

## Ejercicio #4

Objetivo Simplex Gran M → Dual

$$\text{Max } z = x + 3y$$

$$x + 2y \geq 7$$

$$2x - y \leq 4$$

$$4x - y \geq 1$$

$$3x + 2y \leq 20$$

$$x, y \geq 0$$

|    | x | y | A1 | H1 | A2    | H2    | E1 | E2    | VS |
|----|---|---|----|----|-------|-------|----|-------|----|
| y  | 0 | 1 | 0  | 0  | -3/11 | 4/11  | 0  | 3/11  | 7  |
| H1 | 0 | 0 | 0  | 1  | -7/11 | 2/11  | 0  | 7/11  | 7  |
| x  | 1 | 0 | 0  | 0  | 2/11  | 1/11  | 0  | -2/11 | 2  |
| E1 | 0 | 0 | -1 | 0  | -4/11 | 9/11  | 1  | 4/11  | 9  |
| Z  | 0 | 0 | M  | 0  | M/11  | 13/11 | 0  | 7/11  | 23 |

### Primal

$$\text{max } z = x + 3y$$

Sujeto a:

$$x + 2y \geq 7 \quad (y_1) \quad A1 - E1$$

$$2x - y \leq 4 \quad (y_2) \quad H1$$

$$4x - y \geq 1 \quad (y_3) \quad A2 - E2$$

$$3x + 2y \leq 20 \quad (y_4) \quad H2$$

### Tabla Inicial

### Primal con variables

$$\text{max } Z = x + 3y - MA1 - MA2$$

Sujeto a:

$$x + 2y - E1 + A1 = 7$$

$$2x - y + H1 = 4$$

$$4x - y - E2 + A2 = 1$$

$$3x + 2y + H2 = 20$$

$$\rightarrow \text{max } Z = x + 3y + MA1 + MA2 = 0$$

### Dual

~~$\text{min } w = x + 3y - MA1 - MA2$~~

~~$\text{Sujeto a: min } w = 7y_1 + 4y_2 + y_3 + 20y_4$~~

4 Sujeto a:

$$y_1 + 2y_2 + 4y_3 + 3y_4 \geq 1 \quad (\text{variable } x)$$

$$2y_1 - y_2 - y_3 + 2y_4 \geq 3 \quad (\text{variable } y)$$

~~$y_1 + 2y_2 + 4y_3 + 3y_4 \geq 1$~~

$$y_1 \leq 0, y_2 \geq 0, y_3 \leq 0, y_4 \geq 0$$

|    | x | y  | A1 | H1 | A2 | H2 | E1 | E2 | VS |
|----|---|----|----|----|----|----|----|----|----|
| A1 | 1 | 2  | 1  | 0  | 0  | 0  | -1 | 0  | 7  |
| H1 | 2 | -1 | 0  | 1  | 0  | 0  | 0  | 0  | 4  |
| A2 | 4 | -1 | 0  | 0  | 1  | 0  | 0  | -1 | 1  |
| H2 | 3 | 2  | 0  | 0  | 0  | 1  | 0  | 0  | 80 |
| Z  | 1 | 3  | -M | 0  | -M | 0  | 0  | 0  | 0  |

## Penalización

$$\text{Nuevo } z = z - MA_1 - MA_2$$

|           | x              | y             | A1 | H1 | A2 | H2 | E1 | E2 | VS    |
|-----------|----------------|---------------|----|----|----|----|----|----|-------|
| $z$       | -1             | -3            | M  | 0  | M  | 0  | 0  | 0  | 0     |
| $-MA_1$   | -M             | $\frac{M}{3}$ | -M | 0  | 0  | 0  | M  | M  | $-7M$ |
| $-MA_2$   | $\frac{-M}{3}$ | 0             | 0  | -M | 0  | 0  | M  | M  | $-M$  |
| Nuevo $z$ | $\frac{M}{3}$  | $\frac{M}{3}$ | 0  | 0  | 0  | 0  | M  | M  | $-8M$ |

$x, y$  negativos, se iteran

## \* Iteración #1

$$VE = x \quad RM: \frac{7}{1} = 7 \quad \frac{U}{2} = 2 \quad \frac{1}{u} = \frac{1}{u} \quad \frac{20}{3} = \frac{20}{3} \quad \text{Pivote} = u$$

$$JS = A_2$$

|                  | x                   | y                       | A1        | H1        | A2        | H2        | E1        | E2        | VS          |
|------------------|---------------------|-------------------------|-----------|-----------|-----------|-----------|-----------|-----------|-------------|
| $A_2 - \alpha x$ | $\frac{u/4}{1} = 1$ | $\frac{-1/4}{-1/4} = 0$ | $0/4 = 0$ | $0/4 = 0$ | $0/4 = 0$ | $0/4 = 0$ | $0/4 = 0$ | $0/4 = 0$ | $1/4 = 1/4$ |

$$w = -5M - 1$$

|    | A1                           | H1                    | H2                   | Z   |
|----|------------------------------|-----------------------|----------------------|---|
| x  | $1 - 1 \cdot 0 = 0$          | $2 - 2 \cdot 1 = 0$   | $3 - 3 \cdot 1 = 0$  | $(\cancel{w} + w \cdot 1) = 0$                                |
| y  | $2 - 1(-1/4) = 9/4$          | $-1 - 2(-1/4) = -1/2$ | $2 - 3(-1/4) = 11/4$ | $(-M - 3) - w \cdot 1 = -(9M + 3)/4$                          |
| A1 | $1 - 1 \cdot 0 = 1$          | $0 - 2(0) = 0$        | $0 - 3(0) = 0$       | $0 - w \cdot 0 = 0$   |
| H1 | $0 - 1 \cdot 0 = 0$          | $1 - 2(0) = 1$        | $0 - 3(0) = 0$       | $0 - w \cdot 0 = 0$   |
| A2 | $0 - 1(1/4) = -1/4$          | $0 - 2(1/4) = -1/2$   | $0 - 3(1/4) = -3/4$  | $0 - w \cdot (1/4) = \cancel{w} \rightarrow \frac{5M + 1}{4}$ |
| H2 | $0 - 1(0) = 0$               | $0 - 2(0) = 0$        | $1 - 3(0) = 1$       | $0 - w \cdot 0 = 0$   |
| E1 | $-1 - 1 \cdot 0 = -1$        | $0 - 2(0) = 0$        | $0 - 3(0) = 0$       | $M - w \cdot 0 = M$   |
| E2 | $0 - 1(-1/4) = \cancel{1/4}$ | $0 - 2(-1/4) = 1/2$   | $0 - 3(-1/4) = 3/4$  | $M - w \cdot (-1/4) = -(M + 1)/4$                             |
| VS | $7 - 1(1/4) = 27/4$          | $4 - 2(1/4) = 7/2$    | $20 - 3(1/4) = 77/4$ | $(-8M) - w(1/4) = \cancel{(1 - 27M)/4}$                       |

# Tabla luego de Iteración 1

|    | X | y                    | A1 | H1 | A2                 | H2 | E1 | E2                 | VS                  |
|----|---|----------------------|----|----|--------------------|----|----|--------------------|---------------------|
| A1 | 0 | $9/4$                | 1  | 0  | $-1/4$             | 0  | -1 | $1/4$              | $27/4$              |
| H1 | 0 | $-1/2$               | 0  | 1  | $-1/2$             | 0  | 0  | $1/2$              | $7/2$               |
| X  | 1 | $-1/4$               | 0  | 0  | $9/4$              | 0  | 0  | $-1/4$             | $1/4$               |
| H2 | 0 | $11/4$               | 0  | 0  | $-3/4$             | 1  | 0  | $3/4$              | $77/4$              |
| Z  | 0 | $\frac{-(9M+13)}{4}$ | 0  | 0  | $\frac{(SM+1)}{4}$ | 0  | M  | $\frac{-(M+1)}{4}$ | $\frac{(1-27M)}{4}$ |

↗ Negativo,  
 a Mayor

## \* Iteración #2

$$VE = 4 \quad RM: \quad \frac{(27M)}{9/4} = 3 \quad \frac{(77M)}{11/4} = 7 \quad \text{PivotC} = 9/4$$

$$VS = A_1 \quad VS$$

|                     | X       | y           | A1       | H1      | A2           | H2      | E1         | E2             | VS             |
|---------------------|---------|-------------|----------|---------|--------------|---------|------------|----------------|----------------|
| $A_1 \rightarrow y$ | $0/9/4$ | $(9/4)/9/4$ | $11/9/4$ | $0/9/4$ | $(-1/4)/9/4$ | $0/9/4$ | $-1/(9/4)$ | $(11/4)/(9/4)$ | $(27/4)/(9/4)$ |
| =0                  | =1      | =4/9        | =0       | =0      | =0           | =-1/9   | =-4/9      | =1/9           | =3             |

