

Higher Secondary Course

XII

Computer Science

Part II



Government of Kerala
DEPARTMENT OF EDUCATION
State Council of Educational Research and Training (SCERT); Kerala

2015



THE NATIONAL ANTHEM

Jana-gana-mana adhinayaka, jaya he
Bharatha-bhagya-vidhata.
Punjab-Sindh-Gujarat-Maratha
Dravida-Utkala-Banga
Vindhya-Himachala-Yamuna-Ganga
Uchchala-Jaladhi-taranga
Tava subha name jage,
Tava subha asisa mage,
Gahe tava jaya gatha.
Jana-gana-mangala-dayaka jaya he
Bharatha-bhagya-vidhata.
Jaya he, jaya he, jaya he,
Jaya jaya jaya, jaya hel

PLEDGE

India is my country. All Indians are my brothers and sisters.

I love my country, and I am proud of its rich and varied heritage. I shall always strive to be worthy of it.

I shall give respect to my parents, teachers and all elders and treat everyone with courtesy.

I pledge my devotion to my country and my people. In their well-being and prosperity alone lies my happiness.

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Dear students,

Computer Science, a subject belonging to the discipline of Science and of utmost contemporary relevance, needs continuous updating. The Higher Secondary Computer Science syllabus has been revised with a view to bringing out its real spirit and dimension. The constant and remarkable developments in the field of computing as well as the endless opportunities of research in the field of Computer Science and Technology have been included.

In Class XI, we started with the history of computing followed by hardware and software components, computer network and Internet. The major part of the textbook as well as the syllabus established a strong foundation to construct and enhance the problem solving and programming skills of the learner.

The syllabus of Class XII gives thrust on the means of handling complex data involved in problem solving and the development of web applications. The textbook, designed in accordance with the syllabus, begins with some advanced features of C++ programming language like structures and pointers. Web technology is introduced with the theoretical background and proceeds with the design of simple web pages followed by a brief idea about both client-side and server-side scripting. The concept of database and facilities of information retrieval are included. An exclusive section about the advances in computing opens the door to the latest developments in the world of computing discipline. Considering the increase in the use of Internet, an awareness about Cyber laws is also presented to safeguard against Cyber crimes.

I hope this book will meet all the requirements for stepping to levels of higher education in Computer Science and pave your way to the peak of success.

Wish you all success.

Dr S. Raveendran Nair
Director
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Icons used in this textbook



Let us do



Know your progress



Information box



Let us practice



Let us conclude



8

Database Management System

Significant Learning Outcomes

After the completion of this chapter, the learner

- recognises the need for files.
- identifies the major limitations of the conventional file management system.
- lists and explains the different advantages of the Database Management System.
- lists the various components of DBMS and explains their purpose.
- recognises the types of users and their roles in the DBMS environment.
- explains the levels of data abstraction and data independence in DBMS.
- explains relational data model by citing examples.
- uses different terminologies in RDBMS, appropriately.
- applies and evaluates various operations in Relational algebra.

This is an era of information. The survival of organisations in this competitive world largely depends on the need for information obtained with high accuracy and speed. We know that information is obtained through the processing of data. For this, a huge amount of data is to be collected, stored and processed to generate information. Every organisation that we can think of like schools, banks, business organisations, etc. are in need of information. Can you imagine how this huge quantity of data was handled traditionally? In earlier days, this was handled manually with data recorded in books termed as 'book keeping'. It is obvious that large storage space is a hazard and processing of data is laborious. With the advent of computers the data could be stored effectively, but the possibility of duplication, inconsistency, invalidity, etc. remained. This chapter provides an effective mechanism to overcome these limitations. The concept of Database Management System (DBMS) is introduced in this chapter as an effective record keeping system (earlier called book keeping). Various operations are also discussed to retrieve the required and relevant information from the database.

8.1 Concept of database

Consider the Single Window System (SWS) of the Department of Higher Secondary Education, maintaining a large collection (say 5,00,000 applications or 19 GB) of data concerning students, courses, schools and grades each year for Class XI admission process. This data is accessed simultaneously by several schools and students. Questions about the allotment of students and schools must be answered quickly, changes made to the data by different schools must be applied consistently, and access to certain parts of the data (e.g., Grades or WGPA) must be restricted.

We can manage the data by storing it in the conventional file management system. But, this approach has many drawbacks:

- We must keep more copies of the same data for different applications. This storage leads to duplication of data.
- There is no mechanism to protect the data from inconsistent changes made by different users accessing the database simultaneously.
- If the data are not properly organised, retrieval of information will be difficult, and time consuming, and there may be chances of inaccuracy in the information..
- There is no way to ensure that data is restored to a consistent state if the system crashes while changes are being made.
- Operating systems provide only a password mechanism for security. This is not sufficiently flexible to enforce security policies in data.
- There is no standardisation on data.

8.1.1 Need of database

The drawbacks mentioned above can be overcome by using database. In situations, where huge amount of data is to be maintained and manipulated, conventional file system will not be sufficient. In such a situation we use database. **Database** is an organized collection of inter-related data stored together with minimum redundancy, in a manner that makes them accessible for multiple applications. Now we can try to manage the data in SWS by storing it in a database. The software Database Management System (DBMS) is essentially a set of programs which facilitates storage, retrieval and management of database. The primary goal of DBMS is to provide an environment that is both convenient and efficient to use in retrieving and storing database.

8.1.2 Advantages of DBMS

Database systems are designed to manage large amounts of data. DBMS involves both the database structures definition for the storage of data and the provision of

mechanisms for the manipulation of data. In addition, the database system must ensure the safety of the data stored, against unauthorized access or system failure. If data is to be shared among several users, the system must avoid possible anomalous results. The database management system has a number of advantages over the traditional file management system. They are listed below.

- **Controlling data redundancy:** In file management systems, data may be placed in many files. The storing of the same data in multiple locations (may be in the same file or different files) or duplication of data is known as data redundancy. Redundancy leads to higher cost in storage and data access. Database systems do not maintain redundant data, instead all the data is kept at one place in a centralized manner. All the applications or users that require data refer to the centrally maintained database. Sometimes there can be technical or business reasons for maintaining several copies of the same data. However, redundancy should be carefully controlled in any case.
- **Data consistency:** Data redundancy may lead to data inconsistency; that is, the various copies of the same data show different values in different files. Assume that your class teacher and Principal maintain separate copies of the address list of all students admitted in your class. During periodic address change a few students report to the Principal and a few students report to the changes to the class teacher. After a certain period of time both the address lists become irrelevant and inconsistent since total corrections are not updated in both. By controlling data redundancy, data consistency is obtained. If a data item appears only once, any update to its value has to be performed only once and the updated value is immediately available to all users.
- **Efficient data access:** A DBMS utilises a variety of techniques to store and retrieve data efficiently.
- **Data integrity:** Data integrity refers to the overall completeness, accuracy and consistency of data in the database. This can be indicated by an absence of any alteration in data between two updates of a data record. Data integrity is imposed within a database at its design stage through the use of standard rules and procedures. Data integrity can be maintained through the use of error checking and validation routines.
- **Data security:** The information inside a database is valuable to any company or organization. Therefore it must be kept secure and private. Data security refers to the protection of data against accidental or intentional disclosure or unauthorized destruction or modification by unauthorized persons. The various programs and users may share data in common. But access to specific information can be limited to selected users by setting the access rights. Through

the use of passwords, the information in a database is made available only to authorised persons.

- **Sharing of data:** The data stored in the database can be shared among several users or programs even simultaneously and each may use it for different purposes.
- **Enforcement of standards:** With central control of the database, a Database Administrator (DBA) defines and enforces the necessary standards. Standards can be defined for data formats to facilitate exchange of data between systems. Applicable standards might include naming conventions, display formats, report structures, terminology, documentation standards, update procedures, access rules and so on. This facilitates communication and cooperation among various departments, projects and users within the organization.
- **Crash recovery:** When a system crashes, all or a portion of the data can become unusable. DBMS provides some mechanism to recover data from the crashes. Thus the DBMS protects data from the effects of system failures.

Know your progress

1. Storing of the same data in different places is called _____.
2. Address of a particular student is stored in two ways in a school record; this situation is known as _____.
3. Unauthorised accessing of data can be prevented from using _____.
4. Sharing of data can reduce data redundancy. State whether true or false?
5. Data redundancy will reduce data consistency. State whether true or false?



8.2 Components of the DBMS environment

DBMS have several components, each performing very significant tasks in its environment. The components are

- Hardware
- Software
- Data
- Users
- Procedures

Hardware: The hardware is the actual computer system used for storage and retrieval of the database. This includes computers (PCs, workstations, servers and supercomputers), storage devices (hard disks, magnetic tapes), network devices (hubs, switches, routers) and other supporting devices for keeping and retrieval of data.

Software: The software part consists of the actual DBMS, application programs and utilities. DBMS acts as a bridge between the user and the database. In other words, DBMS is the software that interacts with the users, application programs, and databases. All requests from users for access to the database are handled by the DBMS. Database management system software consists of several software components that handle various tasks such as data definition, data manipulation, data security, data integrity, data recovery and performance optimization. One general function provided by the DBMS is thus the shielding of database from complex hardware-level detail. The DBMS controls the access and helps to maintain the consistency of the data.

Application programs are most commonly used to access data found within the database to generate reports, tabulations, and other information to facilitate decision making. Utilities are the software tools used to help manage the database system. For example, all major DBMS provide graphical user interfaces (GUIs) to help create database structures, control database access, and monitor database operations.

Data: It is the most important component of DBMS environment from the end users point of view. The database contains operational data and the meta-data (data about data). The database should contain all the data needed by the organization. The major feature of databases is that the actual data and the programs that uses the data are separated from each other. For effective storage and retrieval of information, data is organized as fields, records and files.

Assume a box containing a collection of cards which stores the Admission Number, Name, Batch, Result, Marks of students in a class. Each card will have the same format but the data written on them is different as in Figure 8.2.

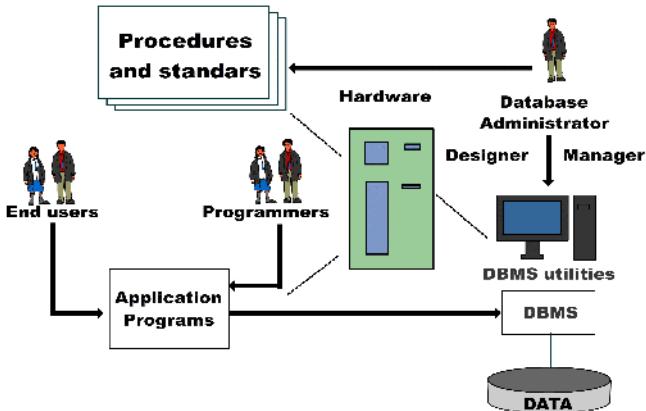


Fig. 8.1: Database system environment

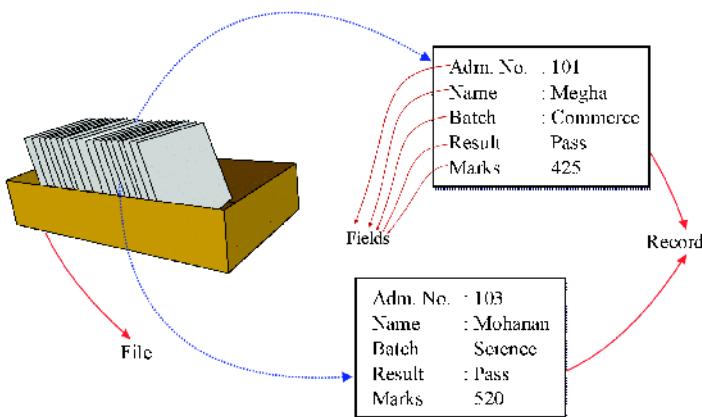


Fig. 8.2: Concept of data organisation

Fields: A field is the smallest unit of stored data. Each field consists of data of a specific type. In Figure 8.2 Adm. No., Name, Batch, Result, and Marks are the fields.

Record: A record is a collection of related fields. In the Figure 8.2, each card in the box contains the related fields of a record. For example, the fields 103, Mohanan, Science, Pass, and 520 constitute a record.

File: A file is a collection of all occurrences of same type of records. The box shown in Figure 8.2 may be considered as a file.

Users: There are a number of users who can access data on demand using application programs. The users of a database system can be classified depending on the mode of their interactions with DBMS. The different categories of users are Database Administrator (DBA), Application Programmers, Sophisticated users and Naive Users.

Procedures: Procedures refer to the instructions and rules that govern the design and use of the database. The users of the system and the person that manages the database require documented procedures on how to use or run the system. These may consist of instruction on how to:

- i. log onto the DBMS.
- ii. use a particular DBMS facility or application program.
- iii. start and stop the DBMS.
- iv. make backup copies of the database or handle hardware or software failures
- v. reorganise the database across multiple disks, improve performance, or archive data to secondary storage.

Know your progress



1. Data about data is called _____.
2. List the name of major components of a database system?
3. Categorize the following components of DBMS environment. Hard disk, Switch, DBA, Payroll system, End user, railway reservation system.

8.3 Data abstraction and data independence

For the system to be usable, it must retrieve data efficiently. The need for efficiency has led designers to use complex data structures to represent data in the database. Since many database system users are not computer trained, developers hide the complexity from users through several levels of abstraction. The data in a DBMS is described at three levels of abstraction, as illustrated in Figure 8.3. The database description consists of a structure at each of these three levels of abstraction: the physical level, conceptual level and view level.

a. Physical level

The lowest level of abstraction describes how data is actually stored on secondary storage devices such as disks and tapes. The physical level describes complex low-level data structures in detail. We must decide what file organisations are to be used to store the relations and create auxiliary data structures, called indexes, to speed up data retrieval operations.

A sample physical schema for the SWS database follows:

- Store all relations as unsorted files of records. (A file in a DBMS is either a collection of records or a collection of data)
- Create indexes on the first column of the files Student, School, and Course.

b. Logical level

The next-higher level of abstraction describes what data is stored in the database, and what relationships exist among those data. The logical level thus describes the entire database in terms of a small number of relatively simple structures. Although

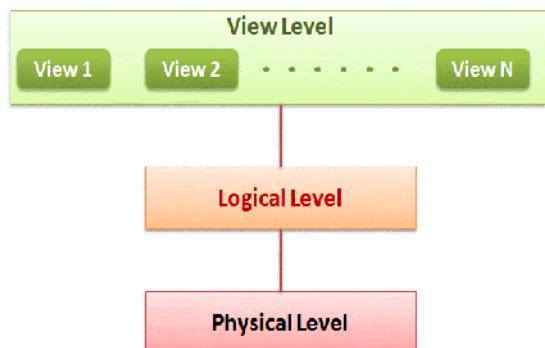


Fig. 8.3: Levels of abstraction

implementation of the simple structures at the logical level may involve complex physical-level structures, the user of the logical level does not need to be aware of this complexity. Database administrators, who must decide what information to keep in the database, use the logical level of abstraction. Logical level is also referred as conceptual level.

c. View level

View level is the highest level of database abstraction and is the closest to the users. It is concerned with the way in which individual users view the data. It describes only a part of the entire database. Most of the users of the database are not concerned with all the information that is contained in the database. Instead they need only a part of the database that is relevant to them. This simplifies their interaction with the system. The system may provide many views for the same database. Figure 8.4 shows the three levels of data abstraction for a STUDENT file with fields AdmNo, Name, Batch, Result, Marks.

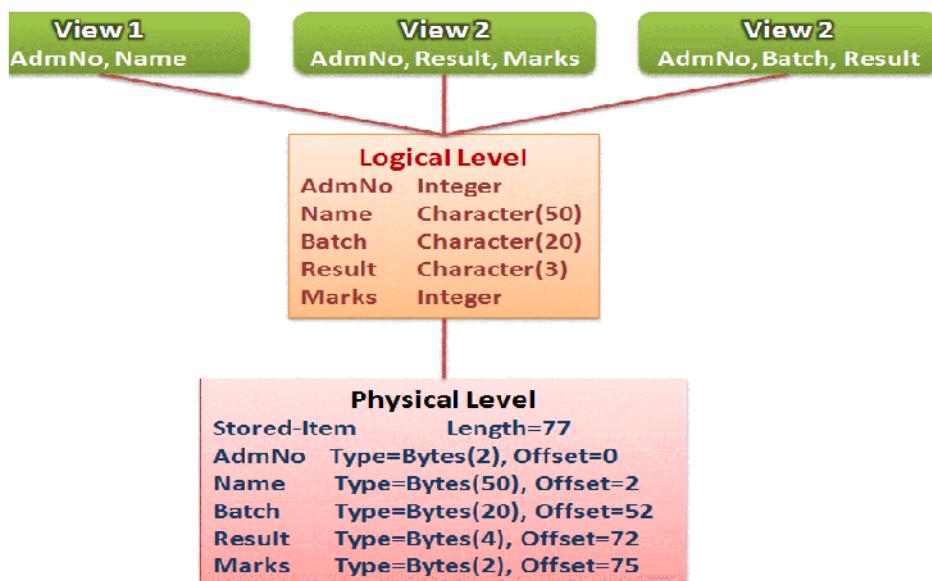


Fig. 8.4: Example for levels of abstraction

8.3.1 Data independence

Since a database may be viewed through three levels of abstraction, any change in the database structure at a particular level may affect the schema of other levels. The frequent changes made on database should not lead to the redesigning and reimplementation of the database. The ability to modify the schema definition (data structure definition) in one level without affecting the schema definition at the next

higher level is called data independence. There are two levels of data independence, physical data independence and logical data independence.

a. Physical data independence

Physical data independence refers to the ability to modify the schema followed at the physical level without affecting the schema followed at the conceptual level. That is, the application programs remain the same even though the schema at physical level gets modified.

b. Logical data independence

Logical data independence refers to the ability to modify a conceptual schema without causing any changes in the schema followed at view (external) level. The logical data independence ensures that the application programs remain the same.

It is more difficult to achieve logical data independence than physical data independence because the application programs are heavily dependent on the logical structure of the database.

8.4 Users of database

Depending on the degrees of expertise or the mode of the interactions with DBMS the users of a database system can be classified into the following groups:

- Database Administrator (DBA)
- Application Programmers
- Sophisticated Users
- Naive Users

8.4.1 Database Administrator

The person who is responsible for the control of the centralized and shared database is the Database Administrator (DBA). The DBA is responsible for many critical tasks such as,

Design of the conceptual and physical schemas: The DBA is responsible for interacting with the users of the system to understand what data is to be stored in the DBMS and how it is likely to be used. Based on this knowledge, the DBA must design the conceptual schema and the physical schema.

Security and authorization: The DBA is responsible for ensuring authorized access of data. For example, in a school, teachers allow students to find out course details, results of the student and the details as to who teaches a particular subject. At the same time students shall not be permitted to see teachers' salaries or grades of

other students. The DBA can enforce this policy by giving permission to students to read only the course view.

Data availability and recovery from failures: The DBA must take steps to restore the data to a consistent state when the system fails to complete a transaction or in case of a system crash. The DBMS provides software support for these functions, but the DBA is responsible for implementing procedures to back up the data periodically and maintain logs (special files for storing all activities in a database such as insertion, deletion, updation etc.) of system activity (to facilitate recovery from a crash).

8.4.2 Application programmers

Application programmers are computer professionals who interact with the DBMS through application programs. Application programs are programs written in any host language (for example Visual Basic, C, C++, Java, etc.) and interact with the DBMS through Data Manipulation Language (DML). Application programs should ideally access data through the external schema.

8.4.3 Sophisticated users

Sophisticated users include engineers, scientists, business analysts, and others who are thoroughly familiar with the facilities of the DBMS. They interact with the systems through their own queries (a request to a database) to meet their complex requirements.

8.4.4 Naive users

Naive users interact with the system by invoking one of the application programs that were written previously. They are not concerned with or even aware of the details of the DBMS. Naive users deal only with the higher level of abstraction. People accessing data over the web, clerical staff in an office, billing clerk in a supermarket or hotels, bank clerk, etc. are examples of some naive users.

Know your progress



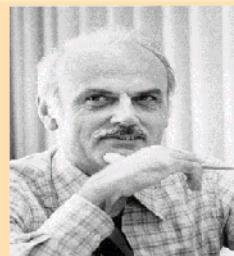
1. The person who interacts with the database through query language is called _____
2. The billing clerk in a Supermarket is a _____ user.
3. Who provides data security in a database?
4. Who changes the structure of a database?
5. _____ interacts with the database through the prewritten application program.

8.5 Relational data model

The relational data model represents database as a collection of tables called relations, each of which is assigned a unique name. In relational model, both data and the relationships among them are represented in tabular form. This representation enables even beginners to understand the concepts of a database easily.



Edgar Frank Codd (19 August 1923 - 18 April 2003) was an English computer scientist who invented the relational model for database management. He was born on the Isle of Portland in England. He served as a pilot in the Royal Air Force during the Second World War. In 1948, he joined IBM. He received the Turing Award in 1981. He died of heart failure at his home in Williams Island, Florida, at the age of 79 on 18 April 2003.



Today, a vast majority of database products are based on the relational model and they are known as Relational DataBase Management System (RDBMS). The major advantages of the relational model over the other data models are its simple data representation and the ease with which even complex queries can be expressed. The popular RDBMS are Oracle, Microsoft SQL Server, MySQL, DB2, Informix and Ingress. Most commercial relational database systems offer a query language that includes Structured Query Language (SQL), Query-by-Example (QBE) or Datalog. We shall study the widely used query language SQL in the Chapter 9.

8.6 Terminologies in RDBMS

Before discussing the operations on relational databases, let us be familiar with some terminologies associated with RDBMS.

a. Entity

An entity is a person or a thing in the real world that is distinguishable from others. For example, each student is an entity, and each school can be considered as another entity.

b. Relation

Relation is a collection of data elements organized in terms of rows and columns. A relation is also called Table. A sample relation named STUDENT is shown in Table 8.1.

STUDENT relation

AdmNo	Roll	Name	Batch	Marks	Result
101	24	Sachin	Science	480	EHS
102	14	Rahul	Commerce	410	EHS
103	4	Fathima	Humanities	200	NHS
104	12	Mahesh	Commerce	180	NHS
105	24	Nelson	Humanities	385	EHS
106	8	Joseph	Commerce	350	EHS
107	24	Shaji	Humanities	205	NIIS
108	2	Bincy	Science	300	EIIS

Table. 8.1: A sample relation

c. Tuple

The rows (records) of a relation are generally referred to as tuples. A row consists of a complete set of values used to represent a particular entity. In Table 8.1, each row in the STUDENT relation represents the result of a particular student.

d. Attribute

The columns of a relation are called attributes. AdmNo, Roll, Name, Batch, Marks and Result are attributes of the STUDENT relation. The values of each attribute are taken from the range of possible values called domain.

e. Degree

The number of attributes in a relation determines the degree of a relation. The relation STUDENT has six columns or attributes and therefore the degree of the STUDENT relation is 6.

f. Cardinality

The number of rows or tuples in a relation is called cardinality of the relation. The relation STUDENT has eight tuples and hence the cardinality of the STUDENT relation is 8.

g. Domain

A domain is a pool of values from which actual values appearing in a given column are drawn. For example, the domain of the column Batch in the relation STUDENT shown in Table 8.1 is the set of values {Science, Humanities, Commerce}. That is,

any one of the values from this set only can appear in the column Batch. Similarly, the set {LHS, NHS} is the domain of the column Results.

h. Schema

The description or structure of a database is called the database schema, which is specified during database design. In the relational model, the schema for a relation specifies its name, the name of each column, and the type of each column. As an example, student information in a School database may be stored in a relation with the following structure:

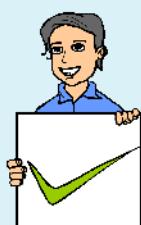
STUDENT	(Admno : integer,
	Roll : integer,
	Name : character(50),
	Batch : character(20),
	Marks : decimal,
	Result : character(4))

i. Instance

An instance of a relation is a set of tuples in which each tuple has the same number of fields as the relational schema. The preceding schema says that each row in the STUDENT relation has six columns, with column names and types as indicated. An example for instance of the STUDENT relation is shown in Table 8.1.

Know your progress

1. Organization of data in terms of rows and columns is called _____.
2. _____ in a table gives the complete data of a particular entity.
3. Number of rows in a relation is called _____.
4. Number of _____ in a relation is called degree of the relation.
5. In the relational model, data is organised as _____.



8.6.1 Keys

A relation is defined as a set of tuples. All the tuples in a relation must be distinct. That is, no two tuples can have the same combination of values for all their attributes. Therefore there should be a way to identify a tuple in a relation. The concept of a key allows us to make such distinctions. A key is an attribute or a collection of attributes in a relation that uniquely distinguishes each tuple from other tuples in a

given relation. If a key consists of more than one attribute then it is called a composite key. In the extreme, the entire tuple is the key since each tuple in the relation is guaranteed to be unique. However, we are interested in smaller keys, if they exist, for a number of practical reasons.

a. Candidate key

A candidate key is the minimal set of attributes that uniquely identifies a row in a relation. In the STUDENT relation of Table 8.1, AdmNo can uniquely identify a row. Therefore it can be considered as a candidate key. There may be more than one candidate key in a relation. Also, a candidate key need not be just one single attribute. It can be a composite key. For example, a combination of Roll, Batch and Marks can also be used to identify a particular student. Therefore, Roll + Batch + Year can be considered as another candidate key of STUDENT relation.

b. Primary key

A primary key is one of the candidate keys chosen to be the unique identifier for that table by the database designer. A primary key is a set of one or more attributes that can uniquely identify tuples within the relation. As it uniquely identifies each entity, it cannot contain null value and duplicate value.

Candidate keys are considered as candidates for primary key position. From the candidate keys the one with the least number of attributes may be selected as primary key. In our example (STUDENT relation), the attribute AdmNo can be used as the primary key. That is, no two students in the STUDENT relation can have the same AdmNo. In Table 8.1, we can see unique values in the column Name, but in real case scenario, more than one student can have the same name.

c. Alternate key

A candidate key that is not the primary key is called an alternate key. In the case of two or more candidate keys, only one of them can serve as the primary key. The rest of them are alternate keys. In our example the combination of Roll + Batch + Year is the alternate key since AdmNo is taken as the primary key.

d. Foreign key

A key in a table can be called foreign key if it is a primary key in another table. Since a foreign key can be used to link two or more tables it is also called a reference key. Suppose we have used Batch code instead of Batch name as shown in Table 8.2 and we have a relation BATCH as shown in Table 8.3. It is clear that BatchCode is the primary key in relation Batch, but it is used in STUDENT table as a non-key attribute. So, BatchCode is referred to as a foreign key with respect to STUDENT relation.

STUDENT relation

AdmNo	Roll	Name	BatchCode	Marks	Result
101	24	Sachin	S2	480	EIIS
102	14	Rahul	C2	410	EHS
103	4	Puthima	H2	200	NHS
104	12	Mahesh	C2	180	NHS
105	24	Nelson	H2	385	EHS
106	8	Joseph	C2	350	EHS
107	24	Shaji	H2	205	NHS
108	2	Bincy	S2	300	EIIS

Table 8.2: Modified STUDENT relation

BATCH relation**Know your progress**

1. The minimal set of attributes that uniquely identifies a row in a relation is _____.
2. In a table Employee Emp_code, Pan_no are the candidate keys. If Emp_code is taken as the primary key then Pan_no is _____ key.
3. How many primary keys are possible in a relation?
4. If a key consists of more than one attributes then it is called _____.

BatchCode	BatchName	Strength
S1	Science	150
S2	Science	150
C1	Commerce	100
C2	Commerce	100
H1	Humanities	100
II2	IIHumanities	100

Table 8.3: Instance of Batch relation

8.7 Relational algebra

We have discussed the features of relational model, which provides facilities for creating a database. Once the database is designed and data is stored, the required information is to be retrieved. A variety of operations are provided by RDBMS. The collection of operations that is used to manipulate the entire relations of a database is known as relational algebra. These operations are performed with the

help of a special language associated with the relational model, called query language. We will learn this language in the next chapter to perform these operations. The operations involved in relational algebra take one or two relations as input and produces a new relation as the result. The fundamental operations in relational algebra are SELECT, PROJECT, UNION, INTERSECTION, SET DIFFERENCE, CARTESIAN PRODUCT, etc. The SELECT and PROJECT operations are unary operations because they operate on one relation. The remaining operations are binary operations as they operate on pairs of relations.

8.7.1 SELECT operation

SELECT operation is used to select rows from a relation that satisfies a given predicate. The predicate is a user defined condition to select rows of user's choice. This operation is denoted using lower case letter sigma (σ). The general format of select is as follows:

$$\sigma_{\text{condition}} (\text{Relation})$$

The result of SELECT operation is another relation containing all the rows satisfying the given predicate (or conditions). The relational algebra uses various comparison operators $<$ (less than), \leq (less than or equal to), $>$ (greater than), \geq (greater than or equal to), $=$ (equal to) and \neq (not equal to) to set up simple conditions, and logical operators \vee (OR), \wedge (AND) and $!$ (NOT) to construct composite conditions.

To illustrate the SELECT operation, consider the relation STUDENT given in Table 8.1. The following examples show how SELECT operations are expressed in relational algebra and what output they produce.

Example 8.1: To select all the students who are eligible for higher studies.

$$\sigma_{\text{Result} = "EHS"} (\text{STUDENT})$$

The output of this operation is a relation as shown in Table 8.4.

Example 8.2: To select all the students in the Commerce batch who are failed.

AdmNo	Roll	Name	Batch	Marks	Result
101	24	Sachin	Science	480	EHS
102	14	Rahul	Commerce	410	EHS
105	24	Nelson	Humanities	385	EHS
106	8	Joseph	Commerce	350	EHS
108	2	Bincy	Science	300	IIIS

Table 8.4: Output of Example 8.1

$$\sigma_{\text{Result}=\text{"NIIS"} \wedge \text{Batch}=\text{"Commerce"}} (\text{STUDENT})$$

The result of this operation is a relation as shown in Table 8.5

AdmNo	Roll	Name	Batch	Marks	Result
104	12	Mahesh	Commerce	180	NHS

Table 8.5: Output of Example 8.2

Example 8.3: To select all the students in the batch Science or Commerce.

$$\sigma_{\text{Batch}=\text{"Science"} \vee \text{Batch}=\text{"Commerce"}} (\text{STUDENT})$$

Table 8.6 shows the output this operation.

AdmNo	Roll	Name	Batch	Marks	Result
101	24	Sachin	Science	480	EHS
102	14	Rahul	Commerce	410	EHS
104	12	Mahesh	Commerce	180	NHS
106	8	Joseph	Commerce	350	EHS
108	2	Bincy	Science	300	EHS

Table 8.6: Output of Example 8.3

8.7.2 PROJECT operation

The PROJECT operation selects certain attributes from the table and forms a new relation. If the user is interested in selecting the values of a few attributes, rather than all the attributes of the relation, then use PROJECT operation. It is denoted by lower case letter π . The general format of project operation is as follows:

$$\pi_{A_1, A_2, \dots, A_n} (\text{Relation})$$

Here A_1, A_2, \dots, A_n refer to the various attributes that would make up the relation specified.

Example 8.4: Select Name, Result and Marks attributes in STUDENT relation.

$$\pi_{\text{Name}, \text{Marks}, \text{Result}} (\text{STUDENT})$$

The output of this operation is given in Table 8.7.

It is possible to combine the SELECT and PROJECT operations into a single statement. The illustration of this is shown in Examples 8.5 and 8.6.

Name	Marks	Result
Sachin	480	EHS
Rahul	410	EHS
Fathima	200	NHS
Mahesh	180	NHS
Nelson	385	EHS
Joseph	350	EIIS
Shaji	205	NIIS
Bincy	300	EHS

Table 8.7: Output relation of Example 8.4

Example 8.5: To select admission number and name of students who are Eligible for Higher Studies.

$$\pi_{\text{AdmNo, Name}} (\sigma_{\text{result} = "EHS"} (\text{STUDENT}))$$

The resultant relation of this operation is given in Table 8.8. Compare it with Table 8.4 for the verification of correctness of the result.

Example 8.6: To select name and marks of those students in the Humanities batch who are Not eligible for Higher Studies.

$$\pi_{\text{Name, Marks}} (\sigma_{\text{result} = "NHS" \wedge \text{Batch} = "Humanities"} (\text{STUDENT}))$$

The result of this nested operation is shown in Table 8.9.

AdmNo	Name
101	Sachin
102	Rahul
105	Nelson
106	Joseph
108	Bincy

Table 8.8: Output relation of Example 8.5

Name	Marks
Fathima	200
Shaji	205

Table 8.9: Output relation of Example 8.6

8.7.3 UNION operation

UNION operation is a binary operation and it returns a relation containing all tuples appearing in either or both of the two specified relations. It is denoted by \cup . The two relations must be union-compatible, and the schema of the result is defined to be identical to the schema of the first relation. If two relations are union-compatible, then they have the same number of attributes, and corresponding attributes, taken in order from left to right, have the same domain. Note that attribute names are not used in defining union-compatibility.

Consider two relations ARTS and SPORTS given in Tables 8.10 and 8.11 containing the details of students who participate in the arts festival and the sports meet of a school, respectively. Both the relations ARTS and SPORTS consist of AdmNo, Name and BatchCode as fields. It is clear that these two relations are union

ARTS relation		
AdmNo	Name	BatchCode
101	Sachin	S2
103	Fathima	H2
106	Joseph	C2
110	Nikitha	S1
132	Vivek	C1
154	Nevin	C1

Table 8.10: Instance of ARTS relation

SPORTS relation		
AdmNo	Name	BatchCode
102	Rahul	C2
103	Fathima	I12
105	Nelson	H2
106	Joseph	C2
108	Bincy	S2
132	Vivek	C1
164	Rachana	S1

Table 8.11: Instance of SPORTS relation

compatible. That is, the two relations have the same number of attributes and the type of the corresponding attributes are also the same.

Relation $\text{ARTS} \cup \text{SPORTS}$ returns the details of the students participated in arts or sports or both. That is, the expression $\text{ARTS} \cup \text{SPORTS}$ returns a table as shown in Table 8.12. This table consists of the records belonging to the tables ARTS or SPORTS or both, eliminating the duplication. In Table 8.12, we can see that records of students with admission numbers 103, 106, and 132 appear only once in the relation.

8.7.4 INTERSECTION operation

INTERSECTION operation is also a binary operation and it returns a relation containing the tuples appearing in both of the two specified relations. It is denoted by \cap . The two relations must be union-compatible, and the schema of the result is defined to be identical to the schema of the first relation.

If we apply INTERSECT operation on the relations in Tables 8.10 and 8.11, the expression $\text{ARTS} \cap \text{SPORTS}$ returns the details of the students participated in both arts and sports. That is $\text{ARTS} \cap \text{SPORTS}$ returns a table consisting of rows common to ARTS and SPORTS as shown in Table 8.13.

