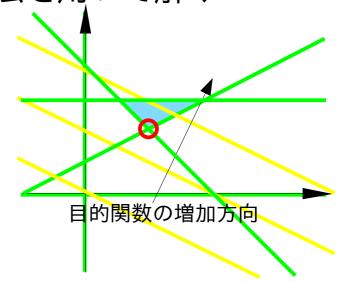
前回(第6回)授業と演習問題の復習

復習:演習問題6

課題:次の線形計画問題を罰則付単体法を用いて解く

maximize $x_1 + 2x_2$ subject to

$$x_1 + x_2 \ge 4$$
, $x_1 - 2x_2 + 2 \le 0$
 $x_2 \le 3$, $x_1, x_2 \ge 0$



注意: 原点は実行可能領域ではありません

ヒント:

min.
$$z=-x_1-2x_2$$
 s.t. $x_1+x_2\geq 4$ $-x_1+2x_2\geq 2$ $x_2\leq 3$ $x_1,x_2\geq 0$

min.
$$z=-x_1-2x_2$$

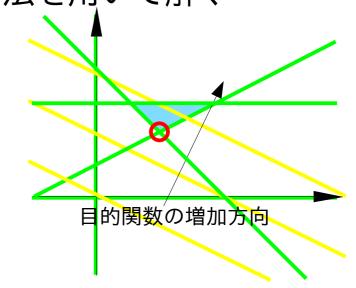
s.t. $x_1+x_2-x_3=4$
 $-x_1+2x_2-x_4=2$
 $x_2+x_5=3$
 $x_1,x_2,x_3,x_4,x_5\geq 0$

復習:演習問題6

課題:次の線形計画問題を罰則付単体法を用いて解く

minimize $z(=-x_1-2x_2)$ subject to

$$\begin{aligned}
 x_1 + x_2 - x_3 &= 4 \\
 -x_1 + 2x_2 &-x_4 &= 2 \\
 x_2 &+x_5 &= 3 \\
 z + x_1 + 2x_2 &= 0 \\
 x_1, x_2, x_3, x_4, x_5 &\ge 0
 \end{aligned}$$



ヒント:

min.
$$z=-x_1-2x_2$$
 s.t. $x_1+x_2\geq 4$ $-x_1+2x_2\geq 2$ $x_2\leq 3$ $x_1,x_2\geq 0$

min.
$$z=-x_1-2x_2$$

s.t. $x_1+x_2-x_3=4$
 $-x_1+2x_2-x_4=2$
 $x_2+x_5=3$
 $x_1,x_2,x_3,x_4,x_5\geq 0$

• 2段階単体法 まず、2*を最小化する z*=0 を得られたら zを最小化して

minimize $z^* \to 0 \Rightarrow \text{minimize } z$ subject to $x_1 + x_2 - x_3 + x_6$ = 4 $-x_1+2x_2$ $-x_4$ $+x_7=2$ $x_2 + x_5 = 3$ =0 $z+x_1+2x_2$ 元の問題の最適解を得る z^* + $3x_2-x_3-x_4$ = 6 $x_1, x_2, x_3, x_4, x_5, x_6, x_7 \ge 0$

• 罰則付単体法 十分大きな M により、 $z + Mz^*$ の最小化で、 $z^*=0$, z の最小化が 同時に実現する

minimize $\tilde{z} = z + Mz^*$ subject to $x_1 + x_2 - x_3 + x_6 = 4$ $-x_1+2x_2$ $-x_4$ $+x_7=2$ $x_2 + x_5 = 3$ $\tilde{z} + x_1 + (3M+2)x_2 - Mx_3 - Mx_4 = 6M$ $x_1, x_2, x_3, x_4, x_5, x_6, x_7 \ge 0$

