

## Linear Programming

- 1) A Person wants to decide the constituents amount of diet which will fulfill his daily requirements of Proteins, Fats and Carbohydrates at a Minimum cost. The choice is to be made from four different types of foods. The yields per unit of those food are given below. Formulate Linear programming Model

Food type	Yield per unit			Cost per unit (Rs)
	Proteins	Fats	Carbohydrates	
1	3	2	6	45
2	4	2	4	40
3	8	7	7	85
4	6	5	4	65
<b>Minimum Requirement</b>	<b>800</b>	<b>200</b>	<b>700</b>	

### Solution:

Let  $X_1$  Amount of Type1 food to be taken, Let  $X_2$  Amount of Type2 to be taken, Let  $X_3$  Amount of Type3 to be taken, Let  $X_4$  Amount of Type4 to be taken,

**$Z_{\min}$**  =  $45X_1 + 40X_2 + 85X_3 + 65X_4$  -----Objective Equation

$3X_1 + 4X_2 + 8X_3 + 6X_4 \geq 800$  [Protein constrain]

$2X_1 + 2X_2 + 7X_3 + 5X_4 \geq 200$  [Fats constrain]

$6X_1 + 4X_2 + 7X_3 + 4X_4 \geq 700$  [Carbohydrates constrain]

$X_1 \geq 0, X_2 \geq 0, X_3 \geq 0, X_4 \geq 0$  { Non negative Constrain}



## Linear Programming

- 1) Old Hens can be bought for Rs. 300 each , Young one cost Rs. 500 each, Old Hen lay 3 eggs per week and young ones lay 5 eggs per week, Each egg being worth 6 Rs. A hen costs of Rs. 15 for feed. If a person has only 15000 to spend on the hens, How many of each kind should he buy to get a profit of more than 600 Rs. Per week Assuming that he cannot house more than 30 hens. Formulate Linear programming Model

### Solution:

Let X be the number of Old Hens to be brought,

Let Y be the number of Young Hens to be brought

	Old Hen	Young Hen
Cost	300	500
Egg	3 Egg per week	5 Egg per week
Feed	15 Rs.	15 Rs.
Each Egg	6	6

Selling price

$Z_{Max} = SP - CP =$

since objective was not defined, i.e max. profit or minimize cost..we calc. profit by this

$$= (6 \times 3)X + (6 \times 5)Y - 15X - 15Y \quad \{15 \times X \text{ indicate feed}\}$$

$$= 18X + 30Y - 15X - 15Y$$

$$Z_{Max} = 3X + 15Y \quad \text{----Objective Equation}$$

$$300X + 500Y \leq 15000 \quad [\text{Cost constrain}]$$

$$X + Y \leq 30 \quad [\text{Space constrain}]$$

$$X \geq 0, Y \geq 0 \quad [\text{Non Negative}]$$

$$3X + 15Y \geq 600 \quad [\text{Income Constrain}]$$

## Linear Programming

- 1) A farmer has a 100 acre farm, He can sell all the Tomatoes, Onion, Radishes he can raise, The price he can obtain is Rs.5 per kg Tomatoes, Rs.10 per kg Onion, Rs. 8 per kg for Radish, The average yield per acre is 2000 kg of Tomatoes, 3000 kg Onion, 1000 kg of Radish, Fertilizer is available at Rs.5 per Kg, Amount of fertilizer require for each Tomatoe, Onion-100 Kg per acre, 50 Kg for Radish, Labour require for cultivating per acre is 5 man day for Tomatoes, 6 man day for Onion, 5 man day for Radish. A total 400 mans are available at Rs.500 per day. Formulate Linear programming Model.

### Solution:

	Tomatoes	Onion	Radish
Selling Price	Rs.5 per kg	Rs.10 per kg	Rs. 8 per kg
Yield	2000kg/Acre	3000kg/Acre	1000kg/Acre
Fertilizer	100kg/Acre	100kg/Acre	50kg/Acre
Cultivating	5 Man/Acre	20 Man/Acre	5 Man/Acre

Fertilizer rate: 5 Rs/kg

Each Labour Cost: Rs.500 per Day

$X_1$	$X_2$	$X_3$
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Let  $X_1$  be the number of acres to be used for growing Tomatoe.

Let  $X_2$  be the numbe of acrs to be used for growing Onion.