AdmNo	Name	BatchCode
101	Sachin	S2
103	Fathima	II2
106	Joseph	C2
110	Nikitha	S1
132	Vivek	C1
154	Nevin	C1
102	Rahul	C2
105	Nelson	II2
108	Bincy	S2
164	Rachana	S1

Table 8.12: Relation of $\text{ARTS} \cup \text{SPORTS}$

AdmNo	Name	BatchCode
103	Fathima	II2
106	Joseph	C2
132	Vivek	C1

Table 8.13: Relation of $\text{ARTS} \cap \text{SPORTS}$

8.7.5 SET DIFFERENCE operation

SET DIFFERENCE operation is also a binary operation and it returns a relation containing the tuples appearing in the first relation but not in the second relation. It is denoted by $-$ (minus). The two relations must be union-compatible, and the schema of the result is defined to be identical to the schema of the first relation.

The result of SET DIFFERENCE operation $\text{ARTS} - \text{SPORTS}$ on Tables 8.10 and 8.11 returns the details of the students participated in arts but not in sports. That is, the resultant table will contain the rows appearing in relation ARTS but not in relation SPORTS as given in Table 8.14.

Relation $\text{SPORTS} - \text{ARTS}$ returns the details of the students participated in sports but not in arts as shown in Table 8.15.

Union and Intersection operations are commutative, that is the order of relation is not important. For example, the result of $\text{ARTS} \cup \text{SPORTS}$ and $\text{SPORTS} \cup \text{ARTS}$ are same. Also the result of $\text{ARTS} \cap \text{SPORTS}$ and $\text{SPORTS} \cap \text{ARTS}$ are the same. But Set Difference operation is not commutative, that is the order of relation is important. For example, the result of $\text{ARTS} - \text{SPORTS}$ and $\text{SPORTS} - \text{ARTS}$

- ARTS are not same (refer to Tables 8.14 and 8.15).

AdmNo	Name	BatchCode
101	Sachin	S2
110	Nikitha	S1
154	Nevin	C1

Table 8.14: Relation of ARTS - SPORTS

AdmNo	Name	BatchCode
101	Rahul	C2
105	Nelson	H2
108	Bincy	S2
164	Rachana	S1

Table 8.15: Relation of SPORTS - ARTS

8.7.6 CARTESIAN PRODUCT operation

CARTESIAN PRODUCT returns a relation consisting of all possible combinations of tuples from two relations. It is a binary operation on relations, which has a degree (number of attributes) equal to the sum of the degrees of the two relations operated upon. The cardinality (number of tuples) of the new relation is the product of the number of tuples of the two relations operated upon. CARTESIAN PRODUCT is denoted by \times (cross). It is also called CROSS PRODUCT. All the tuples of the first relation are concatenated with tuples of the second relation to form tuples of the new relation.

Let us consider a relation TEACHER as shown in Table 8.16, which contains the details of teachers in the school. We can use this relation to perform cartesian production operation with STUDENT

relation in Table 8.2. The output of the operation $\text{STUDENT} \times \text{TEACHER}$ is shown in Table 8.17. This table shows that each record of STUDENT relation is concatenated with the rows in TEACHER relation.

TEACHER relation

TeacherId	Name	Dept
1001	Viswesaran	English
1002	Meenakshi	Computer

Table 8.16: Instance of TEACHER relation

Adm No	Roll	Name	Batch Code	Marks	Result	TeacherId	Name	Dept
101	24	Sachin	S2	480	EHS	1001	Viswesaran	English
101	24	Sachin	S2	480	EHS	1002	Meenakshi	Computer
102	14	Rahul	C2	410	EHS	1001	Viswesaran	English
102	14	Rahul	C2	410	EHS	1002	Meenakshi	Computer
103	4	Fathima	H2	200	NHS	1001	Viswesaran	English
103	4	Fathima	H2	200	NHS	1002	Meenakshi	Computer
104	12	Mahesh	C2	180	NHS	1001	Viswesaran	English
104	12	Mahesh	C2	180	NHS	1002	Meenakshi	Computer
105	24	Nelson	H2	385	EHS	1001	Viswesaran	English
105	24	Nelson	H2	385	EHS	1002	Meenakshi	Computer
106	8	Joseph	C2	350	EHS	1001	Viswesaran	English
106	8	Joseph	C2	350	EHS	1002	Meenakshi	Computer
107	24	Shaji	H2	205	NHS	1001	Viswesaran	English
107	24	Shaji	H2	205	NHS	1002	Meenakshi	Computer
108	2	Bincy	S2	300	EHS	1001	Viswesaran	English
108	2	Bincy	S2	300	EHS	1002	Meenakshi	Computer

Table 8.17: Result of STUDENT X TEACHER operation



A Database model defines the logical design of data. The model describes the relationships between different parts of the data. The different models used in database design are Hierarchical Model, Network Model, Relational Model and Object-Oriented Model. Hierarchical structures were widely used in the early mainframe database management systems, such as the Information Management System (IMS) by IBM. Popular DBMS product in Network model were Cincom Systems' Total and Cullinet's IDMS.



Let us conclude

We have discussed the basic concepts of DBMS and its components. The advantages of database over traditional file system have been detailed. A brief idea about various terminologies associated with database is presented in the context of relational data model. Once the data is organised systematically in database, the operations provided by relational algebra to generate required information are

experienced with the help of sample relations. A good understanding about the concepts introduced by this chapter is essential to learn the next chapter effectively. In that chapter we will discuss how database is created and information is retrieved using a query language.

Let us assess

1. Who is responsible for managing and controlling the activities associated with the database?
 - a. Database administrator
 - b. Programmer
 - c. Naive user
 - d. End user
2. In the relational model, cardinality is the
 - a. number of tuples
 - b. number of attributes
 - c. number of tables
 - d. number of constraints
3. Cartesian product in relational algebra is
 - a. a Unary operator
 - b. a Binary operator
 - c. a Ternary operator
 - d. not defined
4. Abstraction of the database can be viewed as
 - a. two levels
 - b. four levels
 - c. three levels
 - d. one level
5. In a relational model, relations are termed as
 - a. tuples
 - b. attributes
 - c. tables
 - d. rows
6. In the abstraction of a database system the external level is the
 - a. physical level
 - b. logical level
 - c. conceptual level
 - d. view level
7. Related fields in a database are grouped to form a
 - a. data file
 - b. data record
 - c. menu
 - d. bank
8. A relational database developer refers to a record as
 - a. criteria
 - b. relation
 - c. tuple
 - d. attribute
9. An advantage of the database management approach is
 - a. data is dependent on programs
 - b. data redundancy increases
 - c. data is integrated and can be accessed by multiple programs
 - d. none of the above

10. Data independence means
 - a. data is defined separately and not included in programs
 - b. programs are not dependent on the physical attributes of data
 - c. programs are not dependent on the logical attributes of data
 - d. both (b) and (c)
11. Key to represent relationship between tables is called
 - a. primary key
 - b. candidate Key
 - c. foreign Key
 - d. alternate Key
12. Which of the following operations is used if we are interested only in certain columns of a table?
 - a. PROJECTION
 - b. SELECTION
 - c. UNION
 - d. SELECT
13. Which of the following operations need the participating relations to be union compatible?
 - a. UNION
 - b. INTERSECTION
 - c. SET DIFFERENCE
 - d. All of the above
14. Which database level is closest to the users?
 - a. External
 - b. Internal
 - c. Physical
 - d. Conceptual
15. The result of the UNION operation between R1 and R2 is a relation that includes
 - a. all the tuples of R1
 - b. all the tuples of R2
 - c. all the tuples of R1 and R2
 - d. all the tuples of R1 and R2 which have common columns
16. A file manipulation command that extracts some of the records from a file is called
 - a. SELECT
 - b. PROJECT
 - c. JOIN
 - d. PRODUCT
17. An instance of relational schema R (A, B, C) has distinct values of A including NULL values. Which one of the following is true?
 - a. A is a candidate key
 - b. A is not a candidate key
 - c. A is a primary Key
 - d. Both (a) and (c)

18. How many distinct tuples are there in a relation instance with cardinality 22?
- 22
 - 11
 - 1
 - None
19. A set of possible data values is called
- Attribute
 - Degree
 - Tuple
 - Domain
20. Why should you choose a database system instead of simply storing data in conventional files?
21. Explain the different levels of data abstraction in DBMS?
22. How are schema layers related to the concepts of logical and physical data independence?
23. Consider the instance of the EMPLOYEE relation shown in the following table. Identify the attributes, degree, cardinality and domain of Name and Emp_code.

Emp_Code	Name	Department	Designation	Salary
1000	Sudheesh	Purchase	Manager	25000
1001	Dhanya	Sales	Manager	25000
1002	Fathima	Marketing	Clerk	12000
1003	Shajan	Sales	Clerk	13000

24. Identify primary key, candidate keys and alternate keys in the instance of EMPLOYEE relation in Question 23.
25. Consider the instance of the STUDENT relation shown in the following table. Assume Reg_no as the primary key.
- Identify the candidate keys and alternate keys in the STUDENT relation.
 - How are the primary key and the candidate key related?

Reg_no	Name	Batch	Result	Marks
101	Sachin	Science	Pass	480
103	Fathima	Humanities	Fail	200
106	Joseph	Commerce	Pass	350
108	Bincy	Science	Pass	300

26. What is a database? Describe the advantages and disadvantages of using DBMS.
27. What is data independence? Explain the difference between physical and logical data independence.
28. Enforcement of standard is an essential feature of DBMS. How are these standards applicable in a database?
29. Cardinality of a table T1 is 10 and of table T2 is 8 and the two relations are union compatible. If the cardinality of result $T1 \cup T2$ is 13, then what is the cardinality of $T1 \cap T2$? Justify your answer.
30. Cardinality of a table T1 is 10 and of table T2 is 8 and the two relations are union compatible
- What will be the maximum possible cardinality of $T1 \cup T2$?
 - What will be the minimum possible cardinality of $T1 \cap T2$?
31. Consider the relations, City (city_name, state) and Hotel (name, address, city_name). Answer the following queries in relational algebra
- Find the names and address of hotels in Kochi.
 - List the details of cities in Kerala state.
 - List the names of the hotels in Thrissur.
 - Find the names of different hotels.
 - Find the names of hotels in Kozhikode or Munnar.
32. Using the instance of the EMPLOYEE relation shown in question 23, write the result of the following relational algebra expressions.
- $\sigma_{\text{Department}=\text{"Sales"}}(\text{EMPLOYEE})$.
 - $\sigma_{\text{salary} > 20000 \wedge \text{Department}=\text{"Sales"}}(\text{EMPLOYEE})$.
 - $\sigma_{\text{salary} > 20000 \vee \text{Department}=\text{"Sales"}}(\text{EMPLOYEE})$.
 - $\pi_{\text{name}, \text{salary}}(\text{EMPLOYEE})$.
 - $\pi_{\text{name}, \text{salary}}(\sigma_{\text{Designation}=\text{"Manager"}}(\text{EMPLOYEE}))$.
 - $\pi_{\text{name}, \text{Department}}(\sigma_{\text{Designation}=\text{"Clerk"} \wedge \text{salary} > 20000}(\text{EMPLOYEE}))$.
33. Consider the instance of the BORROWER and DEPOSITOR relations shown in following figure which stores the details of customers in a Bank. Answer the following queries in relational algebra.
- Display the details of the customers who are either a depositor or a borrower.
 - Display the name of customers who are both a depositor and a borrower.

- c. Display the details of the customers who are depositors but not borrowers.
- d. Display the name and amount of customer who is a borrower but not depositor.

BORROWER		
Acc_No	Name	Amount
AC123	Albin	50000
AC103	Rasheeda	25000
AC106	Vishnu	25000
AC108	Aiswarya	30000

DEPOSITOR		
Acc_No	Name	Amount
AC123	Albin	500
AC105	Shabana	25000
AC116	Vishnu	125000
AC108	Aiswarya	3000

34. Consider the instance of the CUSTOMER and BRANCH relations shown in the following table. Write the Cartesian Product of the two relations.

CUSTOMER			
Acc_No	Name	Branch_ID	Amount
AC123	Albin	B1001	50000
AC103	Rasheeda	B1001	25000
AC106	Vishnu	B1001	25000
AC108	Aiswarya	B1077	30000

BRANCH	
Branch_ID	Name
B1001	Kochi
B1002	Guruvayur
B1077	Idukki



9

Structured Query Language

Significant Learning Outcomes

After the completion of this chapter, the learner

- recognises the importance and features of Structured Query Language.
- explains the components of SQL.
- distinguishes the features of DDL, DML and DCL commands.
- identifies the characteristics of MySQL.
- lists different data types and their features.
- explains the effect of different constraints in SQL.
- performs operations using DDL commands like CREATE, ALTER, DROP.
- uses DML commands like SELECT, INSERT, UPDATE, DELETE for data manipulation.
- identifies various clauses associated with SQL commands and their purpose.
- uses operators for setting different conditions.
- lists different aggregate functions and explains their usage.
- constructs nested queries for information retrieval.

In the last chapter, we discussed the Relational Database Management System (RDBMS). We know that relational database is a set of related data stored in tables called relations. We also have a basic idea about relational algebra, which deals with various operations performed on relations. Now, we need more clarity on these operations which include creating a table, inserting data into a table, manipulating the data stored in a table and deleting data from a table, modifying the structure of a table, removing a table, etc. on a relational database. This chapter introduces a language called Structured Query Language (SQL) for these operations. Most of the relational database management systems like MySQL, Oracle, Sybase, Informix, Postgres, SQL Server and MS Access use SQL as standard database language. We use one of the most popular open source RDBMS, like MySQL, to implement Structured Query Language.

9.1 Structured Query Language

Structured Query Language (SQL) is a language designed for managing data in relational database management system (RDBMS). SQL provides an easy and efficient

way to interact with relational databases. There are numerous versions of SQL. The original version was developed in the 1970's by Donald D. Chamberlin and Raymond F. Boyce at IBM's San Jose Research Laboratory (now the Almaden Research Centre). This language was originally called Structured English Query Language (Sequel) and later its name was changed to SQL. In 1986, American National Standard Institute (ANSI) published an SQL standard.

As we know a relational database system is a structured collection of tables (relations) and the data is stored in these tables. Tables are uniquely identified by their names and are comprised of columns and rows. A column (field) in a table represents a particular type of information. In a table, each row represents a collection of related data. We know that rows in a table are known as tuples (or records) and columns are known as attributes.



Let us do

Examine the following table, named "Student" (refer to Table 9.1) and answer the questions given below for recollecting the basic terminologies related to database.

Adm_no	Name	Gender	Date_Birth	Income	Course
1001	Alok	M	2/10/1998	24000	Science
1002	Nike	M	26/11/1998	35000	Science
1003	Bharath	M	1/1/1999	45000	Commerce
1004	Virat	M	5/12/1998	22000	Science
1005	Meera	F	15/8/1998		Science
1006	Divakar	M	21/2/1998		Humanities

Table 9.1: Student table

- i. The cardinality of the table is _____.
- ii. The degree of the table is _____.
- iii. List out the different tuples in the table.
- iv. List out the different attributes in the table.
- v. What are the values in the domain of the attribute 'Course'?

SQL is a powerful tool for implementing RDBMS. It provides facilities to create a table, insert data into a table, retrieve information from a table, modify data in the table, delete the existing data from a table, modify the structure of a table, remove a table from a database, etc.

9.1.1 Features of SQL

Structured Query Language is an ANSI/ISO standard language for writing database queries. A query is a request to a database. It can perform all the relational operations mentioned earlier. SQL is effective in framing queries because of the following features:

- SQL is a relational database language, not a programming language like C, C++.
- It is simple, flexible and powerful.
- It provides commands to create and modify tables, insert data into tables, manipulate data in the tables etc.
- It gives guidelines to major popular RDBMS like Oracle, SQL Server, MySQL, MS Access, Sybase, Informix and Postgres to perform database operations.
- SQL is a non-procedural language since it describes what data to retrieve, delete, or insert, rather than how to perform the operation.
- As part of ensuring data security, SQL provides facility to add or remove different types of access permissions to users on databases or tables.
- It provides the concept of views (This concept will be discussed later in this chapter).

9.1.2 Components of SQL

SQL has three components, namely Data Definition Language (DDL), Data Manipulation language (DML) and Data Control Language (DCL). Let us discuss these components and their roles in developing RDBMS.

Data Definition Language

Consider Table 9.1 (Student table). How can we create such a table? Is it possible to add a new column to this table? How can we remove a table from the database? The Data Definition Language (DDL) will give solutions to all these questions.

DDL is a component of SQL that provides commands to deal with the schema (structure) definition of the RDBMS. The **DDL commands** are used to create, modify and remove the database objects such as tables, views and keys. The common DDL commands are CREATE, ALTER, and DROP.

Data Manipulation Language

In Table 9.1, we can see several tuples (or rows or records). How are these tuples inserted into the table? Suppose the monthly family income of a particular student is to be modified. Is it possible? How can we delete the record of a student from

the table? The Data Manipulation Language (DML) provides commands for these types of manipulations.

DML is a component of SQL that enhances efficient user interaction with the database system by providing a set of commands. **DML** permits users to insert data into tables, retrieve existing data, delete data from tables and modify the stored data. The common DML commands are SELECT, INSERT, UPDATE and DELETE.

Data Control Language

Data Control Language (DCL) is used to control access to the database, which is very essential to a database system with respect to security concerns. **DCL** includes commands that control a database, including administering privileges and committing data. The commands GRANT and REVOKE are used as a part of DCL.

GRANT : Allows access privileges to the users to the database.

REVOKE : Withdraws user's access privileges given by using GRANT command.

Know your progress

1. SQL stands for _____.
2. Which are the three components of SQL?
3. SQL can be used to:
 - a. create database structures only.
 - b. query database data only.
 - c. modify database data only.
 - d. All of these can be done by SQL.
4. SQL is:
 - a. a programming language.
 - b. an operating system.
 - c. a data sublanguage.
 - d. a DBMS.
5. Which of the following is not an RDBMS package?
 - a. ORACLE
 - b. SQL SERVER
 - c. MySQL
 - d. HTML

9.2 Working on MySQL

The American National Standards Institute (ANSI) in 1986, and the International Organization for Standardization (ISO) in 1987, standardised SQL. Since 1986, the SQL standard has been evolving to include a larger set of features. The standard has been revised several times and several versions exist. SQL:2011 is the seventh revision of the ISO and ANSI standard for the SQL database query language. It was formally adopted in December 2011. Despite the existence of such standards, the different database software packages provide their own versions of the standard

ANSI SQL. Therefore, most SQL codes are not completely portable among different database software without adjustments. In this chapter, SQL will be discussed using open source database software MySQL.

MySQL is a free, fast, easy-to-use RDBMS, used for many applications. It is developed, marketed, and supported by MySQL AB, which is a Swedish company. MySQL is becoming very popular for many reasons:

- MySQL is released under an open-source license. So it is customizable.
- It provides high security to the database.
- It is portable as it works on many operating systems and with many languages including PHP, PERL, C, C++, JAVA, etc.
- MySQL works rapidly and effectively even with large volume of data.
- It is highly compatible with PHP, one of the popular languages for web development.



MySQL was developed by Michael "Monty" Widenius and David Axmark in 1995. It was originally owned by a Swedish company called MySQL AB, and was bought over by Sun Microsystems in 2008. Sun Microsystems was acquired by Oracle in 2010.

MySQL is often deployed in a Linux-Apache-MySQL-PHP (LAMP), Windows-Apache-MySQL-PHP (WAMP), or Mac-Apache-MySQL-PHP (MAMP) environment. All components in LAMP are free and open-source, inclusive of the Operating System. The official site for MySQL is www.mysql.com. The reference for MySQL is the "MySQL Reference Manual", available at <http://dev.mysql.com/doc>

9.2.1 Opening MySQL

We can work on MySQL by giving commands at the `mysql>` prompt. In Ubuntu Linux, we have to open the Terminal window using the following command sequence to get this prompt:

Applications → Accessories → Terminal

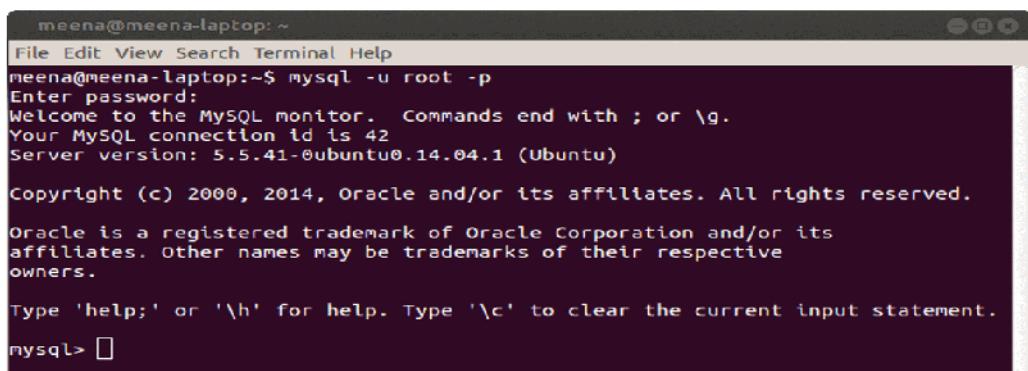
In the Terminal window we give the following command to start MySQL:

```
mysql -u root -p
```



MySQL in Windows OS can be opened by proceeding as follows:

Start → Programs → MySQL → MySQL Server (version number) → MySQL command line client



```
meena@meena-laptop: ~
File Edit View Search Terminal Help
meena@meena-laptop:~$ mysql -u root -p
Enter password:
Welcome to the MySQL monitor.  Commands end with ; or \g.
Your MySQL connection id is 42
Server version: 5.5.41-0ubuntu0.14.04.1 (Ubuntu)

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affiliates. Other names may be trademarks of their respective
owners.

Type 'help;' or '\h' for help. Type '\c' to clear the current input statement.

mysql> □
```

Fig 9.1: MySQL prompt at Ubuntu Linux Terminal window

When we open MySQL, it may ask for the password for verification. (Here we should use the same password that we entered during the installation process). After the password verification, we will get the prompt of MySQL as shown in Figure 9.1.



SQL is not case sensitive. That is, commands can be given in the upper or the lower case or even in a mix. But hereafter, we will use some styles to distinguish SQL commands and keywords from other texts. Commands and keywords will be specified in the upper case letters, whereas user-defined words such as table name, column name etc. will be in the lower case. Commands and outputs (or responses) can be stored in a text file after using the command `tee`. For example, `tee E:\outputs.txt` will create a file `outputs.txt` in E: drive to store whatever appears in the screen after the execution of this command. In this chapter the outputs stored in this file will be presented as figures.

The prompt gives us the message that MySQL is ready to accept any query from the user. Now we can input our queries at this prompt.

To exit from MySQL, give the command `QUIT` or `EXIT` at the prompt as:

```
mysql> EXIT;
```

9.2.2 Creating a database

We need to create a database before we work on the data. The database is the container in which we store the tables. To create a database in MySQL, we use the `CREATE DATABASE` command. The syntax is as follows:

```
CREATE DATABASE <database_name>;
```

While creating a database, the following points are to be remembered:

- The `<database_name>` in the syntax indicates the name of the database that we want to create. It is recommended that the database name should be as meaningful and descriptive as possible.

- The <database_name> should be unique. We cannot have two databases with the same name in a MySQL database server.

Let us start our database operations with the creation of a new database called "*school*". Figure 9.2 shows the screen shot after the execution of the command. We can see the MySQL command prompt and the command in the first line. The second line is the message returned by MySQL as a response to the command being executed. From the message, it is clear that a new database with the name *school* has been created successfully. (*Note that here onwards we will avoid such screen shots as figures, instead the command required for the specified operation will be presented in a separate font.*)

```
meena@meena-laptop: ~
File Edit View Search Terminal Help
mysql> CREATE DATABASE school;
Query OK, 1 row affected (0.00 sec)
mysql>
```

Fig. 9.2: MySQL window after the execution of a command

9.2.3 Opening database

To perform operations on a database, we have to open it explicitly. When we open a database, it becomes the active database in the MySQL server. MySQL gives a command **USE** to open a database. The syntax is:

```
USE <database_name>;
```

Let us open the data base *school* using the command as follows:

```
USE school;
```

The response of this command after the execution is given below:

Database changed

Now the database named *school* is the active database in our system. That means, the different DDL, DML and DCL commands we execute hereafter will be related to the database *school*. We can check the existence of a database. The SHOW DATABASES command is used to check whether a database exists or not. It will list the entire databases in our system. The syntax is:

```
SHOW DATABASES;
```

The output of this command is shown in Figure 9.3.

9.2.4 Data types in SQL

Data type defines the type of value that may be entered in the column of a table. Data types ensure

mysql> SHOW DATABASES;
+-----+
Database
+-----+
information_schema
mysql
school
test
+-----+
4 rows in set (0.00 sec)

Fig. 9.3: Output of SHOW DATABASES command

the correctness of the data, if we use them in a meaningful way. Care should be taken to assign correct data types for columns during the designing of the database. For example, if the numeric value 2 is designated as a text data type, such as a string, then it cannot be used in a mathematical operation; whereas the same number stored in an integer column can be used mathematically. So, let us understand the concept of SQL data types like, the type of data they represent, range of values supported by each of them, etc. Data types differ in different versions of SQL. Here, we look at the different data types available in MySQL.

MySQL data types are classified into three. They are numeric data type, string (text) data type, and date and time data type. All numerical values like 7, 100.234, -456, 0, etc. can be represented by any of the numeric data types. The data "Aleena" (name of a student), "Kerala" (name of a state), 'T' (specification of a gender), etc. are string type by nature. Data like '01-01-2020', '23:34:3' can be represented by Date and Time data types.

a. Numeric Data types

Numeric data type values can be used like any normal number. They can be added, subtracted, multiplied and divided. The most commonly used numeric data types in MySQL are **INT** or **INTEGER** and **DEC** or **DECIMAL**.

(i) **INT** or **INTEGER**

As we know, integers are whole numbers without a fractional part. They can be positive, zero or negative. An integer value can be represented in MySQL by **INT** or **INTEGER** data type. The data items like 69, 0, -112 belong to **INT** data type.

(ii) **DEC** or **DECIMAL**

Numbers with fractional parts can be represented by **DEC** or **DECIMAL** data type. The standard form of this type is **DECIMAL(size,D)** or **DEC(size,D)**. The parameter **size** indicates the total number of digits the value contains including decimal part. The parameter **D** represents the number of digits after the decimal point. For example, the type specification **DEC(5, 2)** or **DECIMAL(5, 2)** denotes that 5 is the precision and 2 is the scale. The column with this specification is able to store any value having a maximum of five digits, out of which two are after the decimal point. That is, the range of values will be from -999.99 to 999.99.

Table 9.2 shows an overview of numeric data types in MySQL. Remember that the values are version dependent.

Data types	Usage	Signed	Unsigned	Storage in Bytes
TINY INT	Very small integer values	-128 to 127	0 to 255	1
SMALL INT	A small integer	-32768 to 32767	0 to 65535	2
MEDIUM INT	A medium-sized integer value	-8388608 to 8388607	0 to 16777215	3
INT	Normal sized integer value	2147483648 to 2147483647	0 to 4294967295	4
BIG INT	Large integer value	Value up to 19 digits	Value up to 264	8
FLOAT (M, D)	Floating point numbers	Decimal precision can go to 24 places		4
DOUBLE (M, D)	A double precision floating-point number	Decimal precision can go to 53 places		8
DECIMAL (M, D)	Store exact precision values	A Decimal type can store a Maximum of 65 Digits, with 30 digits after decimal point.		8

Table 9.2: Numeric data types of MySQL and their characteristics

b. String (Text) data types

String is a group of characters. The most commonly used string data types in MySQL are **CHARACTER** or **CHAR** and **VARCHAR**.

(i) **CHAR** or **CHARACTER**

Character includes letters, digits, special symbols etc. The CHAR is a fixed length character data type. The syntax of this data type is **CHAR (x)**, where x is the maximum number of characters that constitutes the data. The value of x can be between 0 and 255. CHAR is mainly used when the data in a column are of the same fixed length and small in size. For example, if we want to store data like 'M' for male and 'F' for female, in the column *Gender* of a table, it is better to declare that column as of type CHAR. It always uses the specified amount of space even though the data

need not require that much. If the number of characters in the data is less than the declared size of the column, the remaining character positions in the string will be filled with white spaces (spacebar character). But when we retrieve this value from the table, all trailing spaces are removed. Note that if the size of a column of type CHAR is 1, it is not necessary to mention the size, because the default size of CHAR type is 1.

(ii) **VARCHAR (size)**

VARCHAR represents variable length strings. It is similar to CHAR, but the space allocated for the data depends only on the actual size of the string, not on the declared size of the column. For example, if we want to store data in the column *Name* of a table, it is better to declare that column as of type VARCHAR, because the data in the column may contain different number of characters. The length of the string can vary from 0 to 65535 characters (MySQL, version dependent). The VARCHAR type saves memory space since VARCHAR type did not append spaces with the values when they are stored. The data like name of people, addresses etc. are examples of this data type.

C. Date and Time data types

MySQL has data types for storing dates and times. The data type used to store date type value is **DATE** and to store time value is **TIME**.

(i) **DATE**

The DATE data type is used to store dates. MySQL represents date values in YYYY-MM-DD format. The supported range is from 1000-01-01 to 9999-12-31. Dates are displayed in MySQL in one format, but we can use various date formats in our SQL statements. The YYYY-MM-DD is the standard format. But we can use any punctuation character between the date parts. For example, '2011-01-24', '2011/01/25', '20110126' are valid date combinations in MySQL. We can insert date type values into a column of DATE data type in any of the above formats. Although MySQL tries to interpret values in several formats, date parts must always be given in year-month-day order (for example, '98-09-04').

(ii) **TIME**

The TIME data type is used to specify a column to store time values in MySQL. It shows values in the standard HH:MM:SS format. The TIME data type can be used to store a specific point in time (like 10 hours 05 minutes 25 seconds) as well as an interval of time between two points in time (like the time between now and the weekend) that may sometimes be larger than 23 hours. When manually entering a time into MySQL, it is highly recommended that you use the exact format HH:MM:SS.

**Let us do**

Now look at Table 9.3 and fill the **Data type** column with suitable MySQL data type for the given data.

Value	Data type
325.678	
'A'	
'Computer'	
'2016-01-01'	
450	
22:32:45	
456787	

Table 9.3: Data type of values

Know your progress

1. SQL stands for _____.
2. _____ command is used to make a database active.
3. How can we see the names of databases in the system?
4. What is the difference between CHAR and VARCHAR data types?
5. Which is the format for storing date type data in MySQL?
6. Can we store the number 234 in a column declared with CHAR(5) data type?

9.3 SQL commands

SQL provides commands to perform different operations on database. As we mentioned earlier, the commands are classified as DDL commands, DML commands and DCL commands. Here, we will discuss the most commonly used DDL commands and DML commands. DDL commands are used to perform operations associated with the structure of database. The operations include creation of tables, modification in the structure of tables and removal of tables. DML commands are associated with the operations on the content of tables. These operations include insertion of records, retrieval of records, modification or updation of records and deletion of records.

These commands will be introduced in such a way that we can create a table for organizing data of a particular entity, retrieve required information and remove those we do not want to keep further.

9.4 Creating tables

Tables are the central and the most important objects in any relational database. The primary purpose of any database is to hold data that are stored in tables. Now

let us again consider the table *student* given in Table 9.1. How can we create a table with a set of columns? The DDL command **CREATE TABLE** is used to define a table by specifying the name of the table and giving the column definitions consisting of name of the column, data type and size, and constraints if any, etc. Remember that each table must have at least one column. The syntax of **CREATE TABLE** command is:

```
CREATE TABLE <table_name>
  (<column_name> <data_type> [<constraint>]
   [, <column_name> <data_type> [<constraint>],]
   .....
   .....
   );

```

Here, the **<table_name>** represents the name of the table that we want to create; **<column_name>** represents the name of a column in the table; **<data_type>** represents the type of data in a column of the table; and **<constraint>** specifies the rules that we can set on the values of a column. All the columns are defined within a pair of parentheses, and are separated by commas. We can define all the columns even in a single line.

9.4.1 Rules for naming tables and columns

While naming the tables and columns, certain points are to be remembered and they are listed below.

- The name may contain letters (A - Z, a - z), digits (0 - 9), under score (_) and dollar (\$) symbol.
- The name must contain at least one character. (Names with only digits are invalid).
- The name must not contain white spaces, special symbols.
- The name must not be an SQL keyword.
- The name should not duplicate with the names of other tables in the same data base and with other columns in the same table.



In some MySQL versions, the table name can be a quoted identifier. The identifier quote character is the backtick ("`"). If we use table name as quoted, then we can include any special symbols in the name of the table.

Now, let us create a table *student* to store the details of a group of higher secondary students in a school. The fields of the table and their descriptions are given in Table 9.4.

Sl. No.	Attributes	Description
1	Admission number	Integer value
2	Name	String of 20 characters long
3	Gender	A single character
4	Date of birth	Date type
5	Course	String of 15 characters long
6	Family income	Integer value

Table 9.4: Attributes of student table

The SQL statement or query to create a table in MySQL to incorporate the details shown in Table 9.4 is given in Query 9.1.

Query 9.1

```
CREATE TABLE student
(adm_no INT,
name VARCHAR(20),
gender CHAR,
dob DATE,
course VARCHAR(15),
f_income INT);
```

Here, the CREATE TABLE statement creates a table named student with five columns adm_no, name, gender, dob, course and f_income. The columns adm_no can contain integer values, name can contain strings up to a maximum of 20 characters, gender can store a single character indicating whether a student is a boy or a girl, dob can store date of birth, course can contain the group in which he/she is studying and f_income can hold the monthly income of the family. The columns name and course will spare only the actual space required by the respective string data.

After creating a table, when we insert records in that table, some kind of restriction may need to be enforced in certain columns. Restrictions may be in the form of denying empty values in some columns and refusing duplicate values in some other columns. But it should be addressed during the table creation itself. MySQL provides some keywords called constraints, for this purpose.

