**1.5 CLASSIFICATION OF OPTIMIZATION PROBLEMS**

Optimization problems can be classified in several ways, as described below.

**1.5.1 Classification Based on the Existence of Constraints**

Optimization problem can be classified as constrained or unconstrained, depending on whether constraints exist in the problem.

**1.5.2 Classification Based on the Nature of the Design Variables**

Based on the nature of design variables encountered, optimization problems can be classified into two broad categories. In the first category, the problem is to find values to a set of design parameters that make some prescribed function of these parameters minimum subject to certain constraints.

**1.5.3 Classification Based on the Physical Structure of the Problem**

Depending on the physical structure of the problem, optimization problems can be classified as optimal control and nonoptimal control problems. Optimal Control Problem. An optimal control (OC) problem is a mathematical programming problem involving a number of stages, where each stage evolves from the preceding stage in a prescribed manner. It is usually described by two types of variables: the control (design) and the state variables.

The control variables define the system and govern the evolution of the system from one stage to the next, and the state variables describe the behavior or status of the system in any stage.

The problem is to find a set of control or design variables such that the total objective function (also known as the performance index, PI) over all the stages is minimized subject to a set of constraints on the control and state variables.

**1.5.4 Classification Based on the Nature of the Equations Involved**

Another important classification of optimization problems is based on the nature of expressions for the objective function and the constraints. According to this classification, optimization problems can be classified as linear, nonlinear, geometric, and quadratic programming problems. This classification is extremely useful from the computational point of view since there are many special methods available for the efficient solution of a particular class of problems. Thus the first task of a designer would be to investigate the class of problem encountered. This will, in many cases, dictate the types of solution procedures to be adopted in solving the problem.

**1.5.5 Classification Based on the Permissible Values of the Design Variables**

Depending on the values permitted for the design variables, optimization problems can be classified as integer and real-valued programming problems. Integer Programming Problem. If some or all of the design variables x1, x2, . . . , xn of an optimization problem are restricted to take on only integer (or discrete) values, the problem is called an integer programming problem. On the other hand, if all the design variables are permitted to take any real value, the optimization problem is called a real-valued programming problem.

**1.5.6 Classification Based on the Deterministic Nature of the Variables**

Based on the deterministic nature of the variables involved, optimization problems can be classified as deterministic and stochastic programming problems. Stochastic Programming Problem. A stochastic programming problem is an optimization problem in which some or all of the parameters (design variables and/or preassigned parameters) are probabilistic (nondeterministic or stochastic).

**1.5.7 Classification Based on the Separability of the Functions**

Optimization problems can be classified as separable and nonseparable programming problems based on the separability of the objective and constraint functions.

**1.5.8 Classification Based on the Number of Objective Functions**

Depending on the number of objective functions to be minimized, optimization problems can be classified as single- and multiobjective programming problems.