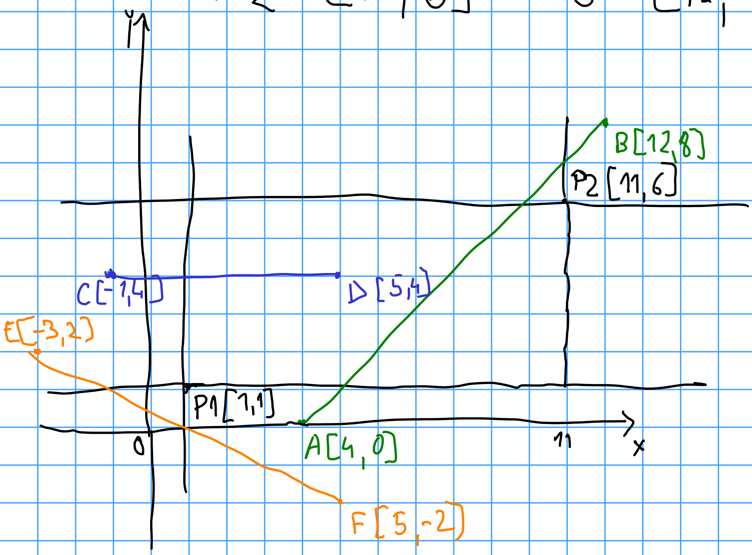
1

$P1 = [1,1]$ $A = [4,0]$ $C = [-1,4]$ $E = [-3,2]$

$P2 = [11,6]$ $B = [12,8]$ $D = [5,4]$ $F = [5,-2]$



DOMÁCA ÚLOHA
ALŽBETA SVITKOVÁ

a Cohen-Sutherland

1001	0001	0101
1000	0000	0100
1010	0010	0110

1. $x < x_{min}$ 2. $x > x_{max}$
3. $y < y_{min}$ 4. $y > y_{max}$

$x_{min} = 1$ $x_{max} = 11$
$y_{min} = 1$ $y_{max} = 6$

1 |AB|

$A[4,0] = 0010$ $B[12,8] = 0101$

$0010 \,\&\, 0101 \rightarrow 0000$ – nekončí

$A \neq 0$ $B \neq 0$ → nevykresluje ešte

$A \neq 0$ → orežeme A

$A = 0010$ – orežeme zdola (podľa y_{min})

$y_A = 1$ $m = \frac{\Delta y}{\Delta x} = \frac{8}{8} = 1$

$x_A = \frac{1}{m}(1-0) + 4 = 1 + 4$

$x_A = 5$

$A = [5,1] = 0000$ A je nula ⇒ orežeme B

$B[12,8] = 0101$ → orežeme sprava (podľa x_{max})

$x_B = 11$

$y_B = m(11-12) + 8 = 1 \cdot (-1) + 8 = 7$

$B[11,7] = 0001$ → orežeme zhora (podľa y_{max})

$y_B = 6$

$x_B = \frac{1}{m}(6-7) + 11 = 1 \cdot (-1) + 11 = 10$

$B[10,6] = 0000$ ∧ $A[5,1] = 0000$ → vykreslíme

2 |CD|

$C[-1,4] = 1000$ $D[5,4] = 0000$

$1000 \,\&\, 0000 = 0000$ – nekončí

$C \neq 0$ – ešte nevykreslujeme

$C = 1000$ – orežeme zľava (x_{min})

