Zadanie domowe 1

Aleksander Profic

29. października 2018

Główne źródła w internecie oraz literatura, z których korzystałem:
- Wykład dr Pawła Góry
- William H. Press Saul A. Teukolsky William T. Vetterling Brian P. Flannery “Numerical Recipes in C: The Art of Scientific Computing” Second Edition
- www.math.ucla.edu/~yanovsky/Teaching/Math151B

Zadanie 1. Program wyliczający wartości własne macierzy o wymiarze N (4-10).

Gdy C = 1

$$\begin{pmatrix} 6 & 1 & 0 & 1 \\ 1 & 6 & 1 & 0 \\ 0 & 1 & 6 & 1 \\ 1 & 0 & 1 & 6 \end{pmatrix}$$

Gdy C = 0

$$\begin{pmatrix} 6 & 1 & & 0 \\ 1 & 6 & & \\ & & 6 & 1 \\ 0 & & 1 & 6 \end{pmatrix}$$

- Do wyliczenia wartości własnych macierzy skorzystałem z faktoryzacji QR wraz z algorytmem QR.

- Program rozkłada macierz A na postać iloczynu dwóch macierzy Q i R, gdzie Q jest macierzą ortogonalną, a R - macierzą trójkątną górną.
  Dalej poprzez iloczyn R*Q wylicza macierz podobną do A.

$$A_i = Q_i R_i$$
$$A_{i+1} = R_i Q_i$$

- Dla wymiaru 4 już po kilku iteracjach pętli można zauważyć, że na głównej diagonali macierzy A tworzą się jej wartości własne. Im większy wymiar, tym więcej trzeba wykonać iteracji, aby obliczenia były równie dokładne.

- Zauważyłem, że jeśli znamy wartości własne macierzy trójdiagonalnej (jedynki pod i nad diagonalą oraz wartość ***'a'*** na diagonali) o wymiarze n, dla której C = 0, to można łatwo wyliczyć wartości własne macierzy o wymiarze n+1, dla której C = 1.
  - Pierwsza wartość własna jest zawsze równa **a+2**.
  - Jeśli wymiar macierzy, dla której szukamy wartości własnych jest parzysty to ostatnia wartość własna będzie równa **a - 2**.
  - Kolejne wartości (po dwie) to parzyste wartości własne macierzy o 1 wymiar mniejszej, dla której C = 0.

- Przykład: **a = 6.** Wartości własne macierzy 4x4, C = 0 wynoszą odpowiednio:

[7.61803, 6.61803, 5.38197, 4.38197]

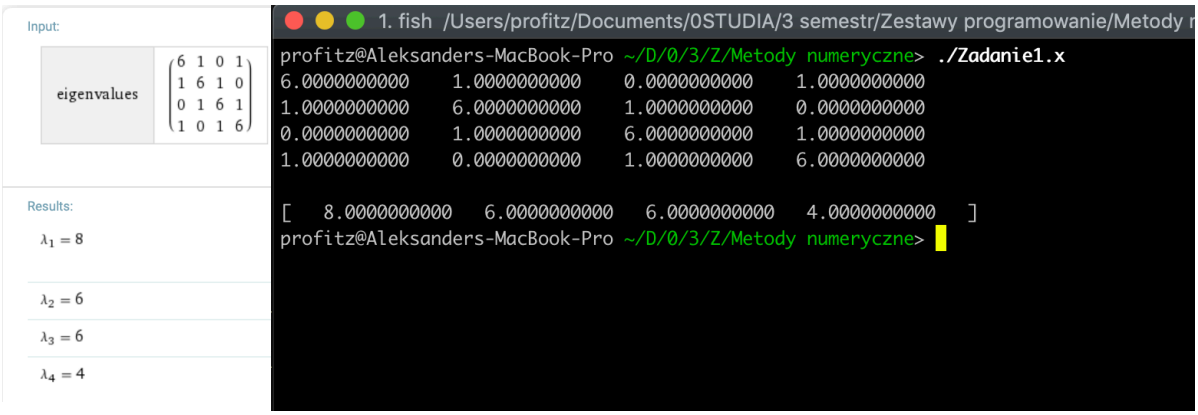
Wtedy dla macierzy 5x5, C = 1: [8, , , ,]

- Przykład 2: **a = 6**. Dla macierzy 5x5, C = 0, wartości własne wynoszą odpowiednio:

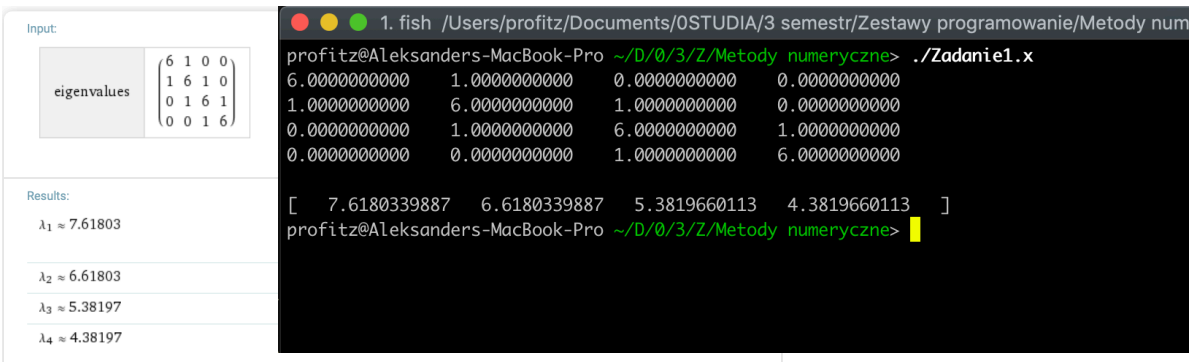
[7.73205, 7.00000, 6.00000, 5.00000, 4.26795]

Wtedy dla macierzy 6x6, C = 1: [8, , , , , 4]