Let  $X_3$  be the numbe of acrs to be used for growing Radishes.

$$Z_{\max} = (2000 \times 5) X_1 + (3000 \times 10) X_2 + (1000 \times 8) X_3 - (100 \times 5) X_1 - (100 \times 5) X_2 - (50 \times 5) X_3 - (500 \times 5) X_1 - (20 \times 500) X_2 - (500 \times 5) X_3$$

profit= SP-CP

$$=10000X_1 + 30000 X_2 + 8000 X_3 - 500 X_1 - 500 X_2 - 250 X_3 - 2500 X_1 - 10000 X_2 - 2500 X_3$$

$$\mathbf{Z_{max} = 7000 X_1 + 19500 X_2 + 5250 X_3 \quad \{ Objective equation \}}$$

**Constrains:**

$$5 X_1 + 20 X_2 + 5 X_3 \leq 400 \quad \{ Labour \text{ Constrain} \}$$

$$X_1 + X_2 + X_3 \leq 100 \quad \{ Land \text{ Constrain} \}$$

$$X_1 \geq 0, X_2 \geq 0, X_3 \geq 0 \quad \{ Non \text{ negative Constrain} \}$$



2) A hospital has the following minimal daily requirement of nurses

Period	Clock time	Minimal Number of Nurses Requaired
1	6 AM to 10 AM	2
2	10 AM to 2 PM	7
3	2 PM to 6 PM	15
4	6 PM to 10 PM	8
5	10 PM to 2 AM	20
6	2 AM to 6 AM	6

Nurses report to the hospital at the beginning of each period and work for 8 consecutive hours. The hospital wants to determine the minimal number of nurses to be employed so that there is sufficient number of nurses available for each period. Formulate this as Linear programming problem

**Solution:**

Let  $X_1, X_2, X_3, X_4, X_5, X_6$  number of nurses to be appointed for period 1,2,3,4,5,6 respectively.

**Objective equation:**  $Z_{\min} = X_1 + X_2 + X_3 + X_4 + X_5 + X_6$

**Constrains**

$$X_1 + X_2 \geq 2$$

$$X_2 + X_3 \geq 7$$

$$X_3 + X_4 \geq 15$$

$$X_4 + X_5 \geq 8$$

$$X_5 + X_6 \geq 20$$

$$X_6 + X_1 \geq 6$$

$$X_1 \geq 0, X_2 \geq 0, X_3 \geq 0, X_4 \geq 0, X_5 \geq 0, X_6 \geq 0,$$

### Linear Programming

- 1) Consider the following problem faced by a production planner in a soft drink plant. He has 2 bottling machines A and B. A is assigned for 8-ounce bottle and B is assigned for 16-ounce bottle. The following data are available

Machine A	8ounce bottle	16ounce bottle
A	100/ Minute	40/Minute
B	60/Minute	75/Minute

The machines can be run for 8-hours per day, 5 days a week, Profit on 8 ounce bottle is 15 paise and on 16 ounce bottle is 25 paise. Weekly production of the drink cannot exceed 300000 ounces and the market can observe 25000 eight ounce bottle and 7000 sixteen ounce bottles per week. The planner wishes to maximize his profit, of course, to all the production and marketing constraints. Formulate Linear programming model.

### Solution

Let  $X_1$  be the number of 8 Ounce bottle to be produced on Machine A,  $X_2$  be the number of 16 ounce bottle to be produced on Machine A.

Let  $Y_1$  be the number of 8 ounce bottle to be produced on B,  $Y_2$  be the number of 16 ounce bottle to be produced on B.

$$Z_{\max} = (X_1 + Y_1) 0.15 + (X_2 + Y_2) 0.25 \quad [\text{Objective equation}]$$

1 Min----100 products then 1 product  $\frac{1}{100}$  duration requires

Similarley for  $X_1$  products  $\frac{X_1}{100}$  [ 8 Ounce bottles]

1 Min----- 40 products    1 product  $\frac{1}{40}$  duration requires

Similarley for  $X_2$  products     $\frac{X_2 [16 \text{ Ounce bottles}]}{40}$

$$\frac{X_1}{100} + \frac{X_2}{40} \leq 5 \cdot 8 \cdot 60$$

$$\frac{Y_1}{60} + \frac{Y_2}{75} \leq 5 \cdot 8 \cdot 60$$

$$\frac{2X_1 + 5X_2}{200} \leq 2400$$

$$2X_1 + 5X_2 \leq 480000$$

$$X_1 + Y_1 \geq 25000 [\text{Market Constrain 8 ounce bottle}]$$

$$X_2 + Y_2 \geq 7000 [\text{Market Constrain 16 ounce bottle}]$$

$$8(X_1 + Y_1) + 16(X_2 + Y_2) \leq 300000$$

$$X_1 \geq 0, X_2 \geq 0, Y_1 \geq 0, Y_2 \geq 0$$



- 2) A manufacture of a line of patent medicines is preparing a production plan on medicines A and B. There are sufficient ingredient available to make 20,000 bottles of A and 40000 bottles of B but there are only 45000 bottles into which both the medicines can be put. Further more it take 3 hours to prepare enough materials to fill 1000 bottles of A, it take 1 hour to prepare enough materials to fill 1000 bottles of B and there are 66 hours available for this operations. The profit is Rs.8 per bottle for A and Rs.7 per bottle for B. Formulate the linear programming model

