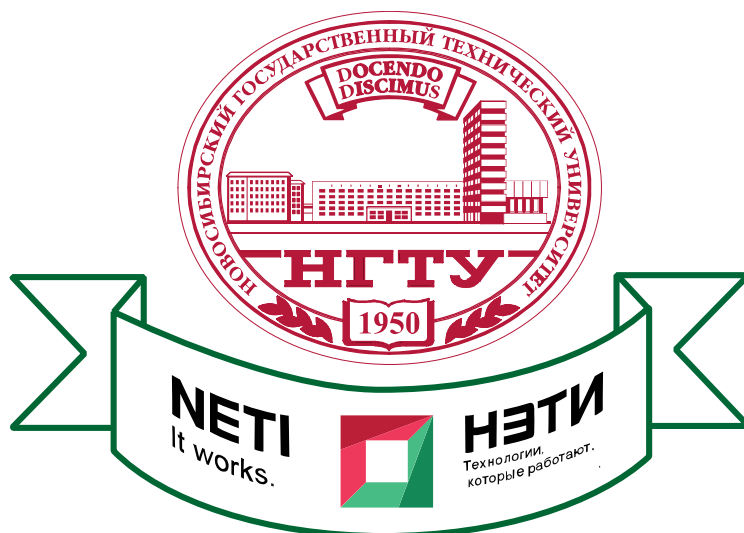


Министерство науки и высшего образования  
Российской Федерации

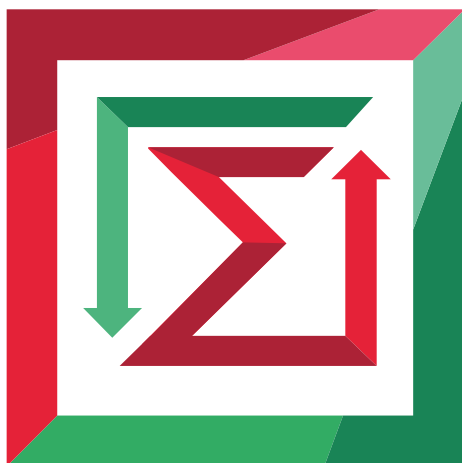
Федеральное государственное бюджетное  
образовательное учреждение высшего образования  
«НОВОСИБИРСКИЙ ГОСУДАРСТВЕННЫЙ ТЕХНИЧЕСКИЙ УНИВЕРСИТЕТ»



Кафедра прикладной математики

Практическое задание № 2  
по дисциплине «Численные методы»

## ИТЕРАЦИОННЫЕ МЕТОДЫ РЕШЕНИЯ СЛАУ



|                |  |
|----------------|--|
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Новосибирск  
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## 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.

## 2. Условие задачи

$$x_i^{(k+1)} = x_i^{(k)} + \frac{\omega}{a_{ii}} \left[ f_i - \sum_{j=1}^n a_{ij} x_j^{(k)} \right], \quad 0 < \omega \leq 1$$

1. Реализовать метод Якоби с параметром релаксации

Метод Гаусса-Зейделя с параметром релаксации

$$x_i^{(k+1)} = x_i^{(k)} + \frac{\omega}{a_{ii}} \left[ f_i - \sum_{j=1}^{i-1} a_{ij} x_j^{(k+1)} - \sum_{j=i}^n a_{ij} x_j^{(k)} \right], \quad 0 < \omega < 2$$

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.

2. Протестировать разработанную программу.

3. Провести исследование реализованных методов на матрице с диагональным преобладанием, построенной следующим образом:

$$a_{ii} = \begin{cases} -\sum_{i \neq j} a_{ij}, & i > 1 \\ -\sum_{i \neq j} a_{ij} + 1, & i = 1, \end{cases}$$

и  $a_{ij} \in \{0, -1, -2, -3, -4\}$  выбираются достаточно произвольно, а правая часть  $F$  получается умножением матрицы  $A$  на вектор  $x^* = (1, \dots, n)$ .

Для каждого метода решения (Якоби, Гаусса-Зейделя, блочной релаксации) определить оптимальный вес  $\omega$  (вес, при котором метод сходится за наименьшее число итераций). Оптимальный вес определять с точностью 0.01.

Для каждого метода построить таблицу:

| $\omega$ | $x$ | $x^* - x$ | (кол-во итераций) |
|----------|-----|-----------|-------------------|
|          |     |           |                   |

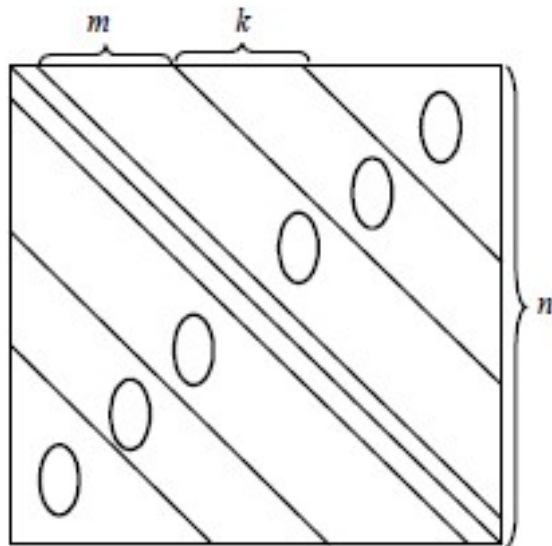
Для полученного решения с помощью невязки и погрешности

оценить число обусловленности  $\nu_A \geq \frac{\|x - x^*\|}{\|x^*\|} / \frac{\|F - Ax\|}{\|F\|}$ .