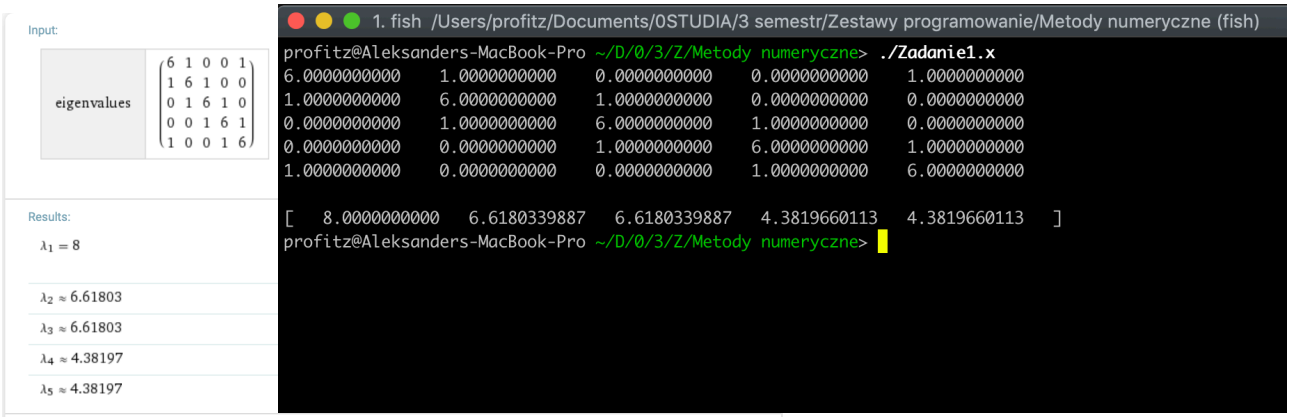
MACIERZ 4x4 C = 1



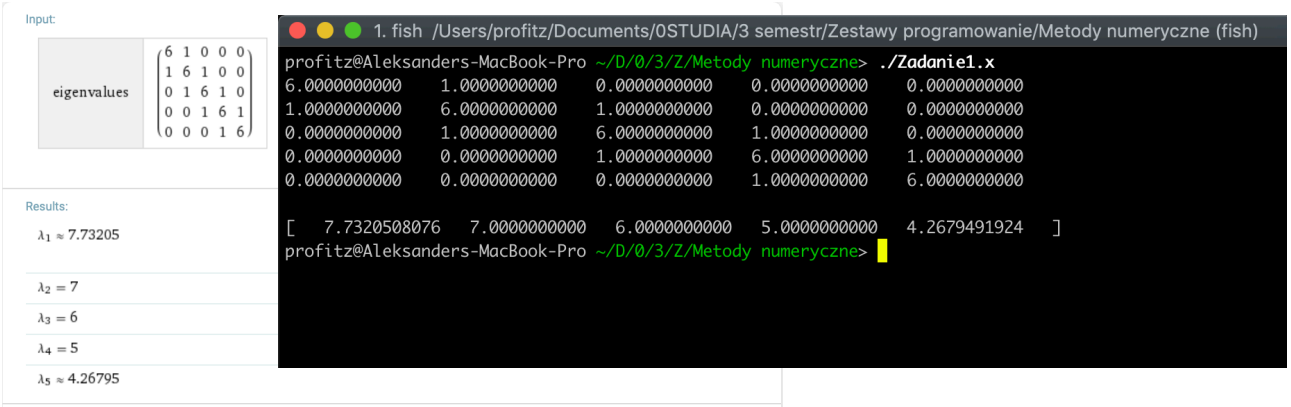
MACIERZ 4x4 C = 0



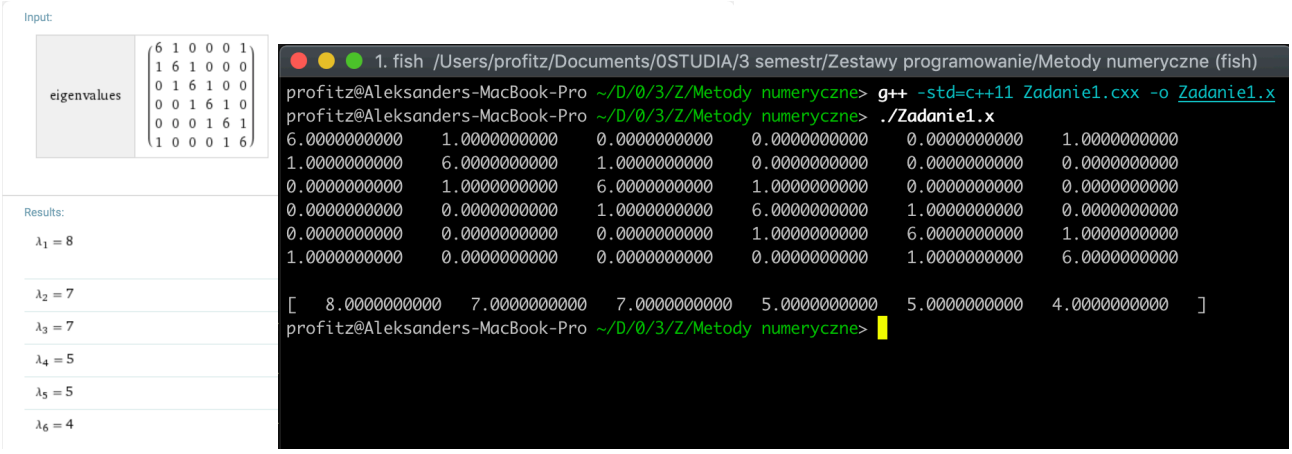
MACIERZ 5x5 C = 1



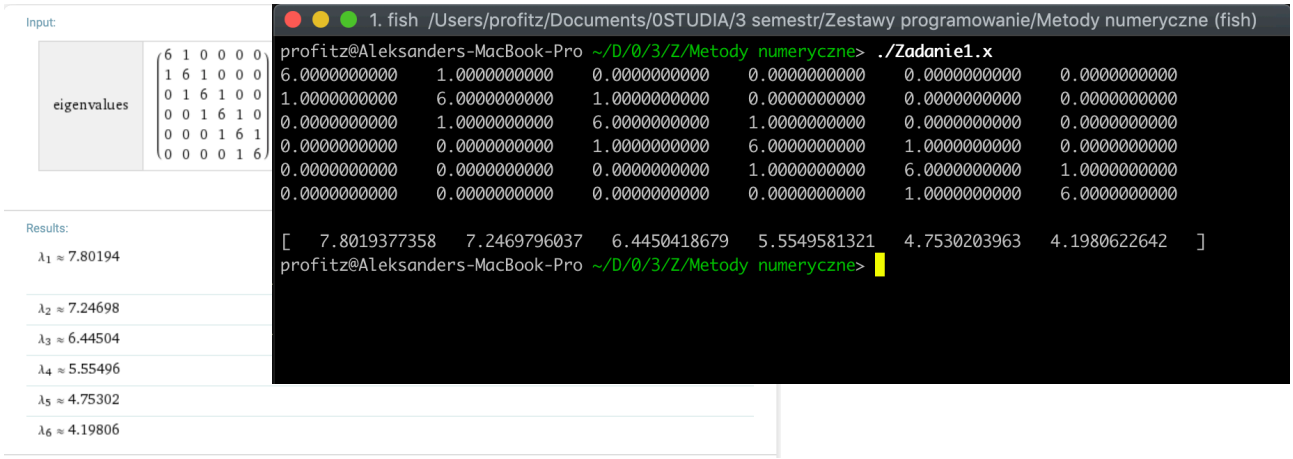
MACIERZ 5x5 C = 0



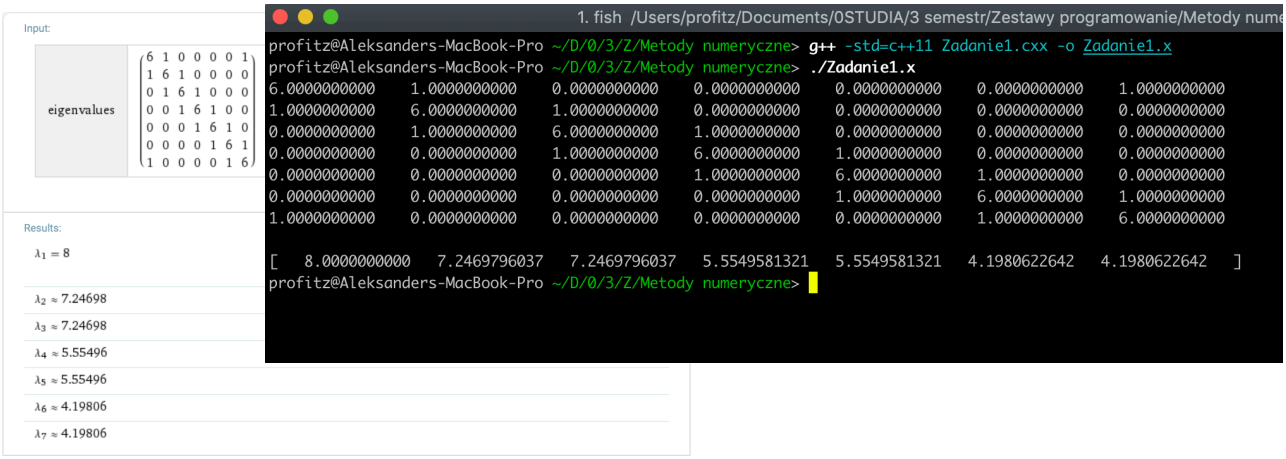
MACIERZ 6x6 C = 1



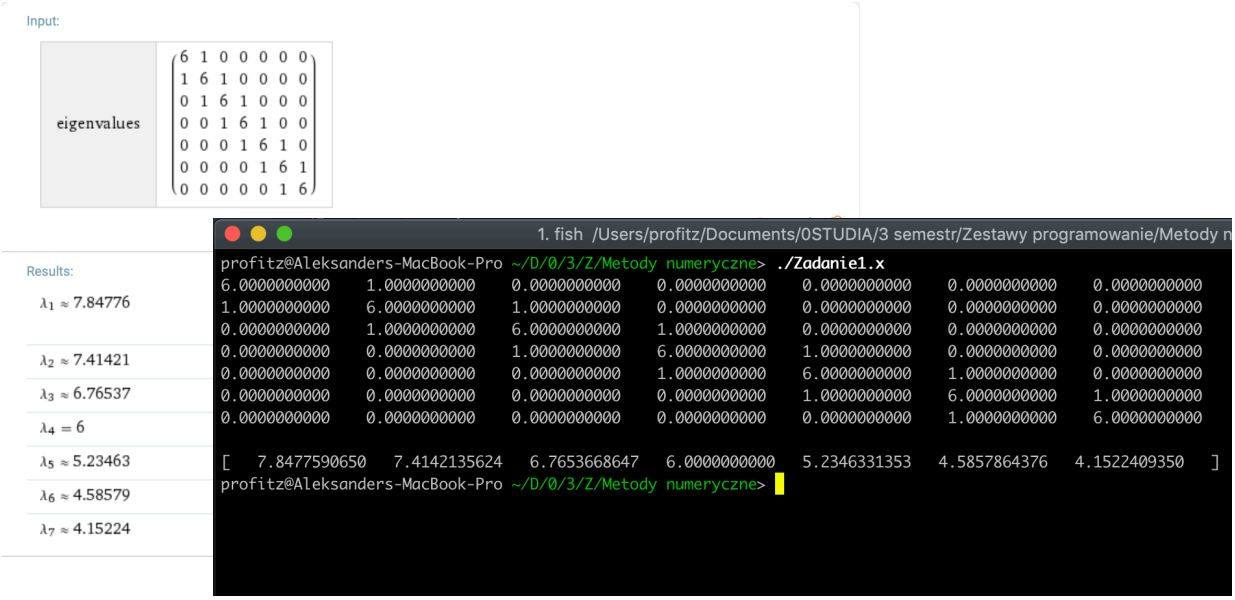
MACIERZ 6x6 C = 0



MACIERZ 7x7 C = 1



MACIERZ 7x7 C = 0



MACIERZ 8x8 C = 1

Input:

eigenvalues

$$\begin{pmatrix} 6 & 1 & 0 & 0 & 0 & 0 & 0 & 1 \\ 1 & 6 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 6 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 6 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 6 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 6 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 6 & 1 \\ 1 & 0 & 0 & 0 & 0 & 0 & 1 & 6 \end{pmatrix}$$

```
1. fish  /Users/profitz/Documents/0STUDIA/3 semestr/Zestawy programowanie/Metody numeryczne (fish)
profitz@Aleksanders-MacBook-Pro ~/D/0/3/Z/Metody numeryczne> ./Zadanie1.x
6.0000000000    1.0000000000    0.0000000000    0.0000000000    0.0000000000    0.0000000000    0.0000000000    1.0000000000
1.0000000000    6.0000000000    1.0000000000    0.0000000000    0.0000000000    0.0000000000    0.0000000000    0.0000000000
0.0000000000    1.0000000000    6.0000000000    1.0000000000    0.0000000000    0.0000000000    0.0000000000    0.0000000000
0.0000000000    0.0000000000    1.0000000000    6.0000000000    1.0000000000    0.0000000000    0.0000000000    0.0000000000
0.0000000000    0.0000000000    0.0000000000    1.0000000000    6.0000000000    1.0000000000    0.0000000000    0.0000000000
0.0000000000    0.0000000000    0.0000000000    0.0000000000    1.0000000000    6.0000000000    1.0000000000    0.0000000000
0.0000000000    0.0000000000    0.0000000000    0.0000000000    0.0000000000    1.0000000000    6.0000000000    1.0000000000
1.0000000000    0.0000000000    0.0000000000    0.0000000000    0.0000000000    0.0000000000    1.0000000000    6.0000000000

[   8.0000000000    7.4142135624    7.4142135624    6.0000000000    6.0000000000    4.5857864376    4.5857864376    4.0000000000    ]
profitz@Aleksanders-MacBook-Pro ~/D/0/3/Z/Metody numeryczne>
```

