000000014e+000 | 1.412e-013 | 6.963e-001 | 444,00 |
| 1.99999999999963e+000 | 3.750e-013 |
| 3.00000000000019e+000 | 1.887e-013 |
| 3.99999999999987e+000 | 1.252e-013 |
| 4.99999999999993e+000 | 7.105e-014 |
| 5.99999999999939e+000 | 6.093e-013 |
| 7.00000000000109e+000 | 1.094e-012 |
| 7.99999999999902e+000 | 9.788e-013 |
| 9.00000000000009e+000 | 9.415e-014 |
| 1.00000000000005e+001 | 4.530e-013 |
| 1.10000000000003e+001 | 2.665e-013 |
| 1.19999999999998e+001 | 2.203e-013 |

5.2.Исследования для матрицы с положительным знаком внедиагональных элементов.

B=

Начальное приближение – нулевой вектор.

Максимальное число итераций – 1000000

Целевая относительная невязка – 1.0E-14

Якоби:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | x |  |  | Количество итераций |
| 0.1 | 9.99999999977830e-001 | 2.217e-011 | 2.513e+001 | 3226 |
| 2.00000000002451e+000 | 2.451e-011 |
| 2.99999999998354e+000 | 1.646e-011 |
| 4.00000000001350e+000 | 1.350e-011 |
| 4.99999999999271e+000 | 7.286e-012 |
| 5.99999999999776e+000 | 2.239e-012 |
| 7.00000000002457e+000 | 2.457e-011 |
| 7.99999999997489e+000 | 2.511e-011 |
| 9.00000000002074e+000 | 2.074e-011 |
| 9.99999999997824e+000 | 2.176e-011 |
| 1.10000000000142e+001 | 1.424e-011 |
| 1.19999999999889e+001 | 1.106e-011 |
| 0.2 | 9.99999999977990e-001 | 2.201e-011 | 2.514e+001 | 1607 |
| 2.00000000002433e+000 | 2.433e-011 |
| 2.99999999998366e+000 | 1.634e-011 |
| 4.00000000001340e+000 | 1.340e-011 |
| 4.99999999999277e+000 | 7.234e-012 |
| 5.99999999999778e+000 | 2.222e-012 |
| 7.00000000002439e+000 | 2.439e-011 |
| 7.99999999997507e+000 | 2.493e-011 |
| 9.00000000002059e+000 | 2.059e-011 |
| 9.99999999997839e+000 | 2.161e-011 |
| 1.10000000000141e+001 | 1.413e-011 |
| 1.19999999999890e+001 | 1.098e-011 |
| 0.3 | 9.99999999977992e-001 | 2.201e-011 | 2.513e+001 | 1067 |
| 2.00000000002433e+000 | 2.433e-011 |
| 2.99999999998367e+000 | 1.633e-011 |
| 4.00000000001340e+000 | 1.340e-011 |
| 4.99999999999277e+000 | 7.233e-012 |
| 5.99999999999778e+000 | 2.222e-012 |
| 7.00000000002439e+000 | 2.439e-011 |
| 7.99999999997507e+000 | 2.493e-011 |
| 9.00000000002059e+000 | 2.059e-011 |
| 9.99999999997839e+000 | 2.161e-011 |
| 1.10000000000141e+001 | 1.413e-011 |
| 1.19999999999890e+001 | 1.098e-011 |
| 0.4 | 9.99999999977999e-001 | 2.200e-011 | 2.513e+001 | 797 |
| 2.00000000002432e+000 | 2.432e-011 |
| 2.99999999998367e+000 | 1.633e-011 |
| 4.00000000001339e+000 | 1.339e-011 |
| 4.99999999999277e+000 | 7.232e-012 |
| 5.99999999999778e+000 | 2.220e-012 |
| 7.00000000002438e+000 | 2.438e-011 |
| 7.99999999997508e+000 | 2.492e-011 |
| 9.00000000002058e+000 | 2.058e-011 |
| 9.99999999997840e+000 | 2.160e-011 |
| 1.10000000000141e+001 | 1.413e-011 |
| 1.19999999999890e+001 | 1.098e-011 |
| 0.5 | 9.99999999978010e-001 | 2.199e-011 | 2.514e+001 | 635 |
| 2.00000000002431e+000 | 2.431e-011 |