• 2段階単体法 まず、z*を最小化する z*=0 を得られたら zを最小化して

* 2段階単体法
$$x_1 + x_2 - x_3 + x_6 = 4$$
 $x_1 + x_2 - x_3 + x_6 = 4$ $x_1 + x_2 - x_3 + x_6 = 4$ $x_1 + x_2 - x_3 + x_6 = 4$ $x_1 + x_2 - x_3 + x_6 = 4$ $x_1 + x_2 - x_3 + x_6 = 4$ $x_2 + x_3 + x_5 = 3$ $x_2 + x_5 = 3$ $x_3 + x_4 + x_5 = 3$ $x_4 + x_5 = 3$ $x_5 + x_5 + x_5 + x_5 = 3$ $x_5 + x_5 + x_5 + x_5 = 3$ $x_5 + x_5 + x_5 + x_5 = 3$ $x_5 + x_5 + x_5 + x_5 = 3$ $x_5 + x_5 + x_5 + x_5 + x_5 = 3$ $x_5 + x_5 + x_5 + x_5 + x_5 + x_5 = 3$ $x_5 + x_5 +$

| Z , Z * | x1 | | x2 | x3 | x4 | x5 | x6 | x7 | 定数 |
|-----------------------|----|----|----|----|----|----|----|----|----|
| | | 1 | 1 | -1 | | | 1 | | 4 |
| | | -1 | 2 | | -1 | | | 1 | 2 |
| | | | 1 | | | 1 | | | 3 |
| | 1 | 1 | 2 | | | | | | 0 |
| • | 1 | | 3 | -1 | -1 | | | | 6 |

| z , z * | x1 # | x2 # | x3 # | x4 # | x5 | х6 | x7 | 定数 |
|-----------------------|------|------|------|------|----|----|----|----|
| | 1 | 1 | -1 | _ | | 1 | | 4 |
| | -1 | 2 | | -1 | | | 1 | 2 |
| | | 1 | | | 1 | | | 3 |
| 1 | | 3 | -1 | -1 | | | | 6 |
| 1 | 1 | 2 | | | | | | 0 |

人工問題の最初のsimplex表 最下段は元の問題の目的関数

| Z,Z^* | x1 ‡ | = x | 2 🗱 | x 3 | 非 | x4 | 3 F | x5 | x6 | x7 | 3= | 定数 | |
|-----------------------|-------------|-----|-----|------------|----|----|------------|----|----|----|----|----|---------------|
| | | 1 | 1 | | -1 | | <u>-</u> | | | 1 | - | | 4/1= |
| | | -1 | (2 | | | | -1 | | | | 1 | | (2/2= |
| | | | | | | | | | 1 | | | | 3/1= |
| | 1 | | (3 | | -1 | | -1 | | | | | | 6 |
| | 1 | 1 | 2 | | _ | | _ | | | | _ | | 0 |
| Z , Z * | x1 | X | 2 | х3 | 非 | x4 | 非 | x5 | x6 | x7 | 非 | 定数 | |
| | | | 0 | | - | | - | | | | | | |
| | | | 1 | | | | | | | | | | |
| | | | 0 | | | | | | | | | | |
| | | | 0 | | | | | | | | | | |
| | | | 0 | | | | | | | | | | |