Results:

$\lambda_1 = 8$

$\lambda_2 \approx 7.41421$

$\lambda_3 \approx 7.41421$

$\lambda_4 = 6$

$\lambda_5 = 6$

$\lambda_6 \approx 4.58579$

$\lambda_7 \approx 4.58579$

$\lambda_8 = 4$

MACIERZ 8x8 C = 0

Input:

eigenvalues

$$\begin{pmatrix} 6 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 1 & 6 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 6 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 6 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 6 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 6 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 6 & 1 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 6 \end{pmatrix}$$

```
1. fish  /Users/profitz/Documents/0STUDIA/3 semestr/Zestawy programowanie/Metody numeryczne (fish)
profitz@Aleksanders-MacBook-Pro ~/D/0/3/Z/Metody numeryczne> ./Zadanie1.x
6.0000000000    1.0000000000    0.0000000000    0.0000000000    0.0000000000    0.0000000000    0.0000000000    0.0000000000
1.0000000000    6.0000000000    1.0000000000    0.0000000000    0.0000000000    0.0000000000    0.0000000000    0.0000000000
0.0000000000    1.0000000000    6.0000000000    1.0000000000    0.0000000000    0.0000000000    0.0000000000    0.0000000000
0.0000000000    0.0000000000    1.0000000000    6.0000000000    1.0000000000    0.0000000000    0.0000000000    0.0000000000
0.0000000000    0.0000000000    0.0000000000    1.0000000000    6.0000000000    1.0000000000    0.0000000000    0.0000000000
0.0000000000    0.0000000000    0.0000000000    0.0000000000    1.0000000000    6.0000000000    1.0000000000    0.0000000000
0.0000000000    0.0000000000    0.0000000000    0.0000000000    0.0000000000    1.0000000000    6.0000000000    1.0000000000
0.0000000000    0.0000000000    0.0000000000    0.0000000000    0.0000000000    0.0000000000    1.0000000000    6.0000000000

[   7.8793852416    7.5320888862    7.0000000000    6.3472963553    5.6527036447    5.0000000000    4.4679111138    4.1206147584    ]
profitz@Aleksanders-MacBook-Pro ~/D/0/3/Z/Metody numeryczne>
```

Results:

$\lambda_1 \approx 7.87939$

$\lambda_2 \approx 7.53209$

$\lambda_3 = 7$

$\lambda_4 \approx 6.3473$

$\lambda_5 \approx 5.6527$

$\lambda_6 = 5$

$\lambda_7 \approx 4.46791$

$\lambda_8 \approx 4.12061$

MACIERZ 9x9 C = 1

Input:

eigenvalues

$$\begin{pmatrix} 6 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \\ 1 & 6 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 6 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 6 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 6 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 6 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 6 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 6 & 1 \\ 1 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 6 \end{pmatrix}$$

```
1. fish  /Users/profitz/Documents/0STUDIA/3 semestr/Zestawy programowanie/Metody numeryczne (fish)
profitz@Aleksanders-MacBook-Pro ~/D/0/3/Z/Metody numeryczne> g++ -std=c++11 Zadanie1.cxx -o Zadanie1.x
profitz@Aleksanders-MacBook-Pro ~/D/0/3/Z/Metody numeryczne> ./Zadanie1.x
6.0000000000    1.0000000000    0.0000000000    0.0000000000    0.0000000000    0.0000000000    0.0000000000    0.0000000000    1.0000000000
1.0000000000    6.0000000000    1.0000000000    0.0000000000    0.0000000000    0.0000000000    0.0000000000    0.0000000000    0.0000000000
0.0000000000    1.0000000000    6.0000000000    1.0000000000    0.0000000000    0.0000000000    0.0000000000    0.0000000000    0.0000000000
0.0000000000    0.0000000000    1.0000000000    6.0000000000    1.0000000000    0.0000000000    0.0000000000    0.0000000000    0.0000000000
0.0000000000    0.0000000000    0.0000000000    1.0000000000    6.0000000000    1.0000000000    0.0000000000    0.0000000000    0.0000000000
0.0000000000    0.0000000000    0.0000000000    0.0000000000    1.0000000000    6.0000000000    1.0000000000    0.0000000000    0.0000000000
0.0000000000    0.0000000000    0.0000000000    0.0000000000    0.0000000000    1.0000000000    6.0000000000    1.0000000000    0.0000000000
0.0000000000    0.0000000000    0.0000000000    0.0000000000    0.0000000000    0.0000000000    1.0000000000    6.0000000000    1.0000000000
1.0000000000    0.0000000000    0.0000000000    0.0000000000    0.0000000000    0.0000000000    0.0000000000    1.0000000000    6.0000000000

[   8.0000000000    7.5320888862    7.5320888862    6.3472963553    6.3472963553    5.0000000000    5.0000000000    4.1206147584    4.1206147584    ]
profitz@Aleksanders-MacBook-Pro ~/D/0/3/Z/Metody numeryczne>
```

Results:

