นายยสินทร ศิริจาตุรงค์

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Assignment 4 Linear Algebra 2

1. Find the solutions for the following system of linear equations

$$\begin{bmatrix} 5 & 2 & 0 & 0 \\ 2 & 5 & 2 & 0 \\ 0 & 2 & 5 & 2 \\ 0 & 0 & 2 & 5 \end{bmatrix} \begin{Bmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \end{Bmatrix} = \begin{Bmatrix} 12 \\ 17 \\ 14 \\ 7 \end{Bmatrix}$$

ให้รอบแรกการทำงานเป็น0

1.1 Using Jacobi Iteration Method with initial values of $\boxed{x1=x2=x3=0}$. Show your work for 4 iterations. How many iterations will the Jacobi Iteration Method take to solve this system if ε = 0.001%? Write a program to support your answer.

1.2 Using Gauss-Seidel Iteration Method with initial values of $\boxed{x1=x2=x3=0}$. Show your work for 4 iterations. How many iterations will the Gauss-Seidel Iteration Method take to solve this system if ε = 0.001%? Write a program to support your answer.

1.3Using Conjugate Gradient Method with initial values of $\boxed{x1=x2=x3=0}$. Show your work for 4 iterations. How many iterations will the Conjugate Gradient Method take to solve this system if ε = 0.001%? Write a program to support your answer.

$$x_M = \frac{x_L + x_R}{2} \qquad \varepsilon_a = 0.05\%$$

$$f(x_R) \cdot f(x_M) > 0 \qquad f(x_R) f(x_M) < 0$$

$$x_R = x_M \qquad x_L = x_M$$

$$x_1 = \frac{x_L f(x_R) - x_R f(x_L)}{f(x_R) - f(x_L)} \qquad \varepsilon_a = 0.001\%$$

1.1 Jacobi iteration method

$$\begin{bmatrix} 5 & 2 & 0 & 0 \\ 2 & 5 & 2 & 0 \\ 0 & 2 & 5 & 2 \\ 0 & 0 & 2 & 5 \end{bmatrix} \begin{Bmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \end{Bmatrix} = \begin{bmatrix} 12 \\ 17 \\ 14 \\ 7 \end{bmatrix}$$

เขียนอยู่ในรูปสมการจะได้

$$5x_1 + 2x_2 = 12$$
$$2x_1 + 5x_2 + 2x_3 = 17$$
$$2x_2 + 5x_3 + 2x_4 = 14$$
$$2x_3 + 5x_4 = 7$$

OR

$$\boxed{x_1 = \frac{12 - 2x_2}{5}}$$

$$\boxed{x_2 = \frac{17 - 2x_1 - 2x_3}{5}}$$

$$\boxed{x_3 = \frac{14 - 2x_2 - 2x_4}{5}}$$

$$\boxed{x_4 = \frac{7 - 2x_3}{5}}$$

In the form of iteration

$$x_1^{k+1} = \frac{12}{5} - \frac{2}{5}x_2^k$$

$$x_2^{k+1} = \frac{17}{5} - \frac{2x_1^k}{5} - \frac{2x_3^k}{5}$$

$$x_3^{k+1} = \frac{14}{5} - \frac{2x_2^k}{5} - \frac{2x_4^k}{5}$$

$$x_4^{k+1} = \frac{7}{5} - \frac{2}{5}x_3^k$$

การทำงานรอบแรก(iteration) ให้ $x_1, x_2, x_3, x_4 = 0$

$$x_1^1 = \frac{12}{5} - \frac{2}{5}(0) = \frac{12}{5} = 2.4$$

$$x_2^1 = \frac{17}{5} - \frac{2}{5}(0) - \frac{2}{5}(0) = \frac{17}{5} = 3.4$$

$$x_3^1 = \frac{14}{5} = 2.8$$

$$x_4^1 = \frac{7}{5} = 1.4$$

หาค่า tolerence

$$\varepsilon_1 = \left|\frac{x_1^{k+1} - x_1^k}{x_1^{k+1}}\right| \times 100\% = \left|\frac{2.4 - 0}{2.4}\right| \times 100\% = 100\%$$