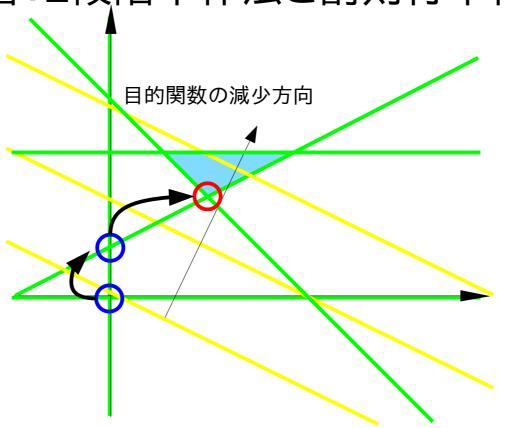
交換する基底/非基底変数を 決め、連立方程式を解く

| z , z * | x1 # | x2 🗱 | x3 非 | x4 # | x5 | x6 | x7 | 定数 | |
|-----------------------|-----------------|------------------------|-------------------|---------------------|---------|---------|---------------------|-----------------|------|
| ×-1 | 1/2 1 | -1 1 | -1 | 1/2 | | 1 | -1/2 | -1 4 | /1=4 |
| ×1/2 | -1/2 -X | 1 (🕱 | | -1/2 - X | | | 1/2 💢 | 1 (2 | /2=1 |
| ×-1 | 1/2 | -1 | | 1/2 | 1 | | -1/2 | -1 3 | /1=3 |
| ×-3 | 1 3/2 | -3 (3 | -1 | 3/2-1 | | | -3/2 | -3 6 | |
| X-2 | 1 1 1 | -2 2 | _ | 1 | | | -1 | -2 0 | |
| | | | | | | | | | |
| z , z * | x1 | x2 | x3 非 | x4 3 = | x5 | x6 | x7 # | 定数 | |
| z, z* | x1 非 3/2 | x2 0 | x3 非 -1 | x4 非 1/2 | x5 | x6 1 | ×7 非 -1/2 | 定数 3 | |
| Z,Z * | | x2 0 1 | 1 | , . | x5 | x6 1 | , , | | |
| Z,Z * | 3/2 | x2 0 1 0 | 1 | 1/2 | x5 1 | x6 1 | , , | | |
| Z,Z* | 3/2 | x2 0 1 0 0 | 1 | 1/2 -1/2 | x5 1 | x6 1 | , , | 3 | |

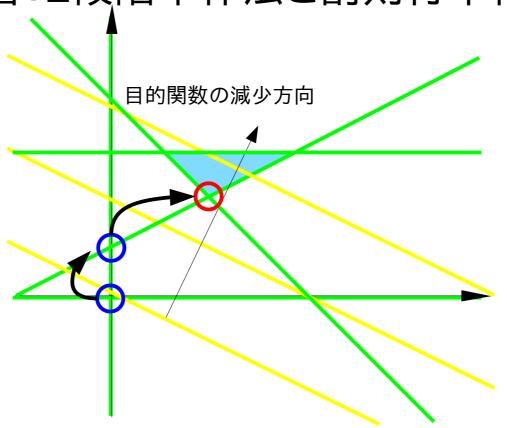
交点 $x_1=0, x_2=1$ へ移動 $z^*=3$ 元の問題の実行可能 領域ではない

| | _ | | | | 1 11 /- | | // 1 7 | 1 11 7 | | | |
|-----------------------|-------------------|------|---|-------------------|----------------------|--------------|-------------|-------------|--------------------|----|----------|
| z , z * | x1 # | x2 | X | (3 # | x4 1= | x5 | x6 | x7 | 定数 | | |
| ×-1 | 1/2 | 1 -1 | 1 | -1 | 1/2 | | 1 | -1/2 | -1 | 4 | /1=4 |
| ×1/2 | -1/2 -> | 1 (| X | | -1/2-> | | | 1/2 | 1 1 | 10 | /2=1 |
| ×-1 | 1/2 | -1 | | | 1/2 2 | | 交換は | | | | /1=3 |
| ×-3 1 | 3/2 | -3(| 3 | -1 | 3/2-X | 1:非基 C.甘忘 | 底→基点 | 医上 | | | • |
| ×-2 1 | 1 . | 1 -2 | 2 | | 1 × | 6:基底 | プチを | <u></u> | | | |
| z , z * | x1 💥 | x2 | × | (3 # | x4 # | x5 | x6 📜 | x7 /3 | 定数 | | |
| ×2/3 | 1 (3)/2 | 2 | 0 | -2/3 X | 1/ 3 ×2 | | 2/3 🛪 | [| 2 2 | (3 | /(3/2) |
| ×1/2 1 | /2-1/2 | 2 | 1 | -1/3 | <mark>1/6</mark> 1/2 | | 1/3 - | 1/61/ | ′2 1 | 1 | /(-1/2)- |
| ×-1/2- | 1/21/2 | 2 | 0 | 1/3 - | 1/61/2 | 1 | -1/3 1 | /61/ | ′2 -1 | 2 | /(1/2)= |
| ×-3/21 | 3/23/2 | 2 | 0 | 1 -1 | <u>-1/2/2</u> | | -1 | 1/23/ | ′2 <mark>-3</mark> | 3 | |
| ×-2 1 | -2 | 2 | 0 | 4/3 | -2/3 1 | | -4/3 | 2/3- | -1 -4 | -2 | |
| Z , Z * | x1 | x2 | × | (3]= | x4 3 = | x5 | x6 非 | x7 3 | 三 定数 | | |
| | - | 1 | | -2/3 | 1/3 | | 2/3 | -1/ | ′3 | 2 | |
| | (| C | 1 | -1/3 | -1/3 | | 1/3 | 1/ | ′3 | 2 | |
| | (| C | | 1/3 | 1/3 | 1 | -1/3 | -1/ | ′3 | 1 | |
| 1 | (| C | | 0 | 0 | | -1 | - | -1 | 0 | |
| 1 | (|) | | 4/3 | 1/3 | | -4/3 | -1/ | 3 | -6 | |