4. Провести аналогичные исследования на матрице с обратным знаком внедиагональных элементов.

### 3. Вариант задания

Матрица из варианта 3. Размер блока в реализации блочной релаксации переменный. Исследовать зависимость скорости сходимости от размеров блока. 7-диагональная матрица с 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)
{
    // Найдем вектор главной диагонали
    auto mainDiagonalOffsetIter = std::find(matrix.offsets.begin(), matrix.offsets.end(),
0);
    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++)
        {
            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] :
x0[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
VECTROPERATIONS_H
#define
VECTROPERATIONS_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

$$A = \begin{pmatrix} 9 & -4 & 0 & 0 & 0 & 0 & -1 & 0 & -3 & 0 & 0 & 0 \\ -2 & 8 & 0 & 0 & 0 & 0 & 0 & -2 & 0 & -4 & 0 & 0 \\ 0 & -1 & 8 & -3 & 0 & 0 & 0 & 0 & 0 & 0 & -4 & 0 \\ 0 & 0 & 0 & 7 & -3 & 0 & 0 & 0 & 0 & -2 & 0 & -2 \\ 0 & 0 & 0 & -2 & 9 & -4 & 0 & 0 & 0 & 0 & -3 & 0 \\ 0 & 0 & 0 & 0 & -1 & 3 & -1 & 0 & 0 & 0 & 0 & -1 \\ -4 & 0 & 0 & 0 & 0 & 0 & 5 & -1 & 0 & 0 & 0 & 0 \\ 0 & -3 & 0 & 0 & 0 & 0 & -1 & 6 & -2 & 0 & 0 & 0 \\ -2 & 0 & -4 & 0 & 0 & 0 & 0 & 0 & 8 & -2 & 0 & 0 \\ 0 & -1 & 0 & -1 & 0 & 0 & 0 & 0 & -4 & 6 & 0 & 0 \\ 0 & 0 & 0 & 0 & -4 & 0 & 0 & 0 & 0 & -3 & 8 & -1 \\ 0 & 0 & 0 & -4 & 0 & -2 & 0 & 0 & 0 & 0 & -3 & 9 \end{pmatrix}$$

Начальное приближение – нулевой вектор.

Максимальное число итераций – 1000000

Целевая относительная невязка – 1.0E-14

Якоби:

| $\omega$ | $X$                   | $X^* - X$  | $\nu_A$    | 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 |            |                     |

|     |                      |            |            |      |
|-----|----------------------|------------|------------|------|
|     | 8.9999999995564e+000 | 4.436e-011 |            |      |
|     | 9.9999999995511e+000 | 4.489e-011 |            |      |
|     | 1.0999999999542e+001 | 4.580e-011 |            |      |
|     | 1.1999999999540e+001 | 4.596e-011 |            |      |
| 0.4 | 9.9999999961049e-001 | 3.895e-011 | 6.001e+001 | 6967 |
|     | 1.9999999995650e+000 | 4.350e-011 |            |      |
|     | 2.9999999995402e+000 | 4.598e-011 |            |      |
|     | 3.9999999995408e+000 | 4.592e-011 |            |      |
|     | 4.9999999995440e+000 | 4.560e-011 |            |      |
|     | 5.9999999995565e+000 | 4.435e-011 |            |      |
|     | 6.9999999995974e+000 | 4.026e-011 |            |      |
|     | 7.9999999995635e+000 | 4.365e-011 |            |      |
|     | 8.9999999995564e+000 | 4.436e-011 |            |      |
|     | 9.9999999995511e+000 | 4.489e-011 |            |      |
|     | 1.0999999999542e+001 | 4.580e-011 |            |      |
|     | 1.1999999999540e+001 | 4.596e-011 |            |      |
| 0.5 | 9.9999999961080e-001 | 3.892e-011 | 6.001e+001 | 5571 |
|     | 1.9999999995654e+000 | 4.346e-011 |            |      |
|     | 2.9999999995405e+000 | 4.595e-011 |            |      |
|     | 3.9999999995411e+000 | 4.589e-011 |            |      |
|     | 4.9999999995443e+000 | 4.557e-011 |            |      |
|     | 5.9999999995569e+000 | 4.431e-011 |            |      |
|     | 6.9999999995977e+000 | 4.023e-011 |            |      |
|     | 7.9999999995639e+000 | 4.361e-011 |            |      |
|     | 8.9999999995567e+000 | 4.433e-011 |            |      |
|     | 9.9999999995515e+000 | 4.485e-011 |            |      |
|     | 1.0999999999542e+001 | 4.577e-011 |            |      |
|     | 1.1999999999541e+001 | 4.592e-011 |            |      |
| 0.6 | 9.9999999961255e-001 | 3.875e-011 | 6.002e+001 | 4641 |
|     | 1.9999999995673e+000 | 4.327e-011 |            |      |
|     | 2.9999999995426e+000 | 4.574e-011 |            |      |
|     | 3.9999999995432e+000 | 4.568e-011 |            |      |
|     | 4.9999999995464e+000 | 4.536e-011 |            |      |
|     | 5.9999999995588e+000 | 4.412e-011 |            |      |
|     | 6.9999999995995e+000 | 4.005e-011 |            |      |

