Introduction to Engineering Optimization (ME6806)

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Module 6

Integer Programming, Introduction to Non-traditional Optimization Algorithms. Binary and Real-coded Genetic Algorithm.

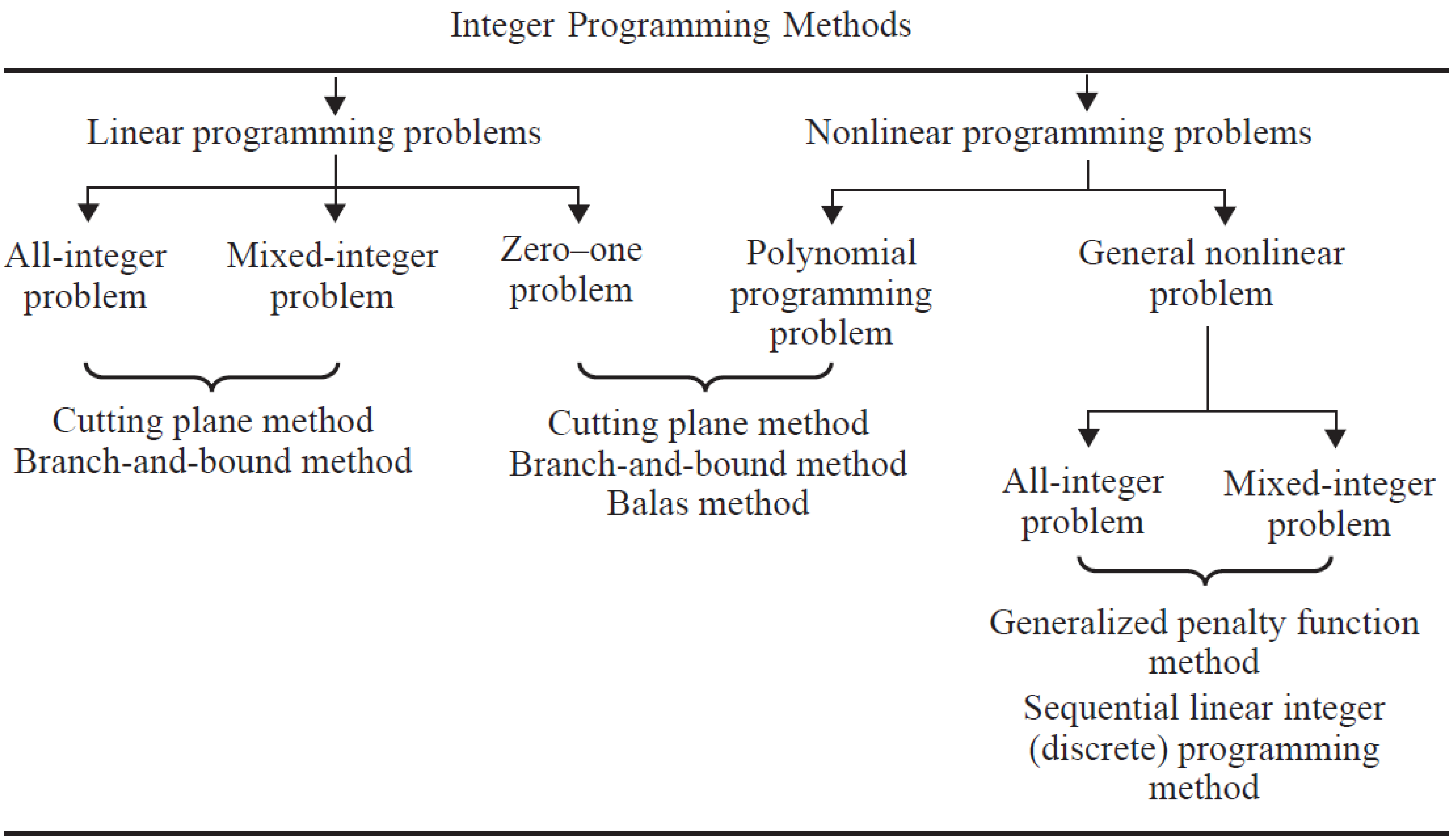
Integer Programming

- In all the optimization techniques considered so far, the design variables are assumed to be continuous, which can take any real value. In many situations it is entirely appropriate and possible to have fractional solutions. For example, it is possible to use a plate of thickness 2.60 mm in the construction of a boiler shell, 3.34 hours of labor time in a project, and 1.78 Kg of nitrate to produce a fertilizer.
- Also, in many engineering systems, certain design variables can only have discrete values. For example, pipes carrying water in a heat exchanger may be available only in diameter increments of $^{1}/_{8}$ in.
- However, there are practical problems in which the fractional values of the design variables are neither practical nor physically meaningful. For example, it is not possible to use 1.6 boilers in a thermal power station, 1.9 workers in a project, and 2.76 lathes in a machine shop.
- If an integer solution is desired, it is possible to use any of the techniques described in previous chapters and round off the optimum values of the design variables to the nearest integer values. However, in many cases, it is very difficult to round off the solution without violating any of the constraints.