| 2.99999999998368e+000 | 1.632e-011 |
| 4.00000000001339e+000 | 1.339e-011 |
| 4.99999999999277e+000 | 7.230e-012 |
| 5.99999999999778e+000 | 2.218e-012 |
| 7.00000000002437e+000 | 2.437e-011 |
| 7.99999999997509e+000 | 2.491e-011 |
| 9.00000000002057e+000 | 2.057e-011 |
| 9.99999999997841e+000 | 2.159e-011 |
| 1.10000000000141e+001 | 1.412e-011 |
| 1.19999999999890e+001 | 1.098e-011 |
| 0.6 | 9.99999999978028e-001 | 2.197e-011 | 2.514e+001 | 527 |
| 2.00000000002429e+000 | 2.429e-011 |
| 2.99999999998369e+000 | 1.631e-011 |
| 4.00000000001338e+000 | 1.338e-011 |
| 4.99999999999278e+000 | 7.223e-012 |
| 5.99999999999778e+000 | 2.218e-012 |
| 7.00000000002435e+000 | 2.435e-011 |
| 7.99999999997511e+000 | 2.489e-011 |
| 9.00000000002055e+000 | 2.055e-011 |
| 9.99999999997843e+000 | 2.157e-011 |
| 1.10000000000141e+001 | 1.411e-011 |
| 1.19999999999890e+001 | 1.096e-011 |
| 0.7 | 9.99999999978217e-001 | 2.178e-011 | 2.513e+001 | 450 |
| 2.00000000002408e+000 | 2.408e-011 |
| 2.99999999998383e+000 | 1.617e-011 |
| 4.00000000001326e+000 | 1.326e-011 |
| 4.99999999999284e+000 | 7.159e-012 |
| 5.99999999999780e+000 | 2.202e-012 |
| 7.00000000002414e+000 | 2.414e-011 |
| 7.99999999997532e+000 | 2.468e-011 |
| 9.00000000002038e+000 | 2.038e-011 |
| 9.99999999997862e+000 | 2.138e-011 |
| 1.10000000000140e+001 | 1.399e-011 |
| 1.19999999999891e+001 | 1.087e-011 |
| 0.8 | 9.99999999978079e-001 | 2.192e-011 | 2.514e+001 | 392 |
| 2.00000000002424e+000 | 2.424e-011 |
| 2.99999999998373e+000 | 1.627e-011 |
| 4.00000000001335e+000 | 1.335e-011 |
| 4.99999999999280e+000 | 7.205e-012 |
| 5.99999999999779e+000 | 2.212e-012 |
| 7.00000000002429e+000 | 2.429e-011 |
| 7.99999999997517e+000 | 2.483e-011 |
| 9.00000000002051e+000 | 2.051e-011 |
| 9.99999999997848e+000 | 2.152e-011 |
| 1.10000000000141e+001 | 1.408e-011 |
| 1.19999999999891e+001 | 1.094e-011 |
| 0.9 | 9.99999999978114e-001 | 2.189e-011 | 2.513e+001 | 347 |
| 2.00000000002420e+000 | 2.420e-011 |
| 2.99999999998375e+000 | 1.625e-011 |
| 4.00000000001332e+000 | 1.332e-011 |
| 4.99999999999281e+000 | 7.194e-012 |
| 5.99999999999779e+000 | 2.212e-012 |
| 7.00000000002426e+000 | 2.426e-011 |
| 7.99999999997521e+000 | 2.479e-011 |
| 9.00000000002048e+000 | 2.048e-011 |
| 9.99999999997851e+000 | 2.149e-011 |
| 1.10000000000141e+001 | 1.405e-011 |
| 1.19999999999891e+001 | 1.092e-011 |
| 0.94 | 9.99999999978622e-001 | 2.138e-011 | 2.514e+001 | 332 |
| 2.00000000002363e+000 | 2.363e-011 |
| 2.99999999998413e+000 | 1.587e-011 |
| 4.00000000001302e+000 | 1.302e-011 |
| 4.99999999999297e+000 | 7.027e-012 |
| 5.99999999999784e+000 | 2.156e-012 |
| 7.00000000002369e+000 | 2.369e-011 |
| 7.99999999997578e+000 | 2.422e-011 |
| 9.00000000002000e+000 | 2.000e-011 |
| 9.99999999997901e+000 | 2.099e-011 |
| 1.10000000000137e+001 | 1.373e-011 |
