9.1 INTRODUCTION

Probability deals with the relative likelihood that certain event will or will not occur, relative to some other events, as for example: birth of a baby boy or a baby girl, likelihood of blood pressure on higher side of the normal range or the chance of a drug being more effective than the other. The outcome of all these and even many more events depends on chance. An element of uncertainty is associated with every outcome or every conclusion. This uncertainty is numerically expressed as probability. It is represented by '*p*'.

9.1.1 Definition

Probability represents the chance of occurrence with which an event is expected to occur on an average. If an event can occur in N mutually exclusive and equally likely ways, and if *m* of these possess a characteristic E, the probability of occurrence of E is equal to

$$\frac{m}{N} \text{ or } p(E) = \frac{m}{N}$$

In case:

N – Represents the number of trials.

X or *n* – Represents the number of successes or the number for which the event has occurred.

p – Represents the probability, then, the probability is expressed as X/N. It is also denoted by *f* and is used to denote chances of appearance of a character in a progeny with small or limited number of individuals. It is denoted by *p* in large number of cases.

The value of probability may vary between 0 to 1. The closer is the probability to zero, the less are the chances for the event to occur. When probability is one, the event is certain to occur or character is certain to appear in the offsprings.

9.3 BASIC FEATURES OF PROBABILITY

Following six basic laws of probability are most specific:

1. If probability of occurrence of an event is 1, the event will occur certainly.
2. If probability of occurrence of an event is 0, the event will never occur.
3. The probability of any event must assume a value between 0 and 1.
4. The sum of probabilities of all the simple events in a sample space must be equal to 1. It can also be said that the probability of the sample space in any experiment is always one.
5. Closer the probability is to 1, the more likely it is that the event will occur.
6. Closer the probability is to 0, the less likely it is that the event will occur.

9.4 TYPES OF PROBABILITY

There are two types of probability:

1. Classical or Mathematical
2. Statistical or Empirical

9.4.1. Classical or Mathematical Probability

9.4.1.1 Definition

When the likelihood of occurrence of various chance events is based on our previous knowledge, it is called **theoretical** or **classical probability.** It is the ratio of number of favourable cases.

9.4.1.2 Explanation

If an experiment has n mutually exclusive, equally likely and exhaustive cases, out of which m are favourable to the happening of the event (E), the probability of the happening of E is denoted by P(E) and is represented as:

$$P(E) = \frac{m}{n}$$

$$= \frac{\text{No. of cases favourable to event E}}{\text{Total number of cases (mutually exclusive, equally likely and exhausted cases)}}$$

and the probability of the event that does not happen is represented as:

$$P(\overline{E}) = \frac{n-m}{n} = \frac{\text{No. of cases unfavourable to event E}}{\text{Total or exhausted number of cases}}$$

Thus, $$P(E) + P(\overline{E}) = \frac{m}{n} + \frac{(n-m)}{n} = 1$$

or $$P(E) = 1 - P(\overline{E})$$

and $$P(\overline{E}) = 1 - P(E)$$

9.4.1.3 Salient Features of Classical Probability

From the above definition, it is clear that:

- The probability of an event is the ratio of the number of favourable cases to the exhaustive number of cases in a trial.
- The probability of an event which can occur is 0 – 1.
- The probability of an event which cannot occur is 0.
- The sum of the probabilities of happening and not happening of an event is always equal to 1.

9.4.1.4 Limitations of Classical Probability

- Classical probability is based on the feasibility of grouping the possible outcomes of the experiments into 'mutually exclusive', 'exhaustive' and 'equally likely events.
- Classical probability is applicable only when sample space is finitely enumerable.
- Classical probability fails to give required probability when number of possible outcomes is infinitely large.
- Classical probability is not applicable to cases where outcomes of an experiment cannot be enumerated.

Example 9.20: A bag contains 5 white and 7 red flowers. Find out the probability of taking out of the bag of each type of flowers.

Solution:

Total number of flowers = 5 + 7 = 12

Total number of events taking out 1 flower = 12

(A) No. of events of taking out one white flower = 5

Probability of taking out one white flower = $\frac{5}{12}$.

(B) No. of events of taking out one red flower = 7

Probability of taking out red flowers = $\frac{7}{12}$.

Probability of getting a white or a red flower = P(A + B) = P(A) + P(B)

$= P(A + B) = \frac{5}{12} + \frac{7}{12} = \frac{12}{12} = 1.$

Example 9.21: While throwing two dice, find out the probability of getting 10 and 11.

Solution: **(*a*) Probability of getting 10**

Two dice have been played together

Total number of events = 6 × 6 = 36

Number of events getting a sum total of 10 = (4, 6), (5, 5), (6, 4) = 3

∴ The probability of getting a sum of 10 = $\frac{3}{36} = \frac{1}{12}$.

(*b*) Probability of getting 11

Number of events getting a sum total of 11 = (5, 6), (6, 5) = 2

Probability of getting a sum total of 11 = $\frac{2}{36} = \frac{1}{18}$.

∴ The probability of getting 10 and 11 = $\frac{3}{36} + \frac{2}{36} = \frac{5}{36}$.

Example 9.23: When two children are born one after the other, find the chances of getting two male children, chances of getting two female children and the chances of getting one of the either sex.

Solution:

	Sequence	Probability
1.	M (male) and M (male)	$\frac{1}{2} \times \frac{1}{2} = \frac{1}{4}$
2.	M (male) and F (Female)	$\frac{1}{2} \times \frac{1}{2} = \frac{1}{4}$
3.	F and M	$\frac{1}{2} \times \frac{1}{2} = \frac{1}{4}$
4.	F and F	$\frac{1}{2} \times \frac{1}{2} = \frac{1}{4}$

Thus, chance of getting two male children $= \frac{1}{4} = 25\%$

Chances of getting two female children $= \frac{1}{4} = 25\%$

Chances of getting one of either sex will be total of second and third sequences $= \frac{1}{4} + \frac{1}{4} = \frac{1}{2} = 50\%$

Thus, if a female child is born first, the probability of the second child being female will be 25%.

Since, probability of two female children one after the other = 25%

Probability of second child being male = 100 – 25% = 75%.

If we consider the inheritance of such genes which assort independently and have 100% expression, say for example, tall and dwarf characters of pea plant, the probability of any one plant in F_2 generation being tall will be $\frac{3}{4}$ and of being dwarf $\frac{1}{4}$. Similarly, in a cross between red and white flowered plants, the probability of red flowered plants in F_2 is $\frac{3}{4}$ and of a plant with white flowers is $\frac{1}{4}$. The probability of redness and tallness to come together will equal to the multiplication product of their individual probabilities. Thus:

(*a*) Probability of appearance of red flowered plants in F_2 generation $= \frac{3}{4}$