9.4.2 Constraints

Constraints are the rules enforced on data that are entered into the column of a table. When we create a table, we can apply constraints on the values that can be entered into its fields. If this is specified in the column definition, SQL will not

accept any values that violate the criteria concerned. This ensures the accuracy and reliability of the data in the database. The constraints ensure database integrity and hence they are often called data base integrity constraints. Constraints could be column level or table level.

a. Column Constraints

Column constraints are applied only to individual columns. They are written immediately after the data type of the column. The following are column constraints:

i. NOT NULL

This constraint specifies that a column can never have NULL values. NULL is a keyword in SQL that represents an empty value. It is important to remember that NULL does not equate to a blank or a zero; it is something else entirely. Though a blank is equal to another blank and a zero is equal to another zero, a NULL is never equal to anything, not even another NULL. Two NULL values cannot be added, subtracted or compared.

ii. AUTO_INCREMENT

MySQL uses the AUTO_INCREMENT keyword to perform an auto-increment feature. If no value is specified for the column with AUTO_INCREMENT constraint, then MySQL will assign serial numbers automatically and insert the newly assigned value in the corresponding column of the new record. By default, the starting value for AUTO_INCREMENT is 1, and it will be incremented by 1 for each new record. This special behavior also occurs if we explicitly assign the value NULL to the column. The AUTO_INCREMENT feature makes it easy to assign a unique ID to each new row, because MySQL generates the values for us. The auto increment column must be defined as the primary key of the table. Only one AUTO_INCREMENT column per table is allowed.

iii. UNIQUE

It ensures that no two rows have the same value in the column specified with this constraint.

iv. PRIMARY KEY

This constraint declares a column as the primary key of the table. This constraint is similar to UNIQUE constraint except that it can be applied only to one column or a combination of columns. The primary keys cannot contain NULL values. In other words, it can be considered as a combination of UNIQUE and NOT NULL constraints. A PRIMARY KEY constraint is used to enforce a rule that a column should contain only unique, non-NULL data.

v. DEFAULT

Using this constraint, a default value can be set for a column, in case the user does not provide a value for that column of a record.

Let us apply some of these constraints in the student table and modify Query 9.1 as given in Query 9.2.

Query 9.2

```
CREATE TABLE student
(adm_no INT PRIMARY KEY AUTO_INCREMENT,
name VARCHAR(20) NOT NULL,
gender CHAR DEFAULT 'M',
dob DATE,
course VARCHAR(15)
f_income INT);
```

In Query 9.2, the constraints PRIMARY KEY and AUTO_INCREMENT are applied to the column adm_no. So, this column will not allow duplicate values during data entry. If we do not specify a value for this column, MySQL will generate a data automatically. The constraint NOT NULL applied to the column name does not allow to leave the column with a null value. That is, data is a must in this column. Similarly, if we do not give a value to the column gender, 'M' will be stored as the default value.

b. Table constraints

Table constraints are similar to column constraints; the main difference is that table constraints can be used not only on individual columns, but also on a group of columns. When a constraint is to be applied on a group of columns of a table, it is called table constraint. The table constraint appears at the end of the table definition. For example, Query 9.3 creates a table named **stock**. The constraint UNIQUE is applied to the combination of icode and iname.

Query 9.3

```
CREATE TABLE stock
(icode CHAR(2) PRIMARY KEY AUTO_INCREMENT,
iname VARCHAR(30) NOT NULL,
dt_purchase DATE,
rate DECIMAL(10,2),
qty INT,
UNIQUE (icode, iname));
```

In Query 9.3, the constraint UNIQUE is applied to the combination of values of columns icode and iname. It enforces a situation that no two rows can have the same values for the columns icode and iname when taken together.

9.4.3 Viewing the structure of a table

We have created two tables, *student* and *stock*. How do we know the structure of the table after its creation? The **DESCRIBE** command is used to display the structure definitions of a table. The syntax is:

```
DESCRIBE <table_name>;
```

OR

```
DESC <table_name>;
```

The structure of the table *student* can be viewed using the command:

```
DESC student;
```

Figure 9.4 shows the output of this command.

Field	Type	Null	Key	Default	Extra
adm_no	int(11)	NO	PRI	NULL	auto_increment
name	varchar(20)	NO		NULL	
gender	char(1)	YES		M	
dob	date	YES		NULL	
course	varchar(15)	YES		NULL	
f_income	int(11)	YES		NULL	

6 rows in set (0.02 sec)

Fig. 9.4: Structure of student table

Note that in Query 9.2, we did not mention the size for the columns *adm_no* and *f_income* while creating the table. But MySQL takes the default size 11 as the size of these two columns. The column *adm_no* is declared with PRIMARY KEY and AUTO_INCREMENT. So this column will not allow duplicate values and null values. If we do not specify a value for this column, a new value will be generated by adding 1 to the value of the respective column of the previous record. In the absence of a value for this column for the first record, MySQL gives 1 as the value. We can also see that a default value 'M' is set for the column *gender*. Figure 9.4 illustrates these aspects. There is a command **SHOW TABLES**, which shows the tables created in the current database as given in Figure 9.5.

Tables_in_school
student
1 row in set (0.00 sec)

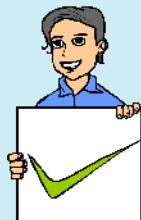
Fig. 9.5: Output of SHOW TABLES



Write the structure of the table *stock*, referring to Figure 9.4 and Query 9.3. Verify your answer in the lab with the command, DESC *stock*;

Let us do

Know your progress



1. Which of the following commands is used to display the structure of a table?
a. LIST b. SHOW c. DESCRIBE d. STRUCT
2. Write the syntax of CREATE TABLE command.
3. Name the different column constraints.
4. What is the difference between primary key constraint and unique constraint?
5. What are the features of AUTO_INCREMENT constraint?
6. Write down the rules for naming a table.
7. How many columns in a table can be specified as primary key of the table?

9.5 Inserting data into tables

We have created a database and its tables. Now we need to put some records into these tables. We have the details of six students in Table 9.1. Let us discuss how these records can be inserted into the table.

The DML command **INSERT INTO** is used to insert tuples into tables. The syntax is:

```
INSERT INTO <table_name> [<column1>,<column2>,...,<columnN>]  
VALUES (<value1>,<value2>,...,<valueN>);
```

Here **<table_name>** is the name of the table into which the tuples are to be inserted; **<column1>,<column2>,...,<columnN>** indicate the name of columns in the table into which values are to be inserted; **<value1>,<value2>,...,<valueN>** are the values that are inserted into the columns specified in the **<column_list>**.

For example, let us insert a new record into the table *student* with data 1001, 'Alok', 'M', 1998/10/2, 'Science', 24000 into the columns adm_no, name, gender, dob, course and f_income, respectively. Query 9.4 makes it possible.

Query 9.4

```
INSERT INTO student  
VALUES (1001,'Alok','M','1998/10/2', 'Science',  
24000);
```

The response of the system will be:

```
Query OK, 1 row affected (0.05 sec).
```

The `INSERT` statement adds a new row to the table `student` giving a value for every column in the table. While inserting a row, if we provide values for all the columns of the table, we need not specify the name of column(s) in the query. But we need to make sure that the order of the values is in accordance with the order of the columns in the table. Now let us insert another row with some modifications as shown in Query 9.5.

Query 9.5

```
INSERT INTO student (name, dob, course, f_income)
VALUES ('Nike', '1998/11/26', 'Science', 35000);
```

The response for this statement will be:

Query OK, 1 row affected (0.01 sec)

In Query 9.5, admission number and gender are not provided. Being a record after the one with admission number 1001, the admission number of this student will be 1002. The gender will be set with the default value 'M'.

While inserting data into tables, the following points are to be taken care of:

- While adding a new row, we should ensure the data type of the value and the column matches.
- We follow the integrity constraints, if any, defined for the table.
- CHAR or VARCHAR type data should be enclosed in single quotes or double quotes.
- Column values for DATE type columns are to be provided within single quotes. The string will internally be converted into DATE data type.
- Null values are specified as `NULL` (or `null`) without quotes.
- If no data is available for all columns, then the column list must be included, following the table name.

MySQL allows inserting several rows into a table with a single `INSERT` command by specifying multiple value lists. The general format is as follows:

```
INSERT INTO <table-name> VALUES(...), (...), ... ;
```

Let us insert two more records given in Table 9.1 using Query 9.6.

Query 9.6

```
INSERT INTO student (name, dob, course, f_income)
VALUES ('Bharath', '1999/01/01', 'Commerce', 45000),
       ('Virat', '1998/12/05', 'Science', 22000);
```

The response of the system will be:

Query OK, 2 rows affected (0.02 sec)
Records: 2 Duplicates: 0 Warnings: 0

We can observe that the two records are given within separate pairs of parentheses. The response indicates that the two records are inserted successfully.

Suppose we do not have the monthly income data of a student. How can we insert the record? Query 9.7 illustrates the solution.

Query 9.7

```
INSERT INTO student(name, dob, gender, course)
VALUES ('Meera', '1998/08/15', 'F', 'Science');
```

As a response to this query, the value for `adm_no` will be generated by the system, but the value for `f_income` column will be kept as `NULL`. The order of columns is also changed in this query. The absence of values in a row can be managed in another way also as shown in Query 9.8.

Query 9.8

```
INSERT INTO student(name, dob, gender, course,
f_income)
VALUES ('Divakar', '1998/02/21', 'Science', NULL);
```

Note that, in the `VALUES` clause, `NULL` is given for `f_income`.

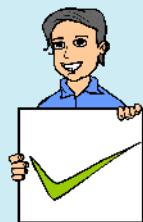


Let us insert some more records in table `student`. Write queries to store the details of students shown in Table 9.5.

Let us do

adm_no	name	gender	dob	course	f_income
1025	Kaushi	M	1998/10/2	Commerce	17000
1026	Niveditha	F	1999/03/04	Humanities	52000
1027	Sreekumar	M	1998/06/06	Science	15000
1057	Chaithanya	F	1999/06/03	Science	

Table 9.5: More records for Student table

Know your progress

- Which of the following is used to add a row into a table?
a. ADD b. CREATE c. INSERT d. MAKE
- Which statement is used to insert new data into a table?
a. ADD RECORD b. INSERT RECORD
c. INSERT INTO d. INSERT ROW
- Write the essential keywords used along with `INSERT` command.



Write SQL statements to insert some records in the table stock created using Query 9.3. While giving values to the columns, utilise the facility of AUTO_INCREMENT and UNIQUE constraints.

9.6 Retrieving information from tables

We have created a database school and a table student, and then inserted ten records into it. Now let us learn how information is retrieved from the data stored in tables. It is a kind of data manipulation operation and SQL provides the command **SELECT** for this purpose. It is used to retrieve information from specified columns in a table. The SELECT command has several forms of its own. The simplest form of SELECT command is:

```
SELECT <column_name>[,<column_name>,<column_name>, ...]
FROM <table_name>;
```

Here <column_name> indicates the column from which data is retrieved and <table_name> denotes the name of the table from which the information is retrieved. The name of the table is given with the keyword **FROM**, which is an essential clause with SELECT command. The SELECT command will display the data in columns, in the order in which they appear along with the SELECT command.

Now let us illustrate the execution of SELECT command through various queries. On executing Query 9.9 we get the name and course of students in the table *student* as shown in Figure 9.6.

Query 9.9

```
SELECT name, course
FROM student;
```

If we want to display the entire column values of a table, we need not give a complete list of columns of the relation. Instead, an asterisk (*) symbol can be used to substitute the complete list of columns as shown in Query 9.10. The output is shown in Figure 9.7.

name	course
Alok	Science
Nike	Science
Bharath	Commerce
Virat	Science
Meera	Science
Divakar	Science
Kaushi	Commerce
Niveditha	Humanities
Sreekumar	Science
Chaithanya	Science

10 rows in set (0.00 sec)

Fig. 9.6: Output of Query 9.9

Query 9.10

```
SELECT * FROM student;
```

adm_no	name	gender	dob	course	f_income
1001	Alok	M	1998-10-02	Science	24000
1002	Nike	M	1998-11-26	Science	35000
1003	Bharath	M	1999-01-01	Commerce	45000
1004	Virat	M	1998-12-05	Science	22000
1005	Meera	F	1998-08-15	Science	NULL
1006	Divakar	M	1998-02-21	Science	NULL
1025	Kaushi	M	1998-10-02	Commerce	17000
1026	Niveditha	F	1999-03-04	Humanities	52000
1027	Sreekumar	M	1998-06-06	Science	15000
1057	Chaithanya	F	1999-06-03	Science	NULL

10 rows in set (0.00 sec)

Fig. 9.7: Entire content of student table

We can see NULL values in column f_income of some rows in Figure 9.7. It is due to the missing of values in the insertion of those rows (refer Queries 9.7, 9.8 and Table 9.1, and 9.5).

9.6.1 Eliminating duplicate values in columns using DISTINCT

Suppose we want to know the names of different courses in the table *student*. If we construct a query **SELECT course FROM student**; it will display the column course with all the ten values as shown in Figure 9.7. Data will be selected from all rows of the relation to display, even if the data appearing in the result get duplicated. This duplication can be eliminated using the keyword **DISTINCT** as given in Query 9.11. Observe the output given in Figure 9.8.

Query 9.11 `SELECT DISTINCT course
FROM student;`

In the output, there are no duplicate values. If the column used with DISTINCT keyword contains more than one NULL value, only one will be shown in the result.

If we give the keyword **ALL** in the place of DISTINCT, then the result will contain all the duplicate values in the column. That is, the output will be the same as that in the case when we neither specify DISTINCT nor ALL.

course
Science
Commerce
Humanities

3 rows in set (0.25 sec)

Fig. 9.8: Use of DISTINCT

9.6.2 Selecting specific rows using WHERE clause

In certain situations, we need to display only a subset of a table. For example, we may require the details of female students only, or the details of students whose family monthly income is below Rs. 25000/- . In these cases, there is a selection in

the retrieval of records. Obviously the selection is based on some condition(s). SQL enables us to impose some selection criteria for the retrieval of records with **WHERE** clause of SELECT command. The syntax of SELECT command with WHERE clause is:

```
SELECT <column_name>[,<column_name>,<column_name>, ...]
FROM <table_name>
WHERE <condition>;
```

When a WHERE clause is present, the SELECT command goes through the entire table one row at a time and examines whether the row satisfies the condition(s) or not. If a row satisfies the condition, that row is displayed in the output. The conditions are expressed with the help of relational operators and logical operators. MySQL provides a variety of such operators and they are listed in Table 9.6.

	Operator	Meaning/Result
Relational Operators	=	Equal to
	<> or !=	Not equal to
	>	Greater than
	<	Less than
	>=	Greater than or equal to
	<=	Less than or equal to
Logical operators	NOT	True when condition is false
	AND	True if both the conditions are true
	OR	True if either of the conditions is true

Table 9.6: Operators used for setting conditions

Let us write an SQL statement to display the details of female students in the table. Query 9.12 is the required statement which contains a WHERE clause and = operator for setting the condition and Figure 9.9 shows the output.

Query 9.12

```
SELECT * FROM student
WHERE gender='F';
```

adm_no	name	gender	dob	course	f_income
1005	Meera	F	1998-08-15	Science	NULL
1026	Niveditha	F	1999-03-04	Humanities	52000
1057	Chaithanya	F	1999-06-03	Science	NULL

3 rows in set (0.06 sec)

Fig. 9.9: List of female students - the output of Query 9.12

Suppose we want to see the name, course and monthly family income of only the Science group students whose income is below Rs. 25000. Here we have to constitute two conditions - one for checking the income and the other for checking the course. When these two conditions are matched while going through the records in the table, the values of their name, course and f_income columns will be retrieved for display. Query 9.13 is the required query and Figure 9.10 shows the output. Note that **AND** operator is used to combine the two conditions.

Query 9.13

```
SELECT name, course, f_income FROM student
WHERE course='Science' AND f_income<25000;
```

Write a query to display the name, course and monthly income of students studying in courses other than *Science* group (i.e., the students of *Commerce* and *Humanities* groups).

While writing the above query, you might have used **OR** operator for setting the condition. The same information can be obtained by the use of **NOT** operator. Query 9.14 illustrates this and Figure 9.11 shows the corresponding output.

Query 9.14

```
SELECT name, course, f_income FROM student
WHERE NOT course='Science';
```

Identify some requirements with respect to the table **stock** which can be attained by setting different conditions, and construct queries using appropriate operators.

SQL has a set of special operators for setting conditions. These include

BETWEEN . . . AND, **IN**, **LIKE** and **IS**. Let us discuss how these operators help us to constitute conditions.

a. Condition based on a range of values

A range of values can be given as condition. The SQL operator **BETWEEN . . . AND** is used to specify the range. Suppose we need a list of students whose monthly income falls in the range of Rs. 25000/- to Rs. 45000/-. We know that this can be obtained by the statement given in Query 9.15. Figure 9.12 shows the output.

Query 9.15

```
SELECT name, f_income FROM student
WHERE f_income>=25000 AND f_income<=45000;
```

name	course	f_income
Alok	Science	24000
Virat	Science	22000
Sreekumar	Science	15000

3 rows in set (0.00 sec)

Fig. 9.10: Use of *AND* operator

name	course	f_income
Bharath	Commerce	45000
Kaushi	Commerce	17000
Niveditha	Humanities	52000

3 rows in set (0.00 sec)

Fig. 9.11: Use of *NOT* operator

The same output can be obtained by using the statement given in Query 9.16. In this statement the operator BETWEEN...AND is used to construct the condition. The output includes both the lower and upper values given in the range.

Query 9.16

```
SELECT name, f_income FROM student
WHERE f_income BETWEEN 25000 AND 45000;
```

From Query 9.16 and Figure 9.12, we can conclude that the BETWEEN...AND operator allows specifying a range of values which belong to either numeric or date and time type data.

name	f_income
Nike	35000
Bharath	45000

2 rows in set (0.00 sec)

Fig. 9.12: Use of BETWEEN...AND operator

b. Conditions based on a list of values

While setting conditions for the retrieval of records, a list of values can be provided. The values may be of any data type, but it should match with those of the column used in the condition. In such a case, the operator IN is used with the list. Suppose we want to retrieve the details of students in *Commerce* and *Humanities* groups. The statement in Query 9.17 can generate the details as shown in Figure 9.13.

Query 9.17

```
SELECT * FROM student
WHERE course='Commerce' OR course='Humanities';

+-----+-----+-----+-----+-----+
| adm_no | name      | gender | dob       | course    | f_income |
+-----+-----+-----+-----+-----+
| 1003  | Bharath   | M      | 1999-01-01 | Commerce  | 45000   |
| 1025  | Kaushi    | M      | 1998-10-02 | Commerce  | 17000   |
| 1026  | Niveditha | F      | 1999-03-04 | Humanities | 52000   |
+-----+-----+-----+-----+-----+
3 rows in set (0.00 sec)
```

Fig. 9.13: Output of Query 9.17

The same output can be obtained by using IN operator in the condition as shown in Query 9.18.

Query 9.18

```
SELECT * FROM student
WHERE course IN('Commerce', 'Humanities');
```

As we see in Query 9.18, the IN operator checks whether the value in the specified column (here it is course) of a record matches any of the values in the given list. When matches are found while going through the records, they will be displayed. Since there are only three courses in the table, the result shown in Figure 9.13 can also be obtained using Query 9.19.

Query 9.19

```
SELECT * FROM student
WHERE course NOT IN('Science');
```

c. Conditions based on pattern matching

There may be the need of retrieving data based on some pattern matching. That is, string data having some similarities in characters may be the criterion for the retrieval of records. SQL provides a pattern matching operator **LIKE** for this purpose. Patterns are specified using two special wildcard characters % and _ (underscore), where % (percentage) matches a substring of characters and _ (underscore) matches a single character. Patterns are case sensitive; i.e.; uppercase characters do not match lower case characters. Consider the following examples:

- "Ab%" matches any string beginning with "Ab".
- "%cat%" matches any string containing "cat" as substring. For example, "education", "indication", "catering" etc.
- "_____" matches any string of exactly four characters without any space in between them.
- "___%" matches any string of at least 3 characters.

Query 9.20 illustrates the use of **LIKE** operator. It gives a list of names in the table that end with the substring 'ar'. Figure 9.14 shows the output of this query.

Query 9.20

```
SELECT name FROM student
WHERE name LIKE '%ar';
```

The following query will display only 'Divakar', since there are two _ (underscore) characters for pattern matching.

```
SELECT name FROM student
WHERE name LIKE 'Div__ar';
```

name
Divakar
Sreekumar

2 rows in set (0.00 sec)

Fig. 9.14: Use of pattern matching

d. Conditions based on NULL value search

We have seen that there may be NULL values in some fields of a record. We can retrieve such records with the help of **IS** operator. The condition will be true when the specified column contains a NULL value in the records. In the *student* table, the *f_income* column contains NULL value in three records (refer to Figure 9.7). Query 9.21 retrieves these records and Figure 9.15 shows the output.

name	course
Meera	Science
Divakar	Science
Chaithanya	Science
3 rows in set (0.00 sec)	

Fig. 9.15: NULL value checking

Query 9.21

```
SELECT name, course FROM student
WHERE f_income IS NULL;
```

On the other hand, if we want to retrieve the records containing non-null values in the `f_income` column, the following statement can fulfill the task:

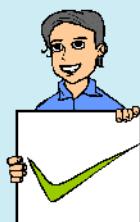
```
SELECT name, course FROM student
WHERE f_income IS NOT NULL;
```



Let us do

Identify some requirements with respect to the table `stock` which need the use of the special SQL operators we discussed, and construct queries to solve the problems.

Know your progress



1. Name the keyword used with `SELECT` command to avoid duplication in the values of a column.
2. Which is the essential clause for `SELECT` query?
3. Which of the following operators is used to check for `NULL` value in a column?
 - a. `IN`
 - b. `LIKE`
 - c. `IS`
 - d. `NOT`
4. The operator used for checking pattern matching is _____.
5. What is wrong with the following statement?
`SELECT * FROM emp WHERE grade = NULL;`
6. The command that extracts records from a table is _____.

9.6.3 Sorting results using ORDER BY clause

As we can see in the results of the `SELECT` queries discussed so far, the records are always obtained in the order in which they appear in the table. Is it possible to display them in a specific order - ascending or descending, of some column values? Yes. The result of a query can be sorted in the ascending or descending order by making use of `ORDER BY` clause. The order is to be specified by using the keyword `ASC` (for ascending) or `DESC` (for descending) along with the column name that is used with `ORDER BY` clause. By default, the display will be in the ascending order. Remember that only the results that appear on the screen are sorted. The order of records in the table will be kept unaltered.

Query 9.22 will display the details of students in the alphabetical order of their names. Figure 9.16 shows the output.

Query 9.22

```
SELECT * FROM student ORDER BY name;
```

adm_no	name	gender	dob	course	f_income
1001	Alok	M	1998-10-02	Science	24000
1003	Bharath	M	1999-01-01	Commerce	45000
1057	Chaithanya	F	1999-06-03	Science	NULL
1006	Divakar	M	1998-02-21	Science	NULL
1025	Kaushi	M	1998-10-02	Commerce	17000
1005	Meera	F	1998-08-15	Science	NULL
1002	Nike	M	1998-11-26	Science	35000
1026	Niveditha	F	1999-03-04	Humanities	52000
1027	Sreekumar	M	1998-06-06	Science	15000
1004	virat	M	1998-12-05	Science	22000

10 rows in set (0.00 sec)

Fig. 9.16: Details of students according to the alphabetical order of their names

Suppose we want to see the details according to their monthly family income. If we have to obtain the result from the highest income to the lowest, Query 9.23 can serve the purpose. Figure 9.17 shows the output.

Query 9.23

```
SELECT * FROM student
ORDER BY f_income DESC;
```

adm_no	name	gender	dob	course	f_income
1026	Niveditha	F	1999-03-04	Humanities	52000
1003	Bharath	M	1999-01-01	Commerce	45000
1002	Nike	M	1998-11-26	Science	35000
1001	Alok	M	1998-10-02	Science	24000
1004	Virat	M	1998-12-05	Science	22000
1025	Kaushi	M	1998-10-02	Commerce	17000
1027	Sreekumar	M	1998-06-06	Science	15000
1006	Divakar	M	1998-02-21	Science	NULL
1005	Meera	F	1998-08-15	Science	NULL
1057	Chaithanya	F	1999-06-03	Science	NULL

10 rows in set (0.00 sec)

Fig. 9.17: Age-based listing of students (younger to older)

As shown in Figure 9.17, if the column used with ORDER BY clause contains NULL values, they will be listed last.

Multiple sorting can be performed after selection with the help of ORDER BY clause. For example, if we need a course-based listing of students in the alphabetical order of their names, a statement as given in Query 9.24 can be used. Figure 9.18 shows its output.

Query 9.24

```
SELECT name, course FROM student
ORDER BY course, name;
```

Look at the output shown in Figure 9.18. First the values in the column course is arranged alphabetically and then the names are arranged under each course.

Earlier we have used the WHERE clause for condition based retrieval of records. The retrieved records can be displayed in a particular order using ORDER BY clause. Suppose we want to display the name and family income of Science group students according to the descending order of income. The two clauses can be combined to generate this output as shown in Query 9.25. The output is shown in Figure 9.19.

name	course
Bharath	Commerce
Kaushi	Commerce
Niveditha	Humanities
Alok	Science
Chaitanya	Science
Divakar	Science
Meera	Science
Nike	Science
Sreekumar	Science
Virat	Science

10 rows in set (0.00 sec)

Fig. 9.18: Multiple sorting

Query 9.25

```
SELECT name, course, f_income FROM student
WHERE course='Science'
ORDER BY f_income DESC;
```

As shown in Figure 9.19, the records with NULL values in the sorted column will appear at last as they appear in the table. Another important aspect is that, if an ORDER BY clause is used in a SELECT statement, it should appear only after the WHERE clause, if any. Because, the records should be selected first, then only they are given for reordering.

name	course	f_income
Nike	Science	35000
Alok	Science	24000
virat	Science	22000
Sreekumar	Science	15000
Meera	Science	NULL
Divakar	Science	NULL
Chaitanya	Science	NULL

7 rows in set (0.00 sec)

Fig. 9.19: Condition based selection and sorting

Know your progress

- What is the meaning of ORDER BY clause?
- Which keyword is used for sorting the data in descending order in MySQL?
 - DESC
 - ASC
 - SORT
 - MODIFY
- In which order are the records displayed in the absence of ORDER BY clause?
- In SQL, what is the default sort order of the ORDER BY clause?



**Let us do**

Identify some requirements with respect to the table **stock** which need the sorting of records based on different conditions, and construct queries to solve the problems.

9.6.4 Aggregate functions

MySQL provides a number of built-in functions that can be applied to all rows in a table or to a subset of the table specified by WHERE clause. These functions are called aggregate functions because they operate on aggregate of tuples (records). The result of an aggregate function is a single value.

Commonly used aggregate functions are given in Table 9.7.

Function	Return value
SUM()	Total of the values in the column specified as argument.
AVG()	Average of the values in the column specified as argument.
MIN()	Smallest value in the column specified as argument.
MAX()	Largest of the values in the column specified as argument.
COUNT()	Number of non NULL values in the column specified as argument.

Table 9.7: Some built-in functions of MySQL

Let us discuss these functions to generate useful information from the table. Query 9.26 gives the highest, lowest and average family monthly incomes of the students. Figure 9.20 shows the result.

Query 9.26 `SELECT MAX(f_income), MIN(f_income), AVG(f_income)
FROM student;`

While calculating these values, the NULL values in the argument column are not considered.

MAX(f_income)	MIN(f_income)	AVG(f_income)
52000	15000	30000.0000

1 row in set (0.03 sec)

Fig. 9.20: Use of aggregate functions

These functions can be applied to a subset of the table formed by some selection criterion as shown in Query 9.27. It gives the number of students in the *Science* group. Figure 9.21 shows the output.

Query 9.27 `SELECT COUNT(*), COUNT(f_income)
FROM student
WHERE course='Science';`

If we refer to Figure 9.19, we can see that the correct answer is 7. Then, why is there a mismatch between the two column values in Figure 9.21? The first column is **COUNT (*)** and it gives the number of records having *Science* as the value in column course.

Note that the * (asterisk) symbol stands for the collection of all the columns in the table. So, if there is at least one field in a record, that record will be taken into consideration for COUNT (*). But COUNT (f_income) in Query 9.27 counts only the non-NULL values in column f_income of the records which contains *Science* in column course. This is why the second column in Figure 9.21 contains only 4. Refer to Figure 9.17 and identify the rows that contains NULL in column f_income.

COUNT (*)	COUNT (f_income)
7	4

1 row in set (0.03 sec)

Fig. 9.21: Use of COUNT() function

9.6.5 Grouping of records using GROUP BY clause

Sometimes, we need to divide the tuples in a table into different groups based on the values in a column. The rows of a table can be grouped together based on a common value using the **GROUP BY** clause. The attribute (column) specified in the **GROUP BY** clause is used to form groups. Tuples with the same value in the attribute specified in the **GROUP BY** clause are placed together in one group. Thus different groups are formed based on distinct values in the column. So this process can be considered as categorisation of records.

Using Query 9.27, number of students in *Science* group is obtained. Suppose we want to know the number of students in each group along with average family monthly income. Query 9.28 can be used. The output is shown in Figure 9.22.

Query 9.28

```
SELECT course, COUNT(*), AVG(f_income)
FROM student
GROUP BY course;
```

Here different groups are formed under different values ('Commerce', 'Humanities' and 'Science') in column course and the functions COUNT (*) and AVG (f_income) are applied to each group.

course	COUNT(*)	AVG(f_income)
Commerce	2	31000.0000
Humanities	1	52000.0000
Science	7	24000.0000

3 rows in set (0.00 sec)

Fig. 9.22: Grouping of rows using GROUP BY clause

9.6.6 Applying conditions to form groups using HAVING clause

We have already learnt about the WHERE clause, which places conditions on individual rows. We can apply conditions to form groups with the help of **HAVING** clause.

This clause is used along with GROUP BY clause. The condition in HAVING clause is applied to form groups of records, not individual rows.

Query 9.29 applies a condition for forming groups. Here the groups will be formed only if the condition provided with HAVING clause is satisfied.

Query 9.29

```
SELECT course, COUNT(*) FROM student  
GROUP BY course  
HAVING COUNT(*) > 3;
```

course	COUNT(*)
Science	7

1 row in set (0.00 sec)

If we refer to Figures 9.22 and 9.23, we can find that only *Science* group has more than 3 students. Groups are not formed based on values '*Commerce*' and '*Humanities*', since the number of records with each of these values are 2 and 1, respectively. That is why details of these groups are not shown by Query 9.29.

Fig. 9.23: Condition based grouping

Know your progress



1. List the aggregate functions of SQL.
2. How do COUNT (*) and COUNT(column_name) differ?
3. What is the difference between WHERE clause and HAVING clause?
4. The usage SUM (*) or MAX (*) is invalid. Why?
5. What will be the result of the following query?
`SELECT COUNT(DISTINCT course) FROM student;`



Let us do

Identify some queries with respect to the table **stock** which requires the utilisation of aggregate functions and ORDER BY clause. Write SQL statements to answer these queries.

9.7 Modifying data in tables

In certain situations, we need to change the values in the columns of a table. For example, following a revision in salary or wages, the family monthly income of a student may be changed. Similarly, the missing values (NULL) in monthly income of some students may need to be replaced by valid data at a later stage. This kind of changes can be done using the DML command **UPDATE**. It changes the values in one or more columns of specified rows. These changes may be affected in all or only in selected rows of the table. The new data for the column within these rows is given using the keyword **SET**, which is the essential clause of UPDATE command. The new data can be a constant, an expression or data from other tables.

The syntax of UPDATE command is:

```
UPDATE <table_name>
SET <column_name> = <value> [,<column_name> = <value>, ...]
[WHERE <condition>];
```

Suppose the family monthly income of the student *Kaushi* is to be changed to Rs. 27000/- . Query 9.30 can perform this modification.

Query 9.30

```
UPDATE student
SET f_income=27000
WHERE name='Kaushi';
```

After the execution of this query, the response of MySQL will be as follows:

```
Query OK, 1 row affected (0.08 sec)
Rows matched: 1  Changed: 1  Warnings: 0
```

Let us see the change in the record using the query,

```
SELECT * FROM student WHERE name='Kaushi';
```

The output of this query is shown in Figure 9.24. Compare this figure with Figure 9.17 and see the change.

adm_no	name	gender	dob	course	f_income
1025	Kaushi	M	1998-10-02	Commerce	27000

1 row in set (0.00 sec)

Fig. 9.24: Details of Kaushi with modified data in f_income column

We can use expressions to set the column values in records. Query 9.31 illustrates this concept.

Query 9.31

```
UPDATE student
SET f_income=f_income+1000
WHERE f_income<25000;
```

The output of this query will be as follows:

```
Query OK, 3 rows affected (0.06 sec)
Rows matched: 3  Changed: 3  Warnings: 0
```

The output reveals that three records satisfy the given condition and hence the values in f_income column of these records are incremented by 1000 (refer to Figures 9.17, 9.25).

The columns with NULL values can also be modified with UPDATE command. Suppose we want to store Rs. 20000/- as the monthly income in the respective field of the

records in which the column contains NULL value at present. Query 9.32 makes it possible.

Query 9.32

```
UPDATE student
SET f_income=20000
WHERE f_income IS NULL;
```

The changes made by Queries 9.31 and 9.32 can be observed in Figure 9.25, which is obtained by the query: `SELECT * FROM student;`

adm_no	name	gender	dob	course	f_income
1001	Alok	M	1998-10-02	Science	25000
1002	Nike	M	1998-11-26	Science	35000
1003	Bharath	M	1999-01-01	Commerce	45000
1004	Virat	M	1998-12-05	Science	23000
1005	Meera	F	1998-08-15	Science	20000
1006	Divakar	M	1998-02-21	Science	20000
1025	Kaushi	M	1998-10-02	Commerce	27000
1026	Niveditha	F	1999-03-04	Humanities	52000
1027	Sreekumar	M	1998-06-06	Science	16000
1057	Chaithanya	F	1999-06-03	Science	20000

10 rows in set (0.00 sec)

Fig. 9.25: Modifications in column f_income



With respect to the table **stock**, write SQL statements to make some modifications in some column values.

Let us do

9.8 Changing the structure of a table

In some situations, we may need to modify the structure of tables. It is an operation related to the schema and hence SQL provides a DDL command **ALTER TABLE** to modify the structure of a table. The alteration will be in the form of adding or dropping column(s), changing the data type and size of existing column(s), renaming a table, etc. Let us see how these changes are incorporated.

9.8.1 Adding a new column

One or more columns can be added at any position in an existing table. The syntax for adding a new column to a table is:

```
ALTER TABLE <table_name>
ADD <column_name> <data_type>[<size>] [<constraint>]
[FIRST | AFTER <column_name>];
```

Here the <table_name> indicates the name of the table which is to be altered; **ADD** is the keyword to add the new column; <column_name> <data_type> [<size>] indicates the description of the new column. **FIRST** | **AFTER** indicates the position of the newly added column.

If we want to add a column at the first position, use the clause FIRST. If we want to add a column at a specified position, use the clause AFTER <column_name>. Note that if we do not specify the position of the new column, then by default, it will be added as the last column of the table. Remember that the newly added column contains only NULL values.