| 1.19999999999893e+001 | 1.067e-011 |
| 0.95 | 9.99999999978047e-001 | 2.195e-011 | 2.515e+001 | 328 |
| 2.00000000002427e+000 | 2.427e-011 |
| 2.99999999998370e+000 | 1.630e-011 |
| 4.00000000001337e+000 | 1.337e-011 |
| 4.99999999999278e+000 | 7.217e-012 |
| 5.99999999999778e+000 | 2.215e-012 |
| 7.00000000002433e+000 | 2.433e-011 |
| 7.99999999997513e+000 | 2.487e-011 |
| 9.00000000002054e+000 | 2.054e-011 |
| 9.99999999997845e+000 | 2.155e-011 |
| 1.10000000000141e+001 | 1.410e-011 |
| 1.19999999999890e+001 | 1.096e-011 |
| 0.96 | 9.99999999983380e-001 | 1.662e-011 | 2.174e+001 | 328 |
| 2.00000000001903e+000 | 1.903e-011 |
| 2.99999999998779e+000 | 1.221e-011 |
| 4.00000000001065e+000 | 1.065e-011 |
| 4.99999999999478e+000 | 5.215e-012 |
| 5.99999999999863e+000 | 1.372e-012 |
| 7.00000000001905e+000 | 1.905e-011 |
| 7.99999999998117e+000 | 1.883e-011 |
| 9.00000000001616e+000 | 1.616e-011 |
| 9.99999999998373e+000 | 1.627e-011 |
| 1.10000000000112e+001 | 1.121e-011 |
| 1.19999999999919e+001 | 8.095e-012 |
| 0.97 | 1.00000000000057e+000 | 5.655e-013 | 9.117e-001 | 418 |
| 2.00000000000067e+000 | 6.688e-013 |
| 3.00000000000068e+000 | 6.768e-013 |
| 4.00000000000070e+000 | 6.972e-013 |
| 5.00000000000068e+000 | 6.777e-013 |
| 6.00000000000066e+000 | 6.617e-013 |
| 7.00000000000062e+000 | 6.217e-013 |
| 8.00000000000063e+000 | 6.324e-013 |
| 9.00000000000068e+000 | 6.786e-013 |
| 1.00000000000007e+001 | 6.555e-013 |
| 1.10000000000007e+001 | 6.946e-013 |
| 1.20000000000007e+001 | 6.821e-013 |
| 1.0 | 1.00000000000059e+000 | 5.862e-013 | 9.120e-001 | 3232 |
| 2.00000000000066e+000 | 6.564e-013 |
| 3.00000000000069e+000 | 6.919e-013 |
| 4.00000000000069e+000 | 6.946e-013 |
| 5.00000000000069e+000 | 6.866e-013 |
| 6.00000000000067e+000 | 6.706e-013 |
| 7.00000000000061e+000 | 6.084e-013 |
| 8.00000000000066e+000 | 6.573e-013 |
| 9.00000000000067e+000 | 6.697e-013 |
| 1.00000000000007e+001 | 6.750e-013 |
| 1.10000000000007e+001 | 6.946e-013 |
| 1.20000000000007e+001 | 6.910e-013 |

Гаусс-Зейдель:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | x |  |  | Количество итераций |
| 0.1 | 9.99999999978020e-001 | 2.198e-011 | 2.468e+001 | 3074 |
| 2.00000000002421e+000 | 2.421e-011 |
| 2.99999999998388e+000 | 1.612e-011 |
| 4.00000000001318e+000 | 1.318e-011 |
| 4.99999999999301e+000 | 6.989e-012 |
| 5.99999999999758e+000 | 2.418e-012 |
| 7.00000000002431e+000 | 2.431e-011 |
| 7.99999999997523e+000 | 2.477e-011 |
| 9.00000000002038e+000 | 2.038e-011 |
| 9.99999999997866e+000 | 2.134e-011 |
| 1.10000000000138e+001 | 1.383e-011 |
| 1.19999999999893e+001 | 1.069e-011 |
| 0.2 | 9.99999999978381e-001 | 2.162e-011 | 2.414e+001 | 1449 |
| 2.00000000002372e+000 | 2.372e-011 |
| 2.99999999998436e+000 | 1.564e-011 |
| 4.00000000001273e+000 | 1.273e-011 |
| 4.99999999999340e+000 | 6.604e-012 |
| 5.99999999999740e+000 | 2.602e-012 |