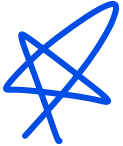
**Solution:** Let  $x$  be the number of A type medicine to be produced  
Let  $y$  be the number of B type medicine to be produced

$$Z_{\max} = 8x + 7y \text{ [ objective]}$$

$$x \leq 20000 \text{ [Bottle A constrain]}$$

$$y \leq 40000 \text{ [Bottle B constrain]}$$

$$x + y \leq 45000 \text{ [Together]}$$



$$\frac{3}{1000} * x = \frac{3x}{1000}$$

$$\frac{1}{1000} * y = \frac{y}{1000}$$

$$\frac{3x}{1000} + \frac{3y}{1000} < = 66 \text{ hrs} \quad \text{Hours constrain}$$

$$X \geq 0, Y \geq 0$$



### Linear Programming

**Q1)** A firm can produce 3 types of cloth A,B,C. 3 kinds of wool required for it, Red wool,green wool, and blue wool.

One unit length of type A cloth needs 2 yards of red Wool and 3 yards of blue wool. one unit of length of type B cloth need 3 yard of red wool, 2 yards of green wool and 2 yards of blue wool. One unit of type c cloth needs 5 yards of green wool and 4 yards of blue wool. The firm has a stock of only 8 yards of red wool, 10 yads of green wool, and 15 yards of blue wool. It is assumed that the income obtained from one unit length of type A cloth is Rs 3, of type B cloth is Rs.5, of type C cloth is Rs. 4. Formulate the problem as a linear programming problem

#### Solution:

Let  $X_1$  be the number of Type A cloth to be produced

Let  $X_2$  be the number of Type B cloth to be produced

Let  $X_3$  be the number of Type C cloth to be produced

$$Z_{\max} = 3X_1 + 5X_2 + 4X_3 \text{ ----Objective Equation}$$

	Red	Green	Blue
Type A	2 Yard	----	3 Yard
Type B	3 Yard	2 Yard	2 Yard
Type C	-----	5 Yard	4 Yard

**Availability    8 Yard            10 Yard            15 Yard**

$$2X_1 + 3X_2 \leq 8 \text{ {Red Wool Constrains}}$$

$$2X_1 + 5X_3 \leq 10 \text{ {Green Wool Constrains}}$$

$$3X_1 + 2X_2 + 4X_3 \leq 15 \text{ {Blue Wool Constrains}}$$

$$X_1 \geq 0, X_2 \geq 0, X_3 \geq 0 \text{ {Non negative Constrains}}$$

**Q2)** A firm Produce 3 Products, these products are processed in 3 different machine. The time required to manufacture one unit of each product and the daily capacity of machine 3 machine given below

Machine	P1	P2	P3	Machine capacity
M1	2	8	2	940 Min/day
M2	4	---	8	970 Min/day
M3	2	5	--	430 Min/day

Profit of product P1,P2,P3 are RS 4, Rs 8, Rs 6 Write a linear programming model to the given problem

**Solution:**

Let **a** be the number of Type P1 Product to be produced

Let **b** be the number of Type P2Product to be produced

Let **C** be the number of Type P3 Product to be produced

**$Z_{\max}$**  =  $4a + 8b + 6c$  -----Objective Equation

$2a + 8b + 2c \leq 940$  { Machine P1 constrain}

$4a + 8c \leq 970$  { Machine P2 constrain}

$2a + 5b \leq 430$  { Machine P3 constrain}

$a \geq 0, b \geq 0, c \geq 0$  { Non negative Constrain}

**Q3)** A farmer has 1000 acres of land on which he grown corn,wheat, and soyabeans. Each acre of corn cost Rs. 100 for preparation, requires 7 man days of work and yields a profit of Rs 30. An acre of wheat costs Rs 120 to prepare, requires 10 man day of work and yields profit of Rs.40, An acre of soyabean costs Rs 70 to prepare requires 8 man days of work and yields of profit Rs.20, If the farmer has Rs. 100000 for preparation and can count on 8000 man days work, formulate the L.P model to allocate the number of acres to each crop to maximize the total profit

**Solution:**

Let  $X_1$  be the land to be used to cultivating Corn

Let  $X_2$  be the land to be used to cultivating Wheat

Let  $X_3$  be the land to be used to cultivating Soyabean

$$Z_{\max} = 30X_1 + 40X_2 + 20X_3 \text{ ----Objective Equation}$$

	<u>Preparation cost</u>	<u>Labour</u>
Corn	100 RS. per Acre	7 Man days per Acre
Wheat	120 Rs. per Acre	10 Man days per Acre
Soyabean	70 RS.per Acre	80Man days per Acre

**Availability      100000 RS**

**8000 Mans Available**

**Acres available: 1000**

$$100X_1 + 120X_2 + 70X_3 \leq 100000 \text{ \{ Preparation cost constrain\}}$$

$$7X_1 + 10X_2 + 8X_3 \leq 8000 \text{ \{Labour constrain\}}$$

$$X_1 + X_2 + X_3 \leq 1000 \text{ \{ Acres constrain\}}$$

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