$\lambda_1 = 8$

$\lambda_2 \approx 7.53209$

$\lambda_3 \approx 7.53209$

$\lambda_4 \approx 6.3473$

$\lambda_5 \approx 6.3473$

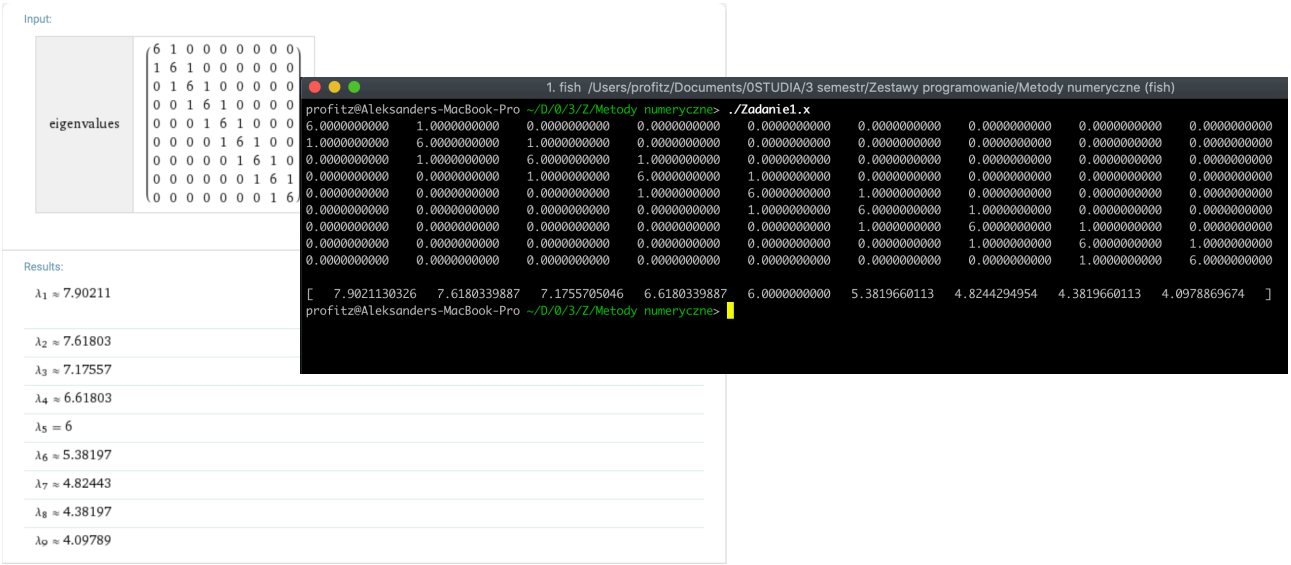
$\lambda_6 = 5$

$\lambda_7 = 5$

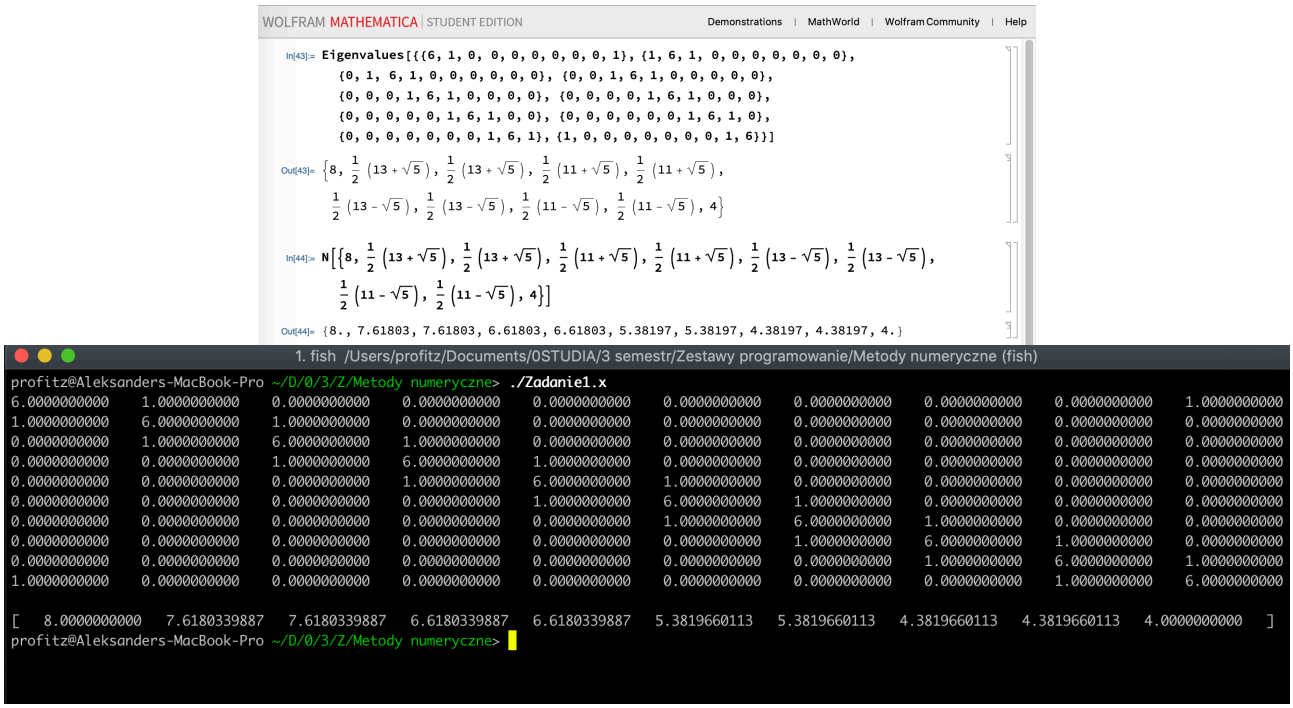
$\lambda_8 \approx 4.12061$

$\lambda_9 \approx 4.12061$

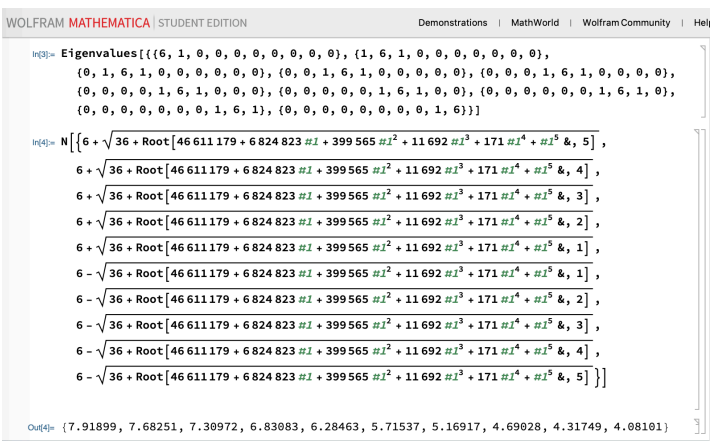
MACIERZ 9x9 C = 0

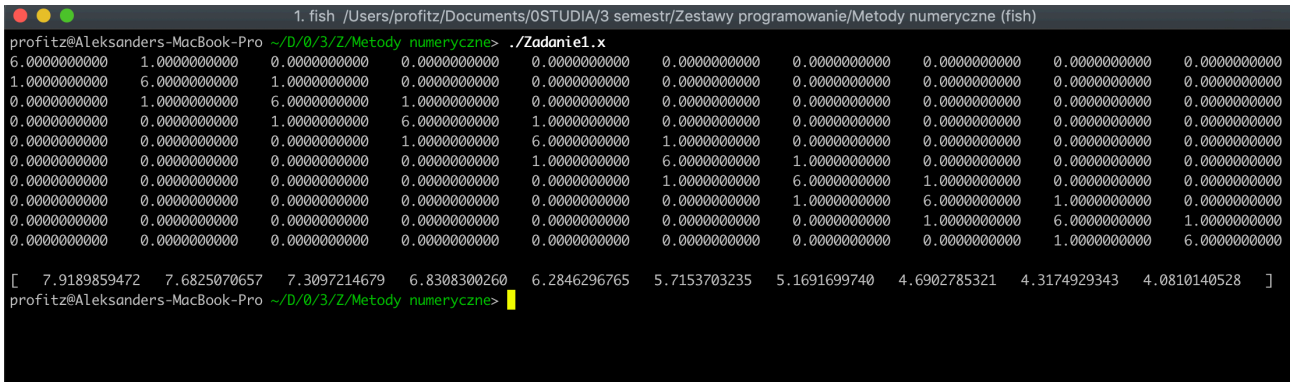


MACIERZ 10x10 C = 1



MACIERZ 10x10 C = 0





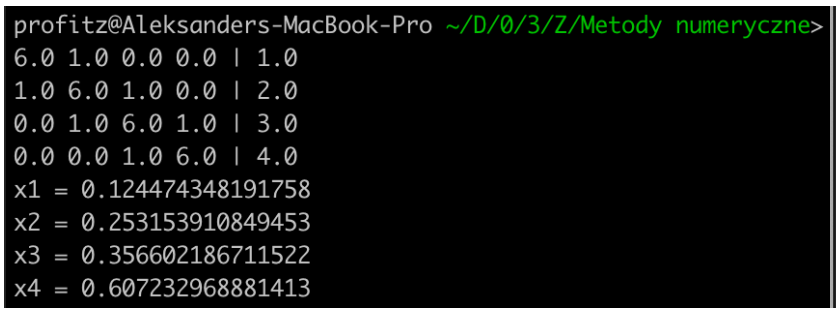
Zadanie 2. Program rozwiązujący układ równań liniowych Ax=y

- Do rozwiązania układu równań posłużyłem się metodą eliminacją Gaussa i metodą backsubstitution.
- Najpierw program zeruje kolumny pod główną diagonalą, a następnie “od końca” po kolei rozwiązuje równania, ponieważ w ostatnim wierszu zostaje tylko jedna zmienna. Potem podstawia jej wynik do poprzednich równań i powtarza czynność, aż wszystkie niewiadome będą miały rozwiązanie.
