

## Zadanie 1

Przedsiębiorstwo produkuje dwa wyroby :  $W_1$  i  $W_2$ . Ograniczeniem w procesie produkcji jest czas pracy maszyn:  $M_1$ ,  $M_2$  i  $M_3$ . W tabelicy podano zużycie czasu pracy każdej z tych maszyn na produkcje jednostki poszczególnych wyrobów, dopuszczalne czasy pracy maszyn oraz ceny wyrobów.

| Maszyny           | Zużycie czasu pracy maszyn w godz.<br>na jednostkowy wyrób |       | Dopuszczalny czas<br>pracy maszyn<br>w godz. |
|-------------------|--|-------|--|
|                   | $W_1$  | $W_2$ |  |
| $M_1$             | 2  | 1     | 1000   |
| $M_2$             | 3  | 3     | 2400   |
| $M_3$             | 1,5  | 0     | 600  |
| Ceny wyrobów (zł) | 30   | 20    |  |

Określić w jakich ilościach produkować poszczególne wyroby, aby przy istniejących ograniczeniach przychód z ich sprzedaży był możliwie największy

## ROZWIĄZANIE.

Sformułowanie zagadnienia.

$x_1$  – ilość wyrobu  $W_1$

$x_2$  – ilość wyrobu  $W_2$

Funkcja celu :  $30x_1 + 20x_2 \rightarrow \max$

Ograniczenia:

- 1)  $2x_1 + x_2 \leq 1000$
- 2)  $3x_1 + 3x_2 \leq 2400$
- 3)  $1,5x_1 \leq 600$
- 4)  $x_1 \geq 0$
- 5)  $x_2 \geq 0$