|     |                      |            |            |      |
|-----|----------------------|------------|------------|------|
|     | 7.9999999995658e+000 | 4.342e-011 |            |      |
|     | 8.9999999995587e+000 | 4.413e-011 |            |      |
|     | 9.9999999995535e+000 | 4.465e-011 |            |      |
|     | 1.0999999999544e+001 | 4.556e-011 |            |      |
|     | 1.1999999999543e+001 | 4.571e-011 |            |      |
| 0.7 | 9.9999999961252e-001 | 3.875e-011 | 6.001e+001 | 3976 |
|     | 1.9999999995673e+000 | 4.327e-011 |            |      |
|     | 2.9999999995426e+000 | 4.574e-011 |            |      |
|     | 3.9999999995431e+000 | 4.569e-011 |            |      |
|     | 4.9999999995463e+000 | 4.537e-011 |            |      |
|     | 5.9999999995588e+000 | 4.412e-011 |            |      |
|     | 6.9999999995995e+000 | 4.005e-011 |            |      |
|     | 7.9999999995658e+000 | 4.342e-011 |            |      |
|     | 8.9999999995587e+000 | 4.413e-011 |            |      |
|     | 9.9999999995534e+000 | 4.466e-011 |            |      |
|     | 1.0999999999544e+001 | 4.557e-011 |            |      |
|     | 1.1999999999543e+001 | 4.572e-011 |            |      |
| 0.8 | 9.9999999961176e-001 | 3.882e-011 | 5.992e+001 | 3477 |
|     | 1.9999999995665e+000 | 4.335e-011 |            |      |
|     | 2.9999999995417e+000 | 4.583e-011 |            |      |
|     | 3.9999999995423e+000 | 4.577e-011 |            |      |
|     | 4.9999999995454e+000 | 4.546e-011 |            |      |
|     | 5.9999999995580e+000 | 4.420e-011 |            |      |
|     | 6.9999999995987e+000 | 4.013e-011 |            |      |
|     | 7.9999999995650e+000 | 4.350e-011 |            |      |
|     | 8.9999999995578e+000 | 4.422e-011 |            |      |
|     | 9.9999999995526e+000 | 4.474e-011 |            |      |
|     | 1.0999999999543e+001 | 4.565e-011 |            |      |
|     | 1.1999999999542e+001 | 4.581e-011 |            |      |
| 0.9 | 9.9999999961136e-001 | 3.886e-011 | 6.001e+001 | 3089 |
|     | 1.9999999995660e+000 | 4.340e-011 |            |      |
|     | 2.9999999995412e+000 | 4.588e-011 |            |      |
|     | 3.9999999995418e+000 | 4.582e-011 |            |      |
|     | 4.9999999995450e+000 | 4.550e-011 |            |      |
|     | 5.9999999995575e+000 | 4.425e-011 |            |      |

|      |                      |            |            |      |
|------|----------------------|------------|------------|------|
|      | 6.9999999995983e+000 | 4.017e-011 |            |      |
|      | 7.9999999995645e+000 | 4.355e-011 |            |      |
|      | 8.9999999995574e+000 | 4.426e-011 |            |      |
|      | 9.9999999995521e+000 | 4.479e-011 |            |      |
|      | 1.0999999999543e+001 | 4.570e-011 |            |      |
|      | 1.1999999999541e+001 | 4.585e-011 |            |      |
| 1    | 9.9999999961240e-001 | 3.876e-011 | 6.000e+001 | 2779 |
|      | 1.9999999995672e+000 | 4.328e-011 |            |      |
|      | 2.9999999995424e+000 | 4.576e-011 |            |      |
|      | 3.9999999995430e+000 | 4.570e-011 |            |      |
|      | 4.9999999995462e+000 | 4.538e-011 |            |      |
|      | 5.9999999995587e+000 | 4.413e-011 |            |      |
|      | 6.9999999995994e+000 | 4.006e-011 |            |      |
|      | 7.9999999995657e+000 | 4.343e-011 |            |      |
|      | 8.9999999995586e+000 | 4.414e-011 |            |      |
|      | 9.9999999995533e+000 | 4.467e-011 |            |      |
|      | 1.0999999999544e+001 | 4.558e-011 |            |      |
|      | 1.1999999999543e+001 | 4.573e-011 |            |      |
|      |                      |            |            |      |
| 1,01 | 9.9999999961113e-001 | 3.889e-011 | 6.001e+001 | 2751 |
|      | 1.9999999995658e+000 | 4.342e-011 |            |      |
|      | 2.9999999995409e+000 | 4.591e-011 |            |      |
|      | 3.9999999995415e+000 | 4.585e-011 |            |      |
|      | 4.9999999995447e+000 | 4.553e-011 |            |      |
|      | 5.9999999995572e+000 | 4.428e-011 |            |      |
|      | 6.9999999995981e+000 | 4.019e-011 |            |      |
|      | 7.9999999995642e+000 | 4.358e-011 |            |      |
|      | 8.9999999995571e+000 | 4.429e-011 |            |      |
|      | 9.9999999995518e+000 | 4.482e-011 |            |      |
|      | 1.0999999999543e+001 | 4.573e-011 |            |      |
|      | 1.1999999999541e+001 | 4.588e-011 |            |      |
|      |                      |            |            |      |
| 1,02 | 9.9999999961152e-001 | 3.885e-011 | 5.991e+001 | 2724 |
|      | 1.9999999995662e+000 | 4.338e-011 |            |      |
|      | 2.9999999995414e+000 | 4.586e-011 |            |      |
|      | 3.9999999995420e+000 | 4.580e-011 |            |      |
|      | 4.9999999995452e+000 | 4.548e-011 |            |      |