- Zauważyłem, że w takim układzie równań (macierz trójdiagonalna symetryczna, z jedynkami pod i nad diagonalą, oraz liczbą **‘a’** na diagonali) występuje zależność:

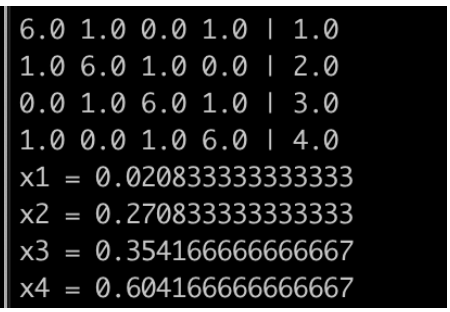
$$\mathbf{a}^{*}x_n + x_{n-1} = \dim(A)$$

- Gdzie **a** - liczba na diagonali, x_n - ostatnia niewiadoma, x_{n-1} - przedostatnia niewiadoma, dim(A) - wymiar macierzy

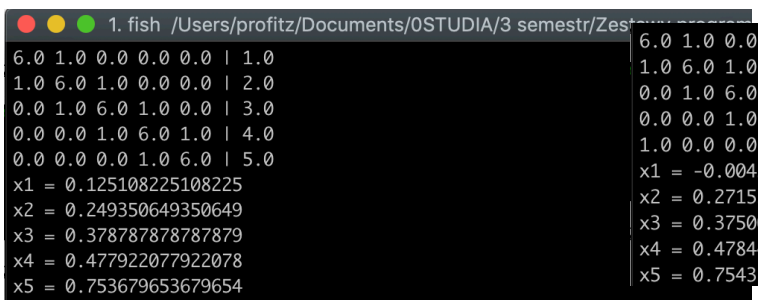
MACIERZ 4x4 C = 0



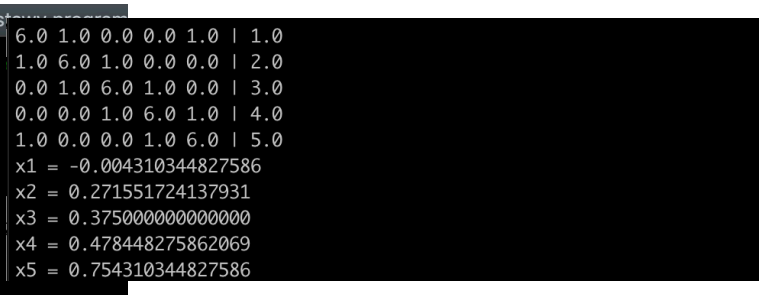
MACIERZ 4x4 C = 1



MACIERZ 5x5 C = 0



MACIERZ 5x5 C = 1



MACIERZ 6x6 C = 0

```
1. fish  /Users/profitz/Documents/0STUDIA/3 semestr/Zestawy prog
6.0 1.0 0.0 0.0 0.0 0.0 | 1.0
1.0 6.0 1.0 0.0 0.0 0.0 | 2.0
0.0 1.0 6.0 1.0 0.0 0.0 | 3.0
0.0 0.0 1.0 6.0 1.0 0.0 | 4.0
0.0 0.0 0.0 1.0 6.0 1.0 | 5.0
0.0 0.0 0.0 0.0 1.0 6.0 | 6.0
x1 = 0.124978336758189
x2 = 0.250129979450868
x3 = 0.374241786536605
x4 = 0.504419301329504
x5 = 0.599242405486371
x6 = 0.900126265752272
```