Let us add two columns **gr_mks** and **reg_no** in the table **student** to hold the grace marks awarded to the students and their register number for the Higher Secondary examinations, respectively. Query 9.33 can make these changes in the structure of the table.

Query 9.33

```
ALTER TABLE student
    ADD gr_mks INTEGER AFTER dob,
    ADD reg_no INTEGER;
```

The response of MySQL for this query will be as follows:

```
Query OK, 10 rows affected (0.25 sec)
Records: 10  Duplicates: 0  Warnings: 0
```

9.8.2 Changing the definition of a column

We can modify the characteristics of a column like data type, size and/or constraints by using the clause **MODIFY** with ALTER TABLE command. The syntax to modify the definition of a column is:

```
ALTER TABLE <table_name>
    MODIFY <column_name> <data_type> [<size>] [<constraint>];
```

Let us modify the newly added column **reg_no** by providing a constraint **UNIQUE** to ensure that no two students have the same register number. Query 9.34 makes this change.

Query 9.34

```
ALTER TABLE student
    MODIFY reg_no INTEGER UNIQUE;
```

The response of MySQL will be the same as that we obtained for Query 9.30. We can observe the changes made by the Queries 9.33 and 9.34 using the command: DESC student;. The output is shown in Figure 9.26.

Field	Type	Null	Key	Default	Extra
adm_no	int(11)	NO	PRI	NULL	auto_increment
name	varchar(20)	NO		NULL	
gender	char(1)	YES		M	
dob	date	YES		NULL	
gr_mks	int(11)	YES		NULL	
course	varchar(15)	YES		NULL	
f_income	int(11)	YES		NULL	
reg_no	int(11)	YES	UNI	NULL	

8 rows in set (0.00 sec)

Fig. 9.26: Structure of table student after alteration

We can see from Figure 9.26 that column gr_mks is added after dob and reg_no as the last column. Also note that column Key for reg_no contains **UNIQUE** constraint. Now, if we see the contents in the new columns using the command `SELECT * FROM student;`, we can see NULL values as shown in Figure 9.27.

adm_no	name	gender	dob	gr_mks	course	f_income	reg_no
1001	Alok	M	1998-10-02	NULL	Science	25000	NULL
1002	Nike	M	1998-11-26	NULL	Science	35000	NULL
1003	Bharath	M	1999-01-01	NULL	Commerce	45000	NULL
1004	Virat	M	1998-12-05	NULL	Science	23000	NULL
1005	Meera	F	1998-08-15	NULL	Science	20000	NULL
1006	Divakar	M	1998-02-21	NULL	Science	20000	NULL
1025	Kaushi	M	1998-10-02	NULL	Commerce	27000	NULL
1026	Niveditha	F	1999-03-04	NULL	Humanities	52000	NULL
1027	Sreekumar	M	1998-06-06	NULL	Science	16000	NULL
1057	Chaithanya	F	1999-06-03	NULL	Science	20000	NULL

10 rows in set (0.00 sec)

Fig. 9.27: Contents in the new columns after modifying the structure of table student



Write SQL statements to fill in data in the new columns with proper values and display the changes in the records.

Make some structural modifications in the table **stock** and store values according to the changes.

9.8.3 Removing column from a table

If we want to remove an existing column from a table, we can use **DROP** clause along with **ALTER TABLE** command. The syntax for removing a column from a table is:

```
ALTER TABLE <table_name>
DROP <column_name>;
```

For example, if we want to remove the column gr_mks from the table *student*, Query 9.35 is sufficient.

Query 9.35

```
ALTER TABLE student
DROP gr_mks;
```

The response of MySQL will be the same as we received for the earlier ALTER TABLE statements. The change can be observed using the command: DESC student;

9.8.4 Renaming a table

We can rename a table in the database by using the clause **RENAME TO** along with ALTER TABLE command. We can rename a table even though it contains tuples. The syntax for renaming a table is:

```
ALTER TABLE <table_name>
RENAME TO <new_table_name>;
```

For example, if we want to rename the table *student* as *student2015*, Query 9.36 can help us.

Query 9.36

```
ALTER TABLE student
RENAME TO student2015;
```

Tables_in_school
student2015

1 row in set (0.00 sec)

The response of this query will be as follows:

Query OK, 0 rows affected (0.06 sec)

Fig. 9.28: Renaming of table

The change can be viewed using the query: SHOW TABLES; and the output will be as shown in Figure 9.28.

9.9 Deleting rows from a table

Sometimes we need to remove one or more records from the table. The DML command **DELETE** is used to remove individual or a set of rows from a table. The rows which are to be deleted are selected by using the WHERE clause. If the WHERE clause is not used, all the rows in the table will be deleted. The DELETE command removes only records and not the individual field values. The syntax of the DELETE command is:

```
DELETE FROM <table_name> [WHERE <condition>];
```

For example, if the record of *Sreekumar* with admission number 1027 is to be deleted from the table, Query 9.37 can be used.

Query 9.37

```
DELETE FROM student2015 WHERE adm_no=1027;
```

The output of this query will be: **Query OK, 1 row affected (0.08 sec)**

Note that the name of the table is specified as *student2015*, because we have renamed the table *student* as *student2015*. The change in the table can be observed in Figure 9.29, which is obtained by the query: SELECT * FROM student2015;

adm_no	name	gender	dob	course	f_income	reg_no
1001	Alok	M	1998-10-02	Science	25000	NULL
1002	Nike	M	1998-11-26	Science	35000	NULL
1003	Bharath	M	1999-01-01	Commerce	45000	NULL
1004	Virat	M	1998-12-05	Science	23000	NULL
1005	Meera	F	1998-08-15	Science	20000	NULL
1006	Divakar	M	1998-02-21	Science	20000	NULL
1025	Kaushi	M	1998-10-02	Commerce	27000	NULL
1026	Niveditha	F	1999-03-04	Humanities	52000	NULL
1057	Chaithanya	F	1999-06-03	Science	20000	NULL

9 rows in set (0.02 sec)

Fig. 9.29: Contents in the renamed table after deleting a record

Figure 9.29 shows only seven columns. This is because of the removal of column gr_mks as a result of Query 9.35.



The deletion of values in a column is not possible. The effect may be brought out by filling the column with NULL values using UPDATE command as follows:

```
UPDATE <table_name>
SET <column_name> = NULL
[WHERE <condition>];
```

9.10 Removing table from a database

If we do not need a table, it can be removed from the database using **DROP TABLE** command. This DDL command removes a table from the database permanently even though the table contains tuples. We have to be very careful while deleting any existing table because once data is lost, it cannot be recovered later. The syntax to remove a table is:

```
DROP TABLE <table_name>;
```

For example, if we want to remove the table *student2015* from the database *school*, Query 9.38 can be used.

Query 9.38 `DROP TABLE student2015;`

Know your progress



1. The command used to edit the structure of a table is _____.
2. Restructuring of a column affects the values in it. State whether true or false.
3. How will you remove a column from a table?
4. Name the command used to remove a row from a table.
5. What happens when we use **DELETE FROM** command without a **WHERE clause**?

9.11 Nested queries

We are all familiar with the concept of nesting as we discussed it in nested if, nested loop, etc. Now, we will discuss nested queries. We know that nested means one inside another. Here the result of one query is dynamically substituted in the condition of another. A MySQL inner query is also called sub query, while the query that contains the sub query is called an outer query. SQL first evaluates the inner query (sub query) within the WHERE clause and the result of inner query is then substituted in the condition of the outer query. While using relational operators, ensure that the sub query (inner query) returns a single row output.

Suppose we want to display the name and course of the students who have the highest family monthly income. Query 9.39 can perform this task and Figure 9.30 shows the output.

Query 9.39

```
SELECT name, course FROM student2015
WHERE f_income=(SELECT MAX(f_income)
                  FROM student2015);
```

In this example, the sub query (here query inside the pair of parentheses) is evaluated first and the highest value in f_income column (here 52000) is returned. This value is then compared with the value in f_income attribute of the records in the table and when a match is found, it is retrieved by the outer query.

name	course
Niveditha	Humanities

1 row in set (0.03 sec)

Fig. 9.30: Result of nested query

9.12 Concept of views

MySQL supports the concept of views, which is a feature of RDBMS. A *view* is a virtual table that does not really exist in the database, but is derived from one or more tables. The table(s) from which the tuples are collected to constitute a view is called base table(s). These tuples are not physically stored anywhere, rather the definition of the view is stored in the database. Views are just like windows through which we can view the desired information that is actually stored in a base table. The contents of a view are taken from other tables depending upon a query condition. A view can be created with the DDL command CREATE VIEW. The syntax is:

```
CREATE VIEW <view_name>
AS SELECT <column_name1> [,<column_name2>,...]
FROM <table_name>
[WHERE <condition>];
```

Let us create a view that contains the details of only those students who were born before January 1, 1999. Query 9.40 creates this view named ***student1998***.

Query 9.40

```
CREATE VIEW student1998
AS SELECT * FROM student2015
WHERE dob < '1999-1-1';
```

The output of this query will be: **Query OK, 0 rows affected (0.31 sec)**

Figure 9.31 shows the structure of the view and Figure 9.32 shows the contents of the view. These can be obtained by the commands `DESC student1998;` and `SELECT * FROM student1998;` respectively.

Field	Type	Null	Key	Default	Extra
adm_no	int(11)	NO		0	
name	varchar(20)	NO		NULL	
gender	char(1)	YES		M	
dob	date	YES		NULL	
course	varchar(15)	YES		NULL	
f_income	int(11)	YES		NULL	
reg_no	int(11)	YES		NULL	

7 rows in set (0.01 sec)

Fig. 9.31: Structure of the view *student1998*

adm_no	name	gender	dob	course	f_income	reg_no
1001	Alok	M	1998-10-02	science	25000	NULL
1002	Nike	M	1998-11-26	science	35000	NULL
1004	Virat	M	1998-12-05	science	23000	NULL
1005	Meera	F	1998-08-15	science	20000	NULL
1006	Divakar	M	1998-02-21	science	20000	NULL
1025	Kaushi	M	1998-10-02	Commerce	27000	NULL

6 rows in set (0.00 sec)

Fig. 9.32: Contents in the view *student1998*

Note that in Figure 9.31, the column Key does not contain the constraints of `adm_no` and `reg_no`, and Figure 9.32 shows the details of students born in the year 1998 only.

We can use all the DML commands with the view in quite a similar fashion as in the case of tables. Figure 9.32 is a result of such a query. Remember that we are accessing the base table through the associated views. So, take care when operations like update and delete are performed on views as they actually reflect in the base tables. Query 9.41 illustrates this concept.

Query 9.41

```
UPDATE student1998
SET reg_no=2201020
WHERE adm_no=1001;
```

Let us check the data in the table '*student2015*' after executing this query. Figure 9.33 shows the output of the query: `SELECT * FROM student2015;`

adm_no	name	gender	dob	course	f_income	reg_no
1001	Alok	M	1998-10-02	Science	25000	2201020
1002	Nike	M	1998-11-26	Science	35000	NULL
1003	Bharath	M	1999-01-01	Commerce	45000	NULL
1004	Virat	M	1998-12-05	Science	23000	NULL
1005	Meera	F	1998-08-15	Science	20000	NULL
1006	Divakar	M	1998-02-21	Science	20000	NULL
1025	Kaushi	M	1998-10-02	Commerce	27000	NULL
1026	Niveditha	F	1999-03-04	Humanities	52000	NULL
1057	Chaitanya	F	1999-06-03	Science	20000	NULL

9 rows in set (0.00 sec)

Fig. 9.33: Effect of updation in the base table through the view

The advantages of views lie in the fact that without sparing extra storage space, we can use the same table as different tables (but virtual). Another advantage is that the views implement sharing along with privacy. It also helps to reduce the complexity of conditions with WHERE clause while retrieving, updating or deleting records from tables.

If a view is no longer needed, it can be removed from the database with **DROP VIEW** command. But it will not affect the base table(s). The syntax is:

`DROP VIEW <view_name>;`

For example, if we want to delete the view *student1998* from the database, Query 9.42 can be used.

Query 9.42 `DROP VIEW student1998;`

Know your progress

- What is mean by nested query?
- What is view in SQL?
- Creation of a view needs a SELECT command. State whether true or false.
- Removal of a view deletes a table from the database. State whether true or false.
- Can we update a table using its view?



We have discussed all the DDL and DML commands of SQL, which are implemented through MySQL, with examples and their outputs. Let us summarise them in Table 9.8. The first two rows are filled in and the remaining rows are left to you.

Let us do

SQL	Command	Essential Keyword(s)	Purpose of the command
DDL	CREATE TABLE		To create tables
	ALTER TABLE	ADD/MODIFY	To change the structure of tables
	DROP TABLE		
	CREATE VIEW		
	DROP VIEW		
	INSERT		
DML	SELECT		
	UPDATE		
	DELETE		

Table 9.8: Summary of SQL command



Let us conclude

Structured Query Language is used to operate on relational database. MySQL is a popular RDBMS package by which we can implement SQL commands. We have used various DDL commands to perform operations related with the structure of database. Constraints have been presented to ensure data validity and integrity in database. We have also discussed different DML commands to perform operations associated with the data contained in tables of a database. These operations include insertion, retrieval, modification and deletion of data in tables. We have also familiarized ourselves with nested queries and the concept of views. A good understanding of this chapter is essential for your higher studies in the field of computers.



Let us practice

1. The structure of a table is given to store the details of marks scored by students in an examination.

Data	Type	Description
Register number	Numeric	A unique and essential data to identify a student
Name	String	A maximum of 30 characters
Course	String	It can be Science, Commerce or Humanities
Marks of six subjects	Numeric each	Six separate columns are required

Write SQL statements for the creation of the table and the following requirements:

- a. Insert data into the fields (at least 10 records).
 - b. Display the details of all students.
 - c. List the details of Science group students.
 - d. Count the number of students in each course.
 - e. Add a new column named Total to store the total marks.
 - f. Fill the column 'Total' with the sum of the six marks of each student.
 - g. Display the highest total in each group.
 - h. Find the highest, lowest and average score in Subject 6 in Commerce group.
 - i. Display the names in the alphabetical order in each course.
 - j. Display the name of the student with the highest total.
2. The structure of a table is given to store the details of items in a computer shop.

Data	Type	Description
Item number	Numeric	A unique and essential data to identify an item
Item name	String	A maximum of 30 characters
Date of purchase	Date	Duplication is allowed
Unit price	Fractional Number	Price of a single item
Quantity	Numeric	Number of items
Manufacturer	String	Name of supplier (can duplicate)

Write SQL statements for the creation of the table and the following requirements:

- a. Insert data into the fields (at least 10 records).
- b. Display the details of all items in the table.
- c. Display the names of items and total price of each.
- d. List the items manufactured by a company (*specify the name*) available in the table.
- e. Find the number of items from each manufacturer.
- f. Display the details of items with the highest price.

- g. List the names of items whose price is more than the average price of all the items.
- h. Display the names of items purchased after 1-1-2015.
- i. Get the details of items manufactured by two or three companies (*specify the names*) available in the table .
- j. Display the details of items from a company (*specify the name*) with a stock of more than 20 pieces.
3. The structure of a table is given to store the details of higher secondary school teachers.

Data	Type	Description
Teacher ID	Numeric	A unique and essential data to identify a teacher
Name	String	A maximum of 30 characters
Gender	Character	Male or Female
Date of joining	Date	Duplication is allowed
Department	String	Science, Commerce, Humanities or Language
Basic pay	Numeric	Basic salary of a teacher

Write SQL statements for the creation of the table and the following requirements:

- a. Insert data into the fields (at least 10 records).
- b. Display the details of all female teachers in the table.
- c. List the details of male teachers in the Science department.
- d. Display the names and basic pay of teachers in the Language department whose basic pay is Rs. 21000/- or more.
- e. Display the names and 71% of basic pay of the teachers.
- f. Find the number of teachers in each department.
- g. Display the details of teachers whose basic pay is less than the average basic pay.
- h. List the male teachers who joined before 1-1-2010.
- i. Increment the basic pay of all teachers by Rs. 1000/-.
- j. Delete the details of teachers from the Language department.

4. The structure of a table is given to store the details of customers in a bank.

Data	Type	Description
Account number	Numeric	A unique and essential data to identify a customer
Name	String	A maximum of 30 characters
Gender	Character	Male or Female
Date of joining	Date	Duplication is allowed
Type of account	String	SB or Current
Balance amount	Numeric	Can be a fractional number

Write SQL statements for the creation of the table and the following requirements:

- Insert data into the fields (at least 10 records).
- Display the details of customers having SB account.
- Display the names of customers with a balance amount greater than Rs. 5000/-.
- Display the details of female customers with a balance amount greater than Rs. 10000/-.
- Count the number of male and female customers.
- Display the names of customers with the highest balance amount.
- Display the names of customers whose names end with 'kumar'.
- Update the balance amount of a particular customer with a deposit amount of Rs. 2000/-.
- Display the details of customers with a tax deduction of 2% of the balance amount for those who have Rs.2,00,000/- in their account.
- Delete the details of customers with current account.

Let us assess

- The command to remove rows from a table 'CUSTOMER' is:
 - REMOVE FROM CUSTOMER
 - DROP TABLE CUSTOMER
 - DELETE FROM CUSTOMER
 - UPDATE CUSTOMER
- If values for some columns are unknown, how is a row inserted?
- Distinguish between CHAR and VARCHAR data types of SQL.
- What is the difference between PRIMARY KEY and UNIQUE constraints?
- What do you mean by NULL value in SQL?

6. Which of the following is the correct order of clauses for the SELECT statements?
- SELECT, FROM, WHERE, ORDER BY
 - SELECT, FROM, ORDER BY, WHERE
 - SELECT, WHERE, FROM, ORDER BY
 - SELECT, WHERE, ORDER BY, FROM
7. The SQL operator _____ is used with pattern matching.
8. Read the following strings:
- (i) 'Sree Kumar' (ii) 'Kumaran' (iii) 'Kumar Shanu' (iv) 'Srekkumar'
- Choose the correct option that matches with the pattern '%Kumar', when used with LIKE operator in a SELECT statement.
- Strings (i) and (ii) only
 - Strings (i), (iii) and (iv) only
 - Strings (i) and (iii) only
 - All the strings
9. List any five built-in functions of SQL and the value returned by each.
10. Distinguish between WHERE clause and HAVING clause.
11. Write any four DML commands in SQL.
12. Write the essential clause required for each of the following SQL command.
- INSERT INTO
 - SELECT
 - UPDATE
13. Consider the given table Customer and write the output of the following SQL queries:

AccNo	Name	Branch	Amount
1001	Kumar	Calicut	10000
1002	Salim	Trivandrum	20000
1003	Fida	Kottayam	18000
1004	John	Kannur	30000
1005	Raju	Thrissur	5000

- SELECT * FROM customer WHERE Amount>25000;
- SELECT Name FROM customer
WHERE Branch IN ('Calicut', 'Kannur');
- SELECT COUNT(*) FROM customer WHERE Amount < 20000;
- SELECT Name FROM customer WHERE Name LIKE "%m%";
- SELECT * FROM customer ORDER BY Amount DESC;

14. Distinguish between COUNT (*) and COUNT (column-name) .
 15. Consider the given table ITEMS.

Item Code	Name	Category	Unit Price	Sales Price
0001	Pencil	Stationery	5.00	8.00
0002	Pen	Stationery	8.00	10.00
0003	NoteBook	Stationery	10.00	20.00
0004	Chappal	Footwear	50.00	70.00
0005	Apple	Fruits	60.00	90.00
0006	Orange	Fruits	40.00	60.00
0007	Pen	Stationery	10.00	12.00

- a. Suggest a suitable primary key for the above table. Give justification.
 b. Write SQL statements for the following:
- To list all stationery items.
 - To list itemcode, name and profit of all items.
 - To count the number of items in each category.
 - To list all stationery items in the descending order of their unit price.
 - To find the item with the highest selling price.
 - To create a view that contains the details of all stationery items.
16. What are the different modifications that can be made on the structure of a table? Which is the SQL command required for this? Specify the clauses needed for each type of modification.
17. A table is created in SQL with 10 records. Which SQL command is used to change the values in a column of specified rows? Write the format.
18. Name the keyword used with SELECT command to avoid duplication of values in a column.
19. Distinguish between DISTINCT and UNIQUE in SQL .
20. Pick the odd one out and give reason:
- CREATE
 - SELECT
 - UPDATE
 - INSERT



10

Server Side Scripting Using PHP

Significant Learning Outcomes

After the completion of this chapter, the learner

- lists the benefits of using PHP.
- explains the syntax of PHP code.
- describes the client server environment.
- illustrates various data types and operators used in PHP.
- constructs code from algorithm using control and looping structures in PHP.
- designs PHP functions for common tasks.
- identifies date, time and string functions.
- differentiates between static and dynamic web page.
- selects the appropriate data submitting methods for different scenarios.
- identifies the role of database connectivity in the creation of dynamic web pages.

In the previous chapters we learned about HTML, and client-side scripting using JavaScript and now we know how to embed a Java script in HTML. In this chapter we will learn server side scripting using PHP and see how we can embed a PHP code into HTML, along with JavaScript. The basic syntax of PHP is similar to that of C++ and Java script, and embedding the PHP code in HTML is similar to Java script. So learning PHP will be easy and interesting.

10.1 Overview of PHP

PHP is one of the most popular server side scripting languages available. It is used for creating dynamic web pages. PHP stands for PHP Hypertext Preprocessor. Usually, PHP runs on a web server and is available on different operating systems and platforms. Furthermore, PHP is an interpreted language and a PHP script is processed by the PHP engine each time it runs. PHP is an HTML embedded language which means that we can write PHP statements within an HTML code. When a PHP script is run it processes the information and produce hypertext (HTML) as a result.



Rasmus Lerdorf (born on 22 November 1968) is a Greenlandic programmer with Canadian citizenship. He created the PHP scripting language. It was first created by him in 1995, and its first official release was in 1997. He is known as the Father of PHP. He authored the first two versions of the language and participated in the development of later versions. He continues to contribute to the project. The official website of PHP is www.php.net



Rasmus Lerdorf

PHP is an open-source project and is completely free, and is supported by a worldwide community of volunteers. It is more robust and error-free than many other server side scripting languages and can access more than 20 different databases including MySQL. PHP can also be used to output images, PDF files and Flash movies. As PHP is free, it helps organisations in reducing the overall development cost by allowing them to save on licensing fees and expensive server hardware. At the same time PHP also helps to produce higher quality products within a short span of time. As a result of this, today, many large-scale websites are developed in PHP.



As per recent statistical data, PHP is installed on more than 20 million websites and around 1 million web servers around the world.

10.1.1 Benefits of using PHP

We know that client-side scripts are executed faster since they are run at the client. Even though it is fast it has certain limitations. A client-side scripting language is usually dependent on the browser in which it is run. Moreover the JavaScript code is visible to the user through the "view source" option of the browser. This makes it less secure.

On the other hand, in the case of PHP, code is executed on the server, and not on the client browser. This allows us to write a program code that is completely independent of browsers. Further, because the code is executed on the server and only the output is sent to the client, it is impossible for users to see the source code of a PHP program.

Benefits of PHP can be consolidated as follows:

- As PHP can be easily embedded into HTML, it is easy to convert an already existing static website into a dynamic one.

- It is compatible with a wide variety of databases.
- It is an independent platform and can run across Windows, Linux or Mac servers.
- It supports most current web servers and interfaces very easily with Apache / MySQL.
- It is simple and easy to learn.
- It operates much faster than other scripting languages, since PHP does not use a lot of system's resources in order to run.
- PHP offers many levels of security to prevent malicious attacks.
- It has a huge support from open source community.
- PHP is completely free and is an open source software product and can legally be used for personal and commercial web site development.



www.hscap.kerala.gov.in, the Kerala State Higher Secondary single window admission portal runs on PHP.

10.1.2 Basics of PHP

A. Setting up the development environment

We need to set up a web development environment in our computer for a PHP program to run successfully. For this we need to install a PHTML compatible web server and PHP interpreter on our machine. They can be installed separately or from a set of free open source software package like WAMP, LAMP or XAMPP, which includes Apache web server, MySQL and PHP. WAMP is for windows, LAMP stack for Linux and XAMPP will work on both Windows and Linux.

After installing a web server, start the web server from the menu. Open the web browser and type "<http://localhost>" or "<http://127.0.0.1>" in the address bar. If we see an administration screen corresponding to the installed web server in the web browser, we can confirm that the web server installation is working properly.

B. Writing and running the script

PHTML scripts are merely plain text containing PHTML instructions. Apart from a simple text editor, no other additional software is required to create PHP code. Within the text document, PHP scripting should begin with "<?php" and end with "?>". When the web server sees this tag, it understands that it is a PHP code that is in between the tags and that it executes the code. The PHTML code containing text documents are to be saved with ".php" extension in the **root directory** of the web server.



WAMP, XAMPP and LAMP

WAMP, LAMP and XAMPP are used for serving PHP websites and acts as the local server, so that we can see our working website on our computer.

All these software help us in reducing the complexity of deployment and handling of services like database handling, code manipulation etc.



WAMP stands for Windows, Apache, MySQL, PHP. WAMPs are packages of independently-created programs installed on computers that use a Windows operating system. The advantage of using WAMP is that it is easy to setup. WAMP is available at www.wampserver.com/en/.

XAMPP stands for X-OS, Apache, MySQL, PHP, PERL. X-OS means it can be used for any operating system. XAMPP is easier to use for a beginner. XAMPP is available at <http://www.apachefriends.org/en/xampp-windows.html>



LAMP stands for Linux, Apache, MySQL, PHP. LAMP is an open source Web development platform that uses Linux as the operating system. Because the platform has four layers, LAMP is sometimes referred to as a LAMP stack.

Let us try out an example step by step.

Step 1: Open a new document in a text editor (e.g: Notepad, Gedit) and type in the following code.

```
<?php
    // this line of code displays a message
    echo 'My First PHP Program';
?>
```

Step 2: Save the file in the web server's document root directory (like "C:\wamp\www" in the case of WAMP server or \var\www in LAMP), under a suitable name with a .PHP extension (e.g.: example.php).

Step 3: Start the web server if it is not **ON**.

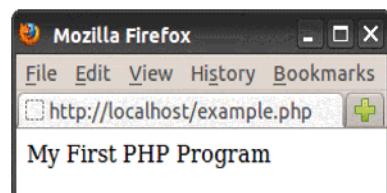


Fig. 10.1: Output of the program First.php

Step 4: Then, open the web browser, and type the URL corresponding to the file location (e.g.: <http://localhost/example.php>) in the address bar to get the output as in Figure 10.1.

In PHP, each line of code is to be terminated with a semi colon (;). For the last statement of PHP code semi colon is not compulsory.



The default root directory for WAMP is "C:\wamp\www", for XAMPP is "C:\xampp\htdocs" and for LAMP in Ubuntu is "/var/www".

The process of running a PHP script on the web server may be consolidated as follows:

1. We request a web page by typing the page's URL (e.g.: <http://localhost/first.php>) in the browser's address bar.
2. The web server recognises that the requested URL is a PHP script, and instructs the PHP engine to process and run the script.
3. The script runs, and when it is finished, it sends an HTML page containing the result back to our web browser.

Create a folder named "letusdo" in your web servers root directory and copy few files (any files) into it, do the following and observe the output.



Let us do

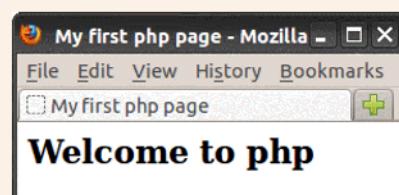
- a. Try the URL, <http://localhost/letusdo> in browser's address bar.
- b. Create an HTML file with name "index.html" in "letusdo" folder and try the previous URL.
- c. Create a PHP file with name "letusdo.php" in "letusdo" folder and try the URL, <http://localhost/letusdo/letusdo.php>.

C. Combining HTML and PHP

PHP and HTML are closely related to each other and often function together. PHP generates HTML, and HTML passes information to PHP. We embed the PHP code into standard HTML documents using the special tags "<?php" and "?>". PHP source code is flexible and can be placed anywhere in a document. Anything outside of PHP tags is read as HTML.

Program 10.1: PHP script in HTML document

```
<HTML>
<HEAD>
<TITLE> My first php page</TITLE>
</HEAD>
<BODY>
<?php
echo "<H2> Welcome to php </H2>"; 
?>
</BODY>
</HTML>
```



When this HTML document is requested by a user, the web server recognises and executes the PHP code blocks and embeds the resulting output into the HTML document before returning it to the requesting user.

D. Comments in PHP

In PHP code, a comment is a line that is not read/executed as part of the program. There are two types of comments in PHP, single line comment (//) and multiline comment /* */.

Program 10.2: PHP script in HTML document

```
<?php  
    /* Program to display the message  
        Welcome to php */  
    echo "Welcome to php"; //Shows a message  
?>
```

E. Output statements in PHP

PHP provides various constructs and functions for getting output. They can be used to output various data types like integer, float, string, arrays, objects etc.

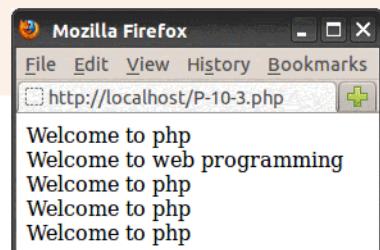
(i) echo and print

In PHP, the two basic constructs 'echo' and 'print' are used to display output on a web page. Both constructs can output all types of data, but multiple outputs can be made only with echo command.

The echo and print statement can be used with or without parentheses.

Program 10.3: PHP script in HTML document

```
<?php  
    echo "Welcome to php<BR>", "Welcome to web programming<BR>";  
    echo ("Welcome to php<BR>");  
    print "Welcome to php<BR>";  
    print ("Welcome to php<BR>");  
?>
```



The following table illustrates the difference between echo and print statements.

echo	print
Can take more than one parameter when used without parenthesis.	Takes only one parameter
Does not return any value.	Returns TRUE or 1 on successful output and FALSE if it was unable to print out the string.
Little faster than print.	Little bit slower than echo

Table 4.1: Comparison between echo and print

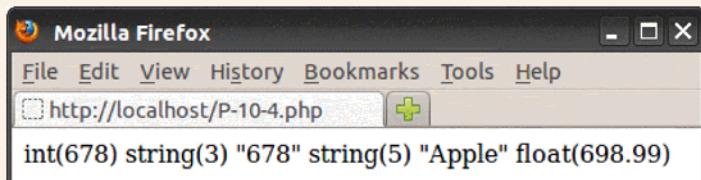
(ii) Var_dump ()

The var_dump () function is used to display both data type and value of variables. It can be used to display integer, float, string, arrays, objects etc. Its syntax is as follows.

```
var_dump(variable1, variable 2, ....variable n)
```

Program 10.4 Program to demonstrate var_dump()

```
<?php
    $a1=678;
    $a2="678";
    $a3="Apple";
    $a4=698.99;
    var_dump($a1);
    var_dump($a2);
    var_dump($a3);
    var_dump($a4);
?>
```



10.2 Fundamentals of PHP

In this section we will discuss variables, data types and operators in PHP.

10.2.1 Variables

In PHP, a variable name starts with the \$ sign, followed by the name of the variable. Unlike other programming languages, in PHP a variable does not need to be declared before using it. It is created when we first assign a value to it. PHP automatically determines the data type of the variable, depending on the type of value assigned to it.

```
$Var_name = value;
```

```
<?php
    $txt = "Hello world";
    $x = 25;
    $y = 23.5;
?>
```

After the execution of the statements above, the variable `$txt` will hold the value Hello world, the variable `$x` will hold the value 25, and the variable `$y` will hold the value 23.5. Put quotes around the value while assigning a text value to a variable.

Variable naming conventions in PHP

A variable can have a short name (like `m` and `n`) or a more descriptive name (like `Age`, `Reg_No`, `Amount`).

Rules for forming PHP variable names:

- A variable name must start with the `$` sign, followed by the name of the variable.
- The name of the variable must start with a letter or the underscore character.
- The name of the variable can only contain alpha-numeric characters and underscores (`a-z`, `A-Z`, `0-9`, and `_`)
- Variable names are case-sensitive (`$name` and `$NAME` are two different variables)
- Punctuation characters such as commas, quotation marks, periods or spaces are not allowed in variable names.

10.2.2 Data types

We know that variables can store data of different types, and different data types are used differently. The data types in PHP can be divided and grouped as in Figure 10.2.

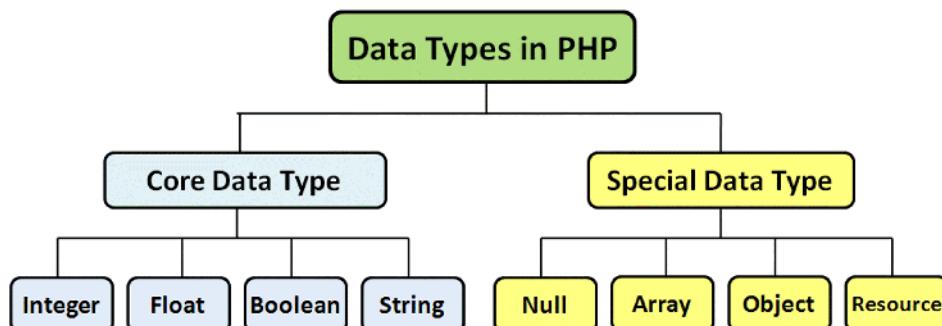


Fig. 10.2: Data types in PHP

A. Core Data Types

The core data types integer, float/double and string data types are almost similar to what we have learned in C++. The size of an integer or float is platform-dependent.

Integer

Integers are whole numbers. It does not include precision. Negative values are also considered as integers. PHP does not support unsigned integer data type.

Example: -32, 32, 986 etc.

Float/Double

Fractional numbers are grouped as floating point numbers or double data type.

Example: 123.56, 5.6, 1.2e3, 7E-10 etc.

String

Strings hold both words and sentences. These are always inserted within quotation marks. Both single and double quotes can be used to represent strings. But while using quotes, the quotes used at the beginning and end of the string should be of the same type. That is, if a string representation started with a single quote then it should also end with a single quote.

Example: "Apple", 'PHP' etc.

Boolean

A Boolean data type can represent two possible states: TRUE or FALSE. Booleans are often used in conditional testing. As discussed earlier, PHP is a case sensitive programming language. So we can use only the defined set of Boolean values like, yes/no, on/off, 1/0, true/false etc.

```
<?php  
    $a=true;      // assign the value TRUE to $a  
    $b=0;         // assign the value FALSE to $b  
?>
```

B. Special data types

Null

Null is a special data type which can have only one value: NULL. PHP will consider a variable as NULL, if we do not set it. NULL data type can also be used for emptying variables.

```
$x = null; // $x is assigned a null value
```

Array

Arrays are variables that hold multiple values. In PHP each array element holds a key and a value. We have three types of array: indexed array, associative array and multidimensional array. Arrays are discussed in detail in Section 10.4.