$x_c = 1$ $m = \frac{\Delta y}{\Delta x} = \frac{0}{6} = 0$

$y_c = 0 \cdot x + q = q = 4$

$C[1,4] = 0000$ ∧ $D[5,4] = 0000$

→ môžeme vykresliť

3 |EF|

$E[-3,2] = 1000$ $F[5,-2] = 0010$

$1000 \,\&\, 0010 = 0000$ – nekončí

$E \neq 0$ $F \neq 0$ nevykreslujeme

→ $E[-3,2] = 1000$ – orežeme zľava

$x_E = 1$ $m = \frac{\Delta y}{\Delta x} = \frac{-4}{8} = -\frac{1}{2}$

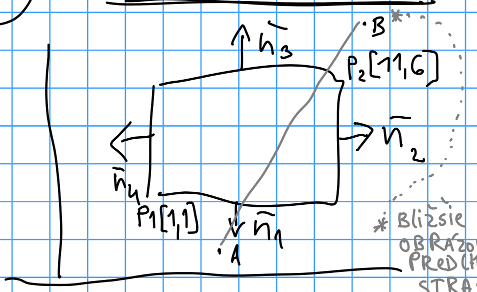
$y_E = -\frac{1}{2}(1+3) + 2 = 0$

$E[1,0] = 0010$ $F = 0010$

$0010 \,\&\, 0010 = 0010 \neq 0$ – mimo okna,

nevykreslujeme a končíme

(b) CYRUS-Beck



$P_1 \in \quad \bar{n}_1 = [0,-1]$

$P_2 \in \quad \bar{n}_2 = [1,0]$

$P_2 \in \quad \bar{n}_3 = [0,1]$

$P_1 \in \quad \bar{n}_4 = [-1,0]$

$B - A = [12,8] - [4,0] = [8,8]$

$P_1 - A = [1,1] - [4,0] = [-3,1]$

$P_2 - A = [11,6] - [4,0] = [7,6]$

$$t = \frac{(P-A)\cdot\bar{n}}{(B-A)\cdot\bar{n}}$$

$$t = \frac{(P1-A)\cdot\bar{n}_1}{(B-A)\cdot\bar{n}_1} = \frac{(-3,1)\cdot(0,1)}{(8,8)\cdot(0,-1)} = \frac{-1}{-8} \to <0 \Rightarrow t_0 = \frac{1}{8}$$

$$t = \frac{(P2-A)\cdot\bar{n}_2}{(B-A)\cdot\bar{n}_2} = \frac{(7,6)(1,0)}{(8,8)(1,0)} = \frac{7}{8} \to >0 \Rightarrow t_1 = \frac{7}{8}$$

$$t = \frac{(P2-A)\cdot\bar{n}_3}{(B-A)\cdot\bar{n}_3} = \frac{(7,6)(0,1)}{(8,8)(0,1)} = \frac{6}{8} \to >0 \Rightarrow t_1 = \frac{6}{8}$$

$$t = \frac{(P1-A)\cdot\bar{n}_4}{(B-A)\,\bar{n}_4} = \frac{(-3,1)(-1,0)}{(8,8)(-1,0)} = \frac{3}{-8} \to <0 \Rightarrow t_0 = \frac{-3}{8}$$

$$t_0 = \max\left\{0, \frac{1}{8}, \frac{-3}{8}\right\} = \frac{1}{8} \qquad t_0 < t_1 \checkmark$$

$$t_1 = \min\left\{1, \frac{7}{8}, \frac{6}{8}\right\} = \frac{6}{8}$$

$A' = A + (B-A)\cdot t_0 = [4,0] + [8,8]\cdot\frac{1}{8} = [5,1]$

$B' = A + (B-A)\cdot t_1 = [4,0] + [8,8]\cdot\frac{6}{8} = [10,6]$

$D - C = [5,4] - [-1,4] = [6,0]$

$P1 - C = [1,1] - [-1,4] = [2,-3]$

$P2 - C = [11,6] - [-1,4] = [12,2]$

$$t = \frac{(P-C)\cdot\bar{n}}{(D-C)\cdot\bar{n}}$$

$$t = \frac{(P1-C)\cdot\bar{n}_1}{(D-C)\cdot\bar{n}_1} = \frac{(2,-3)\cdot(0,-1)}{(6,0)\cdot(0,-1)} = \frac{3}{0}$$

$\to$ rovnobežné s $\bar{n}_1$, neorezáva: $3>0 \Rightarrow \sphericalangle|CP1\,\text{normála}^{\bar{n}1}| > 90° \Rightarrow$ uhol je vo vnútri okna (ak nie je mimo z opačnej strany) $\Leftarrow$ pokračujeme

$$t = \frac{(P2-C)\cdot\bar{n}_2}{(D-C)\cdot\bar{n}_2} = \frac{(12,2)\cdot(1,0)}{(6,0)\cdot(1,0)} = \frac{12}{6} \to >0 \Rightarrow t_1 = 2$$

$$t = \frac{(P2-C)\cdot\bar{n}_3}{(D-C)\cdot\bar{n}_3} = \frac{(12,2)\cdot(0,1)}{(6,0)\cdot(0,1)} = \frac{2}{0}$$