MACIERZ 6x6 C = 1

```
6.0 1.0 0.0 0.0 0.0 1.0 | 1.0
1.0 6.0 1.0 0.0 0.0 0.0 | 2.0
0.0 1.0 6.0 1.0 0.0 0.0 | 3.0
0.0 0.0 1.0 6.0 1.0 0.0 | 4.0
0.0 0.0 0.0 1.0 6.0 1.0 | 5.0
1.0 0.0 0.0 0.0 1.0 6.0 | 6.0
x1 = -0.030357142857143
x2 = 0.276785714285714
x3 = 0.369642857142857
x4 = 0.505357142857143
x5 = 0.598214285714286
x6 = 0.905357142857143
```

MACIERZ 7x7 C = 0

```
1. fish  /Users/profitz/Documents/0STUDIA/3 semestr/Zestawy prog
6.0 1.0 0.0 0.0 0.0 0.0 0.0 | 1.0
1.0 6.0 1.0 0.0 0.0 0.0 0.0 | 2.0
0.0 1.0 6.0 1.0 0.0 0.0 0.0 | 3.0
0.0 0.0 1.0 6.0 1.0 0.0 0.0 | 4.0
0.0 0.0 0.0 1.0 6.0 1.0 0.0 | 5.0
0.0 0.0 0.0 0.0 1.0 6.0 1.0 | 6.0
0.0 0.0 0.0 0.0 0.0 1.0 6.0 | 7.0
x1 = 0.125004247799640
x2 = 0.249974513202161
x3 = 0.375148672987393
x4 = 0.499133448873484
x5 = 0.630050633771706
x6 = 0.720562748496279
x7 = 1.046572875250620
```

MACIERZ 7x7 C = 1

```
6.0 1.0 0.0 0.0 0.0 0.0 1.0 | 1.0
1.0 6.0 1.0 0.0 0.0 0.0 0.0 | 2.0
0.0 1.0 6.0 1.0 0.0 0.0 0.0 | 3.0
0.0 0.0 1.0 6.0 1.0 0.0 0.0 | 4.0
0.0 0.0 0.0 1.0 6.0 1.0 0.0 | 5.0
0.0 0.0 0.0 0.0 1.0 6.0 1.0 | 6.0
1.0 0.0 0.0 0.0 0.0 1.0 6.0 | 7.0
x1 = -0.056213017751479
x2 = 0.281065088757396
x3 = 0.369822485207101
x4 = 0.500000000000000
x5 = 0.630177514792899
x6 = 0.718934911242604
x7 = 1.056213017751479
```

MACIERZ 8x8 C = 0

```
1. fish  /Users/profitz/Documents/0STUDIA/3 semestr/Zestawy
6.0 1.0 0.0 0.0 0.0 0.0 0.0 0.0 | 1.0
1.0 6.0 1.0 0.0 0.0 0.0 0.0 0.0 | 2.0
0.0 1.0 6.0 1.0 0.0 0.0 0.0 0.0 | 3.0
0.0 0.0 1.0 6.0 1.0 0.0 0.0 0.0 | 4.0
0.0 0.0 0.0 1.0 6.0 1.0 0.0 0.0 | 5.0
0.0 0.0 0.0 0.0 1.0 6.0 1.0 0.0 | 6.0
0.0 0.0 0.0 0.0 0.0 1.0 6.0 1.0 | 7.0
0.0 0.0 0.0 0.0 0.0 0.0 1.0 6.0 | 8.0
x1 = 0.124999180091903
x2 = 0.250004919448584
x3 = 0.374971303216591
x4 = 0.500167261251872
x5 = 0.624025129272177
x6 = 0.755681963115068
x7 = 0.841883092037417
x8 = 1.193019484660431
```

MACIERZ 8x8 C = 1

```
6.0 1.0 0.0 0.0 0.0 0.0 0.0 1.0 | 1.0
1.0 6.0 1.0 0.0 0.0 0.0 0.0 0.0 | 2.0
0.0 1.0 6.0 1.0 0.0 0.0 0.0 0.0 | 3.0
0.0 0.0 1.0 6.0 1.0 0.0 0.0 0.0 | 4.0
0.0 0.0 0.0 1.0 6.0 1.0 0.0 0.0 | 5.0
0.0 0.0 0.0 0.0 1.0 6.0 1.0 0.0 | 6.0
0.0 0.0 0.0 0.0 0.0 1.0 6.0 1.0 | 7.0
1.0 0.0 0.0 0.0 0.0 0.0 1.0 6.0 | 8.0
x1 = -0.082107843137255
x2 = 0.285539215686274
x3 = 0.368872549019608
x4 = 0.501225490196078
x5 = 0.623774509803922
x6 = 0.756127450980392
x7 = 0.839460784313725
x8 = 1.207107843137255
```

MACIERZ 9x9 C = 1

Input:

$$\begin{cases} 6x1 + x2 + x9 = 1, \; x1 + 6x2 + x3 = 2, \; x2 + 6x3 + x4 = 3, \\ x3 + 6x4 + x5 = 4, \; x4 + 6x5 + x6 = 5, \; x5 + 6x6 + x7 = 6, \\ x6 + 6x7 + x8 = 7, \; x7 + 6x8 + x9 = 8, \; x1 + x8 + 6x9 = 9 \end{cases}$$

Solution: More digits Exac

$$x1 \approx -0.10799, \quad x2 \approx 0.28997, \quad x3 \approx 0.36815, \quad x4 \approx 0.50114,$$
$$x5 = 0.625, \quad x6 \approx 0.74886, \quad x7 \approx 0.88185, \quad x8 \approx 0.96003, \quad x9 \approx 1.3580$$

```
1. fish  /Users/profitz/Documents/0STUDIA/3 semestr/Zestawy progra
6.0 1.0 0.0 0.0 0.0 0.0 0.0 0.0 1.0 | 1.0
1.0 6.0 1.0 0.0 0.0 0.0 0.0 0.0 0.0 | 2.0
0.0 1.0 6.0 1.0 0.0 0.0 0.0 0.0 0.0 | 3.0
0.0 0.0 1.0 6.0 1.0 0.0 0.0 0.0 0.0 | 4.0
0.0 0.0 0.0 1.0 6.0 1.0 0.0 0.0 0.0 | 5.0
0.0 0.0 0.0 0.0 1.0 6.0 1.0 0.0 0.0 | 6.0
0.0 0.0 0.0 0.0 0.0 1.0 6.0 1.0 0.0 | 7.0
0.0 0.0 0.0 0.0 0.0 0.0 1.0 6.0 1.0 | 8.0
1.0 0.0 0.0 0.0 0.0 0.0 0.0 1.0 6.0 | 9.0
x1 = -0.107994923857868
x2 = 0.289974619289340
x3 = 0.368147208121827
x4 = 0.501142131979696
x5 = 0.625000000000000
x6 = 0.748857868020305
x7 = 0.881852791878172
x8 = 0.960025380710660
x9 = 1.357994923857868
```