|    | H1                                 | X                              | H2                               | Z  |
|----|------------------------------------|--------------------------------|----------------------------------|--|
| X  | $0 + (1/2) \cdot 0 = 0$            | $1 + (1/4) \cdot 0 = 1$        | $0 - 11/4 \cdot 0 = 0$           | $0 + \frac{(9M+13)}{4} \cdot 0 = 0$                |
| Y  | $-\frac{1}{2} + (1/2) \cdot 1 = 0$ | $-1/4 + (1/4) \cdot 1 = 0$     | $11/4 - 11/4 \cdot 1 = 0$        | $\frac{-(9M+13)}{4} + \frac{9M+13}{4} \cdot 1 = 0$ |
| A1 | $0 + (1/2)(4/9) = 2/9$             | $0 + (1/4)(4/9) = 1/9$         | $0 - 11/4 \cdot (4/9) = -11/9$   | $0 + \frac{9M+13}{4}(4/9) = M + 13/9$              |
| H1 | $1 + (1/2) \cdot 0 = 1$            | $0 + 1/4 \cdot 0 = 0$          | $0 - \frac{1}{4} \cdot 0 = 0$    | $0 + \frac{9M+13}{4} \cdot 0 = 0$                  |
| A2 | $-1/2 + 1/2 \cdot (-1/9) = -5/9$   | $1/4 + 1/4 \cdot (-1/9) = 2/9$ | $-3/4 - 1/4 \cdot (-1/9) = -4/9$ | $(5M+1)/4 + (8M+13)/4 \cdot (-1/9) = -M - 13/9$    |
| H2 | $0 + 1/2 \cdot 0 = 0$              | $0 + 1/4 \cdot 0 = 0$          | $1 - 11/4 \cdot 0 = 1$           | $0 + \frac{9M+13}{4} \cdot 0 = 0$                  |
| E1 | $0 + 1/2(-4/9) = -2/9$             | $0 + 1/4 \cdot (-4/9) = -1/9$  | $0 - 11/4(1/9) = 4/1/9$          | $M + \frac{9M+13}{4} \cdot (-4/9) = -13/9$         |
| E2 | $1/2 + 1/2(1/9) = 5/9$             | $-1/4 + 1/4(1/9) = -2/9$       | $3/4 - 11/4(1/9) = 4/9$          | $-(M+1)/4 + \frac{9M+13}{4}(1/9) = 1/9$            |
| VS | $7/2 + 1/2(3) = 5$                 | $1/4 + 1/4(3) = 1$             | $77/4 - 11/4(3) = 11$            | $\frac{(1-27M)}{4} + \frac{9M+13}{4}(3) = 10$      |

## Tabla luego de iteración 2

|               | X | Y | A1       | H1 | A2      | H2 | E1      | E2     | VS |
|---------------|---|---|----------|----|---------|----|---------|--------|----|
| Y             | 0 | 1 | $4/9$    | 0  | $-1/9$  | 0  | $-4/9$  | $1/9$  | 3  |
| H1            | 0 | 0 | $2/9$    | 1  | $-5/9$  | 0  | $-2/9$  | $5/9$  | 5  |
| X             | 1 | 0 | $1/9$    | 0  | $2/9$   | 0  | $-1/9$  | $-2/9$ | 1  |
| <del>A2</del> | 0 | 0 | $-11/9$  | 0  | $-4/9$  | 1  | $11/9$  | $4/9$  | 11 |
| Z             | 0 | 0 | $M+13/9$ | 0  | $M-1/9$ | 0  | $-13/9$ | $1/9$  | 10 |

↑ Negativo, iterar

### \* Iteración #3

$$VE = E1$$

$$RM: \frac{11}{(11/9)} = 9$$

$\curvearrowleft$   
VS

$$VS = H2$$

$$\text{Pivot} = 11/9$$

|                     | X         | Y         | A1            | H1                 | A2     | E1                 | E2                 | VS          | H2          |
|---------------------|-----------|-----------|---------------|--------------------|--------|--------------------|--------------------|-------------|-------------|
| $H2 \rightarrow E1$ | $0(11/9)$ | $0(11/9)$ | $0/_{(11/9)}$ | $(-4/9)/_{(11/9)}$ | $11/9$ | $(11/9)/_{(11/9)}$ | $(11/9)/_{(11/9)}$ | $10/(11/9)$ | $11/(11/9)$ |

|    | Y                           | H1                                  | X                         | Z  |
|----|-----------------------------|-------------------------------------|---------------------------|--|
| X  | $0 + 4/9 \cdot 0 = 0$       | $0 + 2/9 \cdot 0 = 0$               | $1 + 1/9 \cdot 0 = 0$     | $0 + \frac{13}{9} \cdot 0 = 0$             |
| Y  | $1 + 4/9 \cdot 0 = 1$       | $0 + 2/9 \cdot 0 = 0$               | $0 + 1/9 \cdot 0 = 0$     | $0 + \frac{13}{9} \cdot 0 = 0$             |
| A1 | $4/9 + 4/9(-1) = 0$         | $2/9 + 2/9(-1) = 0$                 | $1/9 + 1/9(-1) = 0$       | $(M+13/9) + \frac{13}{9}(-1) = M$          |
| H1 | $0 + 4/9 \cdot 0 = 0$       | $1 + \frac{2}{9}(0) = 1$            | $0 + 1/9 \cdot 0 = 0$     | $0 + \frac{13}{9} \cdot 0 = 0$             |
| A2 | $-1/9 + 4/9(-4/11) = -3/11$ | $-5/9 + \frac{2}{9}(-4/11) = -7/11$ | $1/9 + 1/9(-4/11) = 2/11$ | $(M-1/9) + \frac{13}{9}(-4/11) = M - 7/11$ |
| H2 | $0 + 4/9(0/11) = 0/11$      | $0 + \frac{2}{9}(0/11) = 0/11$      | $0 + 1/9(0/11) = 0/11$    | $0 + 13/9 \cdot (0/11) = 13/11$            |
| E1 | $-4/9 + 4/9 \cdot 1 = 0$    | $-2/9 + \frac{2}{9}(1) = 0$         | $-1/9 + 1/9(1) = 0$       | $-13/9 + \frac{13}{9} \cdot 0 = 0$         |
| E2 | $1/9 + 4/9(4/11) = 3/11$    | $5/9 + \frac{2}{9}(4/11) = 7/11$    | $2/9 + 1/9(4/11) = 2/11$  | $1/9 + 13/9(4/11) = 7/11$                  |
| VS | $3 + 4/9(9) = 7$            | $5 + \frac{2}{9} \cdot 9 = 7$       | $1 + 1/9(9) = 2$          | $10 + \frac{13}{9} \cdot 9 = 23$           |

Tabla luego de la iteración 3

|       | $x$ | $y$ | $A1$ | $M1$ | $A2$      | $H2$    | $E1$ | $E2$    | $V_S$ |
|-------|-----|-----|------|------|-----------|---------|------|---------|-------|
| $y$   | 0   | 1   | 0    | 0    | $-3/11$   | $4/11$  | 0    | $3/11$  | 7     |
| $H_1$ | 0   | 0   | 0    | 1    | $-7/11$   | $2/11$  | 0    | $7/11$  | 7     |
| $x$   | 1   | 0   | 0    | 0    | $2/11$    | $1/11$  | 0    | $-2/11$ | 2     |
| $E_1$ | 0   | 0   | -1   | 0    | $-4/11$   | $9/11$  | 1    | $4/11$  | 9     |
| $Z$   | 0   | 0   | M    | 0    | $-M/7/11$ | $13/11$ | 0    | $7/11$  | 23    |

Matriz Óptima Inversa

Comprobación

"X"

| Matriz Optima Inversa | Operación | X | Desarrollo  | Resultado |
|-----------------------|-----------|---|---|-----------|
| 0 0 $-3/11$ $4/11$    | *         | 1 | $0 \cdot 1 + 0 \cdot 2 + -3/11 \cdot 4 + 4/11 \cdot 3$  | 0         |
| 0 1 $-7/11$ $2/11$    | *         | 2 | $0 \cdot 1 + 1 \cdot 2 + -7/11 \cdot 4 + 2/11 \cdot 3$  | 0         |
| 0 0 $2/11$ $1/11$     | *         | 3 | $0 \cdot 1 + 0 \cdot 2 + 2/11 \cdot 4 + 1/11 \cdot 3$   | 1         |
| -1 0 $-4/11$ $9/11$   | *         | 3 | $-1 \cdot 1 + 0 \cdot 2 + -4/11 \cdot 4 + 9/11 \cdot 3$ | 0         |

"Y"

| Matriz Opt Inv      | Oper | Y  | Desarrollo  | Resultado |
|---------------------|------|----|---|-----------|
| 0 0 $-3/11$ $4/11$  | *    | 2  | $0 \cdot 2 + 0 \cdot -1 + -3/11 \cdot -1 + 4/11 \cdot 2$  | 1         |
| 0 1 $-7/11$ $2/11$  | *    | -1 | $0 \cdot 2 + 1 \cdot -1 + -7/11 \cdot -1 + 2/11 \cdot 2$  | 0         |
| 0 0 $2/11$ $1/11$   | *    | -1 | $0 \cdot 2 + 0 \cdot -1 + 2/11 \cdot -1 + 1/11 \cdot 2$   | 0         |
| -1 0 $-4/11$ $9/11$ | *    | 2  | $-1 \cdot 2 + 0 \cdot -1 + -4/11 \cdot -1 + 9/11 \cdot 2$ | 0         |

"A1"

| Matriz Opt Inv      | Oper | A1 | Desarrollo   | Resultado |
|---------------------|------|----|--|-----------|
| 0 0 $-3/11$ $4/11$  | *    | 1  | $0 \cdot 1 + 0 \cdot 0 + -3/11 \cdot 0 + 4/11 \cdot 0$   | 0         |
| 0 1 $-7/11$ $2/11$  | *    | 0  | $0 \cdot (1) + 1 \cdot 0 + -7/11 \cdot 0 + 2/11 \cdot 0$ | 0         |
| 0 0 $2/11$ $1/11$   | *    | 0  | $0 \cdot 1 + 0 \cdot 0 + 2/11 \cdot 0 + 1/11 \cdot 0$    | 0         |
| -1 0 $-4/11$ $9/11$ | *    | 0  | $-1 \cdot 0 + 0 \cdot 0 + -4/11 \cdot 0 + 9/11 \cdot 0$  | -1        |

"H1"

| Matriz Opt Inv    | Oper | H1 | Desarrollo                            | Resultado |
|-------------------|------|----|---------------------------------------|-----------|
| 0 0 -3/11 4/11 *  | 0    | 0  | 0.0 + 0.1 + -3/11 · 0 + 4/11 · 0      | 0         |
| 0 1 -7/11 2/11 *  | 1    | 0  | 0.0 + 1 · 1 + -7/11 · 0 + 2/11 · 0    | 1         |
| 0 0 2/11 1/11 *   | 0    | 0  | 0.0 + 0 · 1 + 2/11 · 0 + 1/11 · 0     | 0         |
| -1 0 -4/11 9/11 * | 0    | 0  | -1 · 0 + 0 · 1 + -4/11 · 0 + 9/11 · 0 | 0         |

"A2"

| Matriz Opt Inv    | Oper | A2 | Desarrollo                            | Resultado |
|-------------------|------|----|---------------------------------------|-----------|
| 0 0 -3/11 4/11 *  | 0    | 0  | 0.0 + 0 · 0 + -3/11 · 1 + 4/11 · 0    | -3/11     |
| 0 1 -7/11 2/11 *  | 0    | 0  | 0.0 + 1 · 0 + -7/11 · 1 + 2/11 · 0    | -7/11     |
| 0 0 2/11 1/11 *   | 1    | 0  | 0.0 + 0 · 0 + 2/11 · 1 + 1/11 · 0     | 2/11      |
| -1 0 -4/11 9/11 * | 0    | 0  | -1 · 0 + 0 · 0 + -4/11 · 1 + 9/11 · 0 | -4/11     |

"H2"

| Matriz Opt Inv    | Oper | H2 | Desarrollo                            | Resultado |
|-------------------|------|----|---------------------------------------|-----------|
| 0 0 -3/11 4/11 *  | 0    | 0  | 0.0 + 0 · 0 + -3/11 · 0 + 4/11 · 1    | 4/11      |
| 0 1 -7/11 2/11 *  | 0    | 0  | 0.0 + 1 · 0 + -7/11 · 0 + 2/11 · 1    | 2/11      |
| 0 0 2/11 1/11 *   | 0    | 0  | 0.0 + 0 · 0 + 2/11 · 0 + 1/11 · 1     | 1/11      |
| -1 0 -4/11 9/11 * | 1    | 0  | -1 · 1 + 0 · 0 + -4/11 · 0 + 9/11 · 0 | 9/11      |

