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TOSHKENT AXBOROT TEXNOLOGIYALARI UNIVERSITETI

# CHIZIQLI ALGEBRA

MTH 1234

MAVZU

## CHIZIQLI ALGEBRAIK TENGLAMALAR SISTEMASI VA ULARNI YECHISH USULLARI

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**OLIY MATEMATIKA KAFEDRASI**

# CHIZIQLI ALGEBRAIK TENGLAMALAR SISTEMASI VA ULARNI YECHISH USULLARI

1. Chiziqli algebraik tenglamalar sistemalari va ularning turlari

2. Chiziqli tenglamalar sistemasining yechimi mavjudligini zaruriylik va yetarlilik shartlari (Kroneker-Kapelli teoremasi)

3. Chiziqli tenglamalar sistemasini Kramer usulida yechish

# Chiziqli tenglamalar sistemasini qayerda qo‘llaymiz?

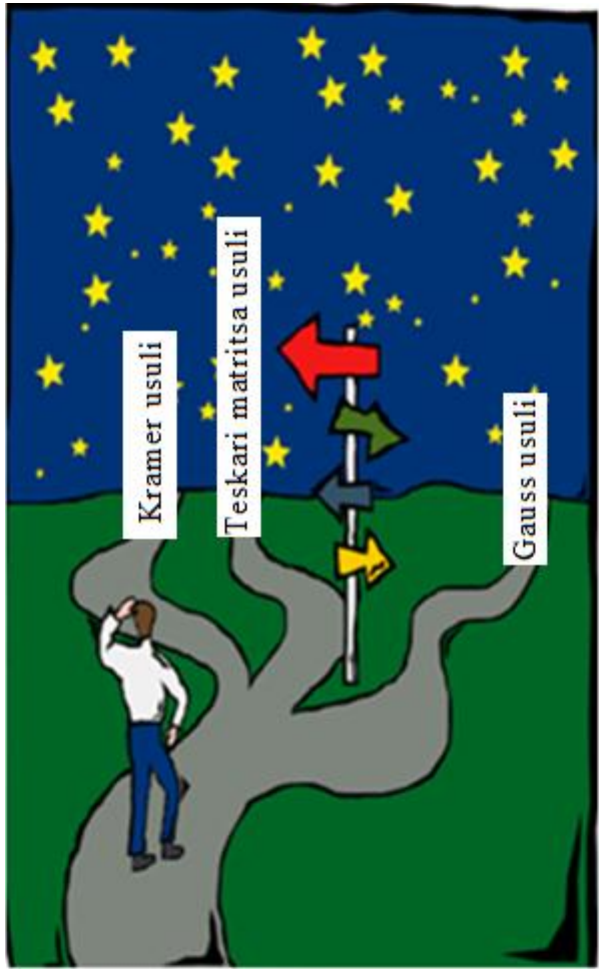
**1-misol.** Korxona 3 xildagi xom ashyo ishlatib, 3 turdagi mahsulot ishlab chiqaradi. Ishlab chiqarish tavsiflari quyida berilgan:

| Xom ashyo turlari | Mahsulot turlari bo‘yicha xom ashyo sarflari | | | Xom ashyo zahirasi |
|---|---|---|---|---|
| | A | B | C | |
| **1** | 5 | 12 | 7 | 2000 |
| **2** | 10 | 6 | 8 | 1660 |
| **3** | 9 | 11 | 4 | 2070 |

Xom ashyo zahirasi to‘la sarflansa, mahsulot turlari bo‘yicha ishlab chiqarish hajmini aniqlashning **matematik modelini** tuzing.

**Yechilishi:** Bu masalaning matematik modeli quyidagi uch noma’lumli chiziqli tenglamalar sistemasidan iborat bo‘ladi:

$$\begin{cases} 5x_1+12x_2+7x_3=2000 \\ 10x_1+6x_2+8x_3=1660 \\ 9x_1+11x_2+4x_3=2070 \end{cases}$$




$$\begin{cases} 5x_1 + 12x_2 + 7x_3 = 2000 \\ 10x_1 + 6x_2 + 8x_3 = 1660 \\ 9x_1 + 11x_2 + 4x_3 = 2070 \end{cases}$$

**chiziqli algebraik tenglamalar sistemasini qanday yechamiz?**

# 1. Chiziqli algebraik tenglamalar sistemalari va ularning turlari

Bir nechta tenglamalar birgalikda qaralsa, ularga **tenglamalar sistemasi** deyiladi.

$$\begin{cases} a_{11}x_1 + a_{12}x_2 + \ldots + a_{1n}x_n = b_1, \\ a_{21}x_1 + a_{22}x_2 + \ldots + a_{2n}x_n = b_2, \\ \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \\ a_{m1}x_1 + a_{m2}x_2 + \ldots + a_{mn}x_n = b_m \end{cases}$$

Ushbu sistemaga *n* ta noma'lumli *m* ta **chiziqli algebraik tenglamalar sistemasi** (yoki oddiygina **chiziqli tenglamalar sistemasi**) deyiladi.

Bu yerda $x_1, x_2, \ldots, x_n -$ noma'lumlar;

$a_{11}, a_{12}, \ldots, a_{mn} -$ noma'lumlar oldidagi koeffitsiyentlar;

$b_1, b_2, \ldots, b_m -$ ozod hadlar.

$a_{ij}$ — $i$- tenglama raqami, $j$- noma'lum raqami

# Chiziqli algebraik tenglamalar sistemalarini 2 xil guruhga ajratish mumkin

**1) Bir jinsli bo‘lmagan chiziqli algebraik tenglamalar sistemasi**

$$\begin{cases} a_{11}x_1 + a_{12}x_2 + \ldots + a_{1n}x_n = b_1, \\ a_{21}x_1 + a_{22}x_2 + \ldots + a_{2n}x_n = b_2, \\ \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \\ a_{m1}x_1 + a_{m2}x_2 + \ldots + a_{mn}x_n = b_m \end{cases}$$

**2) Bir jinsli chiziqli algebraik tenglamalar sistemasi**

$$\begin{cases} a_{11}x_1 + a_{12}x_2 + \ldots + a_{1n}x_n = 0, \\ a_{21}x_1 + a_{22}x_2 + \ldots + a_{2n}x_n = 0, \\ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \\ a_{m1}x_1 + a_{m2}x_2 + \ldots + a_{mn}x_n = 0. \end{cases}$$

# Chiziqli algebraik tenglamalar sistemasining matritsaviy shakli (matritsaning tatbig‘i)

$$\begin{cases} a_{11}x_1 + a_{12}x_2 + \ldots + a_{1n}x_n = b_1, \\ a_{21}x_1 + a_{22}x_2 + \ldots + a_{2n}x_n = b_2, \\ \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \\ a_{m1}x_1 + a_{m2}x_2 + \ldots + a_{mn}x_n = b_m \end{cases} \qquad \textbf{(1)}$$

$$A = \begin{pmatrix} a_{11} & a_{12} & \ldots & a_{1n} \\ a_{21} & a_{22} & \ldots & a_{2n} \\ \ldots & \ldots & \ldots & \ldots \\ a_{m1} & a_{m2} & \ldots & a_{mn} \end{pmatrix} \qquad X = \begin{pmatrix} x_1 \\ x_2 \\ \ldots \\ x_n \end{pmatrix} \qquad B = \begin{pmatrix} b_1 \\ b_2 \\ \ldots \\ b_m \end{pmatrix}$$

$AX = B$ tenglamalar sistemasining matritsaviy shakli

# Chiziqli algebraik tenglamalar sistemasining yechimi

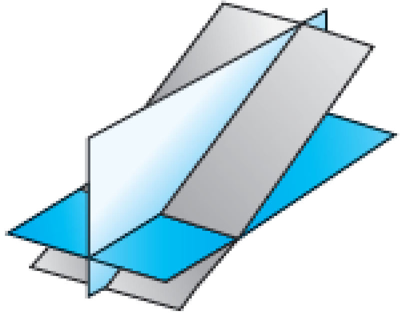
Agar $\alpha_1, \alpha_2, \ldots, \alpha_n$ sonlar $x_1, x_2, \ldots, x_n$ larning o‘rniga qo‘yilganda (1) sistemadagi tenglamalarni to‘g‘ri tenglikka aylantirsa, bu sonlarga (1) sistemaning **yechimlari tizimi** deyiladi:

$$X = \begin{pmatrix} \alpha_1 \\ \alpha_2 \\ \ldots \\ \alpha_n \end{pmatrix} \quad \text{yoki} \quad X = (\alpha_1, \alpha_2, \ldots, \alpha_n)^T$$

**Tenglamalar sistemasini yechish** deganda uning barcha yechimlarini topish yoki yechimga ega emasligini isbotlash tushuniladi.

