

# Assignment 10

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Download all python codes from

[https://github.com/Sowmyabandi99/Assignment10/blob/main/assignment10\\_2.py](https://github.com/Sowmyabandi99/Assignment10/blob/main/assignment10_2.py)

and,

$$18x + 0y \leq 360 \quad (2.0.5)$$

$$\implies x \leq 20 \quad (2.0.6)$$

and latex-tikz codes from

<https://github.com/Sowmyabandi99/Assignment10/blob/main/main.tex>

and,

$$6x + 9y \leq 360 \quad (2.0.7)$$

$$\implies 2x + 3y \leq 120 \quad (2.0.8)$$

$\therefore$  Our problem is

$$\max_{\mathbf{x}} Z = (7.5 \ 5) \mathbf{x} \quad (2.0.9)$$

$$s.t. \quad \begin{pmatrix} 2 & 1 \\ 1 & 0 \\ 2 & 3 \end{pmatrix} \mathbf{x} \leq \begin{pmatrix} 60 \\ 20 \\ 120 \end{pmatrix} \quad (2.0.10)$$

A manufacturer makes two types of toys A and B. Three machines are needed for this purpose and the time (in minutes) required for each toy on the machines is given below:

| Machines      |    |    |     |
|---------------|----|----|-----|
| Types of toys | I  | II | III |
| A             | 12 | 18 | 6   |
| B             | 6  | 0  | 9   |

TABLE 1.1: Toys table

Lagrangian function is given by

$$\begin{aligned} L(\mathbf{x}, \lambda) &= (7.5 \ 5) \mathbf{x} + \left\{ \left[ (2 \ 1) \mathbf{x} - 60 \right] \right. \\ &+ \left[ (1 \ 0) \mathbf{x} - 20 \right] + \left[ (2 \ 3) \mathbf{x} - 120 \right] \\ &+ \left[ (-1 \ 0) \mathbf{x} \right] + \left[ (0 \ -1) \mathbf{x} \right] \left. \right\} \lambda \end{aligned} \quad (2.0.11)$$

where,

$$\lambda = \begin{pmatrix} \lambda_1 \\ \lambda_2 \\ \lambda_3 \\ \lambda_4 \\ \lambda_5 \\ \lambda_6 \end{pmatrix} \quad (2.0.12)$$

Each machine is available for a maximum of 6 hours per day. If the profit on each toy of type A is Rs 7.50 and that on each toy of type B is Rs 5, show that 15 toys of type A and 30 of type B should be manufactured in a day to get maximum profit.

## 2 SOLUTION

Let the number of toys of type A be  $x$  and the number of toys of type B be  $y$  such that

$$x \geq 0 \quad (2.0.1)$$

$$y \geq 0 \quad (2.0.2)$$

According to the question,

$$12x + 6y \leq 360 \quad (2.0.3)$$

$$\implies 2x + y \leq 60 \quad (2.0.4)$$

Now,

$$\nabla L(\mathbf{x}, \lambda) = \begin{pmatrix} 7.5 + (2 \ 1 \ 2 \ -1 \ 0) \lambda \\ 5 + (1 \ 0 \ 3 \ 0 \ -1) \lambda \\ (2 \ 1) \mathbf{x} - 60 \\ (1 \ 0) \mathbf{x} - 20 \\ (2 \ 3) \mathbf{x} - 120 \\ (-1 \ 0) \mathbf{x} \\ (0 \ -1) \mathbf{x} \end{pmatrix} \quad (2.0.13)$$

∴ Lagrangian matrix is given by

$$\begin{pmatrix} 0 & 0 & 2 & 1 & 2 & -1 & 0 \\ 0 & 0 & 1 & 0 & 3 & 0 & -1 \\ 2 & 1 & 0 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 2 & 3 & 0 & 0 & 0 & 0 & 0 \\ -1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & -1 & 0 & 0 & 0 & 0 & 0 \end{pmatrix} \begin{pmatrix} \mathbf{x} \\ \lambda \end{pmatrix} = \begin{pmatrix} -7.5 \\ -5 \\ 60 \\ 20 \\ 120 \\ 0 \\ 0 \end{pmatrix} \quad (2.0.14)$$

