

Learning outcomes

1. *Defining the Objective function and writing the constraints*
2. *Solving the Optimization problem using R , Excel and graphical methods*

1. A furniture maker has 6 units of wood and 28 hours of free time. Two models were sold well in the past. Model 1 requires 2 units of wood and 7 hours and model 2 requires 1 unit of wood and 8 hours of time. Selling Prices are Rs. 200 and 150 each. How many of each should he make to maximize the revenues?

Step 1- Define the Decision Variables and construct the Objective Function.

Let "M1" be the number of pieces of model 1, "M2" be the number of pieces of model 2. Let R be the revenue.

The object function can be defined as $R = 200 * M1 + 150 * M2$; mathematically this function needs to be maximized.

Step 2: Define the Constraints.

1. $2 M1 + 1 M2 \leq 6$ (requires 2 pieces for model 1 & 1 piece for model 2; total 6)
2. $7M1 + 8M2 \leq 28$ – (requires 7 hrs for model 1 & 8 hrs for model2; total 28)
3. $M1 \geq 0$ and $M2 \geq 0$ - Explicitly constraints

Step3: Writing the above in the form of matrix

```
f.obj = c(200, 150)
f.con = matrix (c(2, 1, 7, 8), nrow=2, byrow=TRUE)
f.dir = c("<=", "<=")
f.rhs = c(6,28)
```

Step 4: Solve

```
# library(lpSolve)
```

Linear Programming

```
lp ("max", f.obj, f.con, f.dir, f.rhs)
lp ("max", f.obj, f.con, f.dir, f.rhs)$solution
```

Integer Programming

```
lp ("max", f.obj, f.con, f.dir, f.rhs, int.vec=1:2)
lp ("max", f.obj, f.con, f.dir, f.rhs, int.vec=1:2)$solution
```

2. Solve using graphical method: A farmer has 240 acres to plant. He needs to decide how many acres of corn to plant and how many acres of oats. He can make \$40/acre for corn and \$30/acre for oats. However, corn takes 2 hours of labor/acre to harvest, and the oats take 1hr labor/acre. He has only 320 hours of labor he can invest. To maximize his profit, how many acres of each should he plant? (Try the same with Excel Solver and R).

3. A manufacturer of printed circuit boards has 200 resistors, 120 transistors and 150 capacitors and he is required to produce two different circuit boards that requires:

Type A board: 20 resistors, 10 transistors and 5 capacitors
Type B board: 10 resistors, 12 transistors and 30 capacitors
If the profit on type A board is Rs. 5 and type B board is 12.
How many of each should he manufacture to maximize the profits?

4. Transportation problem: Tropicsun currently has 275,000 bags of citrus at Mt. Dora, 400,000 bags at Eustis, and 300,000 bags at Clermont. Tropicsun has citrus processing plants in Ocala, Orlando, and Leesburg with processing capacities to handle 200,000, 600,000, and 225,000 bags, respectively.

Tropicsun contracts with a local trucking company to transport its fruit from the groves to the processing plants. The trucking company charges a flat rate for every mile that each bushel of fruit must be transported. Each mile a bushel of fruit travels is known as a bushelmile. The following table summarizes the distances (in miles) between the groves and processing plants:

Goal: Minimize cost - i.e. miles travelled between the groves and processing plants:

Truck goes from Grove to Plant. 9 variables (3 groves and 3 plants i.e. destination)

Miles bet groves & plant	To		
From	Ocala	Orlando	Leesburg
Mt. Dora	21	50	40
Eustis	35	30	22
Clermont	55	20	25

5. The coach of a swim team needs to assign swimmers to a 200-yard medley relay team (four swimmers, each swims 50 yards of one of the four strokes). Since most of the best swimmers are very fast in more than one stroke, it is not clear which swimmer should be assigned to each of the four strokes. The five fastest swimmers and their best times (in seconds) they have achieved in each of the strokes (for 50 yards) are shown below.

Question: How should the swimmers be assigned to make the fastest relay team?

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Best Times	Backstroke	Breastroke	Butterfly	Freestyle
Carl	37.7	43.4	33.3	29.2
Chris	32.9	33.1	28.5	26.4
David	33.8	42.2	38.9	29.6
Tony	37.0	34.7	30.4	28.5
Ken	35.4	41.8	33.6	31.1

Class Work / Home Work

1. A painter has exactly 32 units of yellow dye and 54 units of green dye. He plans to mix as many gallons as possible of color A and color B. Each gallon of color A requires 4 units of yellow dye and 1 unit of green dye. Each gallon of color B requires 1 unit of yellow dye and 6 units of green dye. Find the maximum number of gallons he can mix.
2. A construction company has four large bulldozers located at four different garages. The bulldozers are to be moved to four different construction sites. The distances in miles between the bulldozers and the construction sites are given below.

Bulldozer\Site	A	B	C	D
1	90	75	75	80
2	35	85	55	65
3	125	95	90	105
4	45	110	95	115

How should the bulldozers be moved to the construction sites in order to minimize the total distance traveled?

3. Howie earns a profit of \$350 on each Aqua-Spa (X1) he sells and \$300 on each Hydro-Lux (X2) he sells. Only 200 pumps are available and each hot tub requires one pump. He has only 1,566 labor hours available during the next production cycle. Each Aqua-Spa he builds (each unit of X1) requires 9 labor hours and each Hydro-Lux (each unit of X2) requires 6 labor hours. Each Aqua-Spa requires 12 feet of tubing, and each Hydro-Lux produced requires 16 feet of tubing. Total tubing available is 2,880 feet.

Howie's objective is to maximize the profit. How many Aqua-Spas and Hydro-Luxes should be produced? Hidden constraints: There are simple lower bounds of zero on the variables X1 and X2 because it is impossible to produce a negative number of hot tubs.

4. A company has two plants producing a certain product that is to be shipped to three distribution centers. The unit production costs are the same at the two plants, and the shipping cost per unit is shown below. Shipments are made once per week. During each week, each plant produces at most 60 units and each distribution center needs at least 40 units. How many units should be shipped from each plant to each distribution center?

	Distribution	Distribution	Distribution
	Center 1	Center 2	Center 3
Plant A	\$4	\$6	\$4
Plant B	\$6	\$5	\$2

5. You work as a sales director for a garments manufacturer, and you currently have three salespeople on the road meeting buyers. Your salespeople are in Ahmedabad, Bangalore, and Chennai. You want them to fly to three other cities: Delhi, Hyderabad, and Mumbai. The table below shows the cost of airplane tickets in dollars between these cities. How best can you direct your sales team to travel to the destinations cities (from their current location) so that miles travelled is the least?

From/To	Delhi	Hyderabad	Mumbai
Ahmedabad	250	400	350
Bangalore	400	600	350
Chennai	200	400	250