# Chiziqli algebraik tenglamalar sistemalarining quyidagi turlari mavjud

$$\begin{cases} x+y+z=1, \\ 3x+3y+3z=5 \end{cases}$$



yagona yechim

Agar (1) sistema yechimga ega bo‘lsa, u

**birgalikdagi sistema,**

umuman yechimga ega bo‘lmasa, **birgalikda**

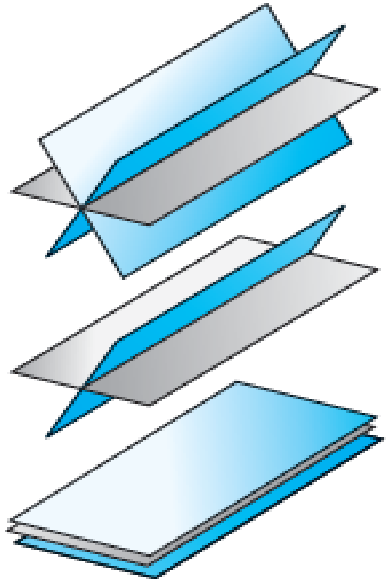
**bo‘lmagan sistema** deyiladi.

Agar sistema yagona yechimga ega bo‘lsa,

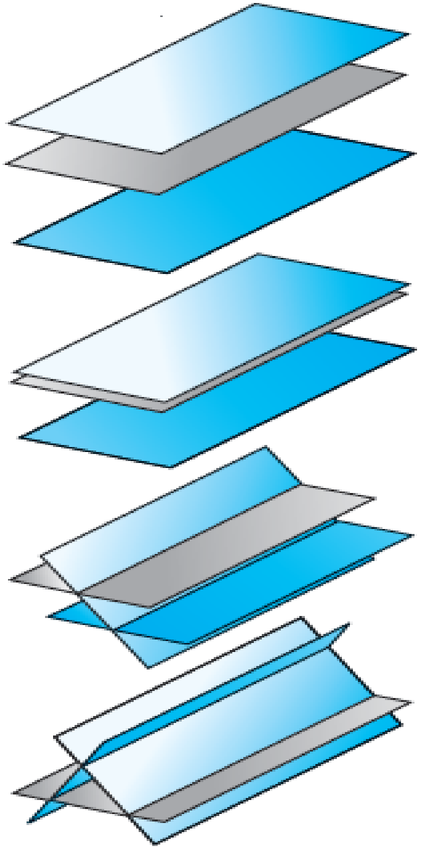
**aniq sistema,**

cheksiz ko‘p yechimga ega bo‘lsa, **aniqmas**

**sistema** deyiladi



cheksiz ko‘p yechim



yechimi yo‘q

# Ekvivalent sistemalar

Birgalikda bo‘lgan tenglamalar sistemalari bir xil yechimga ega bo‘lsa, bunday sistemalar **ekvivalent sistemalar** deyiladi.

$$\begin{cases} 2x+3y=5 \\ x+2y=3 \end{cases} \longleftarrow \textbf{ekvivalent sistemalar} \longrightarrow \begin{cases} 3x-2y=1 \\ 3x+y=4 \end{cases}$$

**Izoh:** Berilgan tenglamalar sistemasining birorta tenglamasini noldan farqli songa ko‘paytirib, boshqa tenglamasiga hadma-had qo‘shish bilan berilgan sistemaga ekvivalent sistema hosil qilish mumkin.

$$\begin{cases} x+3y=5 \\ 3x-y=5 \end{cases} \qquad \begin{cases} x+3y=5 \quad \big|\cdot 3) \\ 3x-y=5 \end{cases} \qquad -\begin{cases} 3x+9y=15 \\ 3x-y=5 \end{cases} \qquad \begin{cases} x+3y=5 \\ 10y=10 \end{cases}$$