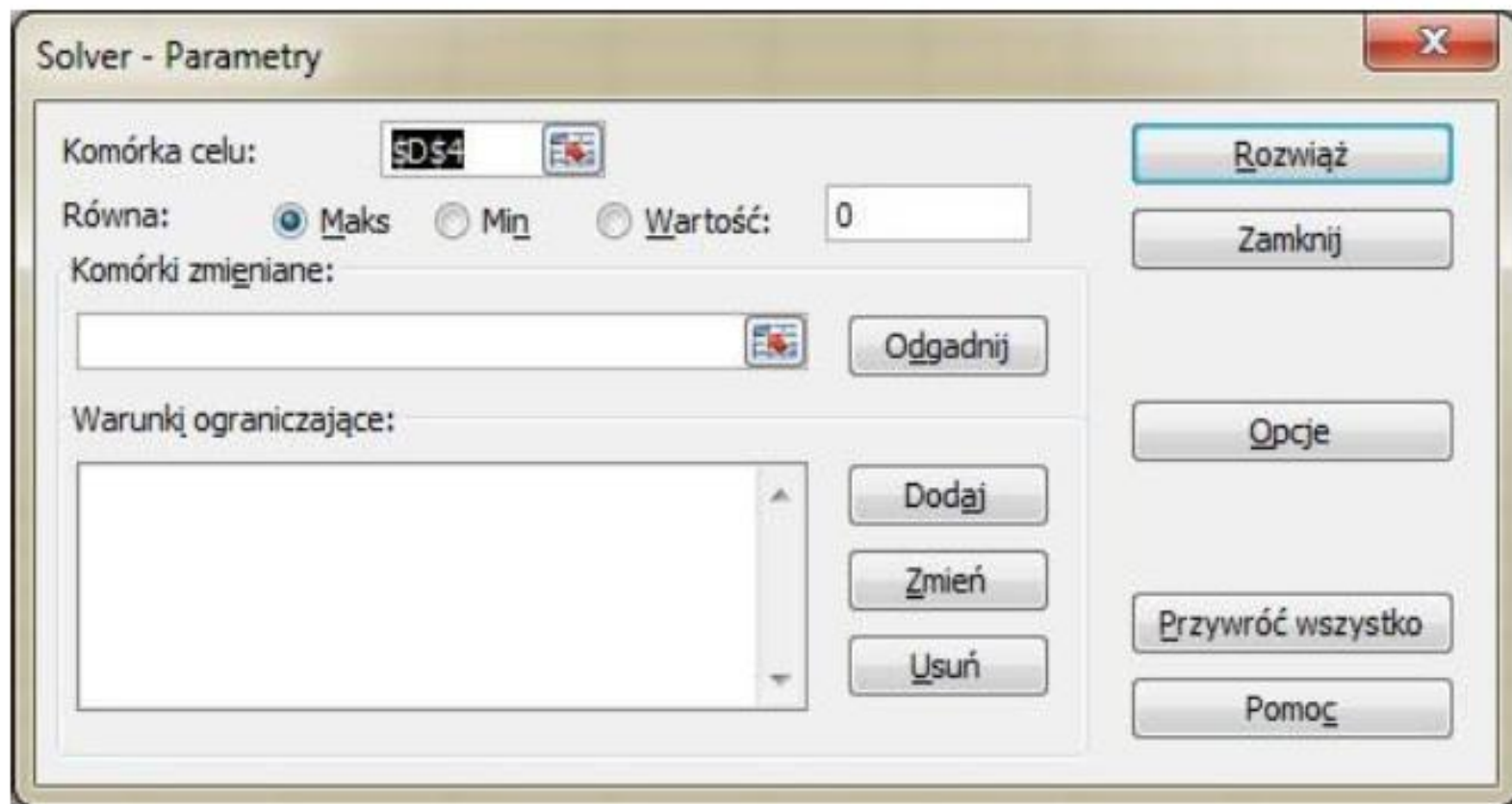
D4

f<sub>v</sub> =SUMA.ILOCZYNÓW(C2:D2;C7:D7)

|    | A                  | B | C   | D  | E    | F  | G    | H | I | J | K | L | M |
|----|--------------------|---|-----|----|------|--|------|---|---|---|---|---|---|
| 1  |                    |   | x1  | x2 |      |  |      |   |   |   |   |   |   |
| 2  | Rozwiązanie:       |   |     |    |      | na początku komórki te są puste, potem pojawi się rozwiązanie  |      |   |   |   |   |   |   |
| 3  |                    |   |     |    |      |  |      |   |   |   |   |   |   |
| 4  | Funkcja celu:      |   | max | 0  |      | wartość funkcji celu: SUMA.ILOCZYNÓW(C2:D2;C7:D7)  |      |   |   |   |   |   |   |
| 5  |                    |   |     |    |      |  |      |   |   |   |   |   |   |
| 6  |                    |   | c1  | c2 |      |  |      |   |   |   |   |   |   |
| 7  | Cel współczynniki: |   | 30  | 20 |      | wartość lewej strony nierówności 1 dla aktualnych wartości x1 i x2:<br>SUMA.ILOCZYNÓW(\$C\$2:\$D\$2;C11:D11) |      |   |   |   |   |   |   |
| 8  |                    |   |     |    |      |  |      |   |   |   |   |   |   |
| 9  | Ograniczenia:      |   |     |    |      |  |      |   |   |   |   |   |   |
| 10 |                    |   |     |    |      | lewa   |      |   |   |   |   |   |   |
| 11 |                    | 1 | 2   | 1  | 0 <= |  | 1000 |   |   |   |   |   |   |
| 12 |                    | 2 | 3   | 3  | 0 <= |  | 2400 |   |   |   |   |   |   |
| 13 |                    | 3 | 1.5 | 0  | 0 <= |  | 600  |   |   |   |   |   |   |
| 14 |                    |   |     |    |      |  |      |   |   |   |   |   |   |
| 15 |                    |   |     |    |      |  |      |   |   |   |   |   |   |
| 16 |                    |   |     |    |      |  |      |   |   |   |   |   |   |
| 17 |                    |   |     |    |      |  |      |   |   |   |   |   |   |
| 18 |                    |   |     |    |      |  |      |   |   |   |   |   |   |
| 19 |                    |   |     |    |      |  |      |   |   |   |   |   |   |
| 20 |                    |   |     |    |      |  |      |   |   |   |   |   |   |
| 21 |                    |   |     |    |      |  |      |   |   |   |   |   |   |
| 22 |                    |   |     |    |      |  |      |   |   |   |   |   |   |
| 23 |                    |   |     |    |      |  |      |   |   |   |   |   |   |
| 24 |                    |   |     |    |      |  |      |   |   |   |   |   |   |
| 25 |                    |   |     |    |      |  |      |   |   |   |   |   |   |
| 26 |                    |   |     |    |      |  |      |   |   |   |   |   |   |

Włączamy SOLVER:

Narzędzia/solver... lub Dane/solver (nowsze wersje EXCELa)



Wpisujemy adres komórki, w której umieszczona jest wartość funkcji celu oraz zaznaczamy Min lub Max

The image shows a Microsoft Excel spreadsheet with a Solver Parameters dialog box open. The spreadsheet contains a linear programming problem with the following data:

|    | A                | B | C   | D   | E    | F    | G | H | I | J | K | L | M | N | O | P    | Q |
|----|------------------|---|-----|-----|------|------|---|---|---|---|---|---|---|---|---|------|---|
| 1  |                  |   | x1  | x2  |      |      |   |   |   |   |   |   |   |   |   |      |   |
| 2  | Rozwiązanie:     |   |     |     |      |      |   |   |   |   |   |   |   |   |   |      |   |
| 3  |                  |   |     |     |      |      |   |   |   |   |   |   |   |   |   |      |   |
| 4  | Funkcja celu:    |   | max |     |      |      |   |   |   |   |   |   |   |   |   |      |   |
| 5  |                  |   |     |     |      |      |   |   |   |   |   |   |   |   |   |      |   |
| 6  |                  |   | c1  | c2  |      |      |   |   |   |   |   |   |   |   |   |      |   |
| 7  | Cel współczynnik |   | 30  | 20  |      |      |   |   |   |   |   |   |   |   |   |      |   |
| 8  |                  |   |     |     |      |      |   |   |   |   |   |   |   |   |   |      |   |
| 9  | Ograniczenia:    |   |     |     |      |      |   |   |   |   |   |   |   |   |   |      |   |
| 10 |                  |   |     |     | lewa |      |   |   |   |   |   |   |   |   |   |      |   |
| 11 |                  |   | 1   | 2   | 1    | 0 <= |   |   |   |   |   |   |   |   |   | 1000 |   |
| 12 |                  |   | 2   | 3   | 3    | 0 <= |   |   |   |   |   |   |   |   |   | 2400 |   |
| 13 |                  |   | 3   | 1.5 | 0    | 0 <= |   |   |   |   |   |   |   |   |   | 600  |   |

The Solver Parameters dialog box is configured as follows:

- Komórka celu: D4
- Równa:  Maks  Min  Wartość: 0
- Komórki zmienne: (empty)
- Warunki ograniczające: (empty)

Buttons in the dialog box include: Rozwiąż, Zamknij, Opcje, Dodaj, Zmień, Usuń, Przywróć wszystko, and Pomoc.

Następnie dodajemy kolejno warunki ograniczające:



The image shows a dialog box titled "Dodaj warunek ograniczający" (Add a constraint) with a close button (X) in the top right corner. The dialog contains two input fields: "Adres komórki:" (Cell address) and "Warunek ograniczający:" (Constraint). The "Adres komórki:" field is empty and has a selection icon to its right. The "Warunek ograniczający:" field is also empty and has a selection icon to its right. Between the two fields is a dropdown menu showing "<=" and a downward arrow. At the bottom of the dialog are four buttons: "OK", "Anuluj" (Cancel), "Dodaj" (Add), and "Pomoc" (Help).

G11  $f_x$  =SUMA ILOCZYNÓW(C2:D2;C7:D7)

|    | A                | B | C   | D   | E | F    | G | H    | I | J | K | L | M | N | O | P | Q    |
|----|------------------|---|-----|-----|---|------|---|------|---|---|---|---|---|---|---|---|------|
| 1  |                  |   | x1  | x2  |   |      |   |      |   |   |   |   |   |   |   |   |      |
| 2  | Rozwiązanie:     |   |     |     |   |      |   |      |   |   |   |   |   |   |   |   |      |
| 3  |                  |   |     |     |   |      |   |      |   |   |   |   |   |   |   |   |      |
| 4  | Funkcja celu:    |   | max |     |   |      |   |      |   |   |   |   |   |   |   |   |      |
| 5  |                  |   |     |     |   |      |   |      |   |   |   |   |   |   |   |   |      |
| 6  |                  |   | c1  | c2  |   |      |   |      |   |   |   |   |   |   |   |   |      |
| 7  | Cel współczynnik |   | 30  | 20  |   |      |   |      |   |   |   |   |   |   |   |   |      |
| 8  |                  |   |     |     |   |      |   |      |   |   |   |   |   |   |   |   |      |
| 9  | Ograniczenia:    |   |     |     |   |      |   |      |   |   |   |   |   |   |   |   |      |
| 10 |                  |   |     |     |   |      |   | lewa |   |   |   |   |   |   |   |   |      |
| 11 |                  |   | 1   | 2   | 1 | 0 <= |   |      |   |   |   |   |   |   |   |   | 1000 |
| 12 |                  |   | 2   | 3   | 3 | 0 <= |   |      |   |   |   |   |   |   |   |   | 2400 |
| 13 |                  |   | 3   | 1.5 | 0 | 0 <= |   |      |   |   |   |   |   |   |   |   | 600  |
| 14 |                  |   |     |     |   |      |   |      |   |   |   |   |   |   |   |   |      |
| 15 |                  |   |     |     |   |      |   |      |   |   |   |   |   |   |   |   |      |
| 16 |                  |   |     |     |   |      |   |      |   |   |   |   |   |   |   |   |      |
| 17 |                  |   |     |     |   |      |   |      |   |   |   |   |   |   |   |   |      |
| 18 |                  |   |     |     |   |      |   |      |   |   |   |   |   |   |   |   |      |
| 19 |                  |   |     |     |   |      |   |      |   |   |   |   |   |   |   |   |      |
| 20 |                  |   |     |     |   |      |   |      |   |   |   |   |   |   |   |   |      |
| 21 |                  |   |     |     |   |      |   |      |   |   |   |   |   |   |   |   |      |
| 22 |                  |   |     |     |   |      |   |      |   |   |   |   |   |   |   |   |      |
| 23 |                  |   |     |     |   |      |   |      |   |   |   |   |   |   |   |   |      |
| 24 |                  |   |     |     |   |      |   |      |   |   |   |   |   |   |   |   |      |
| 25 |                  |   |     |     |   |      |   |      |   |   |   |   |   |   |   |   |      |
| 26 |                  |   |     |     |   |      |   |      |   |   |   |   |   |   |   |   |      |
| 27 |                  |   |     |     |   |      |   |      |   |   |   |   |   |   |   |   |      |
| 28 |                  |   |     |     |   |      |   |      |   |   |   |   |   |   |   |   |      |
| 29 |                  |   |     |     |   |      |   |      |   |   |   |   |   |   |   |   |      |
| 30 |                  |   |     |     |   |      |   |      |   |   |   |   |   |   |   |   |      |
| 31 |                  |   |     |     |   |      |   |      |   |   |   |   |   |   |   |   |      |
| 32 |                  |   |     |     |   |      |   |      |   |   |   |   |   |   |   |   |      |
| 33 |                  |   |     |     |   |      |   |      |   |   |   |   |   |   |   |   |      |
| 34 |                  |   |     |     |   |      |   |      |   |   |   |   |   |   |   |   |      |

**Dodaj warunek ograniczający**

Adres komórki:  <-> Warunek ograniczający:

OK Anuluj Dodaj Pomoc

ZLP\_solver - Microsoft Excel

Narzędzia główne Wstawianie Układ strony Formuły Dane Recenzja Widok Deweloper

G11  $f_x = \text{SUMA.ILOCZYNÓW}(C2:D2;C7:D7)$

|    | A                | B | C   | D   | E | F    | G | H     | I | J | K | L | M | N | O | P | Q |
|----|------------------|---|-----|-----|---|------|---|-------|---|---|---|---|---|---|---|---|---|
| 1  |                  |   | x1  | x2  |   |      |   |       |   |   |   |   |   |   |   |   |   |
| 2  | Rozwiązanie:     |   |     |     |   |      |   |       |   |   |   |   |   |   |   |   |   |
| 3  |                  |   |     |     |   |      |   |       |   |   |   |   |   |   |   |   |   |
| 4  | Funkcja celu:    |   | max |     |   |      |   |       |   |   |   |   |   |   |   |   |   |
| 5  |                  |   |     |     |   |      |   |       |   |   |   |   |   |   |   |   |   |
| 6  |                  |   | c1  | c2  |   |      |   |       |   |   |   |   |   |   |   |   |   |
| 7  | Cel współczynnik |   | 30  | 20  |   |      |   |       |   |   |   |   |   |   |   |   |   |
| 8  |                  |   |     |     |   |      |   |       |   |   |   |   |   |   |   |   |   |
| 9  | Ograniczenia:    |   |     |     |   |      |   |       |   |   |   |   |   |   |   |   |   |
| 10 |                  |   |     |     |   | lewa |   | prawa |   |   |   |   |   |   |   |   |   |
| 11 |                  |   | 1   | 2   | 1 | 0 <= |   | 1000  |   |   |   |   |   |   |   |   |   |
| 12 |                  |   | 2   | 3   | 3 | 0 <= |   | 2400  |   |   |   |   |   |   |   |   |   |
| 13 |                  |   | 3   | 1,5 | 0 | 0 <= |   | 600   |   |   |   |   |   |   |   |   |   |

Dodaj warunek ograniczający

Adres komórki:  Warunek ograniczający:

OK Anuluj Dodaj Pomoc

Arkusz1 Arkusz2 Arkusz3

Wskaz

01:31  
2017-04-08



Wypełnione okno solvera:

Solver - Parametry

Komórka celu:

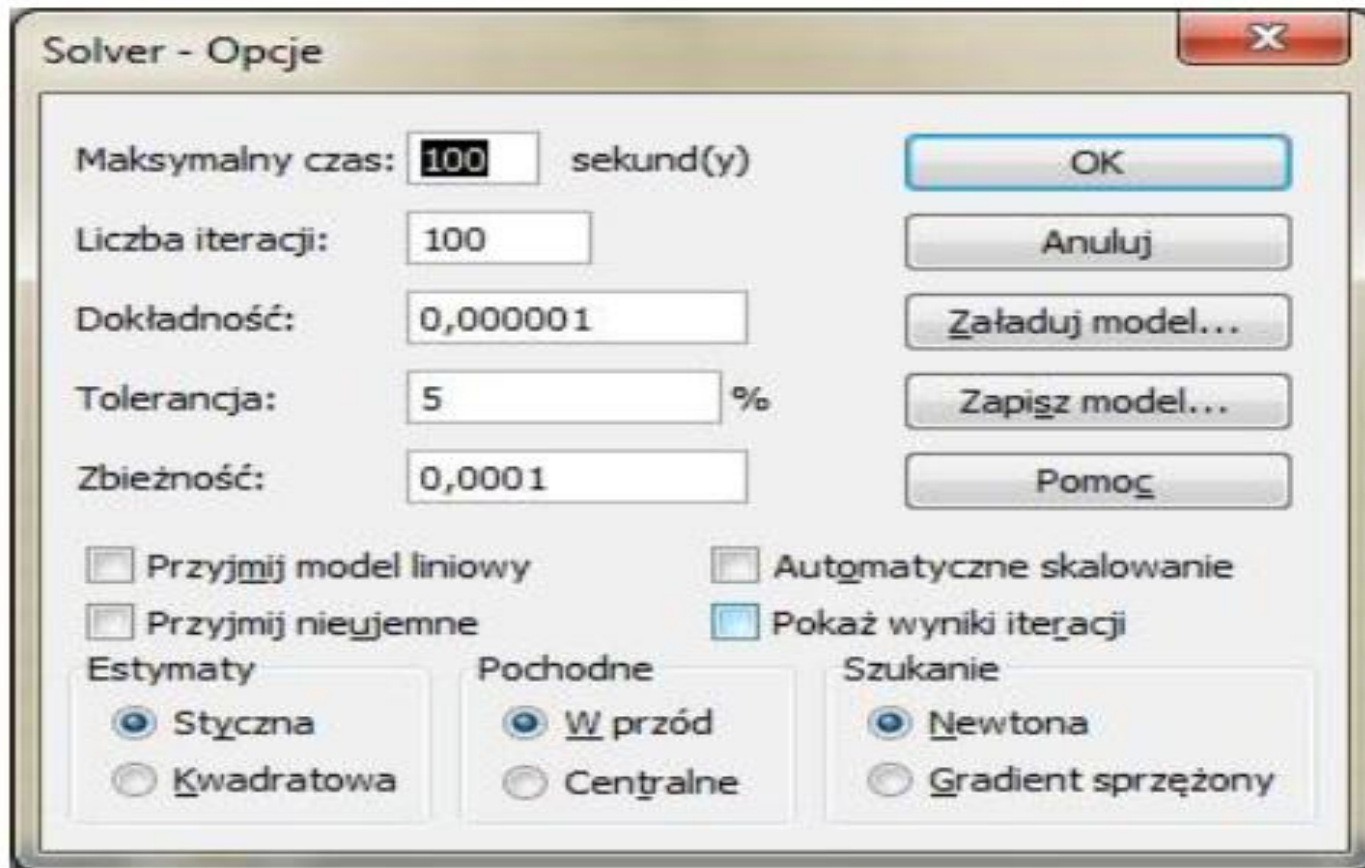
Równa:  Maks  Min  Wartość:

Komórki zmieniane:

Warunki ograniczające:

Sprawdzamy opcje i zaznaczamy:

*Przyjmij model liniowy oraz Przyjmij nieujemne.*



G11  $f_x$  1000

|    | A                | B | C   | D  | E | F    | G | H     | I | J | K | L | M | N | O | P | Q |
|----|------------------|---|-----|----|---|------|---|-------|---|---|---|---|---|---|---|---|---|
| 1  |                  |   | x1  | x2 |   |      |   |       |   |   |   |   |   |   |   |   |   |
| 2  | Rozwiązanie:     |   |     |    |   |      |   |       |   |   |   |   |   |   |   |   |   |
| 3  |                  |   |     |    |   |      |   |       |   |   |   |   |   |   |   |   |   |
| 4  | Funkcja celu:    |   | max |    |   |      |   |       |   |   |   |   |   |   |   |   |   |
| 5  |                  |   |     |    |   |      |   |       |   |   |   |   |   |   |   |   |   |
| 6  |                  |   | c1  | c2 |   |      |   |       |   |   |   |   |   |   |   |   |   |
| 7  | Cel współczynnik |   | 30  | 20 |   |      |   |       |   |   |   |   |   |   |   |   |   |
| 8  |                  |   |     |    |   |      |   |       |   |   |   |   |   |   |   |   |   |
| 9  | Ograniczenia:    |   |     |    |   |      |   |       |   |   |   |   |   |   |   |   |   |
| 10 |                  |   |     |    |   | lewa |   | prawa |   |   |   |   |   |   |   |   |   |
| 11 |                  | 1 | 2   | 1  | 0 | <=   |   | 1000  |   |   |   |   |   |   |   |   |   |
| 12 |                  | 2 | 3   | 3  | 0 | <=   |   | 2400  |   |   |   |   |   |   |   |   |   |
| 13 |                  | 3 | 1.5 | 0  | 0 | <=   |   | 600   |   |   |   |   |   |   |   |   |   |
| 14 |                  |   |     |    |   |      |   |       |   |   |   |   |   |   |   |   |   |
| 15 |                  |   |     |    |   |      |   |       |   |   |   |   |   |   |   |   |   |
| 16 |                  |   |     |    |   |      |   |       |   |   |   |   |   |   |   |   |   |
| 17 |                  |   |     |    |   |      |   |       |   |   |   |   |   |   |   |   |   |
| 18 |                  |   |     |    |   |      |   |       |   |   |   |   |   |   |   |   |   |
| 19 |                  |   |     |    |   |      |   |       |   |   |   |   |   |   |   |   |   |
| 20 |                  |   |     |    |   |      |   |       |   |   |   |   |   |   |   |   |   |
| 21 |                  |   |     |    |   |      |   |       |   |   |   |   |   |   |   |   |   |
| 22 |                  |   |     |    |   |      |   |       |   |   |   |   |   |   |   |   |   |
| 23 |                  |   |     |    |   |      |   |       |   |   |   |   |   |   |   |   |   |
| 24 |                  |   |     |    |   |      |   |       |   |   |   |   |   |   |   |   |   |
| 25 |                  |   |     |    |   |      |   |       |   |   |   |   |   |   |   |   |   |
| 26 |                  |   |     |    |   |      |   |       |   |   |   |   |   |   |   |   |   |
| 27 |                  |   |     |    |   |      |   |       |   |   |   |   |   |   |   |   |   |
| 28 |                  |   |     |    |   |      |   |       |   |   |   |   |   |   |   |   |   |
| 29 |                  |   |     |    |   |      |   |       |   |   |   |   |   |   |   |   |   |
| 30 |                  |   |     |    |   |      |   |       |   |   |   |   |   |   |   |   |   |
| 31 |                  |   |     |    |   |      |   |       |   |   |   |   |   |   |   |   |   |
| 32 |                  |   |     |    |   |      |   |       |   |   |   |   |   |   |   |   |   |
| 33 |                  |   |     |    |   |      |   |       |   |   |   |   |   |   |   |   |   |
| 34 |                  |   |     |    |   |      |   |       |   |   |   |   |   |   |   |   |   |

Solver - Opcje

Maksymalny czas: 100 sekund(y)

Liczba iteracji: 100

Dokładność: 0,000001

Tolerancja: 0%

Zbieżność: 0,0001

Przyjmij model liniowy  Automatyczne skalowanie

Przyjmij nieujemne  Pokaż wyniki iteracji

Estymaty      Pochodne      Szukanie

Styczna       W przód       Newtona

Kwadratowa       Centralne       Gradient sprzężony

Po uzupełnieniu opcji wybieramy *Rozwiąż*:

The image shows a Microsoft Excel spreadsheet with a Solver Parameters dialog box open. The spreadsheet contains the following data:

|    | A                 | B | C   | D  | E    | F | G     | H | I | J | K | L | M | N | O | P | Q |
|----|-------------------|---|-----|----|------|---|-------|---|---|---|---|---|---|---|---|---|---|
| 1  |                   |   | x1  | x2 |      |   |       |   |   |   |   |   |   |   |   |   |   |
| 2  | Rozwiązanie:      |   |     |    |      |   |       |   |   |   |   |   |   |   |   |   |   |
| 3  |                   |   |     |    |      |   |       |   |   |   |   |   |   |   |   |   |   |
| 4  | Funkcja celu:     |   | max |    |      |   |       |   |   |   |   |   |   |   |   |   |   |
| 5  |                   |   |     |    |      |   |       |   |   |   |   |   |   |   |   |   |   |
| 6  |                   |   | c1  | c2 |      |   |       |   |   |   |   |   |   |   |   |   |   |
| 7  | Cel współczynnik: |   | 30  | 20 |      |   |       |   |   |   |   |   |   |   |   |   |   |
| 8  |                   |   |     |    |      |   |       |   |   |   |   |   |   |   |   |   |   |
| 9  | Ograniczenia:     |   |     |    |      |   |       |   |   |   |   |   |   |   |   |   |   |
| 10 |                   |   |     |    | lewa |   | prawa |   |   |   |   |   |   |   |   |   |   |
| 11 |                   | 1 | 2   | 1  | 0 <= |   | 1000  |   |   |   |   |   |   |   |   |   |   |
| 12 |                   | 2 | 3   | 3  | 0 <= |   | 2400  |   |   |   |   |   |   |   |   |   |   |
| 13 |                   | 3 | 1,5 | 0  | 0 <= |   | 600   |   |   |   |   |   |   |   |   |   |   |