Integer Programming

- Frequently, the rounding of certain variables requires substantial changes in the values of some other variables to satisfy all the constraints. Further, the round-off solution may give a value of the objective function that is very far from the original optimum value. All these difficulties can be avoided if the optimization problem is posed and solved as an integer programming problem.
- When all the variables are constrained to take only integer values in an optimization problem, it is called an all-integer programming problem.
- When the variables are restricted to take only discrete values, the problem is called a discrete programming problem.
- When some variables only are restricted to take integer (discrete) values, the optimization problem is called a mixed-integer (discrete) programming problem.
- When all the design variables of an optimization problem are allowed to take on values of either zero or 1, the problem is called a zero–one programming problem.

Integer Programming



Integer Linear Programming

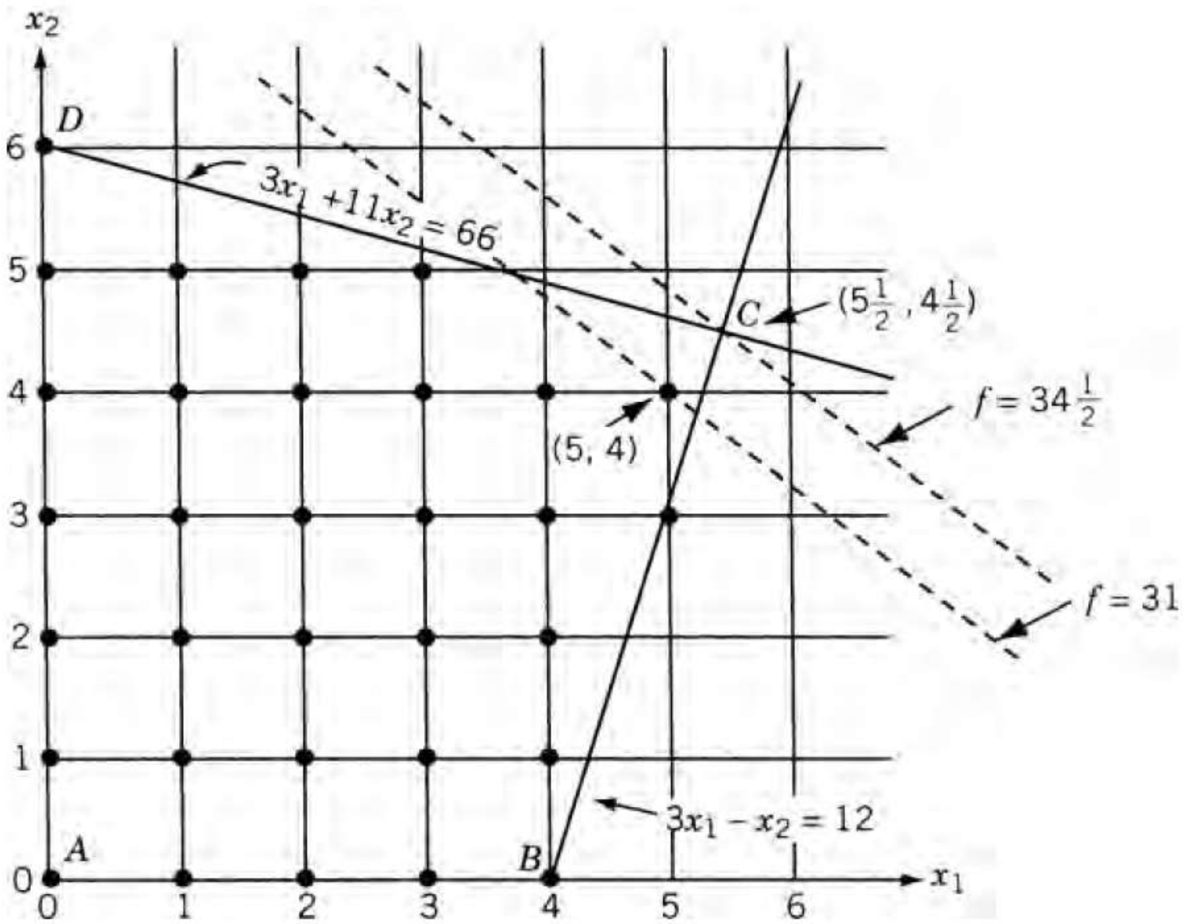
GRAPHICAL REPRESENTATION

Consider the following integer programming problem:

Maximize $f(\mathbf{X}) = 3x_1 + 4x_2$

subject to

$$3x_1 - x_2 \le 12$$
$$3x_1 + 11x_2 \le 66$$
$$x_1 \ge 0$$
$$x_2 \ge 0$$
$$x_1 \text{ and } x_2 \text{ are integers}$$



Integer Linear Programming

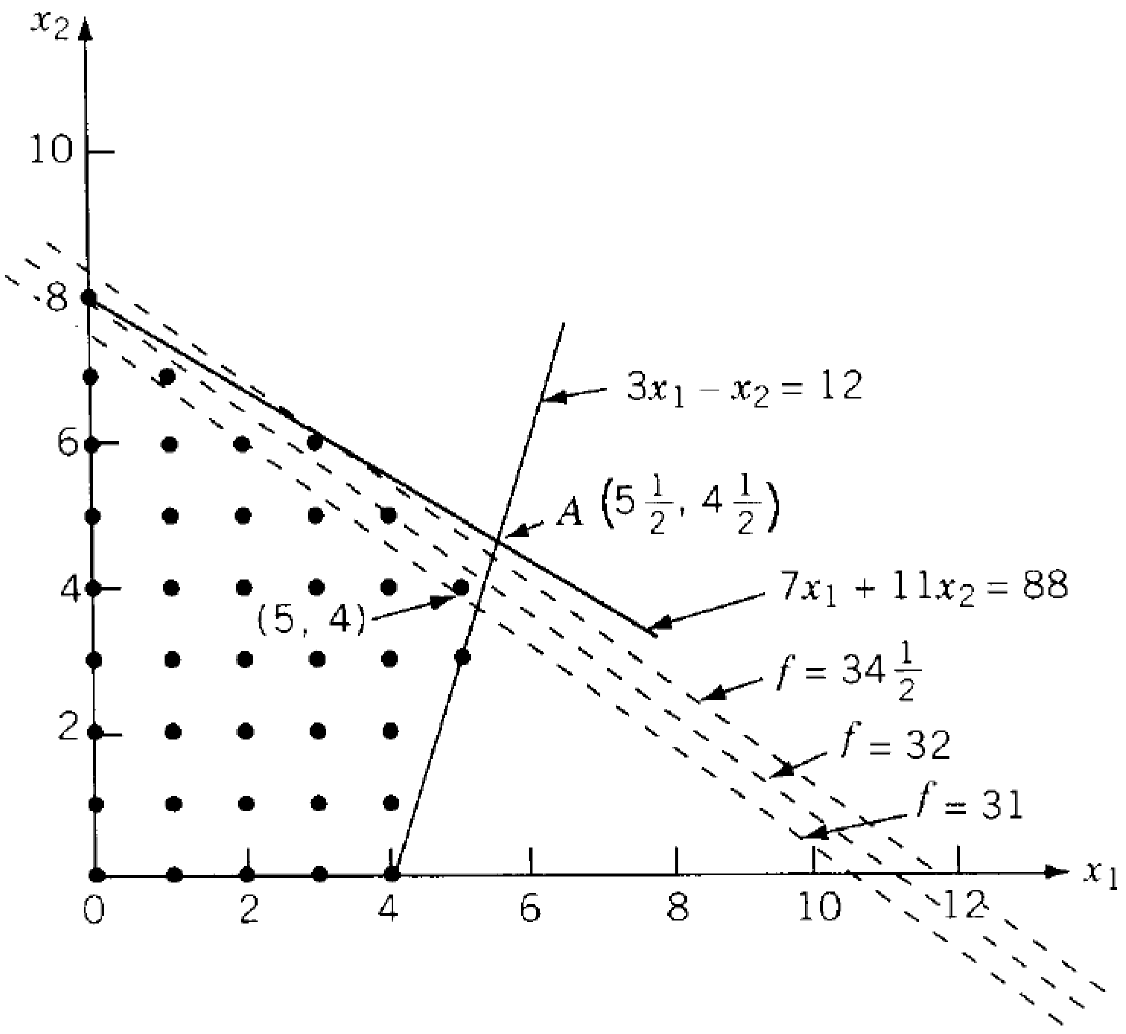
GRAPHICAL REPRESENTATION

Consider the following integer programming problem:

Maximize $f(\mathbf{X}) = 3x_1 + 4x_2$

subject to

$$3x_1 - x_2 \leq 12$$
$$7x_1 + 11x_2 \leq 88$$
$$x_1 \geq 0$$
$$x_2 \geq 0$$
$$x_1 \text{ and } x_2 \text{ are integers}$$



Thanks