# 2. Chiziqli tenglamalar sistemasining yechimi mavjudligini zaruriylik va yetarlilik shartlari

**1-teorema (Kroneker-Kapelli teoremasi).** Chiziqli tenglamalar sistemasi birgalikda bo‘lishi uchun uning *A* asosiy va *A*|*B* kengaytirilgan matritsalarining ranglari teng bo‘lishi zarur va yetarlidir: $rank(A) = rank(A/B)$

$$A = \begin{pmatrix} a_{11} & a_{12} & \dots & a_{1n} \\ a_{21} & a_{22} & \dots & a_{2n} \\ \dots & \dots & \dots & \dots \\ a_{m1} & a_{m2} & \dots & a_{mn} \end{pmatrix}$$

$$A/B = \begin{pmatrix} a_{11} & a_{12} & \dots & a_{1n} & b_1 \\ a_{21} & a_{22} & \dots & a_{2n} & b_2 \\ \dots & \dots & \dots & \dots & \dots \\ a_{m1} & a_{m2} & \dots & a_{mn} & b_m \end{pmatrix}$$

**Natija:** 1) Tenglamalar sistemasi birgalikda emas:

$$rank(A) \neq rank(A/B)$$

2) Tenglamalar sistemasi yagona yechimga ega, *n*-noma’lumlar soni, *m*-tenglamalar soni:

$$rank(A) = rank(A/B) = k = n$$

3) Tenglamalar sistemasi cheksiz ko‘p yechimga ega:

$$rank(A) = rank(A/B) = k < n$$

# Bazis tenglamalar, bazis noma’lumlar, ozod noma’lumlar

$rank(A) = rank(A/B) = k < n$ ushbu holda $n$-$k$ ta tenglama o‘zaro chiziqli erkli bo‘ladi, ular **bazis satrlar** hosil qiladi.

Bazis satrlarga mos bo‘lgan tenglamalar berilgan sistemaning **bazis tenglamalari** deyiladi.

Bazis tenglamalar bazis sistemani tashkil etadi.

Bazis ustunlarda qatnashgan noma’lumlarni **bazis o‘zgaruvchilar**, qolganlarini **ozod o‘zgaruvchilar** deb ataymiz.

**2-teorema.** Chiziqli tenglamalar sistemasi o‘zining bazis tenglamalar sistemasiga ekvivalent.

# Tenglamalar soni noma'lumlar sonidan kichik

**2-misol.** $\begin{cases} x_1 - 2x_2 + x_3 + x_4 = 1 \\ x_1 - 2x_2 + x_3 - x_4 = -1 \\ x_1 - 2x_2 + x_3 + 5x_4 = 5 \end{cases}$ **tenglamalar sistemasini yeching.**

Asosiy matritsa rangini hisoblaymiz:

$$A = \begin{pmatrix} 1 & -2 & 1 & 1 \\ 1 & -2 & 1 & -1 \\ 1 & -2 & 1 & 5 \end{pmatrix} \cdot (-1) \Rightarrow \begin{pmatrix} 1 & -2 & 1 & 1 \\ 0 & 0 & 0 & -2 \\ 0 & 0 & 0 & 4 \end{pmatrix} \cdot 2 \Rightarrow \begin{pmatrix} 1 & -2 & 1 & 1 \\ 0 & 0 & 0 & -2 \\ 0 & 0 & 0 & 0 \end{pmatrix} \div (-2) \Rightarrow \begin{pmatrix} 1 & -2 & 1 & 1 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

$$rankA = 2$$

Endi kengaytirilgan matritsa rangini hisoblaymiz:

$$A/B = \left(\begin{array}{cccc|c} 1 & -2 & 1 & 1 & 1 \\ 1 & -2 & 1 & -1 & -1 \\ 1 & -2 & 1 & 5 & 5 \end{array}\right) \cdot (-1) \Rightarrow \left(\begin{array}{cccc|c} 1 & -2 & 1 & 1 & 1 \\ 0 & 0 & 0 & -2 & -2 \\ 0 & 0 & 0 & 4 & 4 \end{array}\right) \cdot 2 \Rightarrow \left(\begin{array}{cccc|c} 1 & -2 & 1 & 1 & 1 \\ 0 & 0 & 0 & -2 & -2 \\ 0 & 0 & 0 & 0 & 0 \end{array}\right) \div (-2) \Rightarrow$$

$$\Rightarrow \left(\begin{array}{cccc|c} 1 & -2 & 1 & 1 & 1 \\ 0 & 0 & 0 & 1 & 1 \end{array}\right) \qquad \Delta = \begin{vmatrix} 1 & 1 \\ 0 & 1 \end{vmatrix} \neq 0$$

$$rank(A/B) = 2$$

Sistema birgalikda, chunki $rankA = rank(A/B)$

Biroq bazis tenglamalar soni noma'lumlar sonidan kishik bo'lganligi uchun sistema cheksiz ko'p yechimga ega.