| 7.00000000002385e+000 | 2.385e-011 |
| 7.99999999997579e+000 | 2.421e-011 |
| 9.00000000001985e+000 | 1.985e-011 |
| 9.99999999997928e+000 | 2.072e-011 |
| 1.10000000000133e+001 | 1.327e-011 |
| 1.19999999999898e+001 | 1.020e-011 |
| 0.3 | 9.99999999978733e-001 | 2.127e-011 | 2.348e+001 | 904 |
| 2.00000000002322e+000 | 2.322e-011 |
| 2.99999999998487e+000 | 1.513e-011 |
| 4.00000000001225e+000 | 1.225e-011 |
| 4.99999999999382e+000 | 6.181e-012 |
| 5.99999999999718e+000 | 2.823e-012 |
| 7.00000000002339e+000 | 2.339e-011 |
| 7.99999999997635e+000 | 2.365e-011 |
| 9.00000000001929e+000 | 1.929e-011 |
| 9.99999999997992e+000 | 2.008e-011 |
| 1.10000000000127e+001 | 1.268e-011 |
| 1.19999999999903e+001 | 9.676e-012 |
| 0.4 | 9.99999999979766e-001 | 2.023e-011 | 2.265e+001 | 630 |
| 2.00000000002196e+000 | 2.196e-011 |
| 2.99999999998591e+000 | 1.409e-011 |
| 4.00000000001134e+000 | 1.134e-011 |
| 4.99999999999449e+000 | 5.514e-012 |
| 5.99999999999701e+000 | 2.989e-012 |
| 7.00000000002219e+000 | 2.219e-011 |
| 7.99999999997768e+000 | 2.232e-011 |
| 9.00000000001809e+000 | 1.809e-011 |
| 9.99999999998125e+000 | 1.875e-011 |
| 1.10000000000116e+001 | 1.164e-011 |
| 1.19999999999912e+001 | 8.797e-012 |
| 0.5 | 9.99999999980222e-001 | 1.978e-011 | 2.161e+001 | 463 |
| 2.00000000002132e+000 | 2.132e-011 |
| 2.99999999998659e+000 | 1.341e-011 |
| 4.00000000001070e+000 | 1.070e-011 |
| 4.99999999999506e+000 | 4.941e-012 |
| 5.99999999999671e+000 | 3.293e-012 |
| 7.00000000002160e+000 | 2.160e-011 |
| 7.99999999997841e+000 | 2.159e-011 |
| 9.00000000001736e+000 | 1.736e-011 |
| 9.99999999998208e+000 | 1.792e-011 |
| 1.10000000000109e+001 | 1.087e-011 |
| 1.19999999999919e+001 | 8.106e-012 |
| 0.6 | 9.99999999981229e-001 | 1.877e-011 | 2.031e+001 | 350 |
| 2.00000000002006e+000 | 2.006e-011 |
| 2.99999999998774e+000 | 1.226e-011 |
| 4.00000000000966e+000 | 9.658e-012 |
| 4.99999999999588e+000 | 4.120e-012 |
| 5.99999999999641e+000 | 3.593e-012 |
| 7.00000000002042e+000 | 2.042e-011 |
| 7.99999999997976e+000 | 2.024e-011 |
| 9.00000000001609e+000 | 1.609e-011 |
| 9.99999999998348e+000 | 1.652e-011 |
| 1.10000000000097e+001 | 9.706e-012 |
| 1.19999999999929e+001 | 7.093e-012 |
| 0.7 | 9.99999999983043e-001 | 1.696e-011 | 1.861e+001 | 267 |
| 2.00000000001791e+000 | 1.791e-011 |
| 2.99999999998954e+000 | 1.046e-011 |
| 4.00000000000807e+000 | 8.067e-012 |
| 4.99999999999702e+000 | 2.978e-012 |
| 5.99999999999615e+000 | 3.854e-012 |
| 7.00000000001835e+000 | 1.835e-011 |
| 7.99999999998202e+000 | 1.798e-011 |
| 9.00000000001405e+000 | 1.405e-011 |
| 9.99999999998567e+000 | 1.433e-011 |
| 1.10000000000080e+001 | 7.997e-012 |
| 1.19999999999944e+001 | 5.645e-012 |
| 0.8 | 9.99999999985170e-001 | 1.483e-011 | 1.599e+001 | 199 |
| 2.00000000001536e+000 | 1.536e-011 |
| 2.99999999999194e+000 | 8.058e-012 |
| 4.00000000000589e+000 | 5.886e-012 |
| 4.99999999999870e+000 | 1.296e-012 |
| 5.99999999999556e+000 | 4.436e-012 |
| 7.00000000001597e+000 | 1.597e-011 |
| 7.99999999998469e+000 | 1.531e-011 |
| 9.00000000001151e+000 | 1.151e-011 |
| 9.99999999998836e+000 | 1.164e-011 |
| 1.10000000000058e+001 | 5.755e-012 |
| 1.19999999999963e+001 | 3.684e-012 |
| 0.9 | 1.00000000001167e+000 | 1.167e-011 | 1.195e+001 | 151 |
| 1.99999999998840e+000 | 1.160e-011 |
| 3.00000000000436e+000 | 4.364e-012 |
| 3.99999999999751e+000 | 2.493e-012 |
| 4.99999999999866e+000 | 1.339e-012 |
| 6.00000000000539e+000 | 5.392e-012 |
| 6.99999999998749e+000 | 1.251e-011 |
| 8.00000000001141e+000 | 1.141e-011 |
| 8.99999999999227e+000 | 7.725e-012 |
| 1.00000000000077e+001 | 7.715e-012 |
| 1.09999999999976e+001 | 2.437e-012 |
| 1.20000000000008e+001 | 7.585e-013 |
| 1.0 | 9.99999999991906e-001 | 8.094e-012 | 8.970e+000 | 126 |
| 2.00000000000758e+000 | 7.584e-012 |
| 2.99999999999854e+000 | 1.458e-012 |
| 4.00000000000004e+000 | 4.441e-014 |
| 5.00000000000278e+000 | 2.782e-012 |
| 5.99999999999481e+000 | 5.194e-012 |
| 7.00000000000852e+000 | 8.518e-012 |
| 7.99999999999272e+000 | 7.283e-012 |
| 9.00000000000426e+000 | 4.258e-012 |
| 9.99999999999589e+000 | 4.109e-012 |
| 1.10000000000000e+001 | 2.132e-014 |
| 1.20000000000011e+001 | 1.128e-012 |
| 1,1 | 1.00000000000676e+000 | 6.757e-012 | 6.579e+000 | 106 |
| 1.99999999999449e+000 | 5.512e-012 |
| 2.99999999999851e+000 | 1.488e-012 |
| 4.00000000000288e+000 | 2.876e-012 |
| 4.99999999999449e+000 | 5.506e-012 |
| 6.00000000000679e+000 | 6.795e-012 |
| 6.99999999999320e+000 | 6.803e-012 |
| 8.00000000000496e+000 | 4.965e-012 |
| 8.99999999999834e+000 | 1.663e-012 |
| 1.00000000000013e+001 | 1.318e-012 |
| 1.10000000000028e+001 | 2.782e-012 |
| 1.19999999999963e+001 | 3.698e-012 |
| 1,2 | 1.00000000001350e+000 | 1.350e-011 | 1.549e+001 | 93 |
| 1.99999999998605e+000 | 1.395e-011 |
| 3.00000000001062e+000 | 1.062e-011 |
| 3.99999999999101e+000 | 8.991e-012 |
| 5.00000000000492e+000 | 4.916e-012 |
| 6.00000000000111e+000 | 1.108e-012 |
| 6.99999999998631e+000 | 1.369e-011 |
| 8.00000000001364e+000 | 1.364e-011 |
| 8.99999999998829e+000 | 1.171e-011 |
| 1.00000000000112e+001 | 1.118e-011 |
| 1.09999999999928e+001 | 7.239e-012 |
| 1.20000000000058e+001 | 5.771e-012 |
| 1,28 | 9.99999999996105e-001 | 3.895e-012 | 5.289e+000 | 87 |
| 2.00000000000237e+000 | 2.373e-012 |
| 3.00000000000200e+000 | 2.004e-012 |
| 3.99999999999712e+000 | 2.880e-012 |
| 5.00000000000457e+000 | 4.566e-012 |
| 5.99999999999511e+000 | 4.890e-012 |
| 7.00000000000324e+000 | 3.237e-012 |
| 7.99999999999829e+000 | 1.712e-012 |
| 8.99999999999975e+000 | 2.487e-013 |
| 1.00000000000008e+001 | 8.296e-013 |
| 1.09999999999969e+001 | 3.148e-012 |
| 1.20000000000034e+001 | 3.443e-012 |
| 1,29 | 1.00000000000090e+000 | 9.031e-013 | 9.471e+000 | 85 |
| 1.99999999999678e+000 | 3.220e-012 |
| 3.00000000000775e+000 | 7.752e-012 |
| 3.99999999999178e+000 | 8.219e-012 |
| 5.00000000000862e+000 | 8.616e-012 |
| 5.99999999999380e+000 | 6.198e-012 |
| 6.99999999999809e+000 | 1.910e-012 |
| 8.00000000000398e+000 | 3.979e-012 |
| 8.99999999999424e+000 | 5.759e-012 |
| 1.00000000000063e+001 | 6.262e-012 |
| 1.09999999999924e+001 | 7.590e-012 |
| 1.20000000000073e+001 | 7.301e-012 |
| 1,3 | 1.00000000001161e+000 | 1.161e-011 | 1.234e+001 | 86 |
| 1.99999999998834e+000 | 1.166e-011 |
| 3.00000000000851e+000 | 8.506e-012 |
| 3.99999999999293e+000 | 7.068e-012 |
| 5.00000000000339e+000 | 3.395e-012 |
| 6.00000000000169e+000 | 1.693e-012 |
| 6.99999999998844e+000 | 1.156e-011 |
| 8.00000000001123e+000 | 1.123e-011 |
| 8.99999999999061e+000 | 9.390e-012 |
| 1.00000000000087e+001 | 8.674e-012 |
| 1.09999999999949e+001 | 5.102e-012 |
| 1.20000000000039e+001 | 3.885e-012 |
| 1,4 | 9.99999999995565e-001 | 4.435e-012 | 4.315e+000 | 88 |
| 2.00000000000257e+000 | 2.570e-012 |
| 3.00000000000120e+000 | 1.203e-012 |
| 3.99999999999788e+000 | 2.119e-012 |
| 5.00000000000409e+000 | 4.091e-012 |
| 5.99999999999526e+000 | 4.743e-012 |
| 7.00000000000328e+000 | 3.284e-012 |
| 7.99999999999831e+000 | 1.692e-012 |
| 8.99999999999994e+000 | 5.684e-014 |
| 1.00000000000010e+001 | 1.027e-012 |
| 1.09999999999968e+001 | 3.183e-012 |
| 1.20000000000034e+001 | 3.356e-012 |
| 1,5 | 9.99999999999329e-001 | 6.707e-013 | 2.050e+000 | 117 |
| 1.99999999999859e+000 | 1.411e-012 |
| 2.99999999999935e+000 | 6.510e-013 |
| 3.99999999999959e+000 | 4.143e-013 |
| 5.00000000000130e+000 | 1.297e-012 |
| 6.00000000000033e+000 | 3.251e-013 |
| 7.00000000000316e+000 | 3.161e-012 |
| 8.00000000000314e+000 | 3.139e-012 |
| 9.00000000000027e+000 | 2.736e-013 |
| 9.99999999999885e+000 | 1.153e-012 |
| 1.09999999999991e+001 | 9.450e-013 |
| 1.20000000000000e+001 | 3.553e-014 |
| 1,6 | 1.00000000000004e+000 | 3.575e-014 | 1.859e+000 | 292 |
| 2.00000000000121e+000 | 1.205e-012 |
| 3.00000000000118e+000 | 1.175e-012 |
| 3.99999999999982e+000 | 1.799e-013 |
| 4.99999999999858e+000 | 1.423e-012 |
| 5.99999999999867e+000 | 1.330e-012 |
| 6.99999999999753e+000 | 2.473e-012 |
| 7.99999999999778e+000 | 2.223e-012 |
| 8.99999999999925e+000 | 7.532e-013 |
| 1.00000000000016e+001 | 1.581e-012 |
| 1.10000000000009e+001 | 8.562e-013 |
| 1.20000000000004e+001 | 4.299e-013 |

# 

# 6. Вывод:

# Исследование по определению оптимального веса показали, что оптимальный вес различен для каждой матрицы и каждого метода. Также было выявлено, что при увеличении параметра релаксации уменьшается число шагов для получения верного ответа (до некоторого предела). Но при очень больших значениях параметра релаксации происходит ухудшение, вплоть до полной невозможности получить верный ответ.