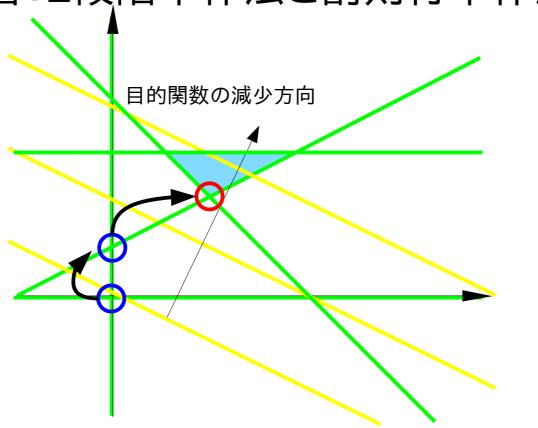
| | دا ب | 又曰: | 4 | XIH | — I/†` | | ガリリリー | | • | |
|------------------|--------------------|------|------------|-------|--------|------------|-----------------|------------|-----------------|---------------------|
| z,z* x1 | 非 | x2 🗱 | , x3 | 非 | x4 # | x5 | x6 | x7 | 定数 | |
| ×-1 1/ | 2 1 | -1 | 1 | -1 | 1/2 | | 1 | -1/2 | -1 4 | /1=4 |
| $\times 1/2$ -1/ | / <mark>2-米</mark> | 1 (| X) | | -1/2 | X | | 1/2 💢 | 1 (2 | /2=1 |
| ×-1 1/ | 2 | -1 | I | | 1/2 | 4 | | 1/0 | 3 | /1=3 |
| ×-3 13/ | 2 | -3(| 3) | -1 | 3/2 | $x_1=2$ | (2=2へ) 佐米kのほ | 移動 | T \ . 4\ | |
| ×-2 11 | 1 | -2 | 2 | - • | 1 | 非基底変り、人工 | | | | |
| z,z* x1 | 类 | x2 | x3 | 非 | x4 # | り、八工 | 回起り | 収辿性で | 1寸/こ。 | |
| ×2/3 1 | 3 /2 | | 0 -2 | 2/3/1 | 1/3> | x6,x7ld | 非主体 | : 水水 光 ナ ン | 力で | /(3/2) } |
| $\times 1/2 1/2$ | 1/2 | | 1 -1 | 1/3 | 1/61/ | $x^*=x6+x$ | | | | /(-1/2)< |
| ×-1/2-1/2 | 1/2 | | 0 1 | /3 - | 1/61/ | 元の問題 | | | を得た | /(1/2)= |
| ×-3/21-3/ | <mark>3</mark> /2 | | 0 | 1 -1 | -1/2/ | _ | | | Δ | |
| ×-2 1 -2 | 2 | | 0 4 | , – | -2/3 | 1 | | | - -2 | |
| z,z* x1 | | x2 | x3 | 非 | x4 非 | x5 | x6] | x7 3= | 定数 | $x_1=2$ |
| | (1 |) _ | | -2/3 | 1/ | 3 | 2/3 | -1/3 | 2 | |
| | 0 | | 1) | -1/3 | -1/ | 3 | 1/3 | 1/3 | 2 | x2=2 |
| | 0 | | | 1/3 | 1/ | 3 1 | -1/3 | -1/3 | 1 | |
| 1 | 0 | | | 0 | | 0 | -1 | -1 | (0 | |
| 1 | 0 | | | 4/3 | 1/ | 3 | -4/3 | | | |
| | | | | | | | | 実 | 行可能领 | 頁域 |