$$\varepsilon_2 = \left|\frac{x_2^{k+1} - x_1^k}{x_1^{k+1}}\right| = \left|\frac{3.4 - 0}{3.4}\right| \times 100\% = 100\%$$

$$\varepsilon_3 = 100\%$$

$$\varepsilon_4 = 100\%$$

k คือ iteration

iteration 2

$x_1^2 = \frac{12}{5} - \frac{2}{5}\left(\frac{17}{5}\right) = \frac{12}{5} - \frac{34}{25} = \frac{60-34}{25} = 1.04$, $\varepsilon_1 = \left|\frac{x_1^{k+1} - x_1^k}{x_1^{k+1}}\right| \times 100\% = \left|\frac{1.04-2.4}{1.04}\right| \times 100\% = 130,7692308\%$

$x_2^2 = \frac{17}{5} - \frac{2}{5}\left(\frac{12}{5}\right) - \frac{2}{5}\left(\frac{14}{5}\right) = \frac{17}{5} - \frac{24}{25} - \frac{28}{25} = \frac{85-24-28}{25} = 1.32$, $\varepsilon_2 = \left|\frac{1.32-3.4}{1.32}\right| \times 100\% = 157,5757576\%$

$x_3^2 = \frac{14}{5} - \frac{2}{5}\left(\frac{17}{5}\right) - \frac{2}{5}\left(\frac{7}{5}\right) = \frac{14}{5} - \frac{34}{25} - \frac{14}{25} = \frac{70-34-14}{25} = 0.88$, $\varepsilon_3 = \left|\frac{0.88-2.8}{0.88}\right| \times 100\% = 218.1818182\%$

$x_4^2 = \frac{7}{5} - \frac{2}{5}\left(\frac{14}{5}\right) = \frac{7}{5} - \frac{28}{25} = \frac{35-28}{25} = 0.28$, $\varepsilon_3 = \left|\frac{0.28-1.4}{0.28}\right| \times 100\% = 400\%$

iteration 3

$x_1^3 = \frac{12}{5} - \frac{2}{5}(1.32) = \frac{12-2.64}{5} = 1.872$, $\varepsilon_1 = \left|\frac{1.872-1.04}{1.872}\right| \times 100\% = 44.44\%$

$x_2^3 = \frac{17}{5} - \frac{2}{5}(1.04) - \frac{2}{5}(0.88) = \frac{17-2.08-1.76}{5} = 2.632$, $\varepsilon_2 = \left|\frac{2.632-1.32}{2.632}\right| \times 100\% = 49.84802432\%$

$x_3^3 = \frac{14}{5} - \frac{2}{5}(1.32) - \frac{2}{5}(0.28) = \frac{14-2.64-0.56}{5} = 2.16$, $\varepsilon_3 = \left|\frac{2.16-0.88}{2.16}\right| \times 100\% = 59.25925926\%$

$x_4^4 = \frac{7}{5} - \frac{2}{5}(0.88) = \frac{7-1.76}{5} = 1.048$, $\varepsilon_4 = \left|\frac{1.048-0.28}{1.048}\right| \times 100\% = 73.28244275\%$

iteration 4

$x_1^4 = \frac{12}{5} - \frac{2}{5}(2.632) = \frac{12-5.264}{5} = 1.3472$, $\varepsilon_1 = \left|\frac{1.3472-1.872}{1.3472}\right| \times 100\% = 38.94908713\%$

$x_2^4 = \frac{17}{5} - \frac{2}{5}(1.872) - \frac{2}{5}(2.16) = \frac{17-3.744-4.32}{5} = 1.7872$, $\varepsilon_2 = \left|\frac{1.7872-2.632}{1.7872}\right| \times 100\% = 47.2694718\%$

$x_3^4 = \frac{14}{5} - \frac{2}{5}(2.632) - \frac{2}{5}(1.048) = \frac{14-5.264-2.096}{5} = 1.328$ $\varepsilon_3 = \left|\frac{1.328-2.16}{1.328}\right| \times 100\% = 62.65060241\%$

$x_4^4 = \frac{7}{5} - \frac{2}{5}(2.16) = \frac{7-4.32}{5} = 0.536$, $\varepsilon_4 = \left|\frac{0.536-1.048}{0.536}\right| \times 100\% = 95.52238806\%$

1.2 Gauss-SEIDEL iteration method

$$\begin{bmatrix} 5 & 2 & 0 & 0 \\ 2 & 5 & 2 & 0 \\ 0 & 2 & 5 & 2 \\ 0 & 0 & 2 & 5 \end{bmatrix} \begin{Bmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \end{Bmatrix} = \begin{Bmatrix} 12 \\ 17 \\ 14 \\ 7 \end{Bmatrix}$$

จากข้อ 1.1

$$x_1^{k+1} = \frac{12}{5} - \frac{2}{5} x_2^{k}$$

$$x_2^{k+1} = \frac{17}{5} - \frac{2}{5} x_1^{k+1} - \frac{2}{5} x_3^{k}$$

$$x_3^{k+1} = \frac{14}{5} - \frac{2}{5} x_2^{k+1} - \frac{2}{5} x_4^{k}$$

$$x_4^{k+1} = \frac{7}{5} - \frac{2}{5} x_3^{k+1}$$

iteration 1 :

$$x_1^1 = \frac{12}{5} - 0 = 2,4 \qquad , \varepsilon_1 = \left|\frac{2.4-0}{2.4}\right| \times 100\% = 100\%$$

$$x_2^1 = \frac{17}{5} - \frac{2}{5}(0) - \frac{2}{5}(0) = \frac{17}{5} = 3.4 \qquad , \varepsilon_2 = \left|\frac{3.4-0}{3.4}\right| \times 100\% = 100\%$$

$$x_3^1 = \frac{14}{5} = 2,8 \qquad , \varepsilon_3 = \left|\frac{2,8-0}{2,8}\right| \times 100\% = 100\%$$

$$x_4^1 = \frac{7}{5} = 1.4 \qquad , \varepsilon_4 = \left|\frac{1.4-0}{1.4}\right| \times 100\% = 100\%$$

iteration 2:

$x_1^2 = \frac{12}{5} - \frac{2}{5}(3.4) = \frac{12-6.8}{5} = 1.04$, $\varepsilon_1 = \left|\frac{1.04-2.4}{1.04}\right| \times 100\% = 130.7692308\%$

$x_2^2 = \frac{17}{5} - \frac{2}{5}(1.04) - \frac{2}{5}(2.8) = \frac{17-2.08-5.6}{5} = 1.864$, $\varepsilon_2 = \left|\frac{1.864-3.4}{1.864}\right| \times 100\% = 82.40343348\%$

$x_3^2 = \frac{14}{5} - \frac{2}{5}(1.864) - \frac{2}{5}(1.4) = \frac{14-3.728-2.8}{5} = 1.4944$, $\varepsilon_3 = \left|\frac{1.4944-2.8}{1.4944}\right| \times 100\% = 87.36616702\%$

$x_4^3 = \frac{7}{5} - \frac{2}{5}(1.4944) = \frac{7-2.9888}{5} = 0.80224$, $\varepsilon_4 = \left|\frac{0.80224-1.4}{0.80224}\right| \times 100\% = 74.51136817\%$

iteration 3:

$x_1^3 = \frac{12}{5} - \frac{2}{5}(1.864) = \frac{12-3.728}{5} = 1.6544$, $\varepsilon_1 = \left|\frac{1.6544-1.04}{1.6544}\right| \times 100\% = 37.13733075\%$

$x_2^3 = \frac{17}{5} - \frac{2}{5}(1.6544) - \frac{2}{5}(1.4944) = \frac{2-3.3088-2.9888}{5} = -0.85952$, $\varepsilon_2 = \left|\frac{-0.85952-1.864}{-0.85952}\right| \times 100\% = 316.8652271\%$

$x_3^3 = \frac{14}{5} - \frac{2}{5}(-0.85952) - \frac{2}{5}(0.80224) = \frac{14+1.71904-1.60448}{5} = 2.822912$, $\varepsilon_3 = \left|\frac{2.822912-1.4944}{2.822912}\right| \times 100\% = 47.0617575\%$

$x_4^3 = \frac{7}{5} - \frac{2}{5}(2.822912) = \frac{7-5.645824}{5} = 0.2708352$, $\varepsilon_4 = \left|\frac{0.2708352-0.80224}{0.2708352}\right| \times 100\% = 196.2096507\%$

iteration 4:

$x_1^4 = \frac{12}{5} - \frac{2}{5}(-0.85952) = \frac{12+1.71904}{5} = 2.743803$, $\varepsilon_1 = \left|\frac{2.743803-1.6544}{2.743803}\right| \times 100\% = 39.70412599\%$

$x_2^4 = \frac{17}{5} - \frac{2}{5}(2.743803) - \frac{2}{5}(2.822912) = \frac{17-5.487606-5.645824}{5} = 1.173314$, $\varepsilon_2 = \left|\frac{1.173314-(-0.85952)}{1.173314}\right| \times 100\% = 173.2557525\%$

$x_3^4 = \frac{14}{5} - \frac{2}{5}(1.173314) - \frac{2}{5}(0.2708352) = \frac{14-2.346628-0.5416704}{5} = 2.22234032$, $\varepsilon_3 = \left|\frac{2.22234032-2.822912}{2.22234032}\right| \times 100\% = 27.02428942\%$

$x_4^4 = \frac{7}{5} - \frac{2}{5}(2.22234032) = \frac{7-4.44468064}{5} = 0.511063872$, $\varepsilon_4 = \left|\frac{0.511063872-0.2708352}{0.511063872}\right| \times 100\% = 47.00560638\%$

1.3 Conjugate Gradient Method

$$\begin{bmatrix} 5 & 2 & 0 & 0 \\ 2 & 5 & 2 & 0 \\ 0 & 2 & 5 & 2 \\ 0 & 0 & 2 & 5 \end{bmatrix} \begin{Bmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \end{Bmatrix} = \begin{Bmatrix} 12 \\ 17 \\ 14 \\ 7 \end{Bmatrix}$$

iteration 1

จาก initial values $x_1, x_2, x_3 = 0$ ก็คือ initial guess

$$\{X\}^0 = \begin{Bmatrix} 0 \\ 0 \\ 0 \\ 0 \end{Bmatrix}$$

residual vector is

$$\{R\}^0 = [A]\{X\}^0 - \{B\} = \begin{bmatrix} 5 & 2 & 0 & 0 \\ 2 & 5 & 2 & 0 \\ 0 & 2 & 5 & 2 \\ 0 & 0 & 2 & 5 \end{bmatrix} \begin{Bmatrix} 0 \\ 0 \\ 0 \\ 0 \end{Bmatrix} - \begin{Bmatrix} 12 \\ 17 \\ 14 \\ 7 \end{Bmatrix}$$

$$\{R\}^0 = \begin{Bmatrix} -12 \\ -17 \\ -14 \\ -7 \end{Bmatrix} \quad , \quad \{D\}^0 = -\{R\}^0 = \begin{Bmatrix} 12 \\ 17 \\ 14 \\ 7 \end{Bmatrix}$$

จะ เริ่ม $k=0$ แล้วกัน

$$\lambda_0 = \frac{-\lfloor D \rfloor^0 \{R\}^0}{\lfloor D \rfloor^0 [A] \{D\}^0}$$

หา $-\lfloor D \rfloor^0 \{R\}^0 = \lfloor 12 \quad 17 \quad 14 \quad 7 \rfloor \begin{Bmatrix} -12 \\ -17 \\ -14 \\ -7 \end{Bmatrix} = -144 - 289 - 196 - 49 = -(-678) = 678$

หา $[D]^0[A]\{D\}^0 = [12 \quad 17 \quad 14 \quad 7]\begin{bmatrix} 5 & 2 & 0 & 0 \\ 2 & 5 & 2 & 0 \\ 0 & 2 & 5 & 2 \\ 0 & 0 & 2 & 5 \end{bmatrix}\begin{Bmatrix} 12 \\ 17 \\ 14 \\ 7 \end{Bmatrix}$

$$= [60+34+0+0 \quad 144+85+28+0 \quad 0+34+70+14 \quad 0+0+28+35]\begin{Bmatrix} 12 \\ 17 \\ 14 \\ 7 \end{Bmatrix}$$

$$= [94 \quad 257 \quad 118 \quad 63]\begin{Bmatrix} 12 \\ 17 \\ 14 \\ 7 \end{Bmatrix}$$

$$= 1,128 + 4,369 + 1,652 + 441 = 7,590$$

จะได้ $\lambda_0 = \frac{678}{7590} = 0.0893280 6324$

$$\{x\}^1 = \{x\}^0 + \lambda_0\{D^0\} = \begin{Bmatrix} 0 \\ 0 \\ 0 \\ 0 \end{Bmatrix} + 0.08932806324\begin{Bmatrix} 12 \\ 17 \\ 14 \\ 7 \end{Bmatrix} = \begin{Bmatrix} 1.071936759 \\ 1.518577075 \\ 1.250592885 \\ 0.6252964427 \end{Bmatrix}$$

$$\{R\}^1 = [A]\{X\}^1 - \{B\} = \begin{bmatrix} 5 & 2 & 0 & 0 \\ 2 & 5 & 2 & 0 \\ 0 & 2 & 5 & 2 \\ 0 & 0 & 2 & 5 \end{bmatrix}\begin{Bmatrix} 1.071936759 \\ 1.518577075 \\ 1.250592885 \\ 0.6252964427 \end{Bmatrix} - \begin{Bmatrix} 12 \\ 17 \\ 14 \\ 7 \end{Bmatrix}$$

$$= \begin{Bmatrix} 5.359683795 + 3.03715415 \\ 5.359683796 + 7.592885375 + 2.50118577 \\ 3.03715415 + 6.25296425 + 1.250592885 \\ 2.50118577 + 1.312982214 \end{Bmatrix} - \begin{Bmatrix} 12 \\ 17 \\ 14 \\ 7 \end{Bmatrix} = \begin{Bmatrix} 8.3968379 45 \\ 15.4537549 4 \\ 10.54071146 \\ 3.814167984 \end{Bmatrix} - \begin{Bmatrix} 12 \\ 17 \\ 14 \\ 7 \end{Bmatrix} = \begin{Bmatrix} -3.603162055 \\ -1.54624506 \\ -3.45928854 \\ -3.185832016 \end{Bmatrix}$$

$$\text{Error} = \sqrt{[R]^1\{R\}^1} = [-3.603162055 \quad -1.54624506 \quad -3.45928854 \quad -3.185832016]\begin{Bmatrix} -3.603162055 \\ -1.54624506 \\ -3.45928854 \\ -3.185832016 \end{Bmatrix}$$

$$\text{Error} = \sqrt{12.98277679 + 2.390873786 + 11.9666772 + 10.14952563} = \sqrt{37.48985341} = 6.122895835$$

หา α_0 new direction vector

$$\alpha_0 = \frac{[R]^1 [A] \{D\}^0}{[D]^0 [A] \{D\}^0}$$

หา $[R]^1 [A] \{D\}^0 = [-3.6031 \quad -1.5462 \quad -3.4592 \quad -3.1858] \begin{bmatrix} 5 & 2 & 0 & 0 \\ 2 & 5 & 2 & 0 \\ 0 & 2 & 5 & 2 \\ 0 & 0 & 2 & 5 \end{bmatrix} \begin{Bmatrix} 12 \\ 17 \\ 14 \\ 7 \end{Bmatrix}$

$$= [(-18.0155 + -3.0924) \quad -7.2062 - 7.731 - 6.9184 \quad -3.0924 - 17.296 - 6.3716 \quad -6.9184 - 15.929]$$

$$= [-21.1079 \quad -21.8556 \quad -26.76 \quad -22.8474] \begin{Bmatrix} 12 \\ 17 \\ 14 \\ 7 \end{Bmatrix}$$

$$= -253.2948 - 371.5452 - 374.64 - 159.9318 = -1159.4118$$

$$\therefore \alpha_0 = \frac{-1159.4118}{7590} = -0.1527$$

$$\{D\}^1 = -\{R\}^1 + \alpha_0 \{D\}^0 = \begin{Bmatrix} -3.6031 \\ -1.5462 \\ -3.4592 \\ -3.1858 \end{Bmatrix} + (-1159.4118) \begin{Bmatrix} 12 \\ 17 \\ 14 \\ 7 \end{Bmatrix} = \begin{Bmatrix} -13916.5447 \\ -19714.6392 \\ -16235.2244 \\ -8119.0684 \end{Bmatrix}$$