Sistemaning yechimlarini topamiz. 3-tenglama bazis tenglamalarning chiziqli kombinatsiyasidan iborat, shuning uchun 3-tenglamani tashlab yuboramiz.

$$\begin{cases} x_1 - 2x_2 + x_3 + x_4 = 1 \\ x_1 - 2x_2 + x_3 - x_4 = -1 \end{cases} \qquad \Delta = \begin{vmatrix} 1 & 1 \\ 0 & 1 \end{vmatrix} \neq 0$$

Noldan farqli minor 3- va 4-noma'lumlar oldidagi koeffitsiyentlardan tuzilgan.

*Demak,* $x_3$ va $x_4$ lar bazis noma'lumlar, $x_1$ va $x_2$ lar "ozod noma'lumlar" bo'ladi.

$$\begin{cases} x_3 + x_4 = 1 - x_1 + 2x_2 \\ x_3 - x_4 = -1 - x_1 + 2x_2 \end{cases}$$

Sistema cheksiz ko'p yechimga ega bo'lganligi uchun $x_1$ va $x_2$ larga ixtiyoriy qiymatlar berib, yechimlardan ba'zilarini ko'rsatish mumkin:

$$\begin{matrix} x_1 = 0 \\ x_2 = 1 \end{matrix} \Rightarrow \begin{cases} x_3 + x_4 = 3 \\ x_3 - x_4 = 1 \end{cases} \Rightarrow \begin{cases} x_3 = 2 \\ x_4 = 1 \end{cases} \Rightarrow \begin{cases} x_1 = 0 \\ x_2 = 1 \\ x_3 = 2 \\ x_4 = 1 \end{cases}$$

# Tenglamalar soni noma’lumlar sonidan ko‘p

**3-misol.** $\begin{cases} x_1+x_2-x_3=4 \\ 2x_1+4x_2+x_3=9 \\ x_1-x_2+x_3=-2 \\ 2x_1+5x_2-3x_3=15 \end{cases}$ **tenglamalar sistemasini yeching.**

Asosiy matritsa rangini hisoblaymiz:

$$A=\begin{pmatrix} 1 & 1 & -1 \\ 2 & 4 & 1 \\ 1 & -1 & 1 \\ 2 & 5 & -3 \end{pmatrix}\cdot(-2),(-1),(-2) \Rightarrow \begin{pmatrix} 1 & 1 & -1 \\ 0 & 2 & 3 \\ 0 & -2 & 2 \\ 0 & 3 & -1 \end{pmatrix}\div 2 \Rightarrow \begin{pmatrix} 1 & 1 & -1 \\ 0 & -1 & 1 \\ 0 & 2 & 3 \\ 0 & 3 & -1 \end{pmatrix}\cdot 2,\cdot 3 \Rightarrow \begin{pmatrix} 1 & 1 & -1 \\ 0 & -1 & 1 \\ 0 & 0 & 5 \\ 0 & 0 & 2 \end{pmatrix}\begin{matrix} \\ \div(-1) \\ \div 5 \\ \div 2 \end{matrix}$$

$$\Rightarrow \begin{pmatrix} 1 & 1 & -1 \\ 0 & 1 & -1 \\ 0 & 0 & 1 \\ 0 & 0 & 1 \end{pmatrix} \Rightarrow \begin{pmatrix} 1 & 1 & -1 \\ 0 & 1 & -1 \\ 0 & 0 & 1 \end{pmatrix}$$

$$\Delta=\begin{vmatrix} 1 & 1 & -1 \\ 0 & 1 & -1 \\ 0 & 0 & 1 \end{vmatrix}\neq 0$$

$$rank\ A=3$$

Endi kengaytirilgan matritsa rangini hisoblaymiz:

$$A/B=\left(\begin{array}{ccc|c}1 & 1 & -1 & 4\\ 2 & 4 & 1 & 9\\ 1 & -1 & 1 & -2\\ 2 & 5 & -3 & 15\end{array}\right)\cdot(-2),(-1),(-2) \Rightarrow \left(\begin{array}{ccc|c}1 & 1 & -1 & 4\\ 0 & 2 & 3 & 1\\ 0 & -2 & 2 & -6\\ 0 & 3 & -1 & 7\end{array}\right)\div(-2) \Rightarrow \left(\begin{array}{ccc|c}1 & 1 & -1 & 4\\ 0 & 1 & -1 & 3\\ 0 & 2 & 3 & 1\\ 0 & 3 & -1 & 7\end{array}\right)\cdot(-2),\cdot(-3)$$