|      |                        |            |            |      |
|------|------------------------|------------|------------|------|
|      | 5.9999999995577e+000   | 4.423e-011 |            |      |
|      | 6.9999999995985e+000   | 4.015e-011 |            |      |
|      | 7.9999999995647e+000   | 4.353e-011 |            |      |
|      | 8.9999999995576e+000   | 4.424e-011 |            |      |
|      | 9.9999999995523e+000   | 4.477e-011 |            |      |
|      | 1.0999999999543e+001   | 4.568e-011 |            |      |
|      | 1.1999999999542e+001   | 4.584e-011 |            |      |
| 1,03 | 9.9999999961368e-001   | 3.863e-011 | 6.004e+001 | 2698 |
|      | 1.9999999995686e+000   | 4.314e-011 |            |      |
|      | 2.9999999995439e+000   | 4.561e-011 |            |      |
|      | 3.9999999995445e+000   | 4.555e-011 |            |      |
|      | 4.9999999995477e+000   | 4.523e-011 |            |      |
|      | 5.9999999995601e+000   | 4.399e-011 |            |      |
|      | 6.9999999996006e+000   | 3.994e-011 |            |      |
|      | 7.9999999995671e+000   | 4.329e-011 |            |      |
|      | 8.9999999995600e+000   | 4.400e-011 |            |      |
|      | 9.9999999995548e+000   | 4.452e-011 |            |      |
|      | 1.0999999999546e+001   | 4.543e-011 |            |      |
|      | 1.1999999999544e+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:

| $\omega$ | $x$                   | $X^* - X$  | $\nu_A$    | 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 |            |         |
|     |                       |            |            |         |

|     |                       |            |            |         |
|-----|-----------------------|------------|------------|---------|
|     | 1.0999999999574e+001  | 4.260e-011 |            |         |
|     | 1.1999999999573e+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 |            |         |
|     | 1.0999999999592e+001  | 4.080e-011 |            |         |
|     | 1.1999999999591e+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 |            |         |
|     |                       |            |            |         |

|      |                       |            |            |         |
|------|-----------------------|------------|------------|---------|
|      | 1.0999999999627e+001  | 3.725e-011 |            |         |
|      | 1.1999999999626e+001  | 3.738e-011 |            |         |
| 1,0  | 9.99999999969876e-001 | 3.012e-011 | 4.606e+001 | 1403,00 |
|      | 1.9999999999662e+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 |            |         |
|      |                       |            |            |         |

|      |                       |            |            |        |
|------|-----------------------|------------|------------|--------|
|      | 1.0999999999724e+001  | 2.765e-011 |            |        |
|      | 1.1999999999723e+001  | 2.775e-011 |            |        |
| 1,30 | 9.99999999978407e-001 | 2.159e-011 | 3.281e+001 | 757,00 |
|      | 1.9999999997624e+000  | 2.376e-011 |            |        |
|      | 2.9999999997474e+000  | 2.526e-011 |            |        |
|      | 3.9999999997473e+000  | 2.527e-011 |            |        |
|      | 4.9999999997499e+000  | 2.501e-011 |            |        |
|      | 5.9999999997579e+000  | 2.421e-011 |            |        |
|      | 6.9999999997801e+000  | 2.199e-011 |            |        |
|      | 7.9999999997635e+000  | 2.365e-011 |            |        |
|      | 8.9999999997596e+000  | 2.404e-011 |            |        |
|      | 9.9999999997600e+000  | 2.400e-011 |            |        |
|      | 1.0999999999755e+001  | 2.449e-011 |            |        |
|      | 1.1999999999754e+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 |            |        |
|      | 7.9999999999932e+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 |            |        |
|      | 4.9999999999993e+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.

$$B = \begin{pmatrix} 9 & 4 & 0 & 0 & 0 & 0 & 1 & 0 & 3 & 0 & 0 & 0 \\ 2 & 8 & 0 & 0 & 0 & 0 & 0 & 2 & 0 & 4 & 0 & 0 \\ 0 & 1 & 8 & 3 & 0 & 0 & 0 & 0 & 0 & 0 & 4 & 0 \\ 0 & 0 & 0 & 7 & 3 & 0 & 0 & 0 & 0 & 2 & 0 & 2 \\ 0 & 0 & 0 & 2 & 9 & 4 & 0 & 0 & 0 & 0 & 3 & 0 \\ 0 & 0 & 0 & 0 & 1 & 3 & 1 & 0 & 0 & 0 & 0 & 1 \\ 4 & 0 & 0 & 0 & 0 & 0 & 5 & 1 & 0 & 0 & 0 & 0 \\ 0 & 3 & 0 & 0 & 0 & 0 & 1 & 6 & 2 & 0 & 0 & 0 \\ 2 & 0 & 4 & 0 & 0 & 0 & 0 & 0 & 8 & 2 & 0 & 0 \\ 0 & 1 & 0 & 1 & 0 & 0 & 0 & 0 & 4 & 6 & 0 & 0 \\ 0 & 0 & 0 & 0 & 4 & 0 & 0 & 0 & 0 & 3 & 8 & 1 \\ 0 & 0 & 0 & 4 & 0 & 2 & 0 & 0 & 0 & 0 & 3 & 9 \end{pmatrix}$$

Начальное приближение – нулевой вектор.