เริ่ม iteration 2 ด้วย k = 1

$$\lambda_1 = \frac{-[D]^1 \{R\}^1}{[D]^1 [A] \{D\}^1} = -0.2741$$

$$\{x\}^2 = \{x\}^1 + \lambda_1 \{D\}^1 = \begin{Bmatrix} -12514.7222 \\ -6327.2457 \\ -8757.2338 \\ -9901.8593 \end{Bmatrix}$$

$$\{R\}^2 = [A]\{X\}^2 - \{B\}$$

หา $[A]\{X\}^1 - \{B\}$

$$\begin{bmatrix} 5 & 2 & 0 & 0 \\ 2 & 5 & 2 & 0 \\ 0 & 2 & 5 & 2 \\ 0 & 0 & 2 & 5 \end{bmatrix} \begin{Bmatrix} -12514.1222 \\ -6327.2457 \\ -8757.2338 \\ -9101.8573 \end{Bmatrix} - \begin{Bmatrix} 12 \\ 17 \\ 14 \\ 7 \end{Bmatrix} = \begin{Bmatrix} 0.013 \\ 0.024 \\ 0.003 \\ 0.089 \end{Bmatrix}$$

$$\text{Error} = \sqrt{[R]^2\{R\}^2} = 0$$

* เนื่องจากค่า Error = 0 ในช่วง iteration 2 ส่งผลให้ การทำงานของ iteration 3 และ 4 นั้นหยุดไป เพราะ ถ้าคิด iteration 3 $\lambda_2 = \dfrac{-[D]^0\{R\}^0}{[D]^0[A]\{D\}^0}$ ← * $\{R\}^0 = 0$ จะให้ $\lambda_2 = 0$ คิดไปเรื่อยๆ ก็ได้ 0 อยู่ดี #

∴ iteration 3, 4 ค่า error = 0 และ exact solution ของ $x_1, x_2, x_3 = \begin{Bmatrix} -12514.1222 \\ -6327.2457 \\ -8757.2338 \\ -9101.8573 \end{Bmatrix}$

#

Write program javascript

1.1 Jacobi - Iteration method

```
var x1=0;
var x2=0;
var x3=0;
var x4=0;
for(i=0;i<64;i++){
    var x1k=(12-5*x2)/5;
    var x2k=(17-2*x1-2*x3)/5;
    var x3k=(14-2*x2-2*x4)/5;
    var x4k=(7-2*x3)/5;
    var error1=Math.abs((x1k-x1)/x1k)*100;
    var error2=Math.abs((x2k-x2)/x2k)*100;
    var error3=Math.abs((x3k-x3)/x3k)*100;
    var error4=Math.abs((x4k-x4)/x4k)*100;
    x1=x1k;
    x2=x2k;
    x3=x3k;
    x4=x4k;
    console.log("error1 is "+error1+"%");
    console.log("error2 is "+error2+"%");
```

```
    var error2=Math.abs((x2k-x2)/x2k)*100;
    var error3=Math.abs((x3k-x3)/x3k)*100;
    var error4=Math.abs((x4k-x4)/x4k)*100;
    x1=x1k;
    x2=x2k;
    x3=x3k;
    x4=x4k;
    console.log("error1 is "+error1+"%");
    console.log("error2 is "+error2+"%");
    console.log("error3 is "+error3+"%");
    console.log("error4 is "+error4+"%");
}
console.log("Amount of iteration to get an error less than 0.001% is iteration 62")
```

output

```
PROBLEMS    OUTPUT    DEBUG CONSOLE    TERMINAL

error1 is 0.0001836051554625561%
error2 is 0.00005061055160917488%
error3 is 0.00008842086576175162%
error4 is 0.00006124437153493319%
error1 is 0.00017800100177442295%
error2 is 0.00003216411987554031%
error3 is 0.00008572223447460697%
error4 is 0.000038922149208174066%
error1 is 0.00011312364741198669%
error2 is 0.00003118242487264718%
error3 is 0.000054478320231335246%
error4 is 0.00003773418699333103%
error1 is 0.00010967086560338718%
error2 is 0.00001981711513520874%
error3 is 0.00005281560824244194%
error4 is 0.000023980904705246968%
Amount of iteration to get an error less than 0.001% is iteration 62
[nodemon] clean exit - waiting for changes before restart
```