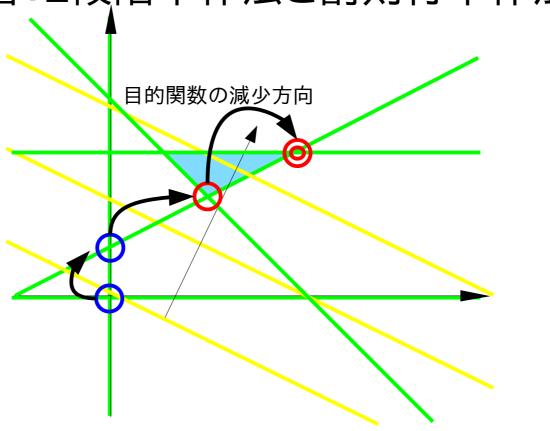
| Z , Z * | x1 | x2 | x3 ‡ | x4 3= 1 | x5 | x6]= | x7 | 定数 |
|-----------------------|----|----|-------------|---------|----|--------------|------|----|
| | 1 | | -2/3 | 1/3 | | 2/3 | -1/3 | 2 |
| | | 1 | -1/3 | -1/3 | | 1/3 | 1/3 | 2 |
| | | | 1/3 | 1/3 | 1 | -1/3 | -1/3 | 1 |
| 1 | | | | | | -1 | -1 | 0 |
| 1 | | | 4/3 | 1/3 | | -4/3 | -1/3 | -6 |



| Z , Z * | x1 | x2 | x3 1 = | x4 | | x6 1 = | x7 # | 定数 |
|-----------------------|----|----|---------------|-------------|---|---------------|------|----|
| | 1 | | -2/3 | 1/3 | | 2/3 | -1/3 | 2 |
| | | 1 | -1/3 | -1/3 | | 1/3 | 1/3 | 2 |
| | | | 1/3 | 1/3 | 1 | -1/3 | -1/3 | 1 |
| 1 | | | | | | -1 | -1 | 0 |
| 1 | | | 4/3 | 1/3 | | -4/3 | -1/3 | -6 |



| Z , Z * | x1 | x2 x | (3 柒 | x4 3= | x5] | 定 | 数 | |
|-----------------------|----|------|-------------|----------------|-------------|----|----|--------|
| ×2/3 | 1 | 2 | 2/32/3 | 2/31/3 | | 2 | 2 | |
| ×1/3 ×3 | | 11 | /31/3 | 1/31/3 | 1 | 1 | 2 | |
| ×3 | | | 1 (1/3 | 1 1/3 | 3 1 | 3 | 1 | /(1/3) |
| | | | | | | | | |
| ×-4/3 | | -4/ | 3(4/3 | -4/B /3 | -4 | -4 | -6 | |



| z , z * | x1 | x2 | x3 | x4 📜 | x5 # | 定数 | $\sqrt{1=4}$ |
|-----------------------|----|----|----|------|------|-----|--------------|
| | 1 | | 0 | 1 | | 4 | X 1 — T |
| | | 1 | 0 | | 1 | 3 | x2=3 |
| | | | 1 | 1 | 4 | 3 | |
| | | | | | | | 是:帝砚 |
| 1 | | | 0 | -1 | -4 | -10 | 最適解 |

• 罰則付単体法 十分大きな M により、 $z^*=0, z$ の最小化が 同時に実現する

minimize $\tilde{z} = z + Mz^*$ subject to $x_1 + x_2 - x_3 + x_6 = 4$ $z + Mz^*$ の最小化で、 $-x_1 + 2x_2$ $-x_4$ $+x_7 = 2$ $x_2 + x_5 = 3$ $\tilde{z} + x_1 + (3M+2)x_2 - Mx_3 - Mx_4 = 6M$ $x_1, x_2, x_3, x_4, x_5, x_6, x_7 \ge 0$

| z~ | x1 | x2 | x3 | x4 | x5 | x6 | x7 | 定数 |
|----|----|------|----|----|----|----|----|----|
| | 1 | 1 | -1 | | | 1 | | 4 |
| | -1 | 2 | | -1 | | | 1 | 2 |
| | | 1 | | | 1 | | | 3 |
| 1 | 1 | 3M+2 | -M | -M | | | | 6M |