Максимальное число итераций – 1000000

Целевая относительная невязка – 1.0E-14

Якоби:

| $\omega$ | x                     | $X^* - X$  | $\nu_A$    | 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 |            |                     |
|          | 4.9999999999271e+000  | 7.286e-012 |            |                     |
|          | 5.9999999999776e+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 |            |                     |

|     |                       |            |            |      |
|-----|-----------------------|------------|------------|------|
|     | 2.9999999998366e+000  | 1.634e-011 |            |      |
|     | 4.00000000001340e+000 | 1.340e-011 |            |      |
|     | 4.9999999999277e+000  | 7.234e-012 |            |      |
|     | 5.9999999999778e+000  | 2.222e-012 |            |      |
|     | 7.00000000002439e+000 | 2.439e-011 |            |      |
|     | 7.9999999997507e+000  | 2.493e-011 |            |      |
|     | 9.00000000002059e+000 | 2.059e-011 |            |      |
|     | 9.9999999997839e+000  | 2.161e-011 |            |      |
|     | 1.10000000000141e+001 | 1.413e-011 |            |      |
|     | 1.1999999999890e+001  | 1.098e-011 |            |      |
| 0.3 | 9.9999999977992e-001  | 2.201e-011 | 2.513e+001 | 1067 |
|     | 2.00000000002433e+000 | 2.433e-011 |            |      |
|     | 2.9999999998367e+000  | 1.633e-011 |            |      |
|     | 4.00000000001340e+000 | 1.340e-011 |            |      |
|     | 4.9999999999277e+000  | 7.233e-012 |            |      |
|     | 5.9999999999778e+000  | 2.222e-012 |            |      |
|     | 7.00000000002439e+000 | 2.439e-011 |            |      |
|     | 7.9999999997507e+000  | 2.493e-011 |            |      |
|     | 9.00000000002059e+000 | 2.059e-011 |            |      |
|     | 9.9999999997839e+000  | 2.161e-011 |            |      |
|     | 1.10000000000141e+001 | 1.413e-011 |            |      |
|     | 1.1999999999890e+001  | 1.098e-011 |            |      |
| 0.4 | 9.9999999977999e-001  | 2.200e-011 | 2.513e+001 | 797  |
|     | 2.00000000002432e+000 | 2.432e-011 |            |      |
|     | 2.9999999998367e+000  | 1.633e-011 |            |      |
|     | 4.00000000001339e+000 | 1.339e-011 |            |      |
|     | 4.9999999999277e+000  | 7.232e-012 |            |      |
|     | 5.9999999999778e+000  | 2.220e-012 |            |      |
|     | 7.00000000002438e+000 | 2.438e-011 |            |      |
|     | 7.9999999997508e+000  | 2.492e-011 |            |      |
|     | 9.00000000002058e+000 | 2.058e-011 |            |      |
|     | 9.9999999997840e+000  | 2.160e-011 |            |      |
|     | 1.10000000000141e+001 | 1.413e-011 |            |      |
|     | 1.1999999999890e+001  | 1.098e-011 |            |      |
| 0.5 | 9.9999999978010e-001  | 2.199e-011 | 2.514e+001 | 635  |



|     |                       |            |            |     |
|-----|-----------------------|------------|------------|-----|
|     | 2.00000000002431e+000 | 2.431e-011 |            |     |
|     | 2.9999999998368e+000  | 1.632e-011 |            |     |
|     | 4.00000000001339e+000 | 1.339e-011 |            |     |
|     | 4.9999999999277e+000  | 7.230e-012 |            |     |
|     | 5.9999999999778e+000  | 2.218e-012 |            |     |
|     | 7.00000000002437e+000 | 2.437e-011 |            |     |
|     | 7.9999999997509e+000  | 2.491e-011 |            |     |
|     | 9.00000000002057e+000 | 2.057e-011 |            |     |
|     | 9.9999999997841e+000  | 2.159e-011 |            |     |
|     | 1.10000000000141e+001 | 1.412e-011 |            |     |
|     | 1.1999999999890e+001  | 1.098e-011 |            |     |
| 0.6 | 9.9999999978028e-001  | 2.197e-011 | 2.514e+001 | 527 |
|     | 2.00000000002429e+000 | 2.429e-011 |            |     |
|     | 2.9999999998369e+000  | 1.631e-011 |            |     |
|     | 4.00000000001338e+000 | 1.338e-011 |            |     |
|     | 4.9999999999278e+000  | 7.223e-012 |            |     |
|     | 5.9999999999778e+000  | 2.218e-012 |            |     |
|     | 7.00000000002435e+000 | 2.435e-011 |            |     |
|     | 7.9999999997511e+000  | 2.489e-011 |            |     |
|     | 9.00000000002055e+000 | 2.055e-011 |            |     |
|     | 9.9999999997843e+000  | 2.157e-011 |            |     |
|     | 1.10000000000141e+001 | 1.411e-011 |            |     |
|     | 1.1999999999890e+001  | 1.096e-011 |            |     |
| 0.7 | 9.9999999978217e-001  | 2.178e-011 | 2.513e+001 | 450 |
|     | 2.00000000002408e+000 | 2.408e-011 |            |     |
|     | 2.9999999998383e+000  | 1.617e-011 |            |     |
|     | 4.00000000001326e+000 | 1.326e-011 |            |     |
|     | 4.9999999999284e+000  | 7.159e-012 |            |     |
|     | 5.9999999999780e+000  | 2.202e-012 |            |     |
|     | 7.00000000002414e+000 | 2.414e-011 |            |     |
|     | 7.9999999997532e+000  | 2.468e-011 |            |     |
|     | 9.00000000002038e+000 | 2.038e-011 |            |     |
|     | 9.9999999997862e+000  | 2.138e-011 |            |     |
|     | 1.10000000000140e+001 | 1.399e-011 |            |     |
|     | 1.1999999999891e+001  | 1.087e-011 |            |     |