MACIERZ 9x9 C = 0

Input:

$$\{6x1+x2=1,\ x1+6x2+x3=2,\ x2+6x3+x4=3,\ x3+6x4+x5=4,\ x4+6x5+x6=5,\ x5+6x6+x7=6,\ x6+6x7+x8=7,\ x7+6x8+x9=8,\ x8+6x9=9\}$$

Solution: More digits | Exact form

$$x1 \approx 0.12500,\quad x2 \approx 0.25000,\quad x3 \approx 0.37501,\quad x4 \approx 0.49997,\quad x5 \approx 0.62519,\quad x6 \approx 0.74892,\quad x7 \approx 0.88131,\quad x8 \approx 0.96320,\quad x9 \approx 1.3395$$

```
1. fish  /Users/profitz/Documents/0STUDIA/3 semestr/Zest
6.0 1.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 | 1.0
1.0 6.0 1.0 0.0 0.0 0.0 0.0 0.0 0.0 | 2.0
0.0 1.0 6.0 1.0 0.0 0.0 0.0 0.0 0.0 | 3.0
0.0 0.0 1.0 6.0 1.0 0.0 0.0 0.0 0.0 | 4.0
0.0 0.0 0.0 1.0 6.0 1.0 0.0 0.0 0.0 | 5.0
0.0 0.0 0.0 0.0 1.0 6.0 1.0 0.0 0.0 | 6.0
0.0 0.0 0.0 0.0 0.0 1.0 6.0 1.0 0.0 | 7.0
0.0 0.0 0.0 0.0 0.0 0.0 1.0 6.0 1.0 | 8.0
0.0 0.0 0.0 0.0 0.0 0.0 0.0 1.0 6.0 | 9.0
x1 = 0.125000156304433
x2 = 0.249999062173402
x3 = 0.375005470655156
x4 = 0.499968113895664
x5 = 0.625185845970859
x6 = 0.748916810279180
x7 = 0.881313292354062
x8 = 0.963203435596446
x9 = 1.339466094067259
```

MACIERZ 10x10 C = 1

Input:

$$\{6x1+x2+x10=1,\ x1+6x2+x3=2,\ x2+6x3+x4=3,\ x3+6x4+x5=4,\ x4+6x5+x6=5,\ x5+6x6+x7=6,\ x6+6x7+x8=7,\ x7+6x8+x9=8,\ x8+6x9+x10=9,\ x1+x9+6x10=10\}$$

Solution: More digits | Exact form

$$x1 \approx -0.13388,\quad x10 \approx 1.5089,\quad x2 \approx 0.29442,\quad x3 \approx 0.36738,\quad x4 \approx 0.50131,\quad x5 \approx 0.62474,\quad x6 \approx 0.75026,\quad x7 \approx 0.87369,\quad x8 \approx 1.0076,\quad x9 \approx 1.0806$$

```
6.0 1.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 1.0 | 1.0
1.0 6.0 1.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 | 2.0
0.0 1.0 6.0 1.0 0.0 0.0 0.0 0.0 0.0 0.0 | 3.0
0.0 0.0 1.0 6.0 1.0 0.0 0.0 0.0 0.0 0.0 | 4.0
0.0 0.0 0.0 1.0 6.0 1.0 0.0 0.0 0.0 0.0 | 5.0
0.0 0.0 0.0 0.0 1.0 6.0 1.0 0.0 0.0 0.0 | 6.0
0.0 0.0 0.0 0.0 0.0 1.0 6.0 1.0 0.0 0.0 | 7.0
0.0 0.0 0.0 0.0 0.0 0.0 1.0 6.0 1.0 0.0 | 8.0
0.0 0.0 0.0 0.0 0.0 0.0 0.0 1.0 6.0 1.0 | 9.0
1.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 1.0 6.0 | 10.0
x1 = -0.133883515559294
x2 = 0.294417577796468
x3 = 0.367378048780488
x4 = 0.501314129520606
x5 = 0.624737174095879
x6 = 0.750262825904121
x7 = 0.873685870479394
x8 = 1.007621951219512
x9 = 1.080582422203532
x10 = 1.508883515559294
profitz@Aleksanders-MacBook-Pro ~/D/0/3/Z/Metody numeryczne>
```

MACIERZ 10x10 C = 0

Input:

$$\{6x1+x2=1,\ x1+6x2+x3=2,\ x2+6x3+x4=3,\ x3+6x4+x5=4,\ x4+6x5+x6=5,\ x5+6x6+x7=6,\ x6+6x7+x8=7,\ x7+6x8+x9=8,\ x8+6x9+x10=9,\ x9+6x10=10\}$$

Solution: More digits | Exact form

$$x1 \approx 0.12500,\quad x10 \approx 1.4859,\quad x2 \approx 0.25000,\quad x3 \approx 0.37500,\quad x4 \approx 0.50001,\quad x5 \approx 0.62496,\quad x6 \approx 0.75020,\quad x7 \approx 0.87381,\quad x8 \approx 1.0069,\quad x9 \approx 1.0845$$

```
1. fish  /Users/profitz/Documents/0STUDIA/3 semestr/Zestawy
6.0 1.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 | 1.0
1.0 6.0 1.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 | 2.0
0.0 1.0 6.0 1.0 0.0 0.0 0.0 0.0 0.0 0.0 | 3.0
0.0 0.0 1.0 6.0 1.0 0.0 0.0 0.0 0.0 0.0 | 4.0
0.0 0.0 0.0 1.0 6.0 1.0 0.0 0.0 0.0 0.0 | 5.0
0.0 0.0 0.0 0.0 1.0 6.0 1.0 0.0 0.0 0.0 | 6.0
0.0 0.0 0.0 0.0 0.0 1.0 6.0 1.0 0.0 0.0 | 7.0
0.0 0.0 0.0 0.0 0.0 0.0 1.0 6.0 1.0 0.0 | 8.0
0.0 0.0 0.0 0.0 0.0 0.0 0.0 1.0 6.0 1.0 | 9.0
0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 1.0 6.0 | 10.0
x1 = 0.124999970500639
x2 = 0.250000176996167
x3 = 0.374998967522362
x4 = 0.500006017869662
x5 = 0.624964925259668
x6 = 0.750204430572331
x7 = 0.873808491306345
x8 = 1.006944621589598
x9 = 1.084523779156069
x10 = 1.485912703473989
```