• 罰則付単体法 十分大きな M により、 $z^*=0, z$ の最小化が 同時に実現する

一罰則付単体法
$$x_1 + x_2 - x_3 + x_6 = 4$$
 $x_1 + x_2 - x_3 + x_6 = 4$ $x_1 + x_2 - x_3 + x_7 = 2$ $x_2 + x_5 = 3$ 司時に実現する $x_1 + x_2 - x_3 + x_5 = 3$ $x_2 + x_5 = 3$ $x_3 + x_4 + x_5 = 3$ $x_4 + x_5 + x_5 = 3$ $x_5 + x_1 + (3M+2)x_2 - Mx_3 - Mx_4 = 6M$ $x_1, x_2, x_3, x_4, x_5, x_6, x_7 \ge 0$

| z~ | x1 | | x2 | x3 | x4 | x5 | x6 | x7 | 定数 |
|----|----|----|-----|------|------|----|----|----|-----|
| | | 1 | 1 | -1 | | | 1 | | 4 |
| | | -1 | 2 | | -1 | | | 1 | 2 |
| | | | 1 | | | 1 | | | 3 |
| - | 1 | 1 | 302 | -100 | -100 | | | | 600 |

| Z , Z * | x1 | 非 | | x2 | 褋 | x 3 | 非 | x4 | 非 | x5 | | x6 | | x7 | 非 | 定数 | | |
|-----------------------|-----|------------------|---|-------------------|-----------|------------|----------------|----------------|-------------------|----|---|----|---|----------|----------------|-----------------------|----------|------|
| | | | 1 | | 1 | | -1 | | · • | | | | 1 | | | | 4 | /1=4 |
| | | | 1 | | 2 | | | | -1 | | | | | | 1 | | (2 | /2=1 |
| | | | | | 1 | | | | | | 1 | | | | | | 3 | /1=3 |
| 1 | | | 1 | (| 302 |) | -100 | _ | 100 | | | | | | | 6 | 00 | |
| Z , Z * | x1 | 非 | 2 | x2 | | х3 | 非 | x4 | 非 | x5 | | x6 | | x7 | 非 | 定数 | | |
| | | | 1 | | | | -1 | | | | | | 1 | | | | 4 | |
| ×1/2 | -1, | /2- | 1 | 1 | (2 | | | -1 | /2-1 | | | | | 1/ | 2 1 | 1 | 2 | |
| | | | | | | | | | | | 1 | | | | | | 3 | |
| 1 | | | 1 | • | 302 | • | -100 | _ | 100 | | | | | | | 6 | 00 | |
| Z , Z * | x1 | 非 | 2 | x2 | 褋 | x 3 | 非 | x4 | 非 | x5 | | х6 | | x7 | 非 | 定数 | | |
| ×-1 | 1/ | /2 | 1 | -1 | 1 | | -1 | 1, | /2 | | | | 1 | -1/ | 2 | -1 | 4 | |
| | -1, | <u>/2-</u> | X | 1 | × | | | -1 | /2 - X | | | | | 1/ | 2 🗶 | 1 | X | |
| ×-1 | · ' | /2 | | -1 | 1 | | | 1, | /2 | | 1 | | | -1/ | 2 | -1 | 3 | |
| <-302 1 | 15 | 51 | 1 | 20 | 302 02 | | -100 | _ | 100 | | | | | -15 | 1 | 6 -302 | 00 | |
| - -* | v1 | ᆲ | , | $\frac{-30}{x^2}$ |) | x3 | ᆲ | 15 x4 | | x5 | | x6 | | x7 | ᆲ | -302 定数 | | |
| Z,Z * | ΧI | 非 3/ | 2 | XZ | \cap | XS | <u>非</u> -1 | X 4 | 非 1/2 | XS | | XO | 1 | X / _ | <u> </u> | 是 数 | 3 | |
| | | <u>3/</u> -1/ | 2 | | 1 | | - 1 | | -1/2 -1/2 | | | | 1 | _ | 1 / 乙 1 / つ | | <u> </u> | |
| | - | - I / - 1 / | 2 | | <u> </u> | | | - | 1 / Z | | 1 | | | | 1 / 乙 1 / つ | | <u>၂</u> | |
| | | 1/ | 2 | | <u> </u> | | 100 | | 1/2 | | | | | - | 1 / Z | | 2 | |
| 1 | | 15 | 2 | | 0 | - | -100 | | 51 | | | | | _ | <u> 151</u> | 2 | 98 | |