|      |                       |            |            |     |
|------|-----------------------|------------|------------|-----|
| 0.8  | 9.9999999978079e-001  | 2.192e-011 | 2.514e+001 | 392 |
|      | 2.00000000002424e+000 | 2.424e-011 |            |     |
|      | 2.9999999998373e+000  | 1.627e-011 |            |     |
|      | 4.00000000001335e+000 | 1.335e-011 |            |     |
|      | 4.9999999999280e+000  | 7.205e-012 |            |     |
|      | 5.9999999999779e+000  | 2.212e-012 |            |     |
|      | 7.00000000002429e+000 | 2.429e-011 |            |     |
|      | 7.9999999997517e+000  | 2.483e-011 |            |     |
|      | 9.00000000002051e+000 | 2.051e-011 |            |     |
|      | 9.9999999997848e+000  | 2.152e-011 |            |     |
|      | 1.10000000000141e+001 | 1.408e-011 |            |     |
|      | 1.1999999999891e+001  | 1.094e-011 |            |     |
|      |                       |            |            |     |
| 0.9  | 9.9999999978114e-001  | 2.189e-011 | 2.513e+001 | 347 |
|      | 2.00000000002420e+000 | 2.420e-011 |            |     |
|      | 2.9999999998375e+000  | 1.625e-011 |            |     |
|      | 4.00000000001332e+000 | 1.332e-011 |            |     |
|      | 4.9999999999281e+000  | 7.194e-012 |            |     |
|      | 5.9999999999779e+000  | 2.212e-012 |            |     |
|      | 7.00000000002426e+000 | 2.426e-011 |            |     |
|      | 7.9999999997521e+000  | 2.479e-011 |            |     |
|      | 9.00000000002048e+000 | 2.048e-011 |            |     |
|      | 9.9999999997851e+000  | 2.149e-011 |            |     |
|      | 1.10000000000141e+001 | 1.405e-011 |            |     |
|      | 1.1999999999891e+001  | 1.092e-011 |            |     |
|      |                       |            |            |     |
| 0.94 | 9.9999999978622e-001  | 2.138e-011 | 2.514e+001 | 332 |
|      | 2.00000000002363e+000 | 2.363e-011 |            |     |
|      | 2.9999999998413e+000  | 1.587e-011 |            |     |
|      | 4.00000000001302e+000 | 1.302e-011 |            |     |
|      | 4.9999999999297e+000  | 7.027e-012 |            |     |
|      | 5.9999999999784e+000  | 2.156e-012 |            |     |
|      | 7.00000000002369e+000 | 2.369e-011 |            |     |
|      | 7.9999999997578e+000  | 2.422e-011 |            |     |
|      | 9.00000000002000e+000 | 2.000e-011 |            |     |
|      | 9.9999999997901e+000  | 2.099e-011 |            |     |
|      | 1.10000000000137e+001 | 1.373e-011 |            |     |
|      |                       |            |            |     |
|      |                       |            |            |     |

|      |                       |            |            |     |
|------|-----------------------|------------|------------|-----|
|      | 1.19999999999893e+001 | 1.067e-011 |            |     |
| 0.95 | 9.9999999978047e-001  | 2.195e-011 | 2.515e+001 | 328 |
|      | 2.00000000002427e+000 | 2.427e-011 |            |     |
|      | 2.9999999998370e+000  | 1.630e-011 |            |     |
|      | 4.00000000001337e+000 | 1.337e-011 |            |     |
|      | 4.9999999999278e+000  | 7.217e-012 |            |     |
|      | 5.9999999999778e+000  | 2.215e-012 |            |     |
|      | 7.00000000002433e+000 | 2.433e-011 |            |     |
|      | 7.9999999997513e+000  | 2.487e-011 |            |     |
|      | 9.00000000002054e+000 | 2.054e-011 |            |     |
|      | 9.9999999997845e+000  | 2.155e-011 |            |     |
|      | 1.10000000000141e+001 | 1.410e-011 |            |     |
|      | 1.1999999999890e+001  | 1.096e-011 |            |     |
|      |                       |            |            |     |
| 0.96 | 9.9999999983380e-001  | 1.662e-011 | 2.174e+001 | 328 |
|      | 2.00000000001903e+000 | 1.903e-011 |            |     |
|      | 2.9999999998779e+000  | 1.221e-011 |            |     |
|      | 4.00000000001065e+000 | 1.065e-011 |            |     |
|      | 4.9999999999478e+000  | 5.215e-012 |            |     |
|      | 5.999999999863e+000   | 1.372e-012 |            |     |
|      | 7.00000000001905e+000 | 1.905e-011 |            |     |
|      | 7.9999999998117e+000  | 1.883e-011 |            |     |
|      | 9.00000000001616e+000 | 1.616e-011 |            |     |
|      | 9.9999999998373e+000  | 1.627e-011 |            |     |
|      | 1.10000000000112e+001 | 1.121e-011 |            |     |
|      | 1.1999999999919e+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 |            |     |
|      |                       |            |            |     |

