

## 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  $f: A \times A \times \dots \times A \rightarrow A$  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

**Yicheng Fang**



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## **Table of Contents Algebraic Structures Solutions Manual**

1. Understanding the eBook Algebraic Structures Solutions Manual
  - The Rise of Digital Reading Algebraic Structures Solutions Manual
  - Advantages of eBooks Over Traditional Books
2. Identifying Algebraic Structures Solutions Manual
  - Exploring Different Genres
  - Considering Fiction vs. Non-Fiction
  - Determining Your Reading Goals
3. Choosing the Right eBook Platform
  - Popular eBook Platforms
  - Features to Look for in an Algebraic Structures Solutions Manual
  - User-Friendly Interface
4. Exploring eBook Recommendations from Algebraic Structures Solutions Manual
  - Personalized Recommendations
  - Algebraic Structures Solutions Manual User Reviews and Ratings
  - Algebraic Structures Solutions Manual and Bestseller Lists
5. Accessing Algebraic Structures Solutions Manual Free and Paid eBooks
  - Algebraic Structures Solutions Manual Public Domain eBooks
  - Algebraic Structures Solutions Manual eBook Subscription Services
  - Algebraic Structures Solutions Manual Budget-Friendly Options
6. Navigating Algebraic Structures Solutions Manual eBook Formats

- ePub, PDF, MOBI, and More
- Algebraic Structures Solutions Manual Compatibility with Devices
- Algebraic Structures Solutions Manual Enhanced eBook Features
- 7. Enhancing Your Reading Experience
  - Adjustable Fonts and Text Sizes of Algebraic Structures Solutions Manual
  - Highlighting and Note-Taking Algebraic Structures Solutions Manual
  - Interactive Elements Algebraic Structures Solutions Manual
- 8. Staying Engaged with Algebraic Structures Solutions Manual
  - Joining Online Reading Communities
  - Participating in Virtual Book Clubs
  - Following Authors and Publishers Algebraic Structures Solutions Manual
- 9. Balancing eBooks and Physical Books Algebraic Structures Solutions Manual
  - Benefits of a Digital Library
  - Creating a Diverse Reading Collection Algebraic Structures Solutions Manual
- 10. Overcoming Reading Challenges
  - Dealing with Digital Eye Strain
  - Minimizing Distractions
  - Managing Screen Time
- 11. Cultivating a Reading Routine Algebraic Structures Solutions Manual
  - Setting Reading Goals Algebraic Structures Solutions Manual
  - Carving Out Dedicated Reading Time
- 12. Sourcing Reliable Information of Algebraic Structures Solutions Manual
  - Fact-Checking eBook Content of Algebraic Structures Solutions Manual
  - Distinguishing Credible Sources
- 13. Promoting Lifelong Learning
  - Utilizing eBooks for Skill Development
  - Exploring Educational eBooks
- 14. Embracing eBook Trends
  - Integration of Multimedia Elements
  - Interactive and Gamified eBooks

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