$$\Rightarrow \left(\begin{array}{ccc|c}1 & 1 & -1 & 4\\ 0 & 1 & -1 & 3\\ 0 & 0 & 5 & -5\\ 0 & 0 & 2 & -2\end{array}\right)\begin{array}{l}\\ \\ \div 5\\ \div 2\end{array} \Rightarrow \left(\begin{array}{ccc|c}1 & 1 & -1 & 4\\ 0 & 1 & -1 & 3\\ 0 & 0 & 1 & -1\\ 0 & 0 & 1 & -1\end{array}\right) \Rightarrow \left(\begin{array}{ccc|c}1 & 1 & -1 & 4\\ 0 & 1 & -1 & 3\\ 0 & 0 & 1 & -1\end{array}\right)$$

$$\Delta=\begin{vmatrix}1 & 1 & -1\\ 0 & 1 & -1\\ 0 & 0 & 1\end{vmatrix}\neq 0$$

$$rank(A/B)=3$$

$$rank(A)=rank(A/B)=k=n$$

1) Matritsalar rangi o‘zaro teng bo‘lgani uchun sistema birgalikda.
2) Rang tenglamalar va noma’lumlar soniga teng bo‘lganligi uchun yagona yechimga ega.

4-tenglama qolgan 3 tasining chiziqli kombinatsiyasidan tashkil topgan. Shuning uchun 4-tenglamani tashlab yuboramiz.
Tenglamalar sistemasining bazis tenglamalarini yozib olamiz:

$$\begin{cases} x_1 + x_2 - x_3 = 4 \\ 2x_1 + 4x_2 + x_3 = 9 \\ x_1 - x_2 + x_3 = -2 \\ 2x_1 + 5x_2 - 3x_3 = 15 \end{cases} \qquad \begin{cases} x_1 + x_2 - x_3 = 4 \\ 2x_1 + 4x_2 + x_3 = 9 \\ 2x_1 + 5x_2 - 3x_3 = 15 \end{cases} \qquad \begin{cases} x_1 = 1 \\ x_2 = 2 \\ x_3 = -1 \end{cases}$$

# 3. Chiziqli tenglamalar sistemasini Kramer usulida yechish

Chiziqli tenglamalar sistemasini **Kramer usulida** yechish **determinantning tatbig‘i** hisoblanadi.

$$\begin{cases} a_{11}x_1 + a_{12}x_2 + \ldots\ldots + a_{1n}x_n = b_1 \\ a_{21}x_1 + a_{22}x_2 + \ldots\ldots + a_{2n}x_n = b_2 \\ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \\ a_{n1}x_1 + a_{n2}x_2 + \ldots\ldots + a_{nn}x_n = b_n \end{cases} \qquad (2)$$

**3-teorema.** Agar tenglamalar sistemasining asosiy determinanti $\Delta \neq 0$ bo‘lsa, u holda sistema yagona yechimga ega bo‘ladi va u quyidagi formulalardan topiladi:

$$\Delta \neq 0, \quad x_1 = \frac{\Delta_{x_1}}{\Delta}, \quad x_2 = \frac{\Delta_{x_2}}{\Delta}, \ldots, \quad x_n = \frac{\Delta_{x_n}}{\Delta},$$

$\Delta \neq 0$ asosiy determinant, $\Delta_{x_1}, \Delta_{x_2}, \Delta_{x_3}, \ldots, \Delta_{x_n}$ yordamchi determinantlar