|     |                        |            |            |      |
|-----|------------------------|------------|------------|------|
|     | 1.100000000000007e+001 | 6.946e-013 |            |      |
|     | 1.200000000000007e+001 | 6.821e-013 |            |      |
| 1.0 | 1.000000000000059e+000 | 5.862e-013 | 9.120e-001 | 3232 |
|     | 2.000000000000066e+000 | 6.564e-013 |            |      |
|     | 3.000000000000069e+000 | 6.919e-013 |            |      |
|     | 4.000000000000069e+000 | 6.946e-013 |            |      |
|     | 5.000000000000069e+000 | 6.866e-013 |            |      |
|     | 6.000000000000067e+000 | 6.706e-013 |            |      |
|     | 7.000000000000061e+000 | 6.084e-013 |            |      |
|     | 8.000000000000066e+000 | 6.573e-013 |            |      |
|     | 9.000000000000067e+000 | 6.697e-013 |            |      |
|     | 1.000000000000007e+001 | 6.750e-013 |            |      |
|     | 1.100000000000007e+001 | 6.946e-013 |            |      |
|     | 1.200000000000007e+001 | 6.910e-013 |            |      |

# Гаусс-Зейдель:

| $\omega$ | $x$                   | $X^* - X$  | $\nu_A$    | 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 |            |                     |
|          | 4.9999999999301e+000  | 6.989e-012 |            |                     |
|          | 5.9999999999758e+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 |            |                     |
|          | 4.9999999999340e+000  | 6.604e-012 |            |                     |
|          | 5.9999999999740e+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 |            |                     |
|          | 4.9999999999382e+000  | 6.181e-012 |            |                     |
|          | 5.9999999999718e+000  | 2.823e-012 |            |                     |
|          | 7.00000000002339e+000 | 2.339e-011 |            |                     |
|          | 7.99999999997635e+000 | 2.365e-011 |            |                     |
|          | 9.00000000001929e+000 | 1.929e-011 |            |                     |

|     |                       |            |            |     |
|-----|-----------------------|------------|------------|-----|
|     | 9.9999999997992e+000  | 2.008e-011 |            |     |
|     | 1.10000000000127e+001 | 1.268e-011 |            |     |
|     | 1.1999999999903e+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 |            |     |
|     | 4.9999999999449e+000  | 5.514e-012 |            |     |
|     | 5.9999999999701e+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 |            |     |
|     | 1.1999999999912e+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 |            |     |
|     | 4.9999999999506e+000  | 4.941e-012 |            |     |
|     | 5.9999999999671e+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 |            |     |
|     | 1.1999999999919e+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 |            |     |
|     | 4.9999999999588e+000  | 4.120e-012 |            |     |
|     | 5.9999999999641e+000  | 3.593e-012 |            |     |
|     | 7.00000000002042e+000 | 2.042e-011 |            |     |
|     | 7.99999999997976e+000 | 2.024e-011 |            |     |
|     | 9.00000000001609e+000 | 1.609e-011 |            |     |

|     |                       |            |            |     |
|-----|-----------------------|------------|------------|-----|
|     | 9.9999999998348e+000  | 1.652e-011 |            |     |
|     | 1.10000000000097e+001 | 9.706e-012 |            |     |
|     | 1.1999999999929e+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 |            |     |
|     | 4.9999999999702e+000  | 2.978e-012 |            |     |
|     | 5.9999999999615e+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 |            |     |
|     | 1.1999999999944e+001  | 5.645e-012 |            |     |
|     |                       |            |            |     |
| 0.8 | 9.99999999985170e-001 | 1.483e-011 | 1.599e+001 | 199 |
|     | 2.00000000001536e+000 | 1.536e-011 |            |     |
|     | 2.9999999999194e+000  | 8.058e-012 |            |     |
|     | 4.00000000000589e+000 | 5.886e-012 |            |     |
|     | 4.9999999999870e+000  | 1.296e-012 |            |     |
|     | 5.9999999999556e+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 |            |     |
|     | 1.1999999999963e+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 |            |     |
|     | 3.9999999999751e+000  | 2.493e-012 |            |     |
|     | 4.9999999999866e+000  | 1.339e-012 |            |     |
|     | 6.00000000000539e+000 | 5.392e-012 |            |     |
|     | 6.99999999998749e+000 | 1.251e-011 |            |     |
|     | 8.00000000001141e+000 | 1.141e-011 |            |     |
|     | 8.9999999999227e+000  | 7.725e-012 |            |     |

|     |                        |            |            |     |
|-----|------------------------|------------|------------|-----|
|     | 1.000000000000077e+001 | 7.715e-012 |            |     |
|     | 1.09999999999976e+001  | 2.437e-012 |            |     |
|     | 1.200000000000008e+001 | 7.585e-013 |            |     |
| 1.0 | 9.9999999991906e-001   | 8.094e-012 | 8.970e+000 | 126 |
|     | 2.000000000000758e+000 | 7.584e-012 |            |     |
|     | 2.99999999999854e+000  | 1.458e-012 |            |     |
|     | 4.000000000000004e+000 | 4.441e-014 |            |     |
|     | 5.000000000000278e+000 | 2.782e-012 |            |     |
|     | 5.99999999999481e+000  | 5.194e-012 |            |     |
|     | 7.000000000000852e+000 | 8.518e-012 |            |     |
|     | 7.99999999999272e+000  | 7.283e-012 |            |     |
|     | 9.000000000000426e+000 | 4.258e-012 |            |     |
|     | 9.99999999999589e+000  | 4.109e-012 |            |     |
|     | 1.100000000000000e+001 | 2.132e-014 |            |     |
|     | 1.200000000000011e+001 | 1.128e-012 |            |     |
| 1,1 | 1.000000000000676e+000 | 6.757e-012 | 6.579e+000 | 106 |
|     | 1.99999999999449e+000  | 5.512e-012 |            |     |
|     | 2.99999999999851e+000  | 1.488e-012 |            |     |
|     | 4.000000000000288e+000 | 2.876e-012 |            |     |
|     | 4.99999999999449e+000  | 5.506e-012 |            |     |
|     | 6.000000000000679e+000 | 6.795e-012 |            |     |
|     | 6.99999999999320e+000  | 6.803e-012 |            |     |
|     | 8.000000000000496e+000 | 4.965e-012 |            |     |
|     | 8.99999999999834e+000  | 1.663e-012 |            |     |
|     | 1.000000000000013e+001 | 1.318e-012 |            |     |
|     | 1.100000000000028e+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 |            |     |
|     | 8.000000000001364e+000 | 1.364e-011 |            |     |
|     | 8.99999999998829e+000  | 1.171e-011 |            |     |