$\to$ ROVNOBEŽNÉ s $\bar{n}3$, $2>0 \Rightarrow \sphericalangle|CP2\,\text{normála}^{\bar{n}3}| > 90° \Rightarrow$ uhol je vnútri okna, pokračujeme

$$t = \frac{(P1-C)\cdot\bar{n}_4}{(D-C)\cdot\bar{n}_4} = \frac{(2,-3)(-1,0)}{(6,0)(-1,0)} = \frac{-2}{-6} \to <0 \Rightarrow t_0 = \frac{2}{6}$$

$$t_0 = \max\left\{0, \frac{2}{6}\right\} = \frac{2}{6} \qquad t_0 < t_1 \checkmark$$

$$t_1 = \min\{1, 2\} = 1$$

$C' = C + (D-C)\cdot t_0 = [-1,4] + [6,0]\cdot\frac{2}{6} = [1,4]$

$D' = C + (D-C)\cdot t_1 = C + (D-C)\cdot 1 = C + D - C = D = [5,4]$

$F - E = [5,-2] - [-3,2] = (8,-4)$

$P1 - E = [1,1] - [-3,2] = (4,-1)$

$P2 - E = [11,6] - [-3,2] = (14,4)$

$$t = \frac{(P-E)\cdot\bar{n}}{(F-E)\cdot\bar{n}}$$

$$t = \frac{(P1-E)\cdot\bar{n}1}{(F-E)\cdot\bar{n}1} = \frac{(4,-1)(0,-1)}{(8,-4)(0,-1)} = \frac{1}{4} > 0 \Rightarrow t_1 = \frac{1}{4}$$

$t = \frac{(P2-E)\cdot \bar{n}_2}{(F-E)\cdot \bar{n}_2} = \frac{(14,4)\cdot(1,0)}{(8,-4)\cdot(1,0)} = \frac{14}{8} \to > 0 \Rightarrow t_1 = \frac{14}{8}$

$t_0 = \max\{0,-1,\frac{1}{2}\} = \frac{1}{2}$

$t = \frac{(P2-E)\cdot \bar{n}_3}{(F-E)\cdot \bar{n}_3} = \frac{(14,4)\cdot(0,1)}{(8,-4)\cdot(0,1)} = \frac{4}{-4} \to < 0 \Rightarrow t_0 = -1$

$t_1 = \min\{1,\frac{1}{4},\frac{14}{8}\} = \frac{1}{4}$

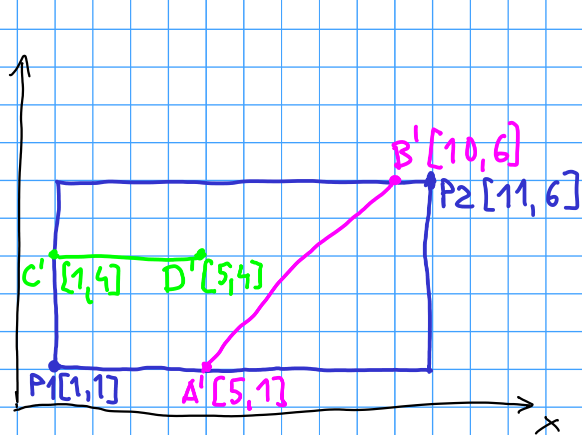
$t = \frac{(P1-E)\cdot \bar{n}_4}{(F-E)\cdot \bar{n}_4} = \frac{(4,-1)(-1,0)}{(8,-4)(-1,0)} = \frac{-4}{-8} \to < 0 \Rightarrow t_0 = \frac{1}{2}$

$t_0 > t_1$!

mimo okna, nevykreslí sa

---

vykreslenie pomocou C.-S aj pomocou C-B vyšlo rovnako:



z úsečky EF sa nič nevykreslilo.

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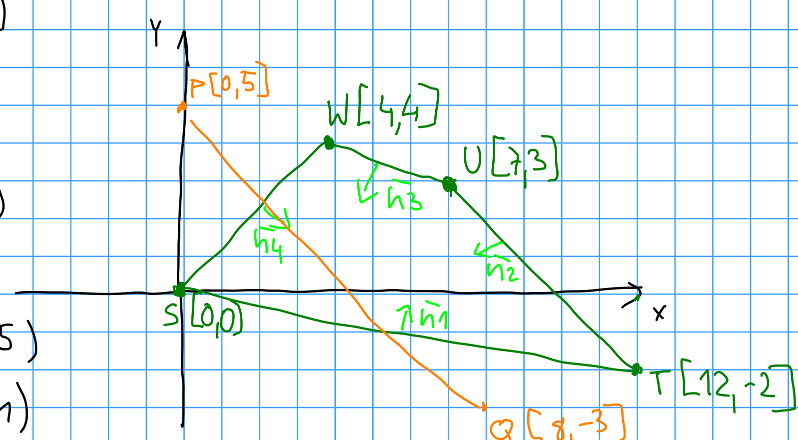
② okno: S[0,0] T[12,-2] U[7,3] W[4,4]

