

## CHAPTER

# 7

# Algebraic Structures

## 7.0 INTRODUCTION :

We known that computer applications does not work on pictorial representation of the graphs and hence it is necessary to represent them into algebraic form. In this chapter we shall discuss the concept of abstract algebra by using a binary operations based on Set theory.

## 7.1 BINARY OPERATION :

If  $A$  is a non-empty set then a function  $f: A \times A \rightarrow A$  is called a **binary operation** on  $A$ .

A function  $f: A \times A \times A \rightarrow A$  is called an  **$n$ -ary operation**. A function  $f: A \rightarrow A$  is called an **unary operation**.

If  $*$  is the binary operation on  $A$  and  $a, b, \in A$  then it may be written as  $a * b$  and  $a * b \in A$  is unique.

The binary operation can also be denoted by the symbols  $+$ ,  $-$ ,  $\oplus$ ,  $\Delta$ ,  $\vee$ ,  $\wedge$ , etc.

Some of the examples of binary operations are :

1. The operation of addition is a binary operation on the set of natural number as addition of any two natural numbers is again a natural number.
2. The operation of subtraction is a binary operation on the set of integers but not on the set of natural numbers.
3. The operation of multiplication is a binary operation on the set of natural numbers and integers.
4. The operations of intersection and union are binary operations on the set of subsets of some set.

A binary operation on set  $A$  is also known as **composition**. If  $A$  is a finite set then binary operation on  $A$  can also be described by means of a table, called

**composite table or cayley table**. For example, consider the set  $A = \{1, 2, 3\}$  and a binary operation  $*$  on  $A$  defined by  $a * b = a$ . Then we have the following table :

$*$	1	2	3
1	1	1	1
2	2	2	2
3	3	3	3

Whereas the operation  $*$  defined by  $a * b = a + 2b$  on  $A = \{1, 2, 3\}$  is not a binary operation as can be seen from the following table :

$*$	1	2	3
1	3	5	7
2	4	6	8
3	5	7	9

We can also define the binary operations directly by representing composite tables. For example, we define binary operation  $\wedge$  and  $\vee$  on  $A = \{0, 1\}$  as

$\wedge$	0	1
0	0	0
1	0	1

$\vee$	0	1
0	0	1
1	1	1

**Example - 1 :** Is addition a binary operation on  $\{-1, 0, 1\}$  ? Justify. (Sept., 2021)

**Solution :** The composition table is :

$+$	-1	0	1
-1	-2	-1	0
0	-1	0	1
1	0	1	2

Since  $-2 \notin \{-1, 0, 1\}$ , addition is not a binary operation.

# Algebraic Structures Solutions Manual

**Xiaolong Qi**



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