|             |                       |            |            |    |
|-------------|-----------------------|------------|------------|----|
|             | 1.00000000000112e+001 | 1.118e-011 |            |    |
|             | 1.0999999999928e+001  | 7.239e-012 |            |    |
|             | 1.20000000000058e+001 | 5.771e-012 |            |    |
| 1,28        | 9.9999999996105e-001  | 3.895e-012 | 5.289e+000 | 87 |
|             | 2.00000000000237e+000 | 2.373e-012 |            |    |
|             | 3.00000000000200e+000 | 2.004e-012 |            |    |
|             | 3.9999999999712e+000  | 2.880e-012 |            |    |
|             | 5.00000000000457e+000 | 4.566e-012 |            |    |
|             | 5.9999999999511e+000  | 4.890e-012 |            |    |
|             | 7.00000000000324e+000 | 3.237e-012 |            |    |
|             | 7.9999999999829e+000  | 1.712e-012 |            |    |
|             | 8.999999999975e+000   | 2.487e-013 |            |    |
|             | 1.00000000000008e+001 | 8.296e-013 |            |    |
|             | 1.0999999999969e+001  | 3.148e-012 |            |    |
|             | 1.20000000000034e+001 | 3.443e-012 |            |    |
| <u>1,29</u> | 1.00000000000090e+000 | 9.031e-013 | 9.471e+000 | 85 |
|             | 1.9999999999678e+000  | 3.220e-012 |            |    |
|             | 3.00000000000775e+000 | 7.752e-012 |            |    |
|             | 3.9999999999178e+000  | 8.219e-012 |            |    |
|             | 5.00000000000862e+000 | 8.616e-012 |            |    |
|             | 5.9999999999380e+000  | 6.198e-012 |            |    |
|             | 6.9999999999809e+000  | 1.910e-012 |            |    |
|             | 8.00000000000398e+000 | 3.979e-012 |            |    |
|             | 8.9999999999424e+000  | 5.759e-012 |            |    |
|             | 1.00000000000063e+001 | 6.262e-012 |            |    |
|             | 1.0999999999924e+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 |            |    |
|             | 3.9999999999293e+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 |            |    |
|             | 8.9999999999061e+000  | 9.390e-012 |            |    |

|     |                        |            |            |     |
|-----|------------------------|------------|------------|-----|
|     | 1.000000000000087e+001 | 8.674e-012 |            |     |
|     | 1.09999999999949e+001  | 5.102e-012 |            |     |
|     | 1.200000000000039e+001 | 3.885e-012 |            |     |
| 1,4 | 9.9999999995565e-001   | 4.435e-012 | 4.315e+000 | 88  |
|     | 2.00000000000257e+000  | 2.570e-012 |            |     |
|     | 3.00000000000120e+000  | 1.203e-012 |            |     |
|     | 3.9999999999788e+000   | 2.119e-012 |            |     |
|     | 5.00000000000409e+000  | 4.091e-012 |            |     |
|     | 5.9999999999526e+000   | 4.743e-012 |            |     |
|     | 7.00000000000328e+000  | 3.284e-012 |            |     |
|     | 7.9999999999831e+000   | 1.692e-012 |            |     |
|     | 8.999999999994e+000    | 5.684e-014 |            |     |
|     | 1.00000000000010e+001  | 1.027e-012 |            |     |
|     | 1.0999999999968e+001   | 3.183e-012 |            |     |
|     | 1.200000000000034e+001 | 3.356e-012 |            |     |
|     |                        |            |            |     |
| 1,5 | 9.9999999999329e-001   | 6.707e-013 | 2.050e+000 | 117 |
|     | 1.9999999999859e+000   | 1.411e-012 |            |     |
|     | 2.9999999999935e+000   | 6.510e-013 |            |     |
|     | 3.9999999999959e+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 |            |     |
|     | 9.9999999999885e+000   | 1.153e-012 |            |     |
|     | 1.0999999999991e+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 |            |     |
|     | 3.9999999999982e+000   | 1.799e-013 |            |     |
|     | 4.9999999999858e+000   | 1.423e-012 |            |     |
|     | 5.9999999999867e+000   | 1.330e-012 |            |     |
|     | 6.9999999999753e+000   | 2.473e-012 |            |     |
|     | 7.9999999999778e+000   | 2.223e-012 |            |     |
|     | 8.9999999999925e+000   | 7.532e-013 |            |     |

|  |                        |            |  |  |
|--|------------------------|------------|--|--|
|  | 1.000000000000016e+001 | 1.581e-012 |  |  |
|  | 1.100000000000009e+001 | 8.562e-013 |  |  |
|  | 1.200000000000004e+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.