úsečka P[0,5] Q[8,-3]

Pomocou Liang-Barsky - normály smerujú do okna



$T-S = [12,-2]-[0,0] = (12,-2)$

$W-S = [4,4]-[0,0] = (4,4)$

$T-U = [12,-2]-[7,3] = (5,-5)$

$W-U = [4,4]-[7,3] = (-3,1)$

$n_1 = ?$ $(-2,-12)$: $(-2,12)\cdot(4,4) < 0$

$(2,12)$: $(2,12)\cdot(4,4) > 0$ ✓

$n_2 = ?$ $(5,5)$: $(5,5)\cdot(-3,1) = -10 < 0$

$(-5,-5)$: $(-5,-5)\cdot(-3,1) = 10 > 0$ ✓

$n_3 = ?$ $(-1,-3)$: $(-1,-3)\cdot(5,-5) = 10 > 0$ ✓

$(1,3)$: $(1,3)\cdot(5,-5) = -10 < 0$

$n_4 = ?$ $(-4,4)$: $(-4,4)(12,-2) < 0$

$(4,-4)$: $(4,-4)(12,-2) > 0$ ✓

$t = \frac{(A-P)\cdot \bar{n}}{(Q-P)\cdot \bar{n}}$ $A \in \{S,U\}$ $\bar{n} \in \{\bar{n}_1,\bar{n}_2,\bar{n}_3,\bar{n}_4\}$

$Q-P = [8,-3]-[0,5] = (8,-8)$

$S-P = [0,0]-[0,5] = (0,-5)$

$U-P = [7,3]-[0,5] = (7,-2)$

$t = \frac{(S-P)\cdot \bar{n}_1}{(Q-P)\cdot \bar{n}_1} = \frac{(0,-5)(2,12)}{(8,-8)(2,12)} = \frac{-60}{-80}$ $-80 < 0 \Rightarrow t_1 = \frac{6}{8}$

$t = \frac{(U-P)\vec{n_2}}{(Q-P)\vec{n_2}} = \frac{(7,-2)(-5,-5)}{(8,-8)(-5,-5)} = \frac{-25}{0}$ ⇒ <0 ⇒ $|\sphericalangle PU\ \text{normála}| < 90°$ → vnútri lichobežníka (ak nevytŕča z 2. strany)

0 → rovnobežná

$t = \frac{(U-P)\vec{n_3}}{(Q-P)\vec{n_3}} = \frac{(7,-2)(-1,-3)}{(8,-8)(-1,-3)} = \frac{-1}{16}$ $\quad 16>0 \Rightarrow t_0 = \frac{-1}{16}$

$t = \frac{(S-P)\vec{n_4}}{(Q-P)\vec{n_4}} = \frac{(0,-5)(4,-4)}{(8,-8)(4,-4)} = \frac{20}{64}$ $\quad 64>0 \Rightarrow t_0 = \frac{5}{16}$

$t_0 = \max\{0, \frac{-1}{16}, \frac{5}{6}\} = \frac{5}{16}$

$t_1 = \min\{1, \frac{6}{8}\} = \frac{6}{8}$

$t_0 < t_1$ ✓

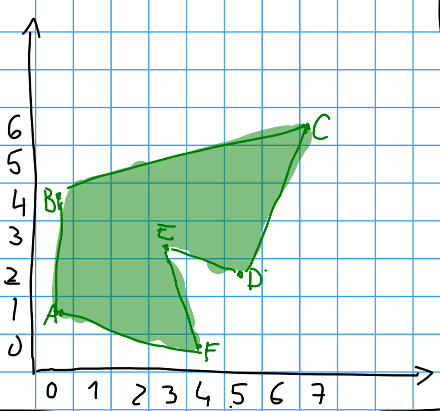
$P' = P + (Q-P)\cdot t_0 = (0,5) + (8,-8)\cdot\frac{5}{16} = [\frac{5}{2}, \frac{5}{2}]$

$Q' = P + (Q-P)\cdot t_1 = (0,5) + (8,-8)\cdot\frac{6}{8} = [6, -1]$

---

3 SCANLINE

A [0, 1]
B [0, 4]
C [7, 6]
D [5, 2]
E [3, 3]
F [4, 0]