"E1"

| Matriz Opt Inv    | Oper | E1 | Desarrollo                            | Resultado |
|-------------------|------|----|---------------------------------------|-----------|
| 0 0 -3/11 4/11 *  | *    | -1 | 0 · 1 + 0 + -3/11 + 4/11 · 0          | 0         |
| 0 1 -7/11 2/11 *  | *    | 0  | 0 · -1 + 1 · 0 + -7/11 · 0 + 2/11 · 0 | 0         |
| 0 0 2/11 1/11 *   | *    | 0  | 0 · -1 + 0 + 2/11 · 0 + 1/11 · 0      | 0         |
| -1 0 -4/11 9/11 * | *    | 0  | -1 · -1 + 0 + -4/11 · 0 + 9/11 · 0    | 1         |

"E2"

| Mut Opt Inv       | Oper | E2 | Desarrollo                          | Resultado   |
|-------------------|------|----|-------------------------------------|-------------|
| 0 0 -3/11 4/11 *  | *    | 0  | 0 + 0 + -3/11 · -1 + 4/11 · 0       | <u>3/11</u> |
| 0 1 -7/11 2/11 *  | *    | 0  | 0 + 1 · 0 + -7/11 · (-1) + 2/11 · 0 | 7/11        |
| 0 0 2/11 1/11 *   | *    | -1 | 0 + 0 + 2/11 · (-1) + 1/11 · 0      | -2/11       |
| -1 0 -4/11 9/11 * | *    | 0  | -1 · 0 + 0 + -4/11 · -1 + 9/11 · 0  | 4/11        |

"VS"

| Mtriz Opt Inv     | Op. | VS | Desarrollo                             | Resultados |
|-------------------|-----|----|--|------------|
| 0 0 -3/11 4/11 *  | *   | 7  | 0.7 + 0.4 + -3/11 - -1 + 4/11 · 20     | 7          |
| 0 1 -7/11 2/11 *  | *   | 4  | 0.7 + 0.4 + -7/11 · 1 + 2/11 · 20      | 7          |
| 0 0 2/11 1/11 *   | *   | 1  | 0.7 + 0.4 + 2/11 · 1 + 1/11 · 20       | 2          |
| -1 0 -4/11 9/11 * | *   | 20 | -1 · 7 + 0.4 + -4/11 · (1) + 9/11 · 20 | 9          |

→ Comprobamos los valores de z:  $y=3, x=1, H_1=E_1=0$

| Y       | H1                | E1 | Mtriz Opt Inv   | Op. | Desarrollo      | Resultados                        |
|---------|-------------------|----|---|-----|-----------------|-----------------------------------|
| 3 0 1 0 | 0 0 -3/11 4/11 *  | *  | 3 · 0 + 0 + 1 · 0 + 0 · 1                                     |     | 0               | $\Rightarrow y_1 = 0$             |
|         | 0 1 -7/11 2/11 *  | *  | 3 · 0 + 0 + 1 · 0 + 0 · 1                                     |     | 0               | $\Rightarrow y_2 = 0$             |
|         | 0 0 2/11 1/11 *   | *  | $3 \cdot -\frac{3}{11} + 0 \cdot -\frac{3}{11}$<br>+ 1 · 2/11 |     | $-\frac{7}{11}$ | $\Rightarrow y_3 = -\frac{7}{11}$ |
|         | -1 0 -4/11 9/11 * | *  | $3 \cdot 4/11 + 0 \cdot 2/11$<br>+ 1 · 1/11 + 0 · 9/11        |     | $13/11$         | $\Rightarrow y_4 = 13/11$         |

Dual:

$$\begin{aligned} \min w &= 7(y_1) + 4(y_2) + y_3 + 20(y_4) \\ &= 7(0) + 4(0) + (-7/11) + 20(13/11) \\ &= 23 \end{aligned}$$

Sujeto a:

$$y_1 + 2y_2 + 4y_3 + 3y_4 \geq 1$$

$$2(y_1) - (y_2) - (y_3) + 2(y_4) \geq 3$$

$$0 + 2 \cdot (0) + 4(-7/11) + 3(13/11) = 1$$

$$2 \cdot 0 - 2 \cdot 0 - 1 \cdot (-7/11) + 2(13/11) = 3$$

$$1 = 1$$

$$3 = 3$$

$$0 = 0$$

Tipo de caso: Es factible porque las variables artificiales salen en la base de la solución final. No hay coeficientes negativos por lo cual es acotado