| z , z * | x1 柒 3/2 | x2 | x3 非 | x4 1 = | x5 | x6 ‡ | x7 # | 定数 | |
|-------------------------------|---|------------------------|--|---|---------------|--|---|--|---------|
| | 3/2 | 0 | -1 | 1/2 | | 1 | -1/2 | 3((| 3/2)=2 |
| | -1/2 | 1 | | -1/2 | | | 1/2 | 1/(| -1/2)<0 |
| | 1/2 | 0 | | 1/2 | 1 | | -1/2 | 2/(| 1/2)=4 |
| 1 | (152 | 0 | -100 | 51 | | | -151 | 298 | |
| Z , Z * | x1 📜 | x2 | x3 3 = | x4 非 | x5 | x6] | ×7. 1= | 定数 | |
| ×2/3 | 1 (3/2 | 0 | -2/3-1 | 1/3/2 | | 2/3 1 | ^{-1/3} 1/2 | 2 3 | |
| | -1/2 | 1 | | -1/2 | | | 1/2 | 1 | |
| | 1/2 | 0 | | 1/2 | 1 | | -1/2 | 2 | |
| 1 | 152 | 0 | -100 | 51 | | | -151 | 298 | |
| | | | | | | | | | J T |
| Z , Z * | x1 ¾ | x2 | | | x5 | x6 # | | 定数 | |
| Z,Z* | x1 非 1 3 人 2 | x2 0 | | _ | x5 | x6 # 2/3 * ** | | | |
| z,z* ×1/2 1 | x1 * 1 3 / 2 /21/2 | x2 0 | | _ | x5 | x6 # 2/3 % 1/3 -1 | | 定数 | |
| z,z* ×1/2 1 ×-1/2- | x1 % 1 3 % 2 /21/2 1/21/2 | 0 | x3 # -2/3×1 | x4 # 1/ 3 % 2 | x5 1 | x6 # 2/3 % 1/3 -1 -1/3 1 | ×7 # -1/31×2 | 定数 | |
| z,z* ×1/2 1 ×-1/2- ×-152 1 | x1 * 1 3 * 2 /21/2 1/21/2 152 | 0 | x3 # -2/3 x -1/3 | x4 # 1/ 3 % 2 1/ 6 1/2 | x5 1 -3 | 2/3 X 1/3 -1 | ×7 # -1/31 X 2 /61/2 | 定数 2 | |
| ×1/2 1 ×-1/2- ×-152 1 | 1 3×2 /21/2 1/21/2 | 0 1 0 9 | x3 -2/3 -1/3 - 1/3 - 04/300 | x4 1/ 3 / 2 1/61/2 1/61/2 _{52/3} 51 | x5 1 -3 | 2/3 % 1/3 -1 -1/3 1 | x7 -1/31 2 /61/2 /61/2 52-/351 | 定数 2 1 1 -1 2 ₀₄ 298 | |
| ×1/2 1 ×-1/2- ×-152 1 | 1 3×2 /21/2 1/21/2 152 52 | 0 1 0 9 | x3 F | x4 # 1/ 3% 2 1/ 6 1/2 1/ 6 1/2 52/3 51 | 1 -3 x5 | 2/3 X 1/3 -1 -1/3 1 04/3 1 x6 # 2/3 | x7 | 定数 2 1 1 -1 2 04 298 定数 2 | |
| ×1/2 1 ×-1/2- ×-152 1 | 1 3×2 /21/2 1/21/2 152 52 | 0 1 0 9 | x3 -2/3 -1/3 | x4 1/ 3 /2 1/61/2 1/61/2 _{52/3} 51 x4 1/3 | 1 -3 x5 | 2/3 X 1/3 -1 -1/3 1 04/3 1 x6 # 2/3 1/3 | x7 | 定数 2 1 -1 2 04 298 定数 2 2 | |
| ×1/2 1 ×-1/2- ×-152 1 | 1 3×2 /21/2 1/21/2 152 52 x1 1 | 0 1 0 9 x2 | x3 -2/3 -1/3 - 1/3 - 04/300 x3 -2/3 | x4 # 1/ 3 x 2 1/ 6 1/2 1/ 6 1/2 52/3 51 x4 # 1/3 -1/3 | 1 -3 x5 | 2/3 X 1/3 -1 -1/3 1 04/3 1 x6 # 2/3 1/3 | x7 | 定数 2 1 -1 2 04 298 定数 2 2 | |