3 Tabuľka hrán

Ymin	HRANY (Ymax, X_{ymin}, $\frac{1}{m} = \frac{\Delta x}{\Delta y}$)
0	FA(1, 4, −4) FE (3, 4, $-\frac{1}{3}$)
1	
2	AB(4, 0, 0) DE (3, 5, −2) DC (6, 5, $\frac{1}{2}$)
3	
4	
5	BC (6, $3\frac{1}{2}$, $\frac{7}{2}$)
6	

1. nájdem neextremálne vrcholy: A, B
Ak hrana z nich vychádza, zapíšeme do y+1 a $x_{min} = x + \frac{1}{m}$
Teda |AB|: y min = 2 $\quad x_{ymin} = 0 + \frac{0}{3} = 0$
|BC|: $y_{min} = 5$ $\quad x_{ymin} = 0 + \frac{7}{2} = 3\frac{1}{2}$

2. nie sú vodorovné hrany, keby boli, vyrasterizujeme ich najskôr

4 TABUĽKA AKTÍVNYCH HRÁN

FOR Y=0 to YMAX=6 DO
1. vložiť hrany z riadku Y (z TH + čo zyšli z TAH)
2. usporiadať podľa x
3. vykresliť body
4. zmazať hrany s ymax=y
5. $x = x + \frac{1}{m}$

$\boxed{Y=0}$
1. FA (1, 4, −4), FE (3, 4, $-\frac{1}{3}$)
2. —— // ——
3. [4, 0] [4, 0]
4. —
5. FA (1, 0, −4), FE (3, $3\frac{2}{3}$, $-\frac{1}{3}$)

$\boxed{Y=1}$
1. FA (1, 0, −4), FE (3, $3\frac{2}{3}$, $-\frac{1}{3}$)
2. —— // —— → $3\frac{3}{3} \doteq 4$
3. [0, 1] [1, 1] [2, 1] [3, 1] [4, 1]
4. − FA
5. FE (3, $3\frac{1}{3}$, $-\frac{1}{3}$)

$\boxed{Y=2}$
1. FE(3, $3\frac{1}{3}$, $-\frac{1}{3}$) AB(4, 0, 0) DE(3, 5, −2) DC (6, 5, $\frac{1}{2}$)
2. AB (4, 0, 0) FE (3, $3\frac{1}{3}$, $-\frac{1}{3}$) DE (3, 5, −2) DC (6, 5, $\frac{1}{2}$)
3. [0, 2] [1, 2] [2, 2] [3, 2] [5, 2] [5, 2]
4. −
5. AB (4, 0, 0) FE (3, 3, $-\frac{1}{3}$) DE (3, 3, −2) DC (6, $5\frac{1}{2}$, $\frac{1}{2}$)

$\boxed{Y=3}$
1. AB(4, 0, 0) FE(3, 3, $-\frac{1}{3}$) DE(3, 3, −2) DC (6, $5\frac{1}{2}$, $\frac{1}{2}$) $\quad 5\frac{1}{2} \doteq 6$
2. —— // ——
3. [0, 3] [1, 3] [2, 3] [3, 3] [3, 3] [4, 3] [5, 3] [6, 3]
4. − FE − DE
5. AB (4, 0, 0) DC (6, 6, $\frac{1}{2}$)

$\boxed{y=4}$

1. $AB(4,0,0)$ $DC(6,6,\frac{1}{2})$
2. —— " ——
3. [0,4][1,4][2,4][3,4][4,4][5,4][6,4]
4. $-AB$
5. $DC(6,6\frac{1}{2},\frac{1}{2})$

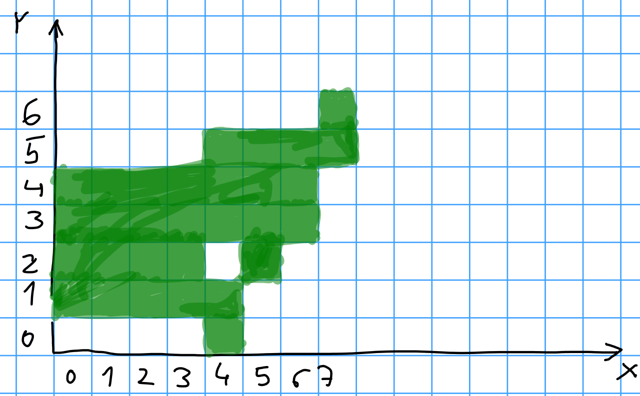
$\boxed{y=5}$

1. $DC(6,6\frac{1}{2},\frac{1}{2})$ $BC(6,3\frac{1}{2},\frac{7}{2})$
2. $BC(6,3\frac{1}{2},\frac{7}{2})$ $DC(6,6\frac{1}{2},\frac{1}{2})$
3. [4,5][5,5][6,5][7,5]
4. −
5. $BC(6,7,\frac{7}{2})$ $DC(6,7,\frac{1}{2})$

