

Resource Allocation (p. 254)

Determine the linear program corresponding to the following problem.

A farmer has set aside 18 acres of land to be used entirely for plots of grapes, potatoes, and lettuce. Each crop has its own requirements for labor and capital and a different profit per acre. The farmer has \$540 of capital and 48 hours of labor. How large should each plot be?

Plot Type	Hours per acre	Capital per acre	Net Profit per acre
Grapes	9	54	60
Potatoes	9	26	45
Lettuce	3	27	30

Resource Allocation (p. 254)

- ▶ What are the decision variables?
Write out in words what each variable represents.
- ▶ What is the objective function? What are we trying to maximize as a function of the decision variables?
- ▶ What are the constraints? What equalities, inequalities must be satisfied by the decision variables? (corresponding to what?)

Diet Problem (p. 255)

Determine the linear program corresponding to the following problem.

The nutrition director of a college wishes to blend a soup to serve the students from two pre-made stocks. Available are an onion stock with 5 units of protein and 10 units of iron at 3¢/ounce and a chicken stock with 7 units of protein and 4 units of iron at 2¢/ounce.

It is determined that the soup must have at least 35 units of protein and 40 units of iron. How many ounces of each should be included to meet or exceed the requirements at least cost?

Diet Problem (p. 255)

Sketch the feasible region for this problem.

Determine the corner points of the region.

Notice that the feasible region is unbounded. This means there might not be a solution to the problem. (Why?)

Why should we expect that there actually is a solution to this problem?

- ▶ Real-world justification:

- ▶ Explanation by simply looking at the linear program:

Determine new prices for the unmixed stocks that would change the optimal solution. [*Hint: the feasible region does not change.*]

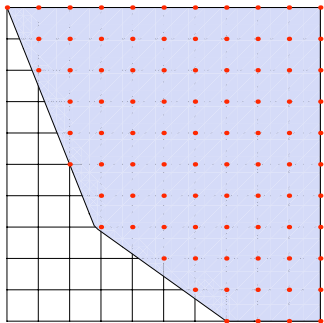
Integer Programming

It might make sense to restrict the decision variables to be integers. Perhaps it is impossible to measure out fractions of ounces of soup?

Definition: A linear program with the added restriction that the decision variables must be integers is called an **integer program**.

One approach to solving an integer program:

- ▶ Solve the linear program by ignoring the integrality constraints
- ▶ Take the solution and round the real-valued solution to the nearest *feasible* integer coordinates.

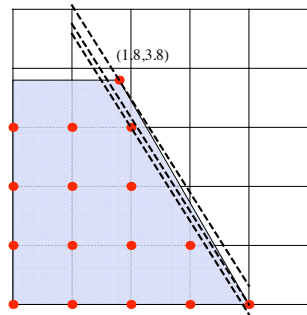


Integer Programming

However, problems may arise if we use this method. (p. 276)

- ▶ It may be difficult to find the nearest feasible point.
- ▶ Nearest point might not be optimal!

$$\begin{array}{l}
 \text{Maximize } 3.8x + 2.4y \\
 \text{subject to: } 3.8x + 2.2y \leq 15.2 \\
 \qquad \qquad \qquad y \leq 3.8 \\
 \qquad \qquad \qquad x, y \geq 0
 \end{array}$$



Solving integer programs is **much harder** than solving linear programs.

We still are able to use *Mathematica*:

```
In[1]: Maximize[{3.8x+2.4y, x>=0 && 0<=y<=3.8 &&
                3.8x+2.2y <= 15.2}, {x, y}, Integers]
```

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Out[1]: {15.2, {x -> 4, y -> 0}}
```

Application: 0-1 variables

Example. Knapsack Problem (p. 277)

A total of m items with fixed weights a_1, a_2, \dots, a_m are to be packed in a knapsack. The total weight cannot exceed a fixed weight, b . The objective is to pack as many items as possible.

Formulation. Create one decision variable x_i for each item i , where we designate that

$$x_i = \left\{ \begin{array}{ll} 1 & \text{if item } i \text{ is to be packed.} \\ 0 & \text{if item } i \text{ is not to be packed.} \end{array} \right\}.$$

Now: What are we trying to maximize? What are our constraints? IP

Application: 0-1 variables

Example. Assignment Problem (p. 258)

Suppose 3 people P_1, P_2, P_3 are being considered for 3 jobs, J_1, J_2, J_3 .

Also suppose that the company knows how much money each person will make the company daily completing each job. (Define it to be a_{ij} .)

	P_1	P_2	P_3
J_1	15	13	12
J_2	11	3	9
J_3	10	5	7

How to assign people to jobs in order to make the most profit?

Formulation. Create a 0-1 decision variables x_{ij} to represent:

$$x_{ij} = \left\{ \begin{array}{l} 1 \quad \text{if person } P_i \text{ is given job } J_j. \\ 0 \quad \text{if person } P_i \text{ is not given job } J_j. \end{array} \right\}.$$

Goal: Maximize $\sum_{i,j} a_{ij}x_{ij}$ subject to $x_{ij} = 0$ or 1 and

Job constraints: $x_{11} + x_{12} + x_{13} = 1$, $x_{21} + x_{22} + x_{23} = 1$, $x_{31} + x_{32} + x_{33} = 1$.

Ppl constraints: $x_{11} + x_{21} + x_{31} = 1$, $x_{12} + x_{22} + x_{32} = 1$, $x_{13} + x_{23} + x_{33} = 1$.