# Uch noma'lumli chiziqli tenglamalar sistemasini Kramer usulida yechish

$$\begin{cases} a_{11}x + a_{12}y + a_{13}z = b_1 \\ a_{21}x + a_{22}y + a_{23}z = b_2 \\ a_{31}x + a_{32}y + a_{33}z = b_3 \end{cases}$$

$$\Delta = \begin{vmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{vmatrix} \qquad \Delta_x = \begin{vmatrix} b_1 & a_{12} & a_{13} \\ b_2 & a_{22} & a_{23} \\ b_3 & a_{32} & a_{33} \end{vmatrix}, \qquad \Delta_y = \begin{vmatrix} a_{11} & b_1 & a_{13} \\ a_{21} & b_2 & a_{23} \\ a_{31} & b_3 & a_{33} \end{vmatrix}, \qquad \Delta_z = \begin{vmatrix} a_{11} & a_{12} & b_1 \\ a_{21} & a_{22} & b_2 \\ a_{31} & a_{32} & b_3 \end{vmatrix}$$

$$x = \frac{\Delta_x}{\Delta}, \qquad y = \frac{\Delta_y}{\Delta}, \qquad z = \frac{\Delta_z}{\Delta}$$

# Δ=0 bo‘lsa, Kramer usulidan foydalanib bo‘ladimi?

$$\begin{cases} a_{11}x + a_{12}y + a_{13}z = b_1 \\ a_{21}x + a_{22}y + a_{23}z = b_2 \\ a_{31}x + a_{32}y + a_{33}z = b_3 \end{cases} \qquad (3)$$

1) Δ=0 bo‘lib, $\Delta_x$, $\Delta_y$, $\Delta_z$ lardan kamida bittasi noldan farqli bo‘lsa, (3) tengamalar sistemasi **yechimga ega bo‘lmaydi**,

2) Δ=0 bo‘lib, $\Delta_x = 0,\ \Delta_y = 0,\ \Delta_z = 0$ bo‘lsa, sistema **cheksiz ko‘p yechimga ega** bo‘ladi.

**4-misol.** $\begin{cases} x+5y-z=3, \\ 2x+4y-3z=2, \\ 3x-y-3z=-7 \end{cases}$ **tenglamalar sistemasini Kramer usulida yeching.**

$$\Delta=\begin{vmatrix} 1 & 5 & -1 \\ 2 & 4 & -3 \\ 3 & -1 & -3 \end{vmatrix}=-12-45+2+12+30-3=-16$$

$$\Delta_x=\begin{vmatrix} 3 & 5 & -1 \\ 2 & 4 & -3 \\ -7 & -1 & -3 \end{vmatrix}=64$$

$$\Delta_y=\begin{vmatrix} 1 & 3 & -1 \\ 2 & 2 & -3 \\ 3 & -7 & -3 \end{vmatrix}=-16$$

$$\Delta_z=\begin{vmatrix} 1 & 5 & 3 \\ 2 & 4 & 2 \\ 3 & -1 & -7 \end{vmatrix}=32$$

$$x=\frac{\Delta_x}{\Delta}, \qquad y=\frac{\Delta_y}{\Delta}, \qquad z=\frac{\Delta_z}{\Delta}$$

$$x=\frac{64}{-16}=-4, \qquad y=\frac{-16}{-16}=1, \qquad z=\frac{32}{-16}=-2.$$

Tenlamalar sistemasining yechimi: **(-4; 1; -2)**

**5-misol.** $\begin{cases} x+2y-3z=7 \\ 2x+y-2z=9 \\ 3x \quad -z=10 \end{cases}$ tenglamalar sistemasini yeching.

$$\Delta=\begin{vmatrix} 1 & 2 & -3 \\ 2 & 1 & -2 \\ 3 & 0 & -1 \end{vmatrix}=-1-12+0+9-0+4=0$$