$\boxed{y=6}$

1. $BC(6,7,\frac{7}{2})$ $DC(6,7,\frac{1}{2})$
2. —— " ——
3. [6,7][6,7]
4. $-BC$ $-DC$
5. −

vyrenderované



4

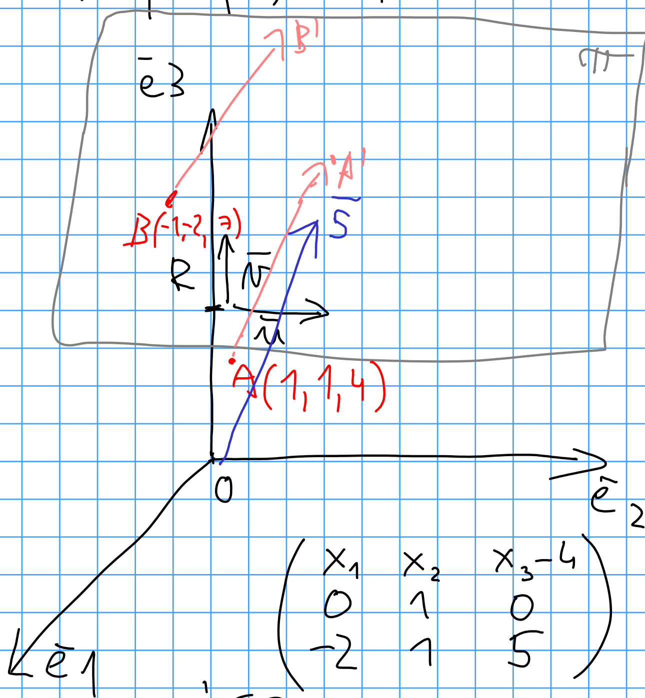
$E^3 \langle O, \bar{e}_1, \bar{e}_2, \bar{e}_3 \rangle$

$\pi \langle R, \bar{u}, \bar{v} \rangle$ $\quad S = (-2, 1, 5)$

$R = (0, 0, 4)$ $\quad A = (1, 1, 4) \quad A' = ?$

$\bar{u} = (0, 1, 0)$ $\quad B = (-1, -2, 7) \quad B' = ?$

$\bar{v} = (0, 0, 1)$



$$x_1' = \frac{(x - R, \bar{v}, \bar{s})}{(\bar{u}, \bar{v}, \bar{s})}$$

$$x_2' = -\frac{(x - R, \bar{u}, \bar{s})}{(\bar{u}, \bar{v}, \bar{s})}$$

$$x_1' = \frac{\begin{pmatrix} x_1 & x_2 & x_3 - 4 \\ 0 & 0 & 1 \\ -2 & 1 & 5 \end{pmatrix}}{\begin{pmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -2 & 1 & 5 \end{pmatrix}}$$

$$x_2' = -\frac{\begin{pmatrix} x_1 & x_2 & x_3 - 4 \\ 0 & 1 & 0 \\ -2 & 1 & 5 \end{pmatrix}}{\begin{pmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -2 & 1 & 5 \end{pmatrix}} = \frac{5x_1 + 2x_3 - 8}{2}$$

$$x_1' = \frac{-2x_2 - x_1}{-2} = \frac{x_1 + 2x_2}{2}$$

A': $x_1' = \frac{1+2}{2} = \frac{3}{2}$

$x_2' = \frac{5 + 8 - 8}{2} = \frac{5}{2}$ $\quad (-1, -2, 7)$

$A' = \left(\frac{3}{2}, \frac{5}{2}\right)$

B': $x_1 = \frac{-1-4}{2} = \frac{-5}{2}$

$x_2 = \frac{-5 + 14 - 8}{2} = \frac{1}{2}$

$B' = \left(-\frac{5}{2}, \frac{1}{2}\right)$