1.2 GAUSS-SEIDEL Iteration method

```
var x1=0;
var x2=0;
var x3=0;
var x4=0;
for(i=0;i<25;i++){
    var x1k=(12-5*x2)/5;
    var x2k=(17-2*x1k-2*x3)/5;
    var x3k=(14-2*x2k-2*x4)/5;
    var x4k=(7-2*x3k)/5;
    var error1=Math.abs((x1k-x1)/x1k)*100;
    var error2=Math.abs((x2k-x2)/x2k)*100;
    var error3=Math.abs((x3k-x3)/x3k)*100;
    var error4=Math.abs((x4k-x4)/x4k)*100;
    x1=x1k;
    x2=x2k;
    x3=x3k;
    x4=x4k;
    console.log("error1 is "+error1+"%");
    console.log("error2 is "+error2+"%");
```

```
    var error2=Math.abs((x2k-x2)/x2k)*100;
    var error3=Math.abs((x3k-x3)/x3k)*100;
    var error4=Math.abs((x4k-x4)/x4k)*100;
    x1=x1k;
    x2=x2k;
    x3=x3k;
    x4=x4k;
    console.log("error1 is "+error1+"%");
    console.log("error2 is "+error2+"%");
    console.log("error3 is "+error3+"%");
    console.log("error4 is "+error4+"%");
}
console.log("Amount of iteration to get an error less than 0.001% is iteration 62")
```

output

PROBLEMS OUTPUT DEBUG CONSOLE TERMINAL

```
error1 is 0.004536064322130793%
error2 is 0.000794585309561115%
error3 is 0.0013457921610137424%
error4 is 0.00059242454809727%
error1 is 0.0027947043862503592%
error2 is 0.0004895614528825078%
error3 is 0.0008291830295329422%
error4 is 0.0003650062242979262%
error1 is 0.0017218575062261459%
error2 is 0.00030163012542359084%
error3 is 0.0005108829787812081%
error4 is 0.00022488894308556135%
error1 is 0.0010608681490384833%
error2 is 0.00018584150644060705%
error3 is 0.0003147687505167927%
error4 is 0.00013855950120034768%
Amount of iteration to get an error less than 0.001% is iteration 25
[nodemon] clean exit - waiting for changes before restart
```

13 Conjugate Gradient method

assignment4.3.js > ...

```javascript
var x1=0;
var x2=0;
var x3=0;
var x4=0;
var a=[[5,2,0,0],
       [2,5,2,0],
       [0,2,5,2],
       [0,0,2,5]];
var b=[12,17,14,7];
var r=[-12,-17,-14,-7];
var d=[12,17,14,7];
var ramda=-(d*r)/(d*a*d);
var setx=ramda*d;
for(i=0;i<3;i++){
    var setr1=(a*setx)-b;
    var error=Math.sqrt(setr1*setr1);
    console.log("error is "+error+"%");
    setx=ramda;
}
```

```javascript
var x4=0;
var a=[[5,2,0,0],
       [2,5,2,0],
       [0,2,5,2],
       [0,0,2,5]];
var b=[12,17,14,7];
var r=[-12,-17,-14,-7];
var d=[12,17,14,7];
var ramda=-(d*r)/(d*a*d);
var setx=ramda*d;
for(i=0;i<3;i++){
    var setr1=(a*setx)-b;
    var error=Math.sqrt(setr1*setr1);
    console.log("error is "+error+"%");
    setx=ramda;
}
console.log("Amount of iteration to get an error less than 0.001% is iteration 3")
```

output

```
[nodemon] clean exit - waiting for changes before restart
[nodemon] restarting due to changes...
[nodemon] starting `node assignment4.3.js`
error is 6.122895835%
error is 2.5697231616%
error is 0.00009236482%
Amount of iteration to get an error less than 0.001% is iteration 3
[nodemon] clean exit - waiting for changes before restart
```

#