Considering  $\lambda_1, \lambda_2$  as only active multiplier,

$$\begin{pmatrix} 0 & 0 & 2 & 2 \\ 0 & 0 & 1 & 3 \\ 2 & 1 & 0 & 0 \\ 2 & 3 & 0 & 0 \end{pmatrix} \begin{pmatrix} \mathbf{x} \\ \lambda \end{pmatrix} = \begin{pmatrix} -7.5 \\ -5 \\ 60 \\ 120 \end{pmatrix} \quad (2.0.15)$$

resulting in,

$$\begin{pmatrix} \mathbf{x} \\ \lambda \end{pmatrix} = \begin{pmatrix} 0 & 0 & 2 & 2 \\ 0 & 0 & 1 & 3 \\ 2 & 1 & 0 & 0 \\ 2 & 3 & 0 & 0 \end{pmatrix}^{-1} \begin{pmatrix} -7.5 \\ -5 \\ 60 \\ 120 \end{pmatrix} \quad (2.0.16)$$

$$\Rightarrow \begin{pmatrix} \mathbf{x} \\ \lambda \end{pmatrix} = \begin{pmatrix} 0 & 0 & \frac{3}{4} & \frac{-1}{4} \\ 0 & 0 & \frac{-1}{2} & \frac{1}{2} \\ \frac{3}{4} & \frac{-1}{2} & 0 & 0 \\ \frac{-1}{4} & \frac{1}{2} & 0 & 0 \end{pmatrix} \begin{pmatrix} -7.5 \\ -5 \\ 60 \\ 120 \end{pmatrix} \quad (2.0.17)$$

$$\Rightarrow \begin{pmatrix} \mathbf{x} \\ \lambda \end{pmatrix} = \begin{pmatrix} 15 \\ 30 \\ -3.125 \\ -0.625 \end{pmatrix} \quad (2.0.18)$$

$$\because \lambda = \begin{pmatrix} -3.125 \\ -0.625 \end{pmatrix} > \mathbf{0}$$

∴ Optimal solution is given by

$$\mathbf{x} = \begin{pmatrix} 15 \\ 30 \end{pmatrix} \quad (2.0.19)$$

$$Z = (7.5 \ 5) \mathbf{x} \quad (2.0.20)$$

$$= (7.5 \ 5) \begin{pmatrix} 15 \\ 30 \end{pmatrix} \quad (2.0.21)$$

$$= 262.5 \quad (2.0.22)$$

By using cvxpy in python ,

$$\mathbf{x} = \begin{pmatrix} 14.99999998 \\ 29.99999996 \end{pmatrix} \quad (2.0.23)$$

$$Z = 262.49999967 \quad (2.0.24)$$

Hence, the manufacturer should manufacture  $x = 15$  toys of type A and  $y = 30$  toys of type

B in a day to get maximum profit  $Z = \text{Rs}262.5$ .

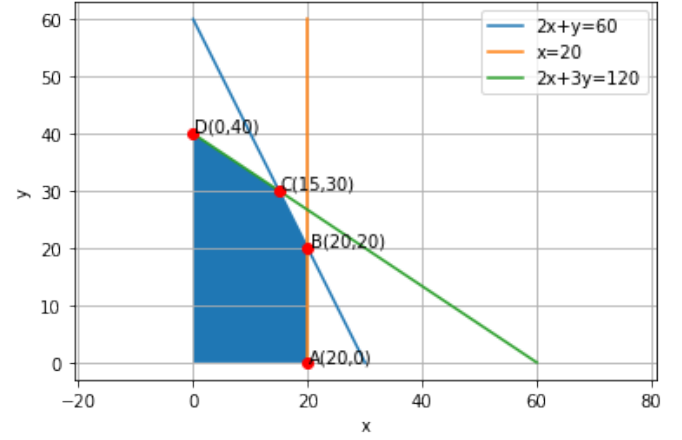


Fig. 2.1: Toy Problem