$$\Delta=0$$

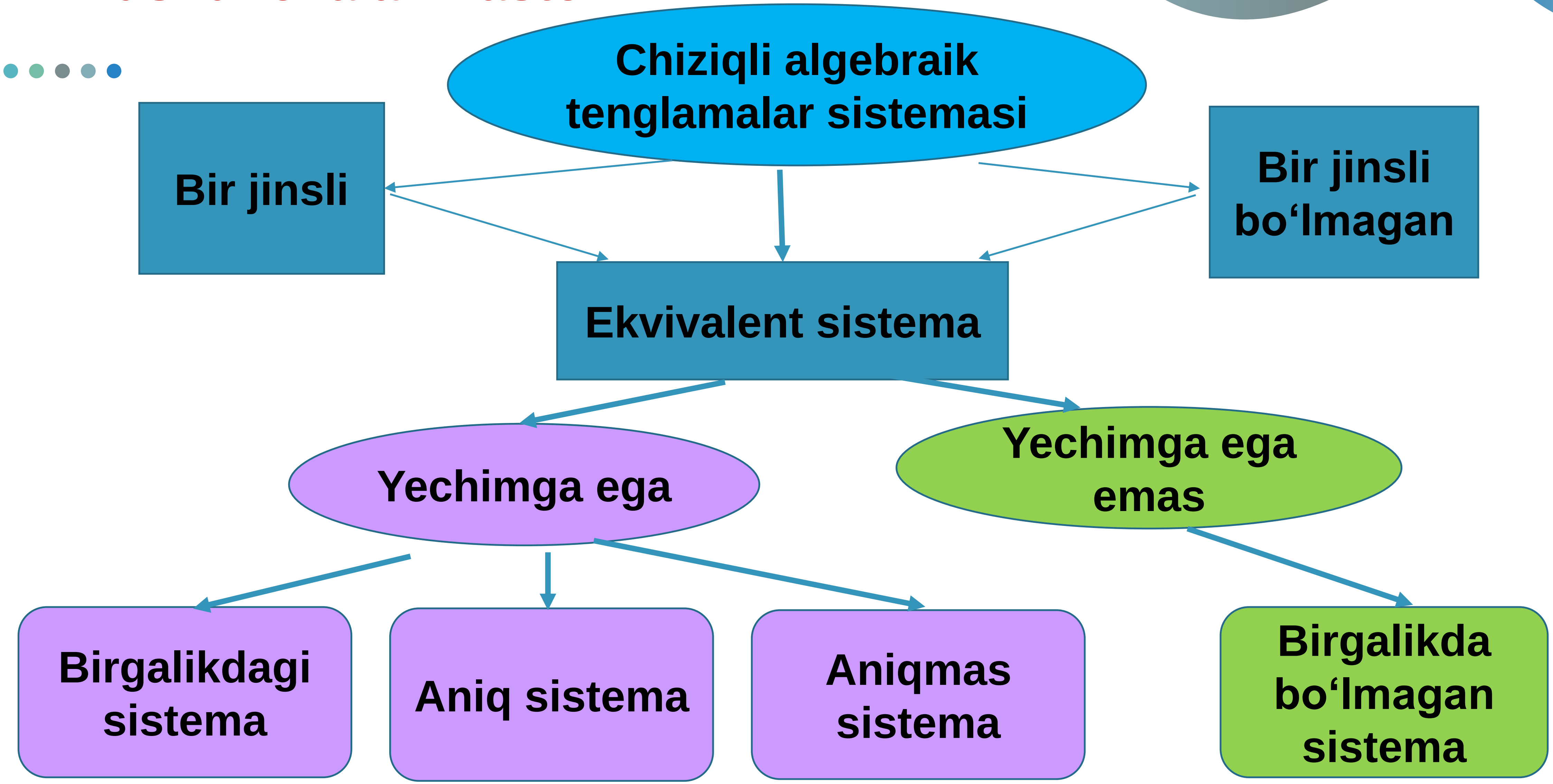
$$\Delta_x=\begin{vmatrix} 7 & 2 & -3 \\ 9 & 1 & -2 \\ 10 & 0 & -1 \end{vmatrix}=-7-40+0+30-0+18=1$$

$$\Delta_x=1\neq 0$$

$$x=\frac{\Delta_x}{\Delta}, \qquad y=\frac{\Delta_y}{\Delta}, \qquad z=\frac{\Delta_z}{\Delta}$$

Tenglamalar sistemasi yechimga ega emas.

# Tushunchalar klasteri



# O‘z-o‘zini tekshirish uchun savollar:

1. Chiziqli tenglamalar sistemasi deb nimaga aytiladi?
2. Chiziqli tenglamalar sistemaning yechimi deb nimaga aytiladi?
3. Chiziqli tenglamalar sistemasining matritsaviy shakli qanday bo’ladi?
4. Qanday sistemalarga birgalikda, aniq, aniqmas va birgalikda bo’lmagan sistemalar deyiladi?
5. Chiziqli tenglamalar sistemasining yechimi mavjudlik va yagonalik yetarli shartlari nimalardan iborat?
6. Kroneker-Kapelli teoremasini ayting.
7. Chiziqli algebraik tenglamalar sistemasini yechimning Kramer usuli.

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# E’TIBORINGIZ UCHUN RAHMAT!

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**OLIY MATEMATIKA KAFEDRASI**