The Solver Parameters dialog box is configured as follows:

- Komórka celu:  $D4$
- Równa:  Maks  Min  Wartość:  $0$
- Komórki zmienne:  $\$C\$2:\$D\$2$
- Warunki ograniczające:
  - $\$E\$11 <= \$G\$11$
  - $\$E\$12 <= \$G\$12$
  - $\$E\$13 <= \$G\$13$

Buttons in the dialog box include: Rozwiąż, Zamknij, Opcje, Dodaj, Zmień, Usuń, Przywróć wszystko, and Pomoc.

Otrzymujemy rozwiązanie:

The image shows a Microsoft Excel window titled "ZLP\_solver - Microsoft Excel" with the Solver Results dialog box open. The spreadsheet contains a linear programming problem with the following data:

|    | A                | B | C   | D     | E    | F  | G | H     | I | J | K | L | M | N | O | P | Q |
|----|------------------|---|-----|-------|------|----|---|-------|---|---|---|---|---|---|---|---|---|
| 1  |                  |   | x1  | x2    |      |    |   |       |   |   |   |   |   |   |   |   |   |
| 2  | Rozwiązanie:     |   | 200 | 600   |      |    |   |       |   |   |   |   |   |   |   |   |   |
| 3  |                  |   |     |       |      |    |   |       |   |   |   |   |   |   |   |   |   |
| 4  | Funkcja celu:    |   | max | 18000 |      |    |   |       |   |   |   |   |   |   |   |   |   |
| 5  |                  |   |     |       |      |    |   |       |   |   |   |   |   |   |   |   |   |
| 6  |                  |   | c1  | c2    |      |    |   |       |   |   |   |   |   |   |   |   |   |
| 7  | Cel współczynnik |   | 30  | 20    |      |    |   |       |   |   |   |   |   |   |   |   |   |
| 8  |                  |   |     |       |      |    |   |       |   |   |   |   |   |   |   |   |   |
| 9  | Ograniczenia:    |   |     |       |      |    |   |       |   |   |   |   |   |   |   |   |   |
| 10 |                  |   |     |       | lewa |    |   | prawa |   |   |   |   |   |   |   |   |   |
| 11 |                  | 1 | 2   | 1     | 1000 | <= |   | 1000  |   |   |   |   |   |   |   |   |   |
| 12 |                  | 2 | 3   | 3     | 2400 | <= |   | 2400  |   |   |   |   |   |   |   |   |   |
| 13 |                  | 3 | 1.5 | 0     | 300  | <= |   | 600   |   |   |   |   |   |   |   |   |   |

The Solver Results dialog box, titled "Solver - Wyniki", displays the following information:

- Message: "Dodatek Solver znalazł rozwiązanie. Wszystkie ograniczenia i warunki optymalizacji są spełnione." (The Solver Add-in found a solution. All constraints and optimization conditions are satisfied.)
- Options:  Przechowaj rozwiązanie (Save solution),  Przywróć wartości początkowe (Restore initial values)
- Reports: Wyników (Results), Wrażliwość (Sensitivity), Granic (Limits)
- Buttons: OK, Anuluj (Cancel), Zapisz scenariusz... (Save scenario...), Pomoc (Help)

Odpowiedź:

Aby otrzymać maksymalny zysk zakład powinien produkować 200 sztuk wyrobu W1 i 600 sztuk wyrobu W2. Zysk ten wyniesie 18 000 zł.