| z,z* x1 | x2 | x3 \$ | x 4 | # x5 | 非 | x6 非 | x7 | 定数 | |
|-----------------|-----|--------------|------------|----------------------|----|-------------|---------------------|-----|--------|
| | 1 | -2 | /3 | 1/3 | 7 | 2/3 | -1/3 | 2 | |
| | 0 | 1 -1 | /3 | -1/3 | | 1/3 | 1/3 | _ | |
| | 0 | 1 | /3 | 1/3 | 1 | -1/3 | -1/3 | | 1/3)=3 |
| 1 | 0 | 4 | | 1/3 | | , | -301/3 | | 1,0,0 |
| z,z* x1 | x2 | x3 3 | | # x5 | 非 | | <u> </u> | 定数 | |
| | 1 | -2 | /3 | 1/3 | 7 | 2/3 | -1/3 | 2 | |
| | 0 | 1 -1 | /3 | -1/3 | | 1/3 | 1/3 | 2 | |
| × 3 | 0 | 1 (1 | /31 | 1/33 | 1 | , | - 1-1/3 | 3 1 | |
| 1 | 0 | 4 | 73 | 1/3 | | • | -301/3 | | |
| z,z* x1 | x2 | x3 3 | x4 | # x5 | 非 | • | 双非 | | |
| z,z* x1 ×2/3 | 1 | 2/32 | _ | 3 /3 2 | -2 | /32/3 | -2/3 1/3 | | |
| ×1/3 | 0 | 11/-3 | /31/ | 3/31 | -1 | /31/3 | -1/3 1/3 | 1 2 | |
| ., . | 0 | 1 1 | ×3 1 | 33 | * | -1133 | <u>-1-1/3</u> | 3 🗶 | |
| ×-4/31 | 0 | 4 | /3 | 1/3 | | ,-304/3 | -301/3 | | |
| | | -4/3 | -4, | /3 -4 | 4/ | /3 | 4/3 | -4 | |
| z,z* x1 | x2 | x3 3 | × 4 | x5 | | x6 非 | x7 非 | 定数 | v1-/ |
| | (1) | | 0 | 1 | 2 | 0 | -1 | 4 | x1=4 |
| | 0 (| 1) | 0 | 0 | 1 | 0 | 0 | 3, | x2=3 |
| | 0 | | 1 | (1) | 3 | -1 | -1 | 3 | |
| 1 | 0 | | 0 | -1 | -4 | -100 | -99 | -10 | 最適解 |

| z , z * | x1 # | x2 💥 | x3 # | x4 # | x5 | x6 | x7 📜 | 定数 | |
|-----------------------|---------------|-----------------|------|---------------|----|----|-------------|-----------|-----------------------|
| ×-1 | 1/2 1 | -1 1 | -1 | 1/2 | | 1 | 1/2 | -1 | 4/1=4 |
| ×1/2 | -1/2 × | 1 (🔀 | | -1/2 × | | | 1/2 🔀 | 1 | 2 /2= 1 |
| ×-1 | 1/2 | -1 | | 1/2 | 1 | | -1/2 | -1 | 3/1=3 |
| ×-3M+2 | 3M/2 -1 | -3M 3N +2 -1 | -M | 3M/2-M -1 | | | -3M/2 +1 | -3M +2 | 6M |

- 非常に大きい数 M を記号で残した場合、
 - シンプレックス表には M の係数と定数の両方を記録しなければならない
 - 連立方程式の解法では M の係数と定数の両方を 掃き出さなければならない
- 結局、2段階単体法で z* と同時に z の式を扱うのと同じことになる

- 2段階法における人工(補助)問題と元の問題の関係
 - まず z^* を最小化して、次に z を最小化する
- 人工問題を同時に解く方法=罰則付単体法
 - -z の最小化と人工変数=0 が成立すれば良い
 - $-z, z^*$ を同時 $(z^*=0$ 優先)に最適化=罰則付単体法
 - $z+M\times z^*$ (M は大きな数)を最小化する M の影響が大きいので z^* の最小化 $\rightarrow z^*=0$ が優先的に実現される
- 安全な罰則(M)を決める方法が無い
 - M を任意の数よりも大きい数として扱う
 - 2段階法と同じ手間になる