Object

Object data type in PHP is similar to an object in C++. An object can contain variables and functions that process the variables. In PHP, an object must be explicitly declared. At first a class is declared and then instances which are objects of the class are created using the command 'new'.

Resources

The resource type is not an actual data type. Resources are special variables that hold references to other external resources like file handler, database object etc. Resources are created and used by special functions.

10.2.3 Operators in PHP

Operators used in PHP are grouped and named categorically as:

- a. Assignment operators
- b. Arithmetic operators
- c. Relational operators
- d. Logical operators
- e. String operators
- f. Combined operators

a. Assignment operators

Assignment operators are used to assign a value to a variable directly or from another variable. The equal character (=) is used as assignment operator.

```
$my_var = 4; // $my_var is assigned a value 4
```

```
$new_var = $my_var; // $new_var is assigned the value of $my_var
```

b. Arithmetic operators

Operator	Meaning	Example	Result
+	Addition	3 + 2	5
-	Subtraction	5 - 3	2
*	Multiplication	6 * 5	30
/	Division	9 / 3	3
%	Modulus	10 % 3	1

c. Relational operators

Operator	Meaning	Example (x = 3, y = 5)	Result
= =	Equal to	\$x == \$y	False
!=	Not equal to	\$x != \$y	True
<	Less than	\$x < \$y	True
>	Greater than	\$x > \$y	False
<=	Less than or equal to	\$x <= \$y	True
>=	Greater than or equal to	\$x >= \$y	False

d. Logical Operators

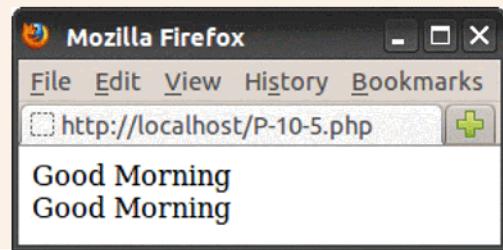
Operator	Meaning	Example (a = 7, b = 2, c = 9)	Result
and	Returns True if two or more relational expressions are true	(a>b) and (a>c)	False
&&	Returns 'True' if two or more relational expressions are true	(a>b) && (a>c)	False
or	Returns 'True' if at least one of the given relational expressions is true	(a>b) or (a>c)	True
	Returns True if at least one of the given relational expressions is true	(a>b) (a>c)	True
xor	Returns True if only one of two expressions is true	(a>b) xor (a>c)	True
!	Returns True if an expression is not true	! (a>b)	False

e. String operators

There are two types of string operators, the **concatenating operator ('.')** and the **concatenating assignment operator ('.=')**. The concatenating operator joins the right and the left string into a single string. The concatenating assignment operator adds the argument that is placed on the right side of the equal operator with the argument placed on the left side of the 'equal' operator.

Program 10.5 Program to illustrate the concatenation operation

```
<HTML>
<BODY>
<?php
    $string1= 'Good';
    $string2= ' Morning';
    $newstring = $string1.$string2; //concatenation
    $string1 .= $string2; //concatenation assignment
    echo $newstring."<BR>";
    echo $string1;
?
</BODY>
</HTML>
```

**f. Combined operators**

Combined operators are the combination of different types of operators, just like in C++.

Operator	Meaning	Example	Equivalent Operation
<code>+=</code>	Plus Equals	<code>\$x += 2;</code>	<code>\$x = \$x + 2;</code>
<code>-=</code>	Minus Equals	<code>\$x -= 4;</code>	<code>\$x = \$x - 4;</code>
<code>*=</code>	Multiply Equals	<code>\$x *= 3;</code>	<code>\$x = \$x * 3;</code>
<code>/=</code>	Divide Equals	<code>\$x /= 2;</code>	<code>\$x = \$x / 2;</code>
<code>%=</code>	Modulo Equals	<code>\$x %= 5;</code>	<code>\$x = \$x % 5;</code>
<code>.=</code>	Concatenate Equals	<code>\$string1.= "hello";</code>	<code>\$string1= \$string1."hello";</code>

g. Increment and decrement operators

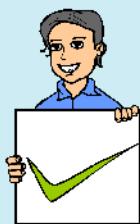
Operator	Meaning	Example (if <code>x = 2</code>)	Output
<code>++value</code>	Pre increment	<code>echo ++\$x;</code>	3
<code>--value</code>	Pre decrement	<code>echo --\$x;</code>	1
<code>value++</code>	Post increment	<code>echo \$x++;</code>	2
<code>value--</code>	Post decrement	<code>echo \$x--;</code>	2

h. Escape sequences

In PHP, a single character, headed by a back slash (\), is an escape character. The HTML <PRE> tag is used to display escape sequences in the user's browser.

Operator	Meaning	Statement	Output
\"	Print double quote	echo \"Hello\";	"Hello"
\'	Print single quote	echo 'Raju\'s';	Raju's
\n	Print new line char	echo "Raju\nHari";	Raju Hari
\t	Print tab	echo "Raju\tHari";	Raju Hari
\r	Print carriage return		
\\$	Print \$	echo "50\\$";	50\$
\\"	Print backslash	echo "C:\\Windows";	C:\Windows;

Know your progress



1. PHP stands for _____.
2. PHP files have a default file extension of _____.
3. Who is known as the Father of PHP?
4. In PHP _____ is used for a single line comment.
5. WAMP stands for _____.
6. LAMP stands for _____.
7. A PHP script should start with _____ and end with _____.
8. Variables always start with a _____ in PHP.
9. The PHP syntax is similar to that of _____ language.
10. What is the use of var_dump()?
11. The dot(.) operator is used for _____.

10.3 Control structures in PHP

The 'Control Structure' controls the program flow of PHP. Conditional statements, such as if/else and switch, allow a program to execute different pieces of code, or none at all, depending on some condition. Loops, such as while, do - while and for, support the repeated execution of particular code.

10.3.1 Conditional statements in PHP

a. if statement

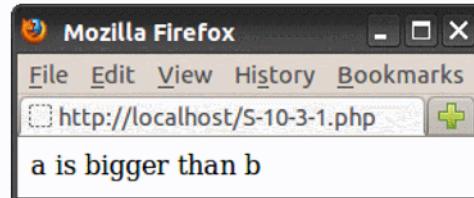
The if statement checks the truthfulness of an expression and, if the expression is true, evaluates a statement.

Syntax

```
if (expression)
{
    //code to execute if the
    //expression evaluates to true
}
```

Example (Check whether a is big)

```
<?php
$a = 10;
$b = 5;
if ($a > $b)
    echo "a is bigger than b";
?>
```



b. else statement

The else statement defines an alternative block of code that should be executed if the expression we are testing evaluates to false.

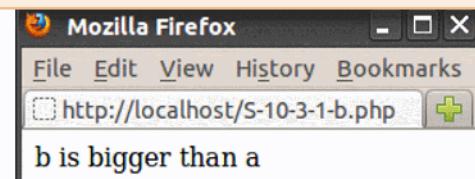
Syntax

```
if (expression)
{
    //code to execute if the
    //expression evaluates to true
}
else
{
    //code to execute if the
    //expression evaluates to false
}
```

Example

(Find the biggest of two numbers)

```
<?php
$a = 10;
$b = 65;
if ($a > $b)
    echo "a is bigger than b";
else
    echo "b is bigger than a";
?>
```



c. elseif statement

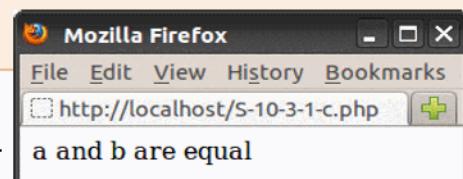
Syntax

```
if (expression)
{
}
elseif (expression)
{
}
elseif (expression)
{
}
else
{
//code to execute in all other cases.
}
```

Example

(Find the biggest of two numbers)

```
<?php
$a = 55;
$b = 55;
if ($a > $b)
    echo "a is bigger than b";
elseif ($b > $a)
    echo "b is bigger than a";
else
    echo "a and b are equal";
?>
```



d. switch statement

The switch statement is similar to a series of if statements on the same expression. Its syntax and working is exactly similar to that of switch statement in C++. One notable difference is that switch in PHP can accept strings as case identifiers.

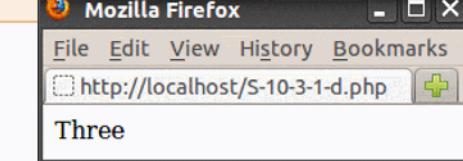
Syntax

```
switch (expression)
{
    case result1:
        //execute this if result of
        //expression is result1
        break;
    case result2:
        //execute this if result of
        //expression is result2
        break;
    default:
        //execute this if result of
        //expression does not match
        //any case results
}
```

Example

(Print a no. from 1 to 3 in words)

```
<?php
$n = 3;
switch ($n)
{
    case 1:
        echo "One";
        break;
    case 2:
        echo "Two";
        break;
    case 3:
        echo "Three";
        break;
    default:
        echo "Enter correct no.";
?>
```



10.3.2 Loops in PHP

a. while loop

The 'while' control structure executes the nested statements repetitively until the expression returns a false value.

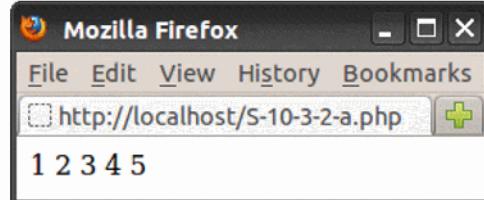
Syntax

```
while (expression)
{
    //code to execute if the
    //expression evaluates to true
}
```

Example

(Prints natural numbers from 1 to 5)

```
<?php
$i = 1;
while ($i <= 5)
{ echo "$i ";
    $i++; }
?>
```



b. do-while loop

The do...while statement will execute a block of code at least once - it then will repeat the loop as long as the condition is true.

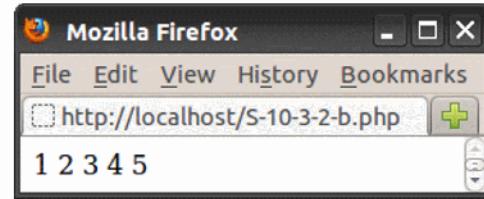
Syntax

```
do
{
    //code to execute if the
    //expression evaluates to true
} while (expression);
```

Example

(Prints natural numbers from 1 to 5)

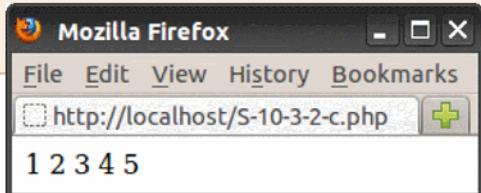
```
<?php
$i = 1;
do
{ echo "$i ";
    $i++; }
while ($i <= 5);
?>
```



c. for loop

The 'for' loop is used when we know how many times we want to execute a statement or a block of statements.

Syntax
<pre>for(initialization; condition; increment) { //code to be executed; }</pre>

Example (Prints natural numbers from 1 to 5)
<pre><?php for (\$i = 1;\$i <= 5; \$i++) { echo "\$i "; } ?></pre> 

e. continue and break in loops

`continue` is used within looping structures to skip the rest of the current loop iteration and continue execution at the condition evaluation and then begin the next iteration.

`break` ends execution of the current `for`, `foreach`, `while`, `do-while` or `switch` structure. `break` accepts an optional numeric argument which tells it how many nested enclosing structures are to be broken out of (like `break 1;`, `break 2;` etc.).

10.4 Arrays in PHP

An array in PHP is a collection of key and value pairs. It maps (associates) values to keys. As in C++, values contain information to be stored and keys are used to identify these values.

For example, in C++ if we write `a[1] = 10;` then we can say, the index '1' is the key and '10' is the value. Both key and value are allocated in a single variable and it is called an array element. In C++ we use only non negative integers as keys (or index). But in PHP we can use either non negative integers or strings as keys.

In PHP, there are three types of arrays:

- Indexed arrays
- Associative arrays
- Multidimensional

Out of this we will be discussing only indexed array and associative array.

10.4.1 Indexed arrays

Arrays with numeric index are called indexed arrays. They are almost similar to arrays in C++. They use non-negative integers as keys. These arrays can store numbers, strings and any object but their index will be represented by numbers. By default array index starts from zero. The function `array()` can be used to create an array.

Syntax for indexed arrays:

```
$array_name = array(value1,value2,value3,etc.);  
OR  
$array[key] = value;
```

Example for indexed arrays:

```
$regno = array(679867, 658367, 673590);  
$colors = array("red","brown","yellow");  
  
OR  
  
$regno[0] = 658367;  
$regno[1] = 658367;  
$regno[2] = 673590;  
$colors[0] = "red";  
$colors[1] = "brown";  
$colors[2] = "yellow";
```

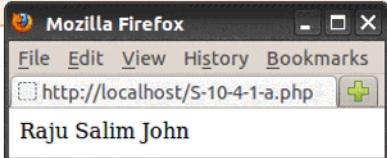
In the above example, the register numbers (679867, 658367, 673590 and "red", "brown", "yellow") are the values and the numeric characters (0, 1 and 2) are the keys of this array.

The function `print_r()` can be used for printing an array in a single statement. The syntax of this function is:

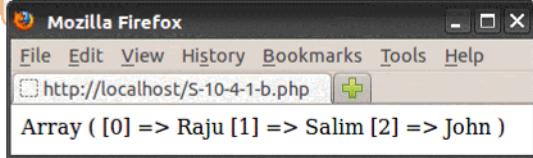
```
print_r(array_name);
```

Example - Simple Array Printing

```
<?php  
$Name = array("Raju",  
             "Salim", "John");  
for ($i = 0; $i < 3; $i++)  
    echo $Name[$i]. " ";  
?>
```

**Example - Array printing using print_r()**

```
<?php  
$Name = array("Raju",  
             "Salim", "John");  
print_r($Name);  
?>
```



10.4.2 Associative arrays

Arrays with named keys are called associative arrays. Associative arrays are very similar to numeric arrays in terms of functionality but they are different in terms of their index. Associative arrays have their index as string.

Syntax for associative arrays:

```
array(key=>value, key=>value, key=>value, etc.);
```

To store the marks of students in an array, a numerically indexed array would not be the best choice. Instead, we could use the student names as the keys in our associative array, and the value would be their respective mark.

```
$result = array("Hari" => "35", "John" => "37", "Mini" => "43");
```

Example for associative array

```
<?php  
$cost=array("Pen"=>"35", "Pencil"=>"5", "Brush"=>"20");  
echo "A pencil costs " . $cost['Pencil'] . " rupees.;"  
?>
```



10.4.3 foreach loops

foreach loop is an extension to for loop. It is used when we have an array with unknown number of elements. It iterates through each key/value pair until the end of the array. The foreach loop works only on arrays and has two formats.

a. foreach (\$array as \$value)

In this type, for every loop iteration, the value of the current array element is assigned to \$value and the array pointer is moved by one, until it reaches the last array element.

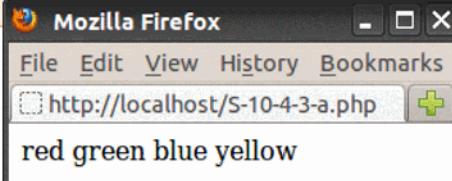
Syntax

```
foreach ($array as $value)
{
    //code to be executed;
}
```

Example

(Demonstration of foreach loop)

```
<?php
$colors = array("red",
    "green", "blue", "yellow");
foreach ($colors as $value)
    {echo "$value "; }
?>
```



b. foreach (\$array as \$key => \$value)

In this type, for every loop iteration, the value of the current array element is assigned to \$value and the key of the current array element is assigned to \$key and the array pointer is moved by one, until it reaches the last array element.

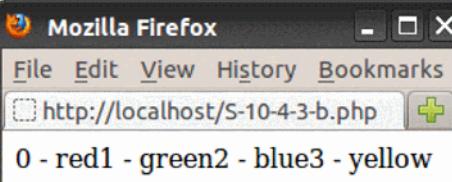
Syntax

```
foreach ($array as $key=>
            $value)
{
    //code to be executed;
}
```

Example

(Demonstration of foreach loop)

```
<?php
$colors = array("red",
    "green", "blue", "yellow");
foreach($colors as $key => $item)
    { echo "$key - $item"; }
?>
```



10.5 Functions in PHP

Just like other languages, in PHP we have user-defined functions and built-in functions.

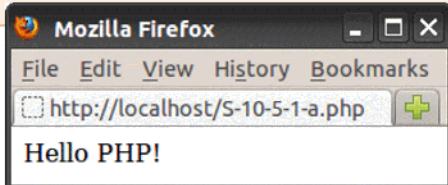
10.5.1 User-defined function in PHP

A user-defined function declaration starts with the word "function". The rules for forming function name are same as that of forming variable names in PHP. The syntax for writing a function is as follows:

```
function functionName()
{
    //code to be executed;
}
```

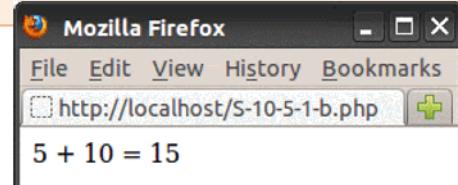
Simple function

```
<?php
function hello()
{
    echo "Hello PHP!";
}
hello(); //call the function
?>
```



Function with argument and return value

```
<?php
function add($a, $b)
{
$c = $a + $b;
return $c;
}
echo "5+10 =" . add(5,10);
?>
```



Create an associative array containing the name and mark of 5 students and display it back (here key is 'name' and value is 'mark').

Let us do

10.5.2 Built in functions

PHP comes with many useful built-in functions. Some of them are:

a. **Date()** function

The PHP date () function is used to format a date and/or a time. Its syntax is

```
date(format,timestamp)
```

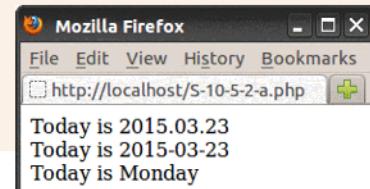
The parameter 'format' specifies the format of the date and the parameter 'timestamp' which is optional specifies a timestamp. Default timestamp is the

current date and time. Some characters that are commonly used for date format are:

- d - day of the month (01 to 31)
- m - month (01 to 12)
- Y - year (in four digits)
- l - day of the week

Example for date function

```
<HTML>
<BODY>
<?php
    echo "Today is ".date("Y.m.d")."<BR>";
    echo "Today is ".date("Y-m-d")."<BR>";
    echo "Today is " . date("l");
?
</BODY>
</HTML>
```



b. String functions

chr() - The chr() function returns a character from the specified ASCII value. Its syntax is `chr(ascii)`

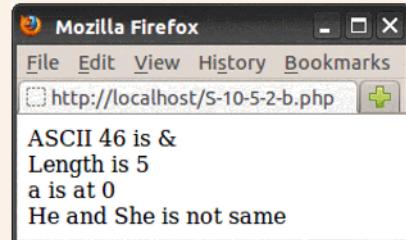
strlen() - The strlen() function returns the length of a string. Its syntax is `strlen(string)`

strpos() - The strpos() function finds the position of the first occurrence of a string inside another string. Its syntax is `strpos(string, find, start)`

strcmp() - The strcmp() function compares two strings. Its syntax is `strcmp(string1, string2)`

Example for string functions

```
<HTML>
<BODY>
<?php
    echo "ASCII 46 is ".chr(046)."<BR>";
    echo "Length is ".strlen("Apple")."<BR>";
    echo "a is at ".strpos("apple", "a")."<BR>";
    if (strcmp("He", "She"))
        echo "He and She is not same";
    else
        echo "He and She is same";
?
</BODY>
</HTML>
```



Know your progress



1. What is the use of array() function in PHP?
2. What are the types of loops that exist in PHP?
3. Which are the different types of arrays in PHP?
4. Which of the following are correct ways of creating an array?
 - i. state[0] = "karnataka";
 - ii. \$state[] = array("karnataka");
 - iii. \$state[0] = "karnataka";
 - iv. \$state = array("karnataka");
 - a. iii and iv
 - b. ii and iii
 - c. Only i
 - d. ii, iii and iv
5. Arrays that use string keys are called _____.
6. What will be the output of the following code?

```
$Rent = 250;
function Expenses ($Other)
{
    $Rent = 250 + $Other;
    return $Rent;
}
Expenses (50);
echo $Rent;
```

 - a. 300
 - b. 250
 - c. 200
 - d. Program will not compile
7. _____ function is used in PHP to return the length of a string.
8. How can we find the current date and time in PHP?



Let us do

1. Write a function in PHP to find the factorial of a number passed as parameter.
2. Write a program to display the current year

10.6 Three tier architecture in PHP

Three-tier architecture is a client-server architecture in which the functionalities like user interface, application programs, data storage etc. are separated into layers. Layers are also called 'tiers'. Even though all these tiers can be in a single machine, usually different tiers are located in physically separate computers as in Fig 10.3. In the 3-tier architecture, it is easy to modify one layer without affecting the other layer. The three tiers in the web based application development are

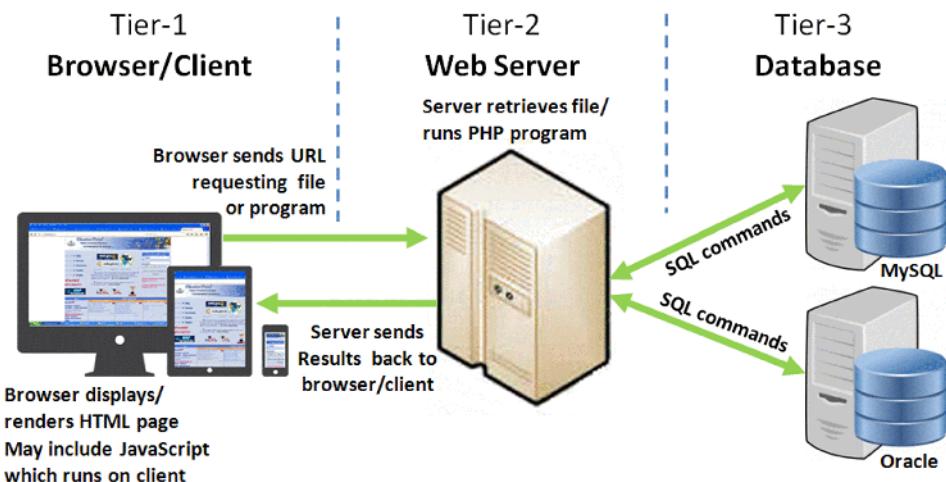


Fig 10.3: Three Tier Architecture

- Tier-1:** The front end in which the content is rendered by the browser. Depending on the content received by the browser from the web server, which may be HTML or HTML embedded with JavaScript, the browser generates static or dynamic page.
- Tier-2:** A middle, dynamic content processing and generation level containing a web server or an application server (e.g.: Apache for PHP platform). It accepts the requests from browser/client, runs the requested script and sends back the output to browser/client as HTML..
- Tier-3:** A back-end database or data store, comprising both data sets and the DBMS software that manages and provides access to the data (e.g.: MySQL server). The DBMS software interprets and executes the SQL commands sent from the web server and sends back the result to web server.

We have already learned HTML, MySQL and client-side scripting using JavaScript. In the next sections we will learn to connect PHP to the client and database, and construct a three tier architecture using PHP.

10.7 PHP forms

In PHP, forms are used to collect information from the client and pass it to the server. PHP is capable of accepting and manipulating input from all the form elements (like textbox, combobox, button etc.). In this section we will learn how the client sends information to the server, how the server acquires and works with the information submitted by client, and how the server sends back the result to the client.

Let us see an example which demonstrates the working of forms. In the following example (Figure 10.4), the form displayed in a browser at the client side collects the register number of a student in a textbox. When the "Submit" button is pressed, client sends this register number to the server. The server receives the register number and searches the database (here MySQL) for data associated with this register number. If it is found, the server creates a webpage containing the data received from the database or else server creates a webpage showing an error message (like "Wrong Register Number"). This web page is then sent back to the client.

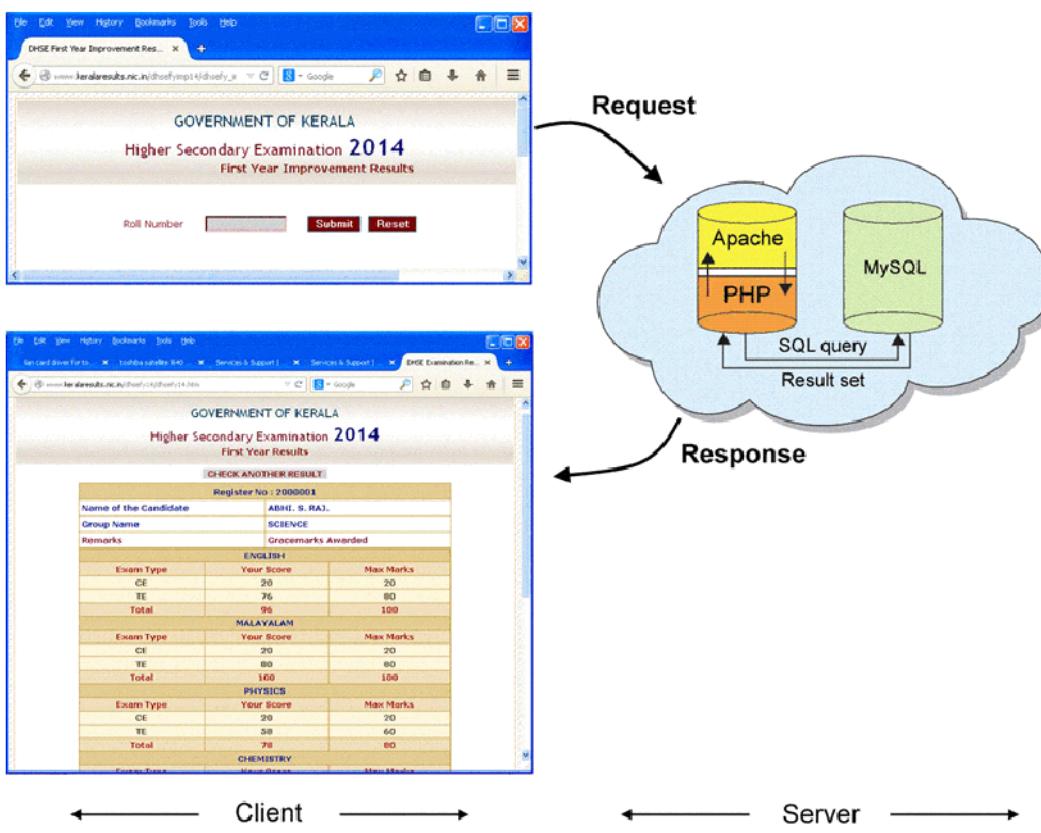


Fig : 10.4 Information flow between client and server

Before discussing how to create a form for acquiring data from the users, we need to understand global variables.

10.7.1 PHP global variables

Global variables are variables that are always accessible from anywhere in the code. Regardless of scope we can access them from any function, class or file. Usually global variables are declared in the initial part of a script and outside a function.

Superglobal arrays

PHP contains certain predefined global arrays called "superglobal". A superglobal array is a special variable that are always available in scripts, regardless of the current scope of the script. Each superglobal has a different useful purpose.

Superglobal	Description
<code>\$GLOBALS</code>	Variables available in the global scope
<code>\$_SERVER</code>	Information about the server
<code>\$_GET</code>	Data passed using the HTTP GET method
<code>\$_POST</code>	Data passed using the HTTP POST method
<code>\$_REQUEST</code>	Data passed via an HTTP request
<code>\$_FILES</code>	Data passed by an HTML file input
<code>\$_SESSION</code>	Current session data specific to the user
<code>\$_COOKIE</code>	Data stored on the user's browser as a cookie

Out of this we will discuss few essential superglobals here.

A. PHP `$GLOBALS`

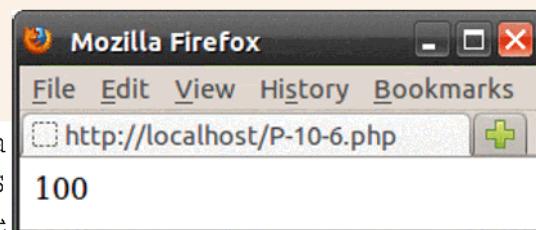
`$GLOBALS` is a PHP super global variable which is used to access global variables from anywhere in the PHP script. PHP stores all global variables in an array called `$GLOBALS [index]`. The index holds the name of the variable.

The example below shows how to use the super global variable `$GLOBALS`:

Program 10.6 to check global array

```
<?php
    $x = 75;
    $y = 25;
    function addition() {
        $GLOBALS['z'] = $GLOBALS['x'] + $GLOBALS['y'];
    }
    addition();
    echo $z;
?>
```

In the example above, since 'z' is a variable present within the `$GLOBALS` array, it is also accessible from outside the function.



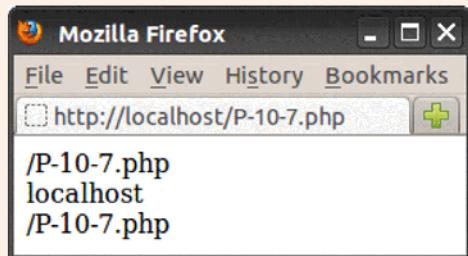
B. PHP \$_SERVER

`$_SERVER` is a PHP super global variable which holds information about headers, paths, and script locations.

The example below shows how to use some of the elements in `$_SERVER`:

Program 10.7 to check `$_SERVER` variable

```
<?php  
echo $_SERVER['PHP_SELF'];  
echo "<BR>";  
echo $_SERVER['SERVER_NAME'];  
echo "<BR>";  
echo $_SERVER['SCRIPT_NAME'];  
?>
```



The following table explains the elements inside `$_SERVER` used above:

Element/Code	Description
<code>\$_SERVER['PHP_SELF']</code>	Returns the filename of the currently executing script
<code>\$_SERVER['SERVER_NAME']</code>	Returns the name of the host server.
<code>\$_SERVER['SCRIPT_NAME']</code>	Same as <code>\$_SERVER['PHP_SELF']</code>

C. PHP \$_REQUEST

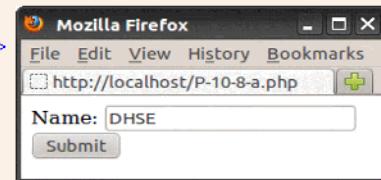
The `$_REQUEST` superglobal is an array that contains the contents of the `$_GET`, `$_POST`, and `$_COOKIE` superglobals. It is used to collect data after submitting an HTML form.

The code in program 10.8(a) shows a form with an input field and a submit button. When a user submits the data by clicking on "Submit", the form data is sent to the file specified in the `Action` attribute of the `<FORM>` tag. Then, the super global variable `$_REQUEST` used in the code given in Program 10.8(b) collects the value of the input field and displays it by putting the text "Hello" in front of this value.

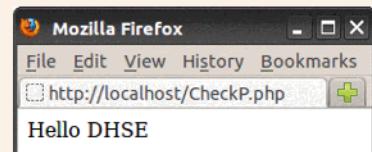
Hereafter we will see two program codes - an HTML code and a PHP code to illustrate the remaining concepts.

Program 10.8(a) [HTML] to check \$_REQUEST variable

```
<HTML>
<BODY>
<FORM Method="post" Action="CheckR.php">
Name :
<INPUT Type="text" Name="fname">
<INPUT Type="submit" Value="Submit">
</FORM>
</BODY>
</HTML>
```

**Program 10.8(b) [CheckR.php] to check \$_REQUEST variable**

```
<?php
$name = $_REQUEST['fname'];
echo "Hello " . $name;
?>
```

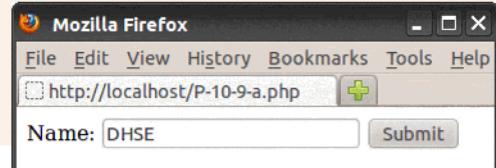
**D. PHP \$_POST**

PHP \$_POST is widely used to collect form data after submitting an HTML form with method="post".

The example below shows a form with an input field and a submit button. When a user submits the data by clicking on "Submit", the form data is sent to the file specified in the action attribute of the <FORM> tag. Then, we can use the super global variable \$_POST to collect the value of the input field:

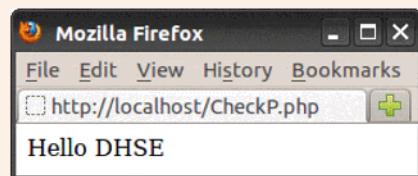
Program 10.9(a) [HTML] to check \$_POST variable

```
<HTML>
<BODY>
<FORM Method="post" Action="CheckP.php">
Name :
<INPUT Type="text" Name="fname">
<INPUT Type="submit" Value = "Submit">
</FORM>
</BODY>
</HTML>
```



**Program 10.9(b) [CheckP.php] to check \$_POST variable**

```
<?php  
    $name = $_POST['fname'];  
    echo "Hello " . $name;  
?>
```

**E. PHP \$_GET**

PHP \$_GET is also used to collect form data after submitting an HTML form with method="get". \$_GET can also collect data sent in the URL..



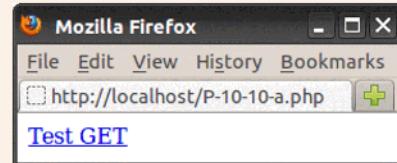
Try executing the example after changing the "POST" in above form (Method="post" with Method="get") and script with "GET" (\$name=\$_POST['fname']); with \$name=\$_GET['fname'];)

Let us do

In GET, the parameters can also be sent along with the hyperlink as in the following example.

Program 10.10(a) [HTML] to check hyperlink with parameters using \$_GET

```
<HTML>  
<BODY>  
    <A href="get.php?exam=March2014&web=  
        www.dhsekerala.gov.in"> Test GET</A>  
</BODY>  
</HTML>
```



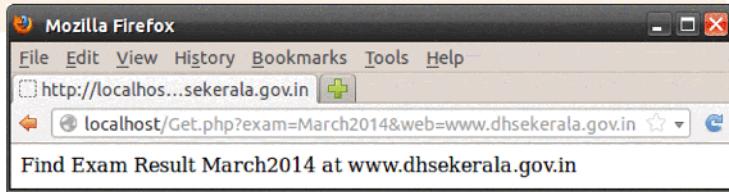
When a user clicks on the link "Test GET", the parameters "exam" and "web" are sent to "get.php", and we can then access their values in "get.php" with \$_GET.

Program 10.10(b) [Get.php] to check \$_GET variable

```
<?php  
    echo "Find Exam Result ".$_GET['exam'];  
    echo " at ".$_GET['web'];  
?>
```

10.7.2 GET and POST comparison

Both GET and POST are methods used to send information from a form to web server. Both creates an array (e.g. array(key1 =>



`value1, key2 => value2, key3 => value3, ...)`) that holds key/value pairs, where keys are the names of the form controls and values are the input data from the user.

The corresponding array names of GET and POST methods are `$_GET` and `$_POST` respectively. These are superglobals, i.e. they are always accessible, regardless of scope - and you can access them from any function, class or file without having to do anything special.

`$_GET` is an array of variables passed to the current script via the URL parameters.

`$_POST` is an array of variables passed to the current script via the HTTP POST method.

A. When to use GET?

Information sent from a form with the GET method is visible to everyone (all variable names and values are displayed in the URL). GET can send only 2000 characters. However, since the variables are displayed in the URL, it is possible to bookmark the page. GET may be used for sending non-sensitive data.



GET should never be used for sending passwords or other sensitive information!

B. When to use POST?

Information sent from a form with the POST method is invisible to others (all names/values are embedded within the body of the HTTP request) and has no limits on the volume of data sent. As this method is secure, most developers prefer POST for sending form data. However, since the variables are not displayed in the URL, it is not possible to bookmark the page.

Method = GET	Method = POST
The data remains visible in the address bar since contents are passed as part of the URL.	The data is not visible as contents are passed to the script as an input file.
Page link can be bookmarked.	Page link can never be bookmarked.
Data is submitted as part of the URL.	Data is submitted as part of an http request.
Data sending is fast but not secure.	Data sending secure but slow as compared to get.
GET can only send 2000 characters.	No limit.

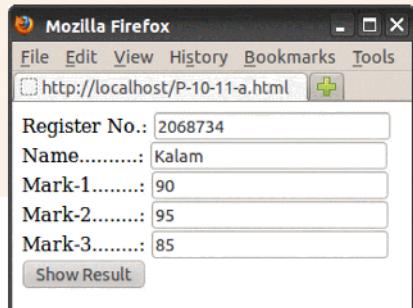
Project

Now we know how a form collects data from the user/client, how it submits (sends) it to the server and how the server sends the result back to user/client. Let us consolidate this by executing a project which would demonstrate what we have learned regarding web based programming.

Create a form which accepts the register number, name and marks (out of 100) in three subjects and submit it to the server. The script at the server should receive the data, calculate the result and send it back to the client. To pass the examination a student should get a minimum of 40 marks in each subject. If the total marks < 150 it is "Passed", total marks ≥ 150 and < 180 it is "Second Class", if total marks ≥ 180 and < 225 it is "First Class" and if total marks ≥ 225 it is "Distinction".

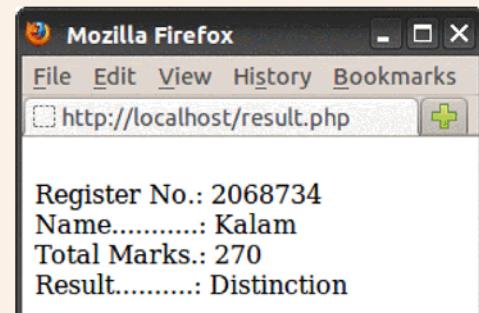
Program 10.11(a) [HTML] Form to accept student data

```
</HTML>
</BODY>
<FORM Method="post" Action="Result.php">
    Register No.:
    <INPUT Type="text" Name="regno"> <BR>
    Name.....:
    <INPUT Type="text" Name="sname"> <BR>
    Mark-1.....:
    <INPUT Type="text" Name="mark1"> <BR>
    Mark-2.....:
    <INPUT Type="text" Name="mark2"> <BR>
    Mark-3.....:
    <INPUT Type="text" Name="mark3"> <BR>
    <INPUT Type="submit" Value="Show Result">
</FORM>
</BODY>
</HTML>
```



Program 10.11(b) [Result.PHP] Script which displays the result

```
<?php
    $m1 = $_POST ['mark1'];
    $m2 = $_POST ['mark2'];
    $m3 = $_POST ['mark3'];
    $tmarks = $m1 + $m2 + $m3;
    if (($m1<40) || ($m2<40) || ($m3<40))
        $result = "Failed";
    elseif ($tmarks < 150)
        $result = "Passed";
    elseif ($tmarks < 180)
        $result = "Second Class";
    elseif ($tmarks < 225)
        $result = "First Class";
    else
        $result = "Distinction";
    echo "<BR> Register No.: " . $_POST ['regno'];
    echo "<BR> Name.....: " . $_POST ['sname'];
    echo "<BR> Total Marks.: " . $tmarks;
    echo "<BR> Result.....: " . $result;
?>
```



Create an HTML form that accepts a register number and submits to "display.php". The display.php displays the received register number on the browser.

Execute the above with the GET method and

- Note down the URL in address bar of the browser, after submitting the form.
- Bookmark the form after submitting and try to recall the form from bookmark.

Change the method to POST and repeat the above steps.



Let us do

10.8 Connecting PHP to database (MySQL)

Static web pages (normal pages we build) always look the same and the content never changes unless we load a new page. Dynamic pages do the opposite, they change every time they are loaded and they can change their content based on what users do, like clicking on some button, text or an image. A dynamic website creates

a new web page each time when someone requests information. These web pages are automatically built by the web server by pulling information from the database into a web page template upon request and send a standard HTML page back to the browser. The web server builds this webpage by following the instructions written using a server side scripting language, by the programmer.

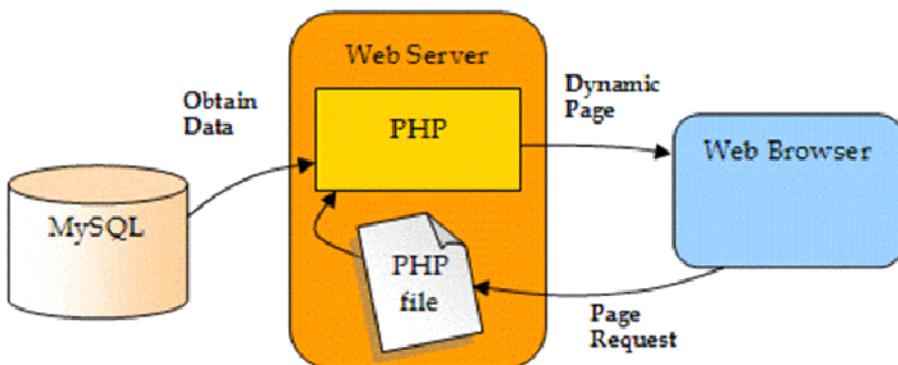


Fig. 10.5: Interactions between Browser, PHP and Database

One example of a database-driven Web site is "keralaresults.nic.in" discussed in the previous section (see Figure 10.5). This is one of the many websites that publishes the higher secondary examination results. The site's server contains a database which stores the examination results of all candidates who appeared for their examination in an academic year. When the register number is submitted through a form (client side), it reaches the web server. The web server hands this over to the PHP program. The PHP program requests the database server for data associated with this register number through an SQL statement (like `SELECT * FROM marks WHERE regno = 2056789`). Database server searches and finds the data (examination result) for this register number from the database and returns it back to PHP. PHP prepares a neatly formatted web page using HTML and embeds the data retrieved in it. This newly created web page is sent back to the client by the web server.

From the discussions in the previous chapters (database management and SQL), we know how to interact with the database using SQL statements. In this section, we will learn to do the same through a PHP program and to combine the retrieved data with HTML to create dynamic web pages.

10.8.1 Establishing connection to MySQL database

For a PHP program to access data from the database, the program should first establish a connection to the database server (here MySQL) and then specify the database to use. Only after this will PHP program be able to issue SQL queries to the database.

Connection to a MySQL database is done in three steps

1. Open a connection to MySQL.
2. Specify the database we want to open.
3. Retrieve data from or insert data in to database.
4. Close the connection.

Step 1 - Open a connection to MySQL

`mysql_connect()` function is used to establish a connection between PHP and MySQL database server. It takes three string arguments, the host/server name, the username, and the password. The function returns a link identifier when it successfully connects to the specified MySQL server or NULL up on error.

```
$link_id = mysql_connect("local host", "User ID", "Password");
```

Program 10.12 [Connect.PHP] script to demonstrate connection to MySQL

```
<?php  
$user_name = "root"; //Initialising variables  
$password = "root";  
$server = "localhost";  
//Connecting to MySQL database server  
$db_handle = mysql_connect($server,$user_name,$password);  
if (!$db_handle) {  
    die('Could not connect: ' . mysql_error());  
}  
echo 'Connected successfully';  
mysql_close($db_handle);  
?>
```

In Program 10.12, first three lines are for setting up variables. In this example the username and password is "root".

```
$user_name = "root";  
$password = "root";  
$server = "localhost";
```

The line that connects to MySQL is

```
mysql_connect($server, $user_name, $password);
```

The parameters to mysql_connect can also be given directly as in the following statement

```
mysql_connect( 'localhost', 'root', 'root' );
```



Try executing the example above with wrong password and note down the output.

Let us do

Step 2 - Specify the database you want to open

The MySQL database server may contain a lot of databases. mysql_select_db() function is used to select a particular MySQL database from them. It takes a string which is the database name and a link identifier as argument. If it finds the database, it returns true; or else, false is returned.

```
mysql_select_db($database);
```

Program 10.13 [DBConnect.PHP] Script to demonstrate connection to Database

```
<?php
$user_name = "root";
$password = "root";
$server = "localhost";
$database = "mysql"; //initializing variable
$db_handle = mysql_connect($server,$user_name,$password);
if (!$db_handle) {
    die('Could not connect: ' . mysql_error());
}
echo 'Connected successfully';
//Opening the database mysql
$db_found = mysql_select_db($database);
if ($db_found) {
    echo "Database Found";
}
else {
    echo "Database NOT Found";
}
mysql_close($db_handle);
?>
```

Here we assigned a variable named \$database with the name of our database, using the statement.

```
$database = "mysql";
```

and opened the database with the statement.

```
$db_found = mysql_select_db($database);
```

Here it assumes that the connection to use is the currently active connection. The following statement can also be used for opening the database when we have to use a different connection. Here the resource link identifier of the connection to be used goes as the second parameter.

```
$db_found = mysql_select_db($database, $db_handle);
```

We have connected to the server and selected the database we want to work with. Now we have to start querying the database and create dynamic webpages.

Step 3 - Reading data from database

Reading data from the database is done in two steps.

- Execute the SQL query on the database using the function mysql_query().
 - Populate the rows in to an array using the function mysql_fetch_array().
- This array is used by the PHP program for manipulating the data.

a. mysql_query()

The function mysql_query() is used to execute the SQL query on database. It sends the query to the database and returns a resource type query handle on successful execution.

```
$result_set = mysql_query(query, connection)
```

- For the SQL statements SELECT, SHOW, DESCRIBE or EXPLAIN, mysql_query() returns a resource type query handle on success, or FALSE on error.
- For other type of SQL statements, UPDATE, DELETE, DROP, etc, mysql_query() returns TRUE on success or FALSE on error.
- mysql_query() will also fail and return FALSE if the user does not have permission to access the table(s) referenced by the query.

The returned result resource is passed to mysql_fetch_array() to retrieve data.



Use mysql_num_rows() to find how many rows were returned for a SELECT statement or mysql_affected_rows() to find out how many rows were affected by a DELETE, INSERT, REPLACE, or UPDATE statement.

b. mysql_fetch_array()

The `mysql_fetch_array()` is used to populate rows of data as an array from a MySQL result handle. It takes a result handle returned from `mysql_query()`, as parameter, and returns an array corresponding to the fetched row. The array can be an associative array, a numeric array, or both. If there are no more rows left to fetch, it returns False.

```
$result_set = mysql_query(query, connection);  
$fetched_row = mysql_fetch_array($result_set);
```



Try executing Program 10.13 with a non existing database name, and note down the output.

Let us do

The working of these two functions can be explained with the help of two examples given below.

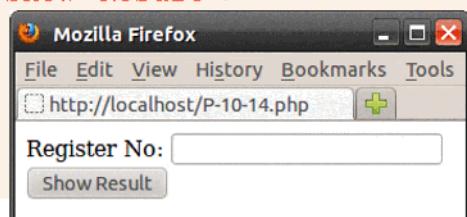
The following program (Program 10.14) accepts a register number using a form and submits it to `showmarks.php`. The PHP program searches the marks table in `mysql` database, finds the data and creates a webpage containing this data.

Note : Before doing the programs Program 10.14 and Program 10.15 listed below, create a table named "Marks" with the following structure in the database named "mysql" and insert a few records into it (Group name should be either Commerce/Science).

Field name	Data Type
regno	Number
sname	Char(20)
sgroup	Char(20)
mark1	Number
mark2	Number
mark3	Number

Program 10.14(a) [HTML] Form to accept student register number

```
<HTML>  
<BODY>  
    <FORM Method="post" Action="showmarks.php">  
        Register No:  
        <INPUT Type="text" name="regno"> <BR>  
        <INPUT Type="submit" Value="Show Result">  
    </FORM>  
</BODY>  
</HTML>
```

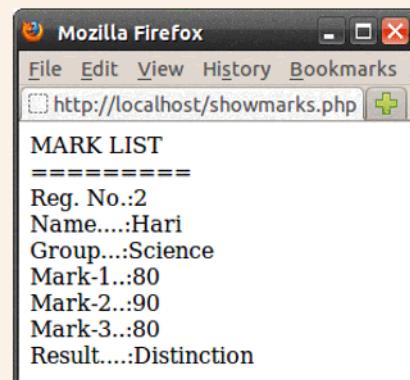


Program 10.14(b) [Showmarks.PHP] Script to search the database and display the result

```

<?php
$user_name = "root";
$password = "root";
$server = "localhost";
$database = "mysql";
$regno = $_POST['regno'];
$db_handle = mysql_connect($server,$user_name,$password);
if (!$db_handle) {
    die("Could not connect: " . mysql_error());
}
$db_found = mysql_select_db($database, $db_handle);
if ($db_found) { //Retrieving data from database
    $SQL = "SELECT * FROM marks WHERE regno = '". $regno."'";
    $result_set = mysql_query($SQL);
    $record = mysql_fetch_array($result_set);
    echo "<BR>MARK LIST";
    echo "<BR>=====";
    echo "<BR>Reg. No.:". $record['regno'];
    echo "<BR>Name....:". $record['sname'];
    echo "<BR>Group...:". $record['sgroup'];
    echo "<BR>Mark-1...:". $record['mark1'];
    echo "<BR>Mark-2...:". $record['mark2'];
    echo "<BR>Mark-3...:". $record['mark3'];
    echo "<BR>Result...:". compute_result($record['mark1'],
                                         $record['mark2'], $record['mark3']);
}
else
{
    echo "<BR>Database NOT Found";
}
mysql_close($db_handle);
//Function to calculate result
function compute_result($m1, $m2, $m3)
{
    $marks = $m1 + $m2 + $m3;
    if (($m1<40) || ($m1<40) || ($m1<40))
        $result = "Failed";
    elseif ($marks < 150)
        $result = "Passed";
    elseif ($marks < 180)
        $result = "Second Class";
    elseif ($marks < 225)
        $result = "First Class";
    else
        $result = "Distinction";
    return $result;
}
?>

```

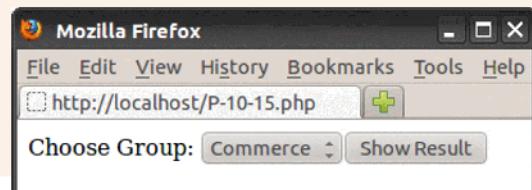


Observe the code enclosed in the rectangle. This portion is responsible for getting data from the database. Here a variable named \$SQL is initialised with the query statement we want to execute. The next statement mysql_query(\$SQL) executes the query statement and returns the result which is stored to the variable \$result_set. This \$result_set is passed to mysql_fetch_array(\$result_set), which returns an associative array created using the data provided by the \$result_set. The array returned by the function is stored in the variable \$record and its content is accessed by specifying the field name as index, like \$record['sname'].

Let us see another program which (Program 10.15) allows us to select a group (science/commerce) using a combo box in a form and displays the result of students studying in that group in a table format.

Program 10.15(a) [HTML] Form to accept the group

```
<HTML>
<BODY>
    <FORM Method="post" Action="showresult.php">
        Choose Group:
        <SELECT Name = "cgroup">
            <OPTION>Science</OPTION>
            <OPTION>Commerce</OPTION>
        <INPUT Type="submit" Value= "Show Result">
    </FORM>
</BODY>
</HTML>
```



Program 10.15(b) [showresult.PHP] Script to search the database and display the result

```
<?php
    $user_name = "root";
    $password = "root";
    $server = "localhost";
    $database = "mysql";
    $db_handle = mysql_connect($server,$user_name,$password);
    if (!$db_handle) {
        die('Could not connect: ' . mysql_error());
    }
    $db_found = mysql_select_db($database, $db_handle);
    if ($db_found)
    {
```

```

$SQL = "SELECT * FROM marks WHERE sgroup =
        '". $_POST[cgroup] . "' ";
$select_query = mysql_query($SQL);
echo "<TABLE Border = 1>";
echo "<TR>";
echo "<TH Colspan=7><CENTER> MARK LIST </CENTER> </TH>";
echo "</TR>";
echo "<TR>";
echo "<TD>Reg No</TD>";
echo "<TD>Name</TD>";
echo "<TD>Group</TD>";
echo "<TD>Mark-1</TD>";
echo "<TD>Mark-2</TD>";
echo "<TD>Mark-3</TD>";
echo "<TD>Result</TD>";
echo "</TR>";
while($record = mysql_fetch_array($select_query)) {
    echo "<TR>";
    echo "<TD>" . $record['regno'] . "</TD>";
    echo "<TD>" . $record['sname'] . "</TD>";
    echo "<TD>" . $record['sgroup'] . "</TD>";
    echo "<TD>" . $record['mark1'] . "</TD>";
    echo "<TD>" . $record['mark2'] . "</TD>";
    echo "<TD>" . $record['mark3'] . "</TD>";
    echo "<TD>" . compute_result($record['mark1'],
        $record['mark2'], $record['mark3']) . "</TD>";
    echo "</TR>";
}
echo "</TABLE>";
}
else {
    echo '<BR>Database NOT Found';
}
mysql_close($db_handle);
//Function to calculate result
function compute_result($m1, $m2, $m3)
{
    $tmarks = $m1 + $m2 + $m3;
    if (($m1<40) || ($m1<40) || ($m1<40))
        $result ="Failed";
    elseif ($tmarks < 150)
        $result ="Passed";
    elseif ($tmarks < 180)
        $result ="Second Class";
    elseif ($tmarks < 225)
        $result ="First Class";
    else
        $result = "Distinction";
return $result;
} ?>

```

The screenshot shows a Mozilla Firefox window with the title bar 'Mozilla Firefox'. Below it is a menu bar with 'File', 'Edit', 'View', 'History', 'Bookmarks', 'Tools', and 'Help'. Under the 'Tools' menu, there is a dropdown with 'http://localhost/showresult.php'. The main content area displays a table titled 'MARK LIST' with the following data:

Reg No	Name	Group	Mark-1	Mark-2	Mark-3	Result
1	Neena	Commerce	75	75	65	First Class
3	Balu	Commerce	45	45	40	Passed
5	Zeenath	Commerce	100	100	100	Distinction

Observe the code enclosed in the rectangle. This portion is responsible for displaying the data from the database in a tabular format. To display the data in a tabular format, the data received through `mysql_fetch_array($result_set)` is arranged using `<TABLE>` tag. During each iteration of while loop, a new row is added to the table using the `<TR> </TR>` tag and the data in the associative array is placed in proper columns using `<TD> </TD>` tag. Each iteration of the loop `mysql_fetch_array($result_set)` loads \$result with new data. Once reading is complete the function returns false and loop exits.

Step 4 - Close the connection

`mysql_close()` is used to close a connection to the database server. The link to the MySQL server is automatically closed when the PHP script is terminated. If we want to close the connection before the termination of the PHP script, this function is used with the link identifier as its argument.

```
mysql_close($db_handle);
```

This function returns True on success and False on error.

See the statement `mysql_close($db_handle);` in the previous examples.



As too many open MySQL connections can cause problems, it is a good practice to close the MySQL connection once all the queries are executed.

10.8.2 Creating a new table using PHP

To create a new table, prepare and execute an SQL statement for creating the table using `mysql_query()` function. An example for this is

```
$SQL = "CREATE TABLE marks (regno number, tname char(20),  
    m1 number,m2 number,m3 number,distinction char(20));"  
$select_query = mysql_query($SQL);
```

10.8.3 Inserting data into a table using PHP

To insert data into table we have to prepare an insert SQL statement and execute it using `mysql_query()` function. Assume that \$sregno, \$sname, \$sm1, \$sm2, \$sm3 and \$sresult contains the data to be inserted. The SQL statement to insert will look like

```
$SQL = "INSERT INTO marks VALUES ('".$sregno."','".$sname."  
    "','".".$sm1."','".$sm2."','".$sm3."','".$sresult."')";  
$select_query = mysql_query($SQL);
```

10.8.4 Updating data in a table using PHP

To update data in a table, we have to prepare an update SQL statement and execute it using `mysql_query()` function. Assume that we want to change mark 'm1' of the register number in the variable \$regno to '70'. The SQL statement for updating will look like

```
$SQL = "UPDATE marks SET m1=70 WHERE regno='".$sregno."'";
$select_query = mysql_query($SQL);
```



Let us conclude

Dynamic webpages are created with the help of server side scripting languages like PHP, Perl, JSP, ASP.NET, etc. Out of various server side scripting languages PHP is the most popular. PHP can run on various web servers and operating systems. With the help of HTML and database like MySQL, PHP can create powerful dynamic web pages and it is easy to learn as it follows the syntax of the language C++.



Let us practice

1. Write a PHP program to display the multiplication table of 5.
2. Write a PHP program to display all palindrome numbers between 100 and 200.
3. Write a PHP program to display all Armstrong numbers below 1000.
4. Display the following table using PHP and HTML. Each cell should display the row number and column number of the cell. You are supposed to use the PHP loop statement to generate the table.

Column 1	Column 2	Column 3	Column 4	Column 5
row 1, col 1	row 1, col 2	row 1, col 3	row 1, col 4	row 1, col 5
row 2, col 1	row 2, col 2	row 2, col 3	row 2, col 4	row 2, col 5
row 3, col 1	row 3, col 2	row 3, col 3	row 3, col 4	row 3, col 5
row 4, col 1	row 4, col 2	row 4, col 3	row 4, col 4	row 4, col 5
row 5, col 1	row 5, col 2	row 5, col 3	row 5, col 4	row 5, col 5
row 6, col 1	row 6, col 2	row 6, col 3	row 6, col 4	row 6, col 5
row 7, col 1	row 7, col 2	row 7, col 3	row 7, col 4	row 7, col 5
row 8, col 1	row 8, col 2	row 8, col 3	row 8, col 4	row 8, col 5
row 9, col 1	row 9, col 2	row 9, col 3	row 9, col 4	row 9, col 5
row 10, col 1	row 10, col 2	row 10, col 3	row 10, col 4	row 10, col 5

5. Write a program to find the biggest of three numbers.
6. Create a registration form which contains the fields Name, Roll No, Gender and a submit button. Write a PHP script which accepts these details and display it back on the browser when the user clicks the submit button.
7. Write a PHP script for the following: Design a form to accept a string. Write a function to count the total number of vowels (a,e,i,o,u) from the string.
8. Create a table in MySQL and insert a few records. Write a PHP script to display the inserted records on a browser.
9. Create a table in MySQL and insert a few records. Write a PHP script to accept a value using a form, search the value in database and display the record on a browser.

Let us assess

1. Which of following functions returns 1 when the output is successful?
a. echo () b. print () c. both d. None
2. Which of the following printing constructs accepts multiple parameters?
a. echo b. print c. printf d. All of the above
3. Which one of the following should not be used while sending passwords or other sensitive information?
a. GET' b. POST' c. REQUEST' d. NEXT'
4. Which of the following functions returns the number of characters in a string variable?
a. count(\$variable) b. len(\$variable)
c. strcount(\$variable) d. strlen(\$variable)
5. Which of the following variables is not a predefined variable?
a. \$GET b. \$ASK c. \$REQUEST d. \$POST
6. When \$_GET' variable is used to collect data, the data is visible to
a. none b. only you c. everyone d. selected few
7. When \$_POST' variable is used to collect data, the data is visible to
a. none b. only you c. everyone d. selected few
8. Which variable is used to collect form data sent with both the GET' and POST' methods?
a. \$BOTH b. \$_BOTH c. \$REQUEST' d. \$_REQUEST
9. Which one of the following parameters is not used in mysql_connect()?
a. database host b. user ID c. password d. database name

10. Study the following steps and determine the correct order
 - i. Open a connection to MySQL server
 - ii. Execute the SQL query
 - iii. Fetch the data from query
 - iv. Select database
 - v. Close Connection

a. 1, 4, 2, 3, 5 b. 4, 1, 2, 3, 5 c. 1, 5, 4, 2, 1 d. 4, 1, 3, 2, 5
11. What is PHP?
12. What is the difference between PHP and JavaScript?
13. What are the steps involved in running a PHP?
14. What is the use of "echo" in PHP?
15. What is the use of 'print' in PHP?
16. What are the differences between "echo" and "print" statements?
17. Why is PHP superior to client-side languages such as JavaScript?
18. Which character is used to terminate a PHP statement? Name one situation where omitting this termination character does not produce an error.
19. What is an escape sequence? Name three commonly used escape sequences.
20. What will be the output of the following PHP scripts?
 - a. <?php
echo "Today looks\nbright and sunny";
?>
 - b. <?php
echo "Ours not to question why:";
echo "Ours but to do and die";
?>
 - c. <?php
\$x = 8;
\$y = 8;
echo (\$x == \$y);
?>

21. Find the error in each of the following PHP scripts:

- <?php
/* print a line of output /
echo 'Hello'
?>
- <?php
echo '<p align="right">Copyright Me, 2008</p>';
?>
- <?php
echo 'Line 1;
?>

22. Which are the different types of loops in PHP?

23. How do we declare an array in php?

24. What is the importance of "action" attribute in an HTML form?

25. How can we extract the string "hotmail.com" from a string "scert@hotmail.com"?

26. What will be the output of the following code?

```
$a = 10;  
if ($a > 5 or < 15)  
    echo 'true';  
else  
    echo 'false';
```

27. What will be the output of the following code?

```
function fn ($var)  
{  
$var = $var - ($var/10*5);  
return $var;  
}  
echo fn(100);
```

28. How do super-global arrays help programming in PHP?

29. What is the use of \$_SERVER?

30. What are the differences between GET and POST methods in form submitting?

31. While submitting a form, the URL displayed on the address bar was `http://localhost:8080/check2.php?exam=March2014&web=www.dhsekerala.gov.in`. Can you identify which method was used here?
32. While trying to open a dynamic webpage from a bookmark saved earlier, the webpage did not show properly. What could be the reason for this?
33. How do we create a MySQL connection?
34. How do we select a MySQL database from PHP?
35. How do we execute an SQL query? How to fetch its result?
36. What is the difference between PHP and JavaScript?
37. Explain the procedure for connecting PHP with MySQL.



11

Advances in Computing

Significant Learning Outcomes

After the completion of this chapter, the learner

- recalls serial computing.
- identifies different distributed computing paradigms.
- compares serial computing and parallel computing.
- distinguishes between cluster computing and grid computing.
- identifies the cluster computing techniques.
- recognises the need of grid computing.
- analyses the need of cloud computing models.
- explains the role of artificial intelligence in modern day computing.
- identifies the use of biometric equipment in service sectors.
- explains the relevance of computer vision by citing the examples.
- identifies the scope of robotics.
- explains bioinformatics and its relevance in the medical field.
- describes remote sensing and its application areas.
- judges the need of GIS.

The growing popularity of the Internet and the availability of powerful computers and high-speed networks with low-cost components have been changing the way of computing. We know that the computing world is constantly changing and requires the use of new technologies to solve emerging real world problems. In this chapter, we will discuss advanced computing paradigms to meet the ever changing computing needs in various fields. The distributed computing system uses multiple computers to solve large-scale problems over the Internet. It becomes data-intensive and network-centric. Nowadays, applications of distributed computing have become increasingly widespread. In distributed computing, the main stress is on large scale resource sharing and always goes for the best performance. Social media sites like Facebook, Twitter, etc., search engine websites like Google, Bind, etc. are implemented on the concept of largely distributed computing systems. These are running in centrally controlled data centers. However, the trend in these massively scalable systems is making use of advanced computing models like cluster, grid, cloud, etc. A brief discussion of all these areas will be made in this chapter.

Computational intelligence is an area where a lot of research is going on. An intelligent computer should be able to interact with human beings. Cybernetics is the study of the interaction between humans and machines. Artificial intelligence was always an area of immense curiosity. Many technologies such as biometrics, Natural Language Processing (NLP), robotics, etc. implement artificial intelligence in varying degrees. Computers are known for accuracy both in accepting input and providing output. In this chapter we also discuss another area of computing called soft computing, which is tolerant of imprecision, uncertainty, partial truth and approximation. Like any other subject, Biology also received contributions from developments in computing. Bioinformatics is the application of computer technology to the management of biological information. Scientists are keen on developing DNA computing which may change the world for the better. These topics are also discussed here. This chapter concludes with the discussion on remote sensing and Geographical Information Systems (GIS).

11.1 Distributed computing paradigms

Historically, the field of computing has gone through a series of changes in hardware, operating system platforms, networking, etc. Computers have become very much part of our daily lives. Distributed computing ensures that computer systems are used effectively. Distributed computing is a method of computer processing in which different parts of a program are run simultaneously on two or more computers that are communicating with each other over a network.

The term paradigm means a pattern or a model in the study of any subject of complexity. We can identify and classify the details of the subject in accordance with these models. Advanced computing paradigms are essential to extend our ability to process information for many sectors of our society. Advanced computing paradigms include parallel computing, cluster computing, grid computing, cloud computing, etc. All these are various forms of parallel and distributed computing which are discussed below.

11.2 Distributed computing

Let us now consider a real world case where we use distributed computing. We know that banks follow the core banking system. As a result of this, money can be withdrawn from any Automatic Teller Machine (ATM) counter. Similarly we can book railway or airline tickets online. All these are possible by making use of the distributed computing environment. World Wide Web (WWW) is the best example of a large distributed system. Nowadays distributed systems dominate the computing environment.

Distributed computing is a method of computing in which large problems can be divided into many small problems which are distributed to many computers. Later, all the small results are assembled to get the desired overall solution. Distributed computing provides a way to reduce the time it takes to perform a large task. It is accomplished by dividing the task among multiple computers that can work simultaneously. Distributed computing completes the job in time less than what a single machine requires. Distributed computing is a method of computing in which different parts of a program are run simultaneously on two or more computers that are communicating with each other over a network.

In distributed computing, all the different processors have their own private non-shareable memory. Thus information is exchanged between the processors solely on the basis of messages. Figure 11.1 shows a distributed computing architecture.

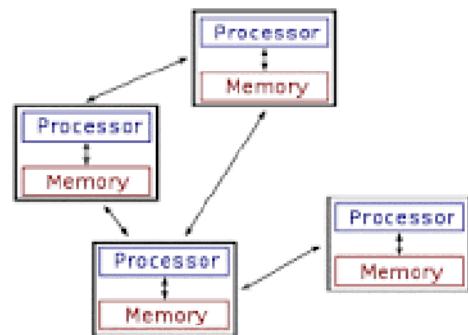


Fig. 11.1: Distributed computing

a. Advantages

The advantages of distributed computing are given below.

Economical: Distributed computing reduces overall computing cost.

Speed: By spreading the computational load across different nodes, each location is under less stress, as a result of which speed increases.

Reliability: Distributed systems can continue to function even if one node ceases to function.

Scalability: In distributed computing the number of nodes can vary according to the demand.

b. Disadvantages

The limitations of distributed computing are listed below.

Complexities: A lot of extra programming is required to set up a distributed system.

Security: Information needs to be passed to the computers in the network. It can be tracked and can be used for illegal purpose.

Network reliance: Distributed system is connected through a network and in case of network failure, the entire system may become unstable.

Let us now discuss various types of distributed computing.

11.2.1 Parallel computing

Traditionally, a software has been written for serial computation. i.e., it is to be run on a single computer having a single processor. Here a problem is broken into a series of instructions. Instructions are to be executed one by one sequentially. Only one instruction is executed at a time. It is referred to as serial computing. Fig.11.2 shows serial processing.

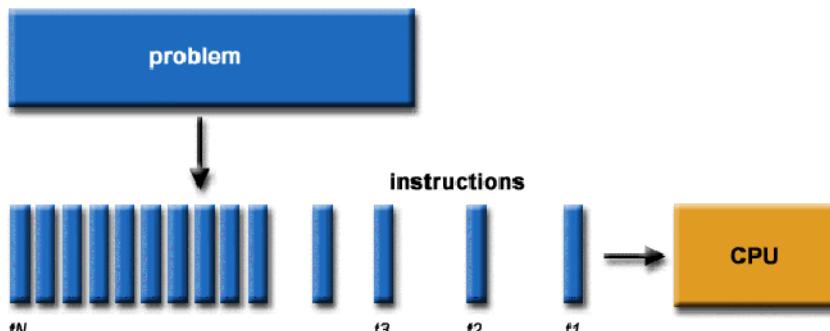


Fig. 11.2: Serial processing

Suppose there are five men lifting a rock with a single rope. Here all of them are trying to lift the rope in parallel. Similarly in parallel computing a problem is solved by different processing units. The problem will be subdivided among the various CPUs. Parallel computing is a form of computation in which many calculations are carried out simultaneously, operating on the principle that large problems can often be divided into smaller ones, which are then solved concurrently. In parallel computing, all the different processors have the access to a shared memory. This memory can also be used to share information between different processors rather than explicitly sending messages. Fig.11.3 shows parallel processing and Fig.11.4 describes the sharing of common memory among various processing units. Table 11.1 compares serial computing and parallel computing. Some of the fields in which parallel computing is applied are weather forecasting, nuclear sciences, aerospace engineering, etc.

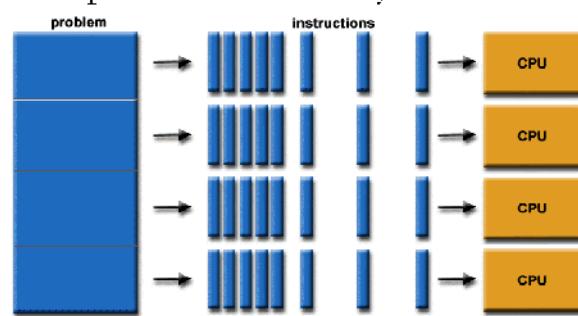


Fig. 11.3: Parallel processing

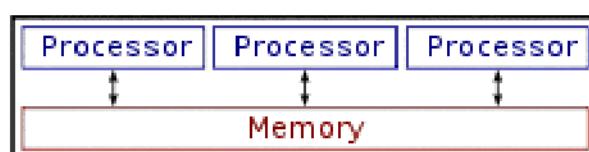


Fig. 11.4: Memory sharing in parallel processing

Serial computing	Parallel computing
A single processor is used.	Multiple processors are used with a shared memory.
A problem is broken into a discrete series of instructions.	A problem is broken into discrete parts that can be solved concurrently.
Instructions are executed sequentially one after another.	Instructions from each part execute simultaneously on different processors.
Only one instruction is executed on a single processor at any moment of time.	More than one instruction is executed on multiple processors at any moment of time.

Table 11.1: Comparison between serial and parallel processing



A supercomputer is simply a fast computer with a large number of CPUs. An ordinary computer uses serial processing. But the super computer works in an entirely different way, typically using parallel processing instead of the serial processing. i.e., instead of doing one thing at a time, it does many things at a time.



AADITYA super computer used by Indian Institute of Tropical Meteorology is currently considered as India's fastest supercomputer. AADITYA is 790 + Tera Flops High Performance Computing System formed using IBM iDataPlex cluster.

a. Advantages of parallel computing

Parallel computing provides several advantages. Some of them are given below:

- In parallel computing environment even when one or more nodes fails, the whole system still work with reduced performance. It is called fault tolerance.
- Each user can share the computing power and storage resources in the system with other users.
- Distributing several tasks to different nodes can help sharing of load to the whole system. It is called load sharing.
- It is easily expandable. It can scale to large extend.

b. Disadvantages of parallel computing

Some of the limitations of parallel computing are:

- Parallel applications are much more complex than corresponding serial applications.
- A program may run on one machine, but when ported to a different computer, significant changes must be made in order to allow the program to run properly.

11.2.2 Grid computing

Imagine that several million computers (servers, desktops, laptops, etc.) and instruments like, mobile phones, telescopes, sensors, etc. owned by thousands of different people are connected together to form a single huge powerful computer. This is grid computing. Grid computing is described as a world in which computational power (resources, services, data) is readily available like electric power. Here users get access to computational power just like electricity through wall sockets with no care or consideration for where or how the electricity is actually generated. Computers on a grid have a program on them, that allows unused resources (usually processing time and memory) to be used by another computer on the grid.

The speed of the connections between the computers on the grid are relatively slow, therefore processing tasks are broken up into independent parts and sent out to different computers on the grid. When a computer completes its part, it sends the results back to the server. Services over grids can be of many types - as Knowledge grid, Data grid, Computational grid, etc. The grids are capable to solve larger, more complex problems in a short time. They are easier to collaborate with and these make better use of existing hardware. Grid computing is used in disaster management, weather forecasting, market forecasting, bio-informatics, etc. A grid computing environment is represented in Figure 11.5.



Fig. 11.5: Grid computing environment

The benefits of using grid computing are:

- Grids are capable to solve larger, more complex problems in a short time.
- Grid computing makes better use of existing hardware.
- Scalable - easy to increase computing power by adding desktops or servers.

b. Disadvantages of grid computing

The drawbacks of grid computing are:

- The interconnection between computers is slower and therefore affects processing speed.
- Licensing issues across different servers/computers may affect working of certain applications.

11.2.3 Cluster computing

Cluster computing is a form of computing in which a group of personal computers, storage devices, etc. are linked together so that they can work like a single computer. The components of a cluster are connected to each other through fast local area networks. Clusters provide computational power through parallel processing. It is a relatively low cost form of a parallel processing machine used for scientific and other applications. Another reason for using clusters is to provide fault tolerance, that is, to ensure that computational power is always available. Figure 11.6 displays a computing cluster.

Clusters have evolved to support applications varying from e-Commerce to high performance database applications. Linux is the most widely used operating system for cluster computers.

a. Advantages of cluster computing

The advantages of using cluster computing are:

Price performance ratio: Cluster computing significantly reduces the cost of processing power.

Availability: If any one of the system components fails, the system as a whole stays highly available.

Scalability: Processors and nodes can be added to a cluster whenever demand increases

b. Disadvantages of cluster computing

The disadvantages of using cluster computing are:

Programmability issues: If there are differences in the software used in the different computers, there may be issues while combining all of them as a single entity.

Problem in finding fault: Since we deal with a single entity, we may have to face the difficulty in identifying the problematic component.



Beowulf Clusters are cheap clusters created using personal computers. We can create a Beowulf cluster with a few old computers and a LAN connection. Computers in Beowulf clusters are normally run using free and open source operating systems like Linux, Solaris, etc. They do not give top level performance, but their performance is many times better than a single computer.

11.2.4 Cloud computing

Cloud computing is an emerging computing technology that uses the Internet and central remote servers to maintain data and applications. It refers to the use of computing resources that reside on a remote machine and are delivered to the end user as a service over a network.

e-mail service is an example of cloud computing. Our web based e-mail service providers like Yahoo!, Gmail, Outlook, etc. takes care of storing all the hardware and software necessary to support our personal e-mail account. When we need to access our e-mail we open our web browser, go to the e-mail client, and log in. The most important part of this process is having an Internet access. Our e-mail messages and the software that manages e-mail are not stored in our computer. The e-mail service providers store them in the cloud. We access it from the cloud through an Internet connection anywhere, anytime.

Similar to e-mail service, office software (word processors, spreadsheets, etc.), graphic software, etc. are now available over cloud. People can use these software for their benefit and can even store the files (documents, spreadsheets, images, etc.) created in their private storage space in the cloud. Cloud computing is a computing model, where resources such as computing power, storage, network and software are combined and provided as services on the Internet in a remotely accessible fashion.

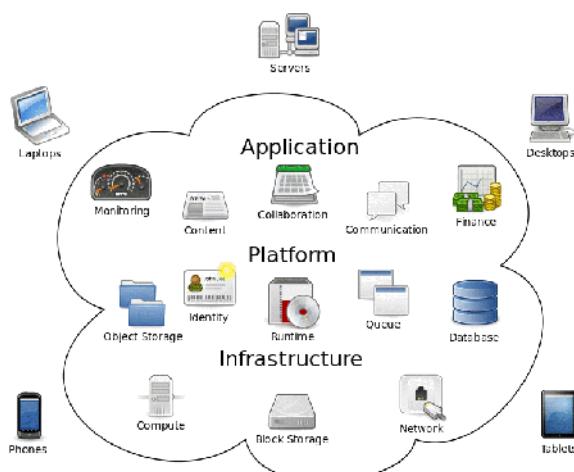
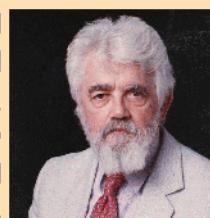


Fig. 11.7: Cloud computing



In 1961, 10 years after coining the term artificial intelligence, Professor John McCarthy conceptualised sharing computer hardware resources and applications.

He envisioned that computing power can be supplied like gas or water for free or a minimal cost. One of the first milestones in cloud computing history was the arrival of Salesforce.com in 1999, which pioneered the concept of delivering enterprise applications through a simple website. It paved the way for both specialist and mainstream software firms to deliver applications over the Internet. Now cloud computing is emerging as one of the hottest topic in field of information technology.



John McCarthy
(1927-2011)

Cloud computing is so named because the information being accessed is found in the 'clouds' or a remote place just like clouds in the sky. To use the cloud computing environment, Internet access and an account with a cloud service provider is required. Cloud computing is a subscription-based service where we can obtain networked storage space and computer resources. Figure 11.7 displays a diagrammatic representation of cloud computing.

a. Cloud service models

Cloud providers offer services that can be grouped into three major services. They are Software as a Service (SaaS), Platform as a Service (PaaS), and Infrastructure as a Service (IaaS). Let us discuss them in detail.

1. Software as a Service

A SaaS provider gives subscribers access to both resources and applications. Here a complete application is offered to the customer, as a service on demand. Consumers purchase the ability to access and use an application or service that is hosted in the cloud.

Suppose we are using Google Docs which is available for free, for all Gmail account holders. Here a single instance of the service runs on the cloud and multiple end users are serviced. SaaS makes it unnecessary for us to have a copy of software to be installed on our devices like desktop, laptop, mobile, etc. In the case of Google Docs, only one copy of word processor runs on the cloud. Users can access this copy and need not have the software installed on their computers. SaaS also makes it easier to have the same version of software on all of your devices at once by accessing it on the cloud. In the case of paid services, customers can access the services after paying the fees.

In a SaaS agreement, customers have the least control over the cloud. On the customer's side, there is no need for high investment in servers or software licenses, while for the provider, the costs are lowered, since only a single application needs to be hosted and maintained. Today SaaS is offered by companies such as Adobe for its image processing software Creative Cloud, Microsoft for its office software Office 365, facebook.com, etc.

2. Platform as a Service

A PaaS system goes a level above the Software as a Service setup. A PaaS provider gives subscribers access to the components that they require to develop and operate applications over the Internet. In other words, the platforms used to design, develop, build and test applications are provided by the cloud infrastructure. The customer

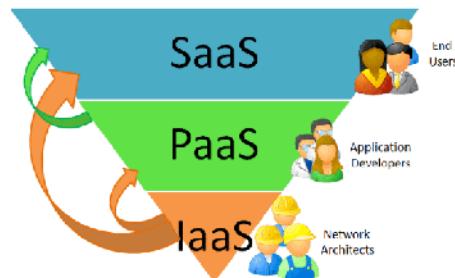


Fig. 11.8: Basic cloud computing models

has the freedom to build his own applications, which run on the provider's infrastructure. To meet manageability and scalability requirements of the applications, PaaS providers offer a predefined combination of OS and application servers, such as LAMP platform (Linux, Apache, MySQL and PHP), ASP.NET, PHP, Python, etc. Google's App Engine, Microsoft Azure, Force.com, etc. are some of the popular PaaS examples.

3. Infrastructure as a Service

An IaaS agreement, as the name states, deals primarily with computational infrastructure. IaaS provides basic storage and computing capabilities as standardised services over the network. Servers, storage systems, networking equipment, data centre space, etc. are pooled and made available to handle workloads. The customer would typically set up his own software on the infrastructure. Some common examples are Amazon Web Services, Joyent, AT&T, GoGrid, etc.

b. Advantages of cloud computing

The following are some benefits in the use of cloud computing:

Cost savings: Companies can reduce their capital expenditures and use operational expenditures for increasing their computing capabilities.

Scalability/Flexibility: Companies can start with a small deployment and grow to a large deployment fairly rapidly, and then scale back if necessary. Also, the flexibility of cloud computing allows companies to use extra resources at peak times, enabling them to satisfy consumer demands.

Reliability: Services using multiple redundant sites help in disaster recovery.

Maintenance: Cloud service providers do the system maintenance, thus reducing maintenance requirements.

Mobile accessible: Employees who travel as part of their job are also able to give better productivity since the systems they use are accessible from anywhere.

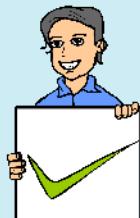
c. Disadvantages of cloud computing

Some of the challenges faced by those who use cloud computing are:

Security and privacy: Whenever data or a program is sent on a publicly accessible communication system and data is stored in a shared disk system, there is a danger of stealing or corrupting the data in the disk storage.

Lack of standards: Clouds have no standards and thus it is unlikely that most clouds are interoperable.

Know your progress



1. List the advantages of cluster computing.
2. What is cloud computing?
3. Name the different cloud service models.
4. What is Software as a Service?
5. Name any two SaaS providers.
6. Specify the names of any two providers of IaaS.

11.3 Artificial Intelligence

Artificial Intelligence (AI) is one of the latest disciplines in computer science and it was only in the 1950's that the first definition of artificial intelligence was established by Alan Turing. Turing studied how machinery could be used to mimic processes of the human brain. His studies resulted in one of the first publications of AI, entitled *Intelligent Machinery*. The term Artificial Intelligence was first coined in 1956 at the Dartmouth conference, organised by John MacCarthy. AI currently encompasses a huge variety of subfields, from general-purpose areas such as perception (insight) and logical reasoning, to specific tasks such as playing chess, proving mathematical theorems, computer vision, natural language processing, medical diagnosis, etc. Often, it is identified as an interdisciplinary area of research where scientists in other fields move gradually into AI, where they find the tools and vocabulary to systematise and automate the intellectual tasks on which they have been working. Similarly, researchers in AI can choose to apply their methods to any area of human intellectual endeavour. In this sense, it is truly a universal field.

Figure 11.9 represents the hierarchy of a knowledge pyramid. It is evident that the knowledge and intelligence that comes at the top of the pyramid are the major areas of study under AI. Here we have to simulate these on computers to make the system intelligent. While successes have been achieved in developing mathematical models of many biological systems including the models of the biological neurons, there are still no solutions to the complex problem of modelling intuition, consciousness and emotion which form integral parts of human intelligence.

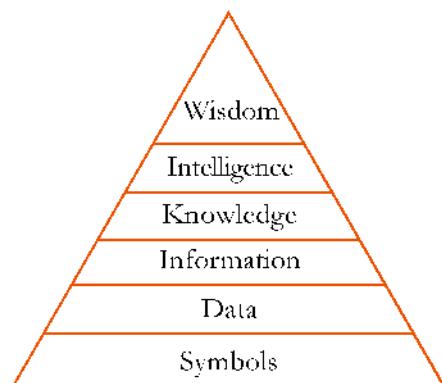


Fig. 11.9: Knowledge pyramid

Alan Turing believed that machines that would mimic the processes of the human brain could be created. Turing strongly believed that a well-designed computer could do everything that a brain could. More than fifty years later his statements are still visionary.

The underlying thrust force behind every intelligent system is knowledge. At the base of the pyramid are symbols which form the basic means of representation. Data is termed as a collection of mere symbols. While processing data we get information, and knowledge is the organised information. It can be a piece of information that helps in decision making. The ability to draw useful inferences from the available knowledge is generally referred as intelligence. Wisdom is the maturity of mind that directs its intelligence to achieve desirable goals.

Here we will study how we can incorporate knowledge to a system and how this can be intelligently used to solve various real life problems which cannot be effectively solved with the help of conventional programming techniques. This is the basics of AI which can be defined as developing computer programs to solve complex problems by application of processes that are similar to human reasoning processes.

Turing Test approach to AI

The Turing Test, proposed by Alan Turing was designed to provide a satisfactory operational definition of intelligence. The details of the Turing Test is already detailed in Chapter 1 of Class XI. Turing defined intelligent behaviour as the ability to achieve human-level performance in all cognitive tasks, sufficient to fool an interrogator. Roughly speaking, the test he proposed is that the computer should be interrogated by a human via a teletype. The computer passes the test if the interrogator cannot distinguish between computer and a human being. A pictorial representation of Turing Test is given in Figure 11.10. As of today, Turing Test is the ultimate test a machine must pass in order to be called as intelligent and for now, programming a computer to pass the test provides plenty to work. In that case the computer would need to possess the following capabilities.

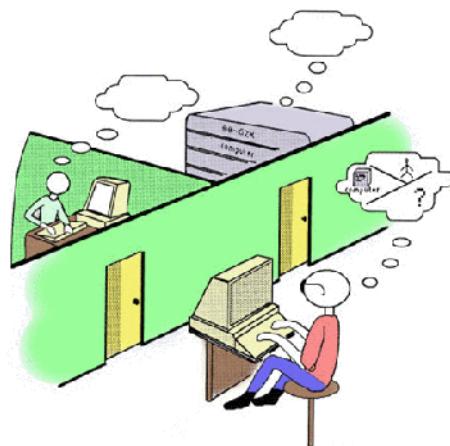


Fig. 11.10: Turing Test

- **Natural Language Processing (NLP):** To enable to communicate successfully in English (or some other regional language). Automatic speech recognition, speech synthesis, machine translation, handwritten character

recognition are some of the practical applications associated with NLP which deals with the methods of communicating with a computer in one's own natural language.

- **Knowledge representation:** To incorporate human knowledge before or during the interrogation.
- **Automated reasoning:** To use the knowledge to answer questions and to draw new conclusions.
- **Machine learning:** To adapt to new circumstances and to detect and deduce patterns.

The issue of acting like a human comes up primarily when AI programs have to interact with people say, when an expert system explains how it came to its diagnosis or a natural language processing system has a dialogue with a user. These programs must behave according to certain normal conventions of human interaction in order to make themselves understood. The underlying representation and reasoning in such a system may or may not be based on a human model. To pass the total Turing Test, the computer will also need the following:

- **Computer vision:** The capability to observe objects. If a machine has to have the capability of vision, it must also perform the activities including image acquisition, transformation, processing, analysis, understanding and interpretation.
- **Robotic activities** to move them about. To make the robot a little smarter, intelligence must be imbibed in it. To cope with the changing environment, intelligent sensors are to form a part of the robot which can sense the environment and supply necessary signals for its intelligent control unit.

The enormous successes achieved through the modelling of biologically inspired algorithms to simulate natural intelligence, resulted in the development of intelligent systems. These intelligent algorithms include Artificial Neural Networks (ANN), Evolutionary Computation (EC), Swarm Intelligence (SI) and Fuzzy logic. These intelligent algorithms form part of the field of AI.



AI and Game Playing

Making computers play games had been one of the major goals of research in computer science, especially in AI. Shannon's paper on chess-playing program and Samuel's Checkers are considered as landmark in this area. The reason why game playing occupies a important role in AI are follows:

- The rules of the game are limited. Hence extensive amounts of domain-specific knowledge are seldom needed.

- Many human experts exist to assist in the development of the programs.
- Games provide a structured task where success and failure can be measured with least effort.
- For human experts, it is easy to explain the rationale for a move unlike other areas.
- Game-playing permits one to simulate real-life situations.



Deep Blue from IBM beat Kasparov in 1997. The system that beat Kasparov was highly optimized, with an extensive knowledge base on chess game.

11.4 Computational Intelligence

From ancient times, we have started using different types of machines to get our work done. We choose machines based on the nature of job to be done. With the invention of digital computers, time consuming and error-prone numeric computations are done with relative ease and accuracy. Then we thought of seeking help of computers in reasoning processing. The seed for this was sown by Allan Turing. Today the design of algorithmic models to solve increasingly complex real life problems using computers is considered as a major challenge.

Since we have started using machines, especially digital computers, to solve our real life problems, human-machine interaction became an interesting area of study and the outcomes of such studies resulted in the development of new branch of discipline known as Cybernetics. Cybernetics is defined as the study of control and communication between man and machines. For example, these studies led to the development of automatic unmanned navigation systems for spacecraft, computers that can take orders in natural language speech or as handwriting inputs and smart weapons like guided nuclear missiles, etc. Computational Intelligence (CI) combines elements of learning, adaptation, evolution and fuzzy linguistic to create programs that are, in some sense, intelligent. Computational Intelligence experts focus on problems that are difficult to solve using artificial systems, but are solved by humans and some animals using intelligence.

A more recent definition of artificial intelligence stated that it is the study of how to make computers do things which people are doing better. AI can be seen as a combination of several research disciplines like computer science, biology, medicine, robotics, etc.

11.4.1 Computational Intelligence paradigms

Computational Intelligence (CI) is the study of adaptive mechanisms (algorithms) to facilitate intelligent behaviour in complex and changing environments so as to solve real life problems. These mechanisms include AI paradigms that exhibit an ability to learn or adapt to new situations and CI paradigms like Artificial Neural Networks (ANN), Evolutionary Computation (EC), Swarm Intelligence (SI) and Fuzzy Systems (FS). While individual techniques from these CI paradigms have been applied successfully to solve real-world problems, the current trend is to develop hybrids of paradigms, since no one paradigm is superior to the others in all situations. We do this to capitalise on the respective strengths of the components of the hybrid CI system, and eliminate weaknesses of individual components. Here we consider four main paradigms of Computation Intelligence (CI), namely Artificial Neural Networks (ANN), Evolutionary Computation (EC), Swarm Intelligence (SI), and Fuzzy Systems (FS).



Soft computing

According to Lotfi A. Zadeh, professor emeritus of computer science at the University of California, soft computing is an emerging approach to computing which parallels the remarkable ability of the human mind to reason and learn in an environment of uncertainty and imprecision. It is also identified as a different grouping of paradigms, which usually refers to the collective set of CI paradigms and probabilistic methods. It is also possible that the techniques from different paradigms can be combined to form hybrid systems as well. Soft computing is tolerant of imprecision, uncertainty, partial truth, and approximation. In effect, the role model for soft computing is the human brain. Soft computing is a group of methodologies that works synergistically and provides flexible information processing capability for handling real-life ambiguous situations.

It is very interesting to understand that each of the above mentioned CI paradigms has its origins in biological systems. Artificial Neural Networks (ANNs) model biological neural systems, Evolutionary Computing (EC) models natural evolution (including genetic and behavioural evolution), Swarm Intelligence (SI) models the social behaviour of organisms living in swarms or colonies, and Fuzzy Systems (FS) originated from studies of how organisms interact with their environment and respond to the uncertain, imprecise, or fuzzy inputs.

A. Artificial Neural Networks

The brain is a complex, nonlinear and parallel computer. It has the ability to perform tasks such as pattern recognition, perception and motor control (body movements)

much faster than any computer - even though events occur in the nanosecond range for silicon gates and milliseconds for neural systems. In addition to these characteristics, others such as the ability to learn, memorise and still generalise, prompted research in algorithmic modelling of biological neural systems - referred to as Artificial Neural Networks (ANN).

It is estimated that there is in the order of 10-500 billion neurons in the human cortex (brain's outer layer of neural tissue in humans), with 60 trillion synapses (a synapse is a structure that permits a neuron to pass an electrical or chemical signal to another cell). The neurons are arranged in approximately 1000 main modules, each having about 500 neural networks. Current successes in neural modelling are for small ANNs aimed at solving a specific task.

B. Evolutionary Computation

Evolutionary Computation (EC) has its objective to mimic processes from natural evolution, where the main concept is survival of the fittest, i.e., the weak must die. In natural evolution, survival is achieved through reproduction. Offspring, reproduced from two parents (sometimes more than two), contain genetic material of both (or all) parents - hopefully the best characteristics of each parent. Those individuals that inherit bad characteristics are weak and lose the battle to survive. This is nicely illustrated in some bird species where one offspring manages to get more food, gets stronger and at the end kicks out all its siblings from the nest to die.

Evolutionary algorithms use a population of individuals, where an individual is referred to as a chromosome. A chromosome defines the characteristics of individuals in the population. Each characteristic is referred to as a gene. The value of a gene is referred to as an allele. For each generation, individuals compete to reproduce offspring.

Those individuals with the best survival capabilities have the best chance to reproduce. Offsprings are generated by combining parts of the parents, a process referred to as crossover. Each individual in the population can also undergo mutation which alters some of the allele of the chromosome. The survival strength of an individual is measured using a fitness function which reflects the objectives and constraints of the problem to be solved.

Evolutionary computation has been used successfully in real-world applications like, data mining, fault diagnosis, classification, scheduling, etc.

C. Swarm Intelligence

Swarm intelligence (SI) originated from the study of colonies or swarms of social organisms (Figure 11.11). Studies of the social behaviour of organisms (individuals) in swarms prompted the design of very efficient algorithms. For example, simulation studies of the graceful, but unpredictable, choreography of bird flocks led to the design of the particle swarm optimisation algorithm and studies of the foraging behaviour of ants resulted in ant colony optimization algorithms.



Fig. 11.11: Swarm of ants



Machine Learning

Machine learning is the study of mechanisms that allow a machine to infer complex patterns and behaviors from empirical data. Machine learning is used extensively in image and speech recognition, as well as in data-mining applications. Though the CI techniques are similar in nature, the main difference is that the core representation of knowledge in machine learning is statistical, whereas the core representation of knowledge in computational intelligence is approximate in nature (fuzzy).

D. Fuzzy systems

Traditional set theory requires elements to be either part of a set or not. Similarly, binary valued logic requires the values of parameters to be either 0 or 1. Human reasoning is, however, almost always not this exact. Our observations and reasoning usually include a measure of uncertainty. For example, humans are capable of understanding the sentence: "Some Computer Science students can program in most languages". But how can a computer represent and reason with this fact? Fuzzy sets and fuzzy logic allow what is referred to as approximate reasoning. With fuzzy sets, an element belongs to a set to a certain degree of certainty. Fuzzy logic allows reasoning with these uncertain facts to infer new facts, with a degree of certainty associated with each fact. In a sense, fuzzy sets and logic allow the modelling of common sense.

Fuzzy systems have been applied successfully to control gear transmission and raking systems in vehicles, controlling lifts, home appliances, controlling traffic signals, etc.

11.4.2 Application of Computational Intelligence

Computational intelligence (commonly referred to as Artificial Intelligence) is a very broad interdisciplinary field which has roots in and intersects with many domains, not only the computing disciplines, but also mathematics, linguistics, psychology, neuroscience, mechanical engineering, statistics, economics, control theory and cybernetics, philosophy, and many others. The latest applications of Computational Intelligence are now being explored. Here we will discuss some of the widespread applications of CI.

A. Biometrics

Biometrics refers to metrics (measurements) related to human characteristics and traits. Biometrics authentication is used in identification of individual. Biometric identifiers are the distinctive, measurable characteristics used to label and describe individuals.

Physiological characteristics are related to the physical shape or characteristics of the body. They include fingerprint, palm veins, face, hand geometry, iris, retina and odour/scent. Behavioral characteristics are related to the pattern of behavior of a person. They include typing rhythm, speed and voice.

Biometric identification is popularly used in attendance management systems, authentication in computers and other devices, Aadhar cards, etc. Figure 11.12 shows the applications of biometrics.



Fig. 11.12: Finger print and retina identification

B. Robotics

Robot is an electromechanical device which is capable of reacting in some way to its environment and take autonomous decisions or actions in order to achieve a specific task. Robotics can be defined as the scientific study associated with the design, fabrication, theory and application of robots. Robotics is a multi-disciplinary branch which spans over mechanical engineering, electrical engineering and computer

science. It includes the design, construction, operation and application of robots as well as computer systems for their control, sensory feedback and information processing. Figure 11.13 shows some of the applications of robots.



Fig. 11.13: Robots in a car assembly, agriculture fields and a military drone

Today robots are popularly used in several areas like vehicle industry, outer space, military, etc. Let us discuss some of them.

Uses in vehicle manufacturing industry: Robotic arms are used in the vehicle manufacturing process. Robotic arms are able to perform multiple tasks such as welding, cutting, lifting, sorting and bending.

Exploration of outer space: Manipulative arms that are controlled by a human are used to unload the docking bay of space shuttles to launch satellites or to construct a space station.

In intelligent homes: Automated systems can now monitor home security, environmental conditions and energy usage. Door and windows can be opened automatically and appliances such as lighting and air conditioning can be pre-programmed to be activated.

Exploration in difficult environments: Robots can visit environments that are harmful to humans. An example is monitoring the environment inside a volcano or exploring our deepest oceans. NASA has used robotic probes for planetary exploration since the early sixties.

Uses in military: Nowadays airborne robots (drones) are used by modern armies. Today drones are mostly used for surveillance purpose. Drones are also used for aerial attacking in hostile environment. In the future automated aircraft and vehicles could be used to carry fuel and ammunition or clear minefields.

Uses in agriculture: In developed countries large farms use automated harvesters that can cut and gather crops. Robotic dairies allow operators to feed and milk animals remotely.



The word 'robotics' was first used in Runaround, a short story published in 1942, by Isaac Asimov, an American author and a professor of biochemistry. The word robot comes from the Czech word 'robota' which means "compulsory doing manual work without receiving any remuneration".

C. Computer vision

Computer vision is the construction of explicit, meaningful descriptions of the structure and the properties of the 3-dimensional world from 2-dimensional images. Computer vision acquires 3 dimensional shape and other properties of objects based on their two dimensional (projection) images through the use of computers and cameras. It is also called image understanding. The purpose of this branch is allowing computers to understand the physical world by visual media means. The image data can take many forms, such as video sequences, views from multiple cameras or multi-dimensional data from a medical scanner.

Computer vision was initially developed for military applications. It is an important component of artificial intelligence and robotics. Sub-domains of computer vision include scene reconstruction, event detection, video tracking, object recognition, learning, indexing, motion estimation, and image restoration. Figure 11.14 displays the image of Mars rover - Curiosity which uses computer vision to explore Mars.

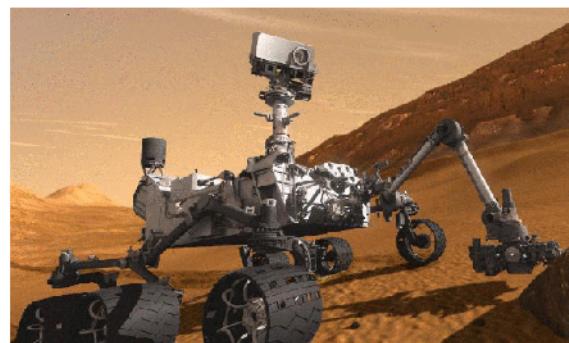


Fig. 11.14: Mars Rover - Curiosity

D. Natural Language Processing

Natural languages are the languages which are spoken by the people. Natural Language Processing (NLP) is the branch of computer science focused on developing systems that allow computers to communicate with people using any human language such as English, Malayalam, etc. Natural Language Processing (NLP) is a subfield of Artificial Intelligence (AI). It allows people to interact with computers without any specialised knowledge. This implies that anybody can simply talk to the computer in their own language. There is no need to learn any programming language. We know that language is a set of symbols and rules. Symbols are combined to convey new information. Rules govern the manipulation of symbols. We call these rules grammar of the particular language. But developing computer programs that can understand natural languages is a difficult task.

NLP computer does two things. Natural Language Understanding (NLU) and Natural Language Generation (NLG). Natural Language Understanding is about understanding and reasoning the input, which is any natural language like English, Malayalam, etc. Natural Language Generation deals with creation of output. Apart from NLP there are voice recognition systems that can convert spoken sounds into written words.

Compared to the international scenario, Natural Language processing in India is in its infancy stage. India, as a multilingual country realised its prospects and Department of Electronics (DOE), Govt. of India under the Technology Development for Indian Languages (TDIL) program has initiated development of NLP based tools.

E. Automatic Speech Recognition

Natural language processing (NLP) refers to artificial intelligence methods of communicating with a computer in a natural language like Malayalam. Automatic speech recognition (ASR) is one of the fastest growing and commercially most promising applications of natural language processing technology. Communication among human beings is dominated by spoken language. Therefore, it is natural for people to expect speech interfaces with computers which can speak and recognize speech in native language. This can be accomplished by developing an Automatic Speech Recognition (ASR) system which allows a computer to identify the words that a person speaks into a microphone or telephone and convert it into written text. As a result it has the potential of being an important mode of interaction between human and computers. Although any task that involves interfacing with a computer can potentially use ASR. The ASR system would support many valuable applications like dictation, command and control, voice dialing, spoken database querying, office dictation devices, and automatic voice translation into foreign languages etc. Figure 11.15 shows a sample interaction between a human and a computer through ASR.

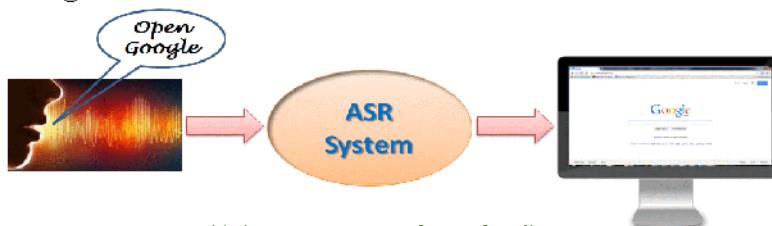


Fig. 11.15: Interaction through ASR

The mobile applications Siri which is a part of Apple iOS, Cortana of Microsoft Phone and Google Now of Android are intelligent personal assistants which can answer oral questions, make recommendations and perform actions on the mobile phone.

F. Optical Character Recognition and Handwritten Character Recognition Systems

Our visual system is capable to recognize image patterns in an impressively fast and accurate way. We recognize various patterns and objects in the daily environment without much effort. The task of Optical Character Recognition (OCR) and Handwritten Character Recognition (HCR) in a more general context are integral parts of pattern recognition. At the early stages of research and development of pattern recognition most of the research involved in the work of OCR. This software converts the scanned images of printed text (numerals, letters or symbols) into computer processable format (such as ASCII). At present, reasonably good OCR packages are available for most of the languages.

Automatic recognition of handwritten text was regarded as an important and challenging research area by scientists and engineers even before the advent of modern electronic computers. According to the way in which handwriting data is generated, two different approaches are present in HCR: on-line and off-line. In the former, the data are captured during the writing process by a special pen on an electronic surface as shown in Figure 11.16. In the latter, the data are acquired by a scanner after the writing process is over.

Many promising research results are reported in the area of handwritten character recognition for many foreign and Indian languages. Google's online handwriting recognition application 'google handwriting input' can recognise handwritten scripts of 82 languages in mobile devices.

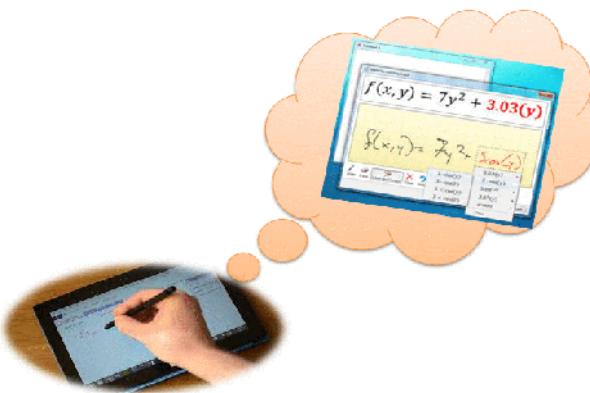


Fig. 11.16: Handwritten recognition system

G. Bioinformatics

Bioinformatics is the application of computer technology to the management of biological information. Computers are used to gather, store, analyse and integrate biological and genetic information which can then be applied to gene-based drug discovery and development. The need for bioinformatics capabilities has been accelerated by the explosion of publicly available genomic information resulting from the Human Genome Project.

The aims of bioinformatics are three-fold. First, bioinformatics organises data in a way that allows researchers to access existing information and to submit new entries as they are produced. The second aim is to develop tools and resources that aid in the analysis of data. The third aim is to use these tools to analyse the data and interpret the results in a biologically meaningful manner.

Human Genome Project



The Human Genome Project was an effort aimed to determine the sequence of the human genome and identify the genes that it contains. All our genes together are known as our "genome". The Project was coordinated by the National Institutes of Health and the United States Department of Energy. The Human Genome Project has helped researchers understand the blueprint of an individual. This research with the extensive use of computing revealed much about the functions of genes and proteins. This knowledge will have a major impact in the fields of medicine, biotechnology and the life sciences.

H. Geographic Information System

We know that there are large number of satellites revolving around the earth. They have designed, built and launched in order to relay images of our planet back to earth. Remotely sensed information is the most widely used one in the application of urban, agriculture, disaster monitoring, oil spill monitoring, etc. Geographic Information System (GIS) technology is developed from digital cartography and Computer Aided Design (CAD) database management system.

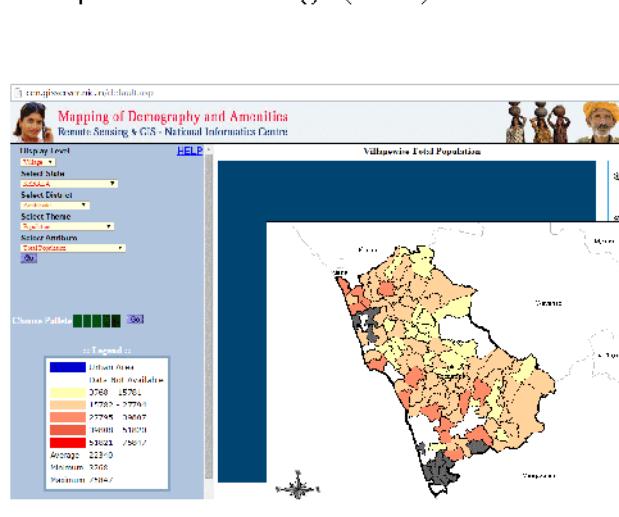


Fig. 11.17a: Mapping population in Kozhikode through GIS

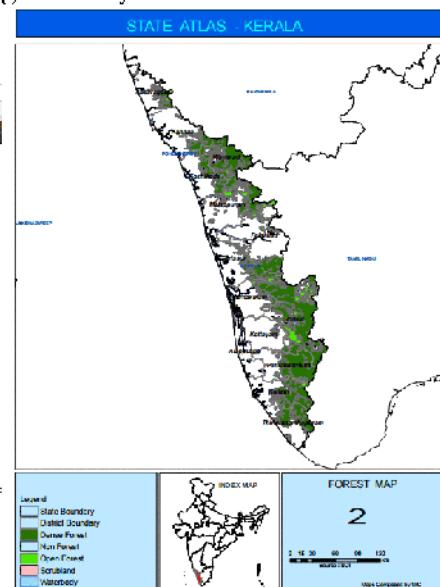


Fig. 11.17b: Mapping forests in Kerala through GIS

GIS is a computer system for capturing, storing, checking and displaying data related to various positions on earth's surface. GIS can show many different kinds of data on a map. This enables people to easily see, analyse and understand patterns and relationships. Figure 11.17 shows the plotting of total population of each village in Kozhikode district.

GIS can be applied in various areas like soil mapping, agricultural mapping, forest mapping, e-Governance, water resource management, natural disaster assessment, etc. The benefits of GIS are better information management, higher quality analysis, ability to carry out 'what if' scenarios, improve project efficiency. GIS applications are also used in planning process for sustainable development including strategic urban planning, infrastructure planning, precision agriculture planning, etc.

Remote sensing



Remote sensing means sensing things from a distance. Remote sensing is the art and science of obtaining information about an object without being in direct contact with the object.

In satellite remote sensing, sensors are used for capturing radiation from many different parts of electromagnetic spectrum which are visible to human eye. This technology is used to extract information about the features and objects on the earth's surface, oceans and atmosphere.

Let us consider the case of weather forecasting. Weather satellites carry instruments called radiometers (not cameras) that can scan the earth to form images. Analysing these data, our meteorologists predict weather. Besides temperature and rain our meteorologists can also predict the possibilities of earthquake, whirlwind, hurricane, etc. In our country India Meteorological Department is setup for this purpose. It is an agency of the Ministry of Earth Sciences of the Government of India. It is the principal agency responsible for meteorological observations, weather forecasting and seismology. Figure 11.18 shows the satellite image for the cyclonic storm Hud Hud gathering over Bay of Bengal during October 2014.

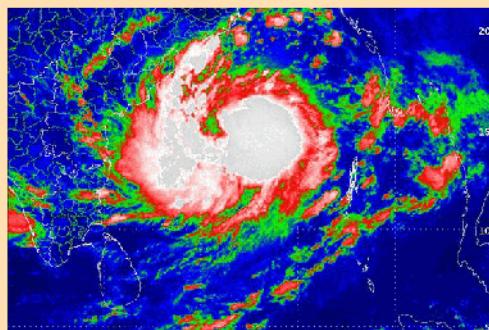
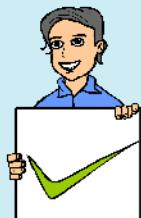


Fig. 11.18: Satellite image of cyclone Hud Hud over Bay of Bengal

Know your progress



1. What is the difference between OCR and HCR systems?
2. What do you mean by GIS?
3. The scientific study associated with the design, fabrication, theory, and application of robots are called _____.
4. What is Natural Language Processing?
5. Give an example where computer vision is used.
6. ANN is _____.



Let us conclude

Recent migrations to distributed computing platforms have increased the need for a better understanding of network computing. Distributed platforms may be connected in a variety of ways ranging from geographically dispersed networks to architecture specific interconnection structures. In parallel computing a problem will be subdivided among the various CPUs. Clusters aggregate many machines into a large, centrally managed entity. Grid computing allows each node to access resources on other nodes as if they were local. Cloud computing refers to applications and services offered over the Internet. Whatever be the choice, it is clear that as processor power becomes less expensive and available through some type of high-speed network will become a standard part of computing in the future. Artificial intelligence is the intelligence exhibited by machines or software. It is an academic field which studies the goal of creating intelligence. GIS is a software system mainly used to help in planning and organising geographic data. Remote sensing is the acquisition of information about an object or phenomenon without making physical contact with the object and thus in contrast to on site observation. Remote sensing is used in various fields such as agriculture, forestry, geology, meteorology, etc.

Let us assess

1. Explain the features of distributed computing.
2. Compare parallel and serial computing.
3. The distributed computing paradigm that uses existing hardware is _____.
4. List advantages of cluster computing.

5. Explain how cloud service models change the way we use computers.
6. Give examples for companies that offer SaaS.
7. List the advantages and limitations of cloud computing.
8. Draw and explain the knowledge pyramid.
9. What is Computational Intelligence?
10. Define Cybernetics?
11. The test used to decide whether a machine is intelligent or not is called _____.
12. What is ANN?
13. Explain Swarm Intelligence.
14. Explain Fuzzy Systems.
15. List some uses of biometrics.
16. Write the uses of robotics.



12

ICT and Society

Significant Learning Outcomes

After the completion of this chapter the learner:

- lists the facilities in e-Governance, e-Business, e-Learning.
- explains the tools used in e-Learning.
- lists various advantages and challenges faced in implementing e-Governance, e-Business, e-Learning applications.
- uses some of the useful websites in each area.
- explains cyberspace.
- distinguishes different types of cyber crimes.
- lists and explains various intellectual property rights.
- details cyber law and ethics.
- identifies the importance of IT Act.
- recognises infomania

The use of Internet has increased rapidly in the last few decades. The modern society cannot think of a day without the Internet and different services provided by it. How could we think of banking without ATM, business without e-commerce, hospitals without latest computer based diagnosis system, education without IT enabled tools, etc. Surely Information and Communication Technology has made life easier. We also learned that Internet has become the largest communication media. Social media has made great impact on the society. E-Governance has opened new ways to deliver government service to its citizen. Business transactions made easier by e-commerce and e-Learning widens the new horizon in the learning and teaching field.

Information and Communication Technology (ICT) is the term often used as an extended synonym for Information Technology (IT). ICT is more specific in integrating telecommunication and computers comprising of many technologies for capturing, storing, processing, interpreting and printing information.

Similar to rights on property like land, house, etc., intellectual properties like music, films,

software, designs, etc. also have ownership rights. These rights called Intellectual Property Rights and the issues related to them are discussed in this chapter. Every technology has a dark side. Internet also has its share of issues and threats. Many people use this medium for performing illegal activities. We will discuss about such actions and how we can safeguard in Internet.

12.1 ICT services

Popularity of Information Technology (IT) has increased the number of services that are available with the help of computers and communication technology. Here we discuss a few services that have changed the procedure of attending such services.

12.1.1 e-Governance

Information Technology (IT) has contributed much to the smooth functioning of governments. It comprises many technologies for capturing, processing, interpreting, storing and transmitting information. IT helps governments to take quick and judicious decisions. It also increases transparency and accountability in all its services. Information and Communication Technology (ICT) aided Governance is generally known as e-Governance.

e-Governance is the application of ICT for delivering Government services to citizens in a convenient, efficient and transparent manner. The objective of e-Governance is to ensure that the services of the Government reach the public promptly and effectively. In Kerala, we have many government departments like the Motor Vehicle Department, Education, Revenue, etc. which have successfully implemented e-Governance. Let us now discuss various types of interactions in e-Governance.

A. Types of interactions in e-Governance

e-Governance facilitates interaction among different stakeholders in governance. Categories of these interactions are described as follows:

Government to Government (G2G) - It is the electronic sharing of data and/or information among government agencies, departments or organisations. The goal of G2G is to support e-Governance initiatives by improving communication, data access and data sharing.

Government to Citizens (G2C) - It creates an interface between the government and citizens. Here the citizens enjoy a large range of public services. It increases the availability and accessibility of public services. It also improves the quality of services. Its primary purpose is to make the government citizen-friendly.

Government to Business (G2B) - Here, e-Governance tools are used to aid the business community to interact with the government. The objective is to cut red-

tatism, save time, reduce operational costs and create a more transparent business environment while dealing with the government.

Government to Employees (G2E) - Government, being the biggest employer has to interact with its employees on a regular basis. This interaction is a two-way process between the government and the employees. The policies and guidelines for implementing various government programmes are made available to the employees as government orders or circulars through e-Governance portals. The salary and personal details of government employees are also managed through e-Governance services. Use of ICT tools helps in making these interactions fast and efficient.

B. e-Governance infrastructure

In India, the e-Governance infrastructure mainly consists of State Data Centers (SDC) for providing core infrastructure and storage, State Wide Area Network (SWAN) for connectivity and Common Service Centers (CSC) as service delivery points. The integration of these three components of e-Governance is shown in Figure 12.1.

i. State Data Centre (SDC)

State Data Centre (SDC) is one of the important constituents of the core infrastructure for supporting e-Governance initiatives of National e-Governance Plan (NeGP). Under NeGP, it is proposed to create SDCs to combine services, applications and

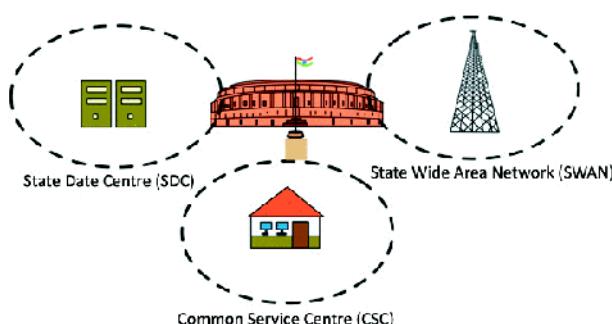


Fig. 12.1: e-Governance infrastructure

infrastructure and to provide efficient electronic delivery of G2G, G2C and G2B services. These services can be rendered by each state government through a common delivery platform. This platform is supported by a core connectivity infrastructure such as State Wide Area Network (SWAN) and Common Service Centre (CSC) connectivity that is extended up to the village level. State Data Centre provides several functionalities. These include keeping central data repository of the state, securing data storage, online delivery of services, citizen information/services portal, state intranet portal, disaster recovery, etc. SDCs also provide better operation and management control and minimize the overall cost of data management, resource management, deployment etc.

ii. Kerala State Wide Area Network (KSWAN)

Kerala State Wide Area Network (KSWAN) has been set up as a backbone of the State Information Infrastructure (SII). It connects Thiruvananthapuram, Kochi and Kozhikode as its hubs and extends to all the 14 districts linking each of the 152 Block Panchayats. The network also connects a large number of various offices of government departments. The infrastructure supports the integration of a large number of G2G, G2C services with the applications received from the State Data Centre.

iii. Common Service Centre (CSC)

Common Service Centres (CSC) are the front-end delivery points of the government, private and social sector services for the rural citizens of India. A highlight of the CSCs is that it offers web-enabled e-Governance services in rural areas. It helps in utility payments such as electricity, telephone and water bills, submission of online applications and generating and distributing the certificates to the needy. Other services that could be offered through CSC are listed below:

- Agriculture services
- Education and training services
- Health services
- Rural banking and insurance services
- Entertainment services
- Commercial services

In Kerala Akshaya centres are working as Common Service Centres.

Akshaya centres

Akshaya centres were initially launched in the year 2002 in the Malappuram district in Kerala. Its intention was to impart e-Literacy to the citizens. Akshaya was conceived as a landmark ICT project by the Kerala State Information Technology Mission (KSITM) to bridge the digital divide and to bring the benefits of ICT to the entire population of the State. The services include e-grants, e-filing, e-district, e-ticketing, submitting online application for ration card and electoral ID, Aadhaar enrolment, Aadhaar based services, insurance and banking services.



Akshaya was launched on 18th November 2002 by the former President of India, Dr. A. P. J. Abdul Kalam. Akshaya works in the PPP (Private Public Partnership) Model. An Akshaya centre is owned by a private entrepreneur preferably from the same panchayath where the Akshaya centre is located and its selection is done by local self governments. The income for the Akshaya Entrepreneurs is the nominal service charge collected either from the citizen or paid by the government for each transaction.



Aadhaar is a 12 digit individual identification number issued as part of e-Governance by the Unique Identification Authority of India (UIDAI) on behalf of the Government of India. This number will serve as a proof of identity and address, anywhere in India. Any individual, irrespective of age and gender, who is a resident in India, can enroll in Aadhaar. Each individual needs to enrol only once which is free of cost. During the enrolment, demographic details (name, age, gender and address) and biometric details (photo, 10-finger-print and 2-iris-images) of a resident are entered. Each Aadhaar number will be unique to an individual and will remain valid throughout life. Aadhaar number will help you provide access to services like banking, taking mobile phone connections and other Government and Non-Government services.

C. Benefits of e-Governance

Implementing e-Governance has many advantages. It informs the public about the functioning of the government and the policies they are trying to implement. Major benefits of e-Governance are listed below:

- e-Governance leads to automation of government services, ensuring the information regarding the activities of public welfare is easily available to all citizens.
- e-Governance strengthens the democracy by ensuring greater participation of citizens at all levels of governance.
- It ensures more transparency in the functioning and thus helps eliminate corruption.
- It makes every government department responsible as they know that they are closely observed.
- Proper implementation of e-Governance saves unnecessary visits of the public to offices. It saves time and money.

D. Challenges to e-Governance

Though e-Governance has many benefits, it faces some challenges too. Let us have a look at a few challenges in the implementation of e-Governance.

- The existing digital divide is an obstacle in utilising the services of e-Governance. Those who live in remote areas with lower e-Literacy will face difficulty to access the services of e-Governance.
- e-Governance applications being computer/web based, security measures are highly required since there is possibility of cyber-attack.

- Usually a huge initial investment and planning are required for the proper implementation and maintenance of e-Governance services.
- Many people are anxious about the sharing of their personal information, biometry, etc. to the agencies designated for data collection.
- Integrity of various departments is very much essential for the efficiency and effectiveness of e-Governance.

E. Useful e-Governance websites

Table 12.1 shows the addresses of some websites that provide various services of the Government of Kerala. Figure 12.2 shows the home page of the Department of Higher Secondary Education, Kerala State and Figure 12.3 shows the home page of e-District portal.

Address of website	Purpose/Service
www.dhsekerala.gov.in	An official site of the Department of Higher Secondary Education, Government of Kerala that provides various facilities and services to students, teachers and school administrators.
www.edistrict.kerala.gov.in www.incometaxindia.gov.in	It provides government services to the public. It provides the services of Income Tax department.
www.keralamvd.gov.in	It is the official website of the Motor Vehicles Department of Kerala.
www.rti.gov.in	Right to Information Act 2005 mandates timely response to a citizen who requests for information from the Government or authorities under it.
www.itmission.kerala.gov.in	It is a Government of Kerala site which provides managerial support to various IT initiatives.
www.spark.gov.in	It is a web based G2E integrated solution for Service and Payroll Management.

Table 12.1: Some e-Governance websites



Fig. 12.2: The home page of DHSE website

 www.dhsekerala.gov.in

As an official site of the Department of Higher Secondary Education, Government of Kerala, www.dhsekerala.gov.in provides various facilities and services to students, teachers and school administrators. The services include registration for the examinations, issue of hall tickets, publication of exam results, distribution of various circulars and notifications, etc. This site also provides facilities for downloading various forms and study materials including model question papers.

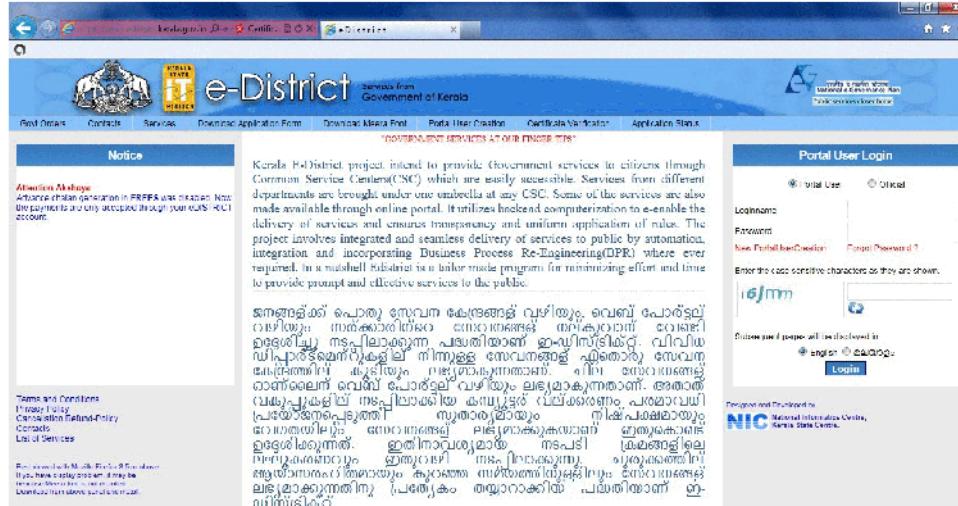


Fig. 12.3: The home page of e-District portal



e-District is a State Mission Mode Project under the National e-Governance plan. The project aims at supporting computerisation for services to the public.

In Kerala, issue of different certificates of the Department of Revenue is integrated with the e-District portal. It has simplified all complex procedures in government offices and made the citizens' life easy. It has been a difficult task for the citizen to obtain copies of public records, submit applications, meet officials, or to seek information regarding their day-to-day needs. This has caused the loss of his/her day's income, time as well as the cost of transportation. At government offices, sometimes, the relevant record, information, or official may not be available, resulting in repeated visits and additional expenses.

To avail a service in e-District, one has to apply online through the web portal or approach a nearby Akshaya centre with essential documents. Akshaya centre submits an online application on behalf of the citizen. This application through a work-flow reaches the village officer. After processing the application, the village officer forwards it to the next higher authority or approves it and issues the certificate using the digital signature. The availability of the certificate in the portal is informed with an SMS alert.

Know your progress



1. Name the application of Information and Communication Technology (ICT) for delivering government services to the citizens in a convenient, efficient and transparent manner.
2. Define the term e-Governance.
3. "e-Governance facilitates interaction between different stakeholders in governance". Say whether the statement is True or False.
4. Give an example for an e-Governance website.
5. What is KSWAN?

12.1.2 e-Business

We often visit shopping places and it takes a considerable amount of time and effort for shopping. What about the idea of shopping without leaving your home? It is one of the realities of the times. Almost all services and business are available online now. They are only a few clicks away.

e-Business is the sharing of business information, maintaining business relationships and conducting business transactions by means of the ICT application. Companies

(business), public institutions (administration), as well as individuals (consumer) engage in e-Business. e-Business helps in effective e-marketing and increasing sales through effective use of e-Commerce services. It also reduces communication and travel cost through online meeting and shared workspace, etc.

A. e-Commerce and e-Business

Although the terms e-Commerce and e-Business are often used interchangeably there are differences. e-Commerce covers business transaction that involve exchange of money, whereas e-Business includes all aspects of running a business such as marketing, obtaining raw materials or goods, customer education, looking for suppliers etc. Thus e-Business is an extension of e-Commerce.

B. Electronic Payment System (EPS)

Can you think of living without money in your pocket? If somebody tells that he/she lived a week without touching currency notes, will you believe? Today we live in a world where almost every commodity has a price tag attached to it. Then how is it possible to buy something without giving money, the paper currency?

Electronic Payment System (EPS) is the solution. When we move on to electronic business, exchange of money also needs to be electronic. It is both convenient and secure if properly implemented. EPS plays an important role in e-Business.

A system of financial exchange between buyers and sellers in an online environment is called an Electronic Payment System (EPS). The financial exchange is facilitated by a digital financial instrument (such as credit/debit card, electronic cheque or digital cash) backed by a bank and/or an intermediary.

C. e-Banking

Banking has also undergone drastic changes with the advancements in Information Technology. Our traditional concept of banking has changed a lot. For example, now there is no need to visit bank for making financial transactions. We can do the transaction using online banking facilities even while travelling. Facilities such as ATM, debit cards, credit cards, Internet banking and core banking help in transforming traditional banking into e-Banking. e-Banking or electronic banking is defined as the automated delivery of banking services directly to customers through electronic channel. It can access data without geographical limitations.

D. Advantages of e-Business

e-Business provides many advantages to customers and firms. Let us discuss some of the major advantages of using e-Business applications.

- It overcomes geographical limitations. If you have a physical store, you are limited by the geographical area where you can provide service. But with e-Commerce, this limitation can be overcome.

- e-Business reduces the operational cost. An e-Commerce merchant does not need a prominent physical location; it reduces the operational cost. A portion of money thus saved can be passed on to the customers in the form of discounts.
- It minimises travel time and cost. Sometimes customers have to travel long distances to reach their preferred store. e-Business allows them to visit the same store virtually.
- It remains open all the time. e-Business application services are always open (24×7). From the merchant's point of view, it increases the number of service requests they receive. From the customer's point of view an 'always open' store is more convenient.
- We can locate the product quicker from a wider range of choices. On an e-Business website the consumers can have a wider range of choices of a product from various sellers. Customers can quickly locate their preferences from the given product lists. Some websites remember customer preferences and shopping lists to facilitate repeat purchase. The features like product characteristics and price comparisons are the other attractions of e-Business applications.



The term M-Business or mobile business covers all the business activities, processes and applications performed by means of mobile devices such as mobile phone, PDA, etc. M-Business can be regarded as a branch of e-Business.

e-tailing (or electronic retailing) is the selling of retail goods on the Internet. It is the most common form of business-to-consumer (B2C) transaction.

E. Challenges to e-Business

Though e-Business has enormous potential in the business world, it faces many challenges, particularly in developing countries like India. Major challenges are discussed below:

- A good percentage of the population is unaware of IT applications and its uses. Surprisingly, most of the regular Internet users also lack knowledge about online business and its possibilities.
- Most of the customers, especially to rural population, do not possess plastic money- credit card, debit card and net banking system, which is necessary for e-Business.
- If not used with caution, customers may lose valuable information like their credit card number, passwords, etc.

- Products like apparel, handicrafts, jewellery, etc are often purchased after examining physically. But in online shopping, customers don't have this 'touch and feel' advantage.
- For the success of e-Business of any organisation or company, perfect and efficient shipment service is a necessity.

F. Useful e-Business websites

Some popular e-Business websites are given in Table 12.2. Figure 12.4 and 12.5 are the home pages of some e-Business websites.

Address of website	Purpose/Service
www.irctc.co.in	Indian Railway Catering and Tourism Corporation Limited web site for reservation and cancellation of railway tickets and hotels for accommodation.
www.amazon.com	US based retailer with headquarters in Washington.
www.ebay.in	It is one of the largest online shopping sites in India.
www.licindia.com	Insurance company website.
www.airindia.com	Online site for booking Air India flight tickets.
www.keralartc.com	Online website for KSRTC bus ticket booking.
www.bookmyshow.com	Movies and theatre ticket booking website.

Table 12.2: Some e-Governance websites



Fig. 12.4: The home page of www.irctc.co.in



www.irctc.co.in

Indian Railway Catering and Tourism Corporation Limited (IRCTC) is a government of India enterprise. It handles the catering, tourism and online ticketing operations of the railways. IRCTC provides online booking facilities of railway tickets and offers other services like checking reservation status, train timing, reservation of hotels for the tourists across the country.

Fig 12.5: The home page of amazon.in



www.amazon.com

amazon.com, Inc is a US based company with headquarters in Washington. It is the world's largest retailer. Initially started as an online bookstore it soon diversified itself into selling software, video games, electronics, furniture, food, toys, jewellery, etc. The company also produces consumer electronics. Amazon has separate retail websites for different countries. In 2013, Amazon launched its site for India, www.amazon.in.

Know your progress



1. The system of financial exchange between buyers and sellers in an online environment is known as _____.
2. Define e-Business.
3. Define e-Banking.
4. Check whether the following statement is true or false.
"e-Business is an extension of e-Commerce".

12.1.3 e-Learning

We are familiar with the traditional classroom consisting of a teacher, students, teaching aids, etc. Think of a virtual class where you are attending classes as a student and a teacher is engaging class from a distant location, may be from a different country. Is this possible? Yes it is! Through e-Learning you can overcome many limitations of conventional teaching-learning process. The use of electronic media and ICT (Information and Communication Technologies) in education is termed **e-Learning**.

A. e-Learning tools

There are many tools for enhancing e-learning process. Some of the e-Learning tools are discussed below:

i. Electronic books reader (e-Books)

Think of going to school without bags packed with text books, but all necessary books are still with you in a small hand-held storage device! It is interesting, isn't it? e-Book reader is a device that can store lot of books in digital form. Portable computer devices that are loaded with digital book content via communication interfaces is called **electronic books reader**. It can open any book, any page quickly, without much effort. In principle, any web document can be downloaded from the Internet, sometimes by making online payment, and read whenever required. In some e-Book readers voice output is also available and the reader needs to just listen the audio of the text.

ii. e-Text

Textual information available in electronic format is called **e-Text**. This text can be read and interacted with an electronic device like computer, e-Book reader, etc. e-Text can be converted to various formats to our liking using softwares. e-Text can be automatically read aloud with the help of a computer or an e-Text reader device. This is quite helpful for visually challenged people.

iii. Online chat

It is a real-time exchange of text messages between two or more persons over the Internet. In the virtual class environment, online chatting is used to discuss the topics with teachers and other students. Chatting can be performed even with a low speed Internet connection. Video chatting facility is also available. It however requires fairly high speed Internet connection and supporting devices such as web camera and speakers.

On line chat is a framework that provides interaction in a social environment. It helps communicating with people at different places. This facility can also be used

to deliver and transfer live lectures given by the faculty. Students can login from the remote locations and attend the lecture.

iv. e-Content

Nowadays lot of e-Learning materials are delivered in different multimedia formats like videos, presentations, graphics, animations, etc. The e-Contents once prepared can be broadcasted through television channels, webcasted or uploaded in websites. Uploaded content can be downloaded, viewed and saved for future reference. The multimedia contents have more scope to convey the subject matter effectively. It can show actual or simulated activities which are not possible in the traditional classroom based teaching.

v. Educational TV channels

There are many telecasting/webcasting channels which are dedicated for the e-Learning purpose. These channels broadcast recorded classes on various subjects, interviews with experts, lab experiments, etc. Some of these channels can be watched in the Internet also. Doordarshan's 'VYAS' and Kerala Government's 'VICIERS' channel are examples of educational television channels.

B. Advantages of e-Learning

e-Learning has lot of advantages. They are listed below:

- e-Learning has the ability to offer courses on variety of subjects to large number of students from distant location.
- In e-Learning cost for learning is much less. It saves journey time and money, instructor fees, etc.
- People with limited financial resources are very much supported by the lower cost of e-Learning.
- It provides facility to do online courses from various nationally or internationally reputed institutions.
- Time and place is not a constraint for e-Learning.

C. Challenges to e-Learning

Listed below are some of the challenges faced by e-Learning:

- Face to face contact between students and teachers is not possible.
- Proper interaction among teachers and students are often limited due to the lack of infrastructural facilities.
- Equipment and technology (computer and high speed Internet) requirement restrict adoption of e-Learning.

- Learners who require constant motivation may not be serviced adequately.
- Hands-on practicals in real laboratory scenario is also a constraint in e-Learning.

D. Useful e-Learning websites

The summary of useful e-Learning websites are shown in Table 12.3. Figure 12.6 shows the home page of IGNOU (Indira Gandhi National Open University).

Address of website	Purpose/Service
www.ignouonline.ac.in	Website of Indira Gandhi National Open University, one of the leading open universities offering various courses in the distance education mode.
www.nptel.iitm.ac.in	National Programme on Technology Enhanced Learning (NPTEL) provides e-Content through online Web and Video for courses in Engineering, Science and humanities streams.
www.ncert.nic.in	Website of National Council of Educational Research and Training. Includes many features such as providing study materials and reference materials in Hindi and English.
www.spoken_tutorial.org	It is an IIT Mumbai initiative. It provides software training through the spoken tutorials. All the courses are offered totally free of cost as it is funded by the Government of India.
www.w3schools.com	W3Schools is a web developer information website, with tutorials and references relating to web development topics such as HTML, CSS, JavaScript, PHP, SQL, and JQuery.
www.gcflearnfree.org	GCFLearnFree.org is supported by the Goodwill Community Foundation. It provides easy-to-follow lessons in mathematics, science and technology and English to help anyone anywhere learn skills and gain knowledge.

Table 12.3: Some e-Learning websites

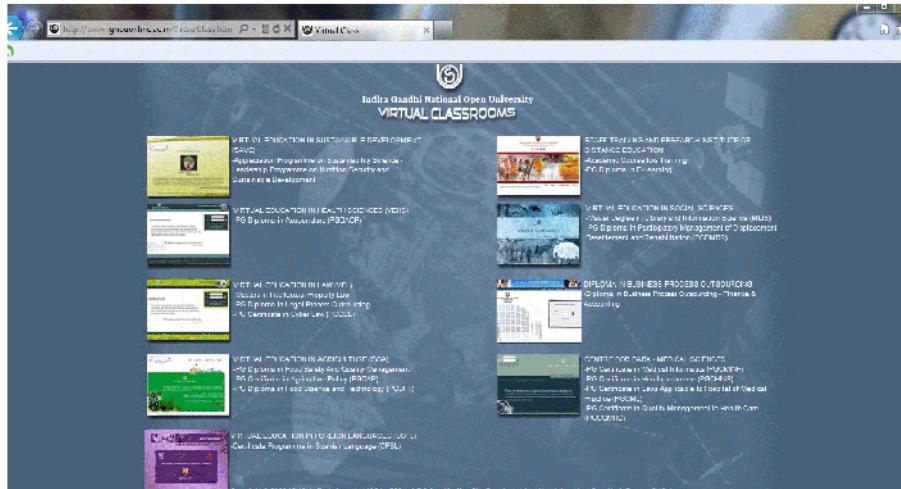


Fig. 12.6: The home page of IGNOU site



www.ignouonline.ac.in

IGNOU (Indira Gandhi National Open University) is an open university under Government of India. The website provides several features including eGyanakosh, which is a digital repository available in text and video format. The site also provides webcasting facility linking to education channels - Gyandarshan, Gyanvani and EDUSAT. Virtual class provides links to all the online programmes conducted by the University.



Fig. 12.7 : The home page of NPTEL site



NPTEL is an abbreviation for National Programme on Technology Enhanced Learning which is an initiative by seven Indian Institutes of Technology (IIT) and Indian Institute of Science (IISc) for creating course content in engineering and science. Web based Course materials have been developed for different courses and are accessible freely through the website. Lecture contents are also made available in web site through video.

Know your progress



1. Real-time exchange of text messages between two or more persons over Internet is termed _____.
2. Pick the odd one out:
 - a. e-Book reader
 - b. e-Text
 - c. television channels
 - d. e-business
3. Define e-Text.
4. Give an example for an e-Learning tool.

12.2 Information security

Today, almost all activities that we perform in real life like, communication, buying goods, banking, etc. can be achieved through the Internet. While executing all these activities, information is exchanged between computers. The security of information passed over Internet is a primary concern. In this section, we will discuss in detail about the cyber world and the various issues like copyright and trademark violations, cyber crimes, etc. that we come across while surfing the Internet.

12.2.1 Intellectual Property Right (IPR)

Many people are engaged in creative work like music, literary work, artistic work, discoveries, inventions, designs and software development. These works are the creation of the mind. They demand a lot of hard work and time. The outcome of such work is called intellectual property. It is unjust to use the idea of a person without his permission. The person involved in developing such properties must get the benefits of it. So it should be protected from unauthorised access.

The importance of intellectual property was first recognised in the Paris Convention for the Protection of Industrial Property in 1883 and the Berne Convention for the Protection of Literary and Artistic Work in 1886. Both treaties are now administered by the World Intellectual Property Organization (WIPO). WIPO was established in 1960 as an agency of United Nations (UN). It is dedicated to ensure that the rights of creators or owners of intellectual property are protected worldwide and the

inventors and authors are recognised and rewarded by their creation. The logo of WIPO and its Indian counterparts is given in Figure 12.8.

Intellectual property rights are similar to any other property right like right over land, house, etc. IPR refers to the exclusive right given to a person over the creation of his/her mind for a period of time. IPR enables people to earn recognition and financial benefit from what they invent or create. IPR owners can disclose their creations in exchange for money. The company which receives the rights, markets and sells this innovation to the society. In this way, the IPR owner, the company and the society benefit from the creation. IPR is encouraged by UN and almost all countries worldwide with the intention of encouraging innovations.

Each country has its own IPR registration system which is applicable to that country. WIPO serves as an international registration system for trademark, industrial design, etc. which is applicable to its member countries.

Intellectual property is divided into two categories - industrial property and copyright.

A. Industrial property



Fig. 12.9: Logo of IP India

Industrial property right applies to industry, commerce and agricultural products. It protects patents to inventions, trademarks, industrial designs and geographical indications. In India, industrial property rights can be registered with Controller General of Patents Designs and Trademarks under Ministry of Commerce and Industry. Logo of Intellectual Property India is given in Figure 12.9.

Patents: A patent is the exclusive rights granted for an invention. An invention means a new product or process (procedure) involving an inventive step, and capable of industrial application. It is the legal right obtained by an inventor for exclusive control over the production and sale of his/her mechanical or scientific invention for a limited period of time. To be patentable, an invention must:

- relate to a process or product
- be new
- involve an inventive step
- be capable of industrial use
- not be developed with the intention to harm others



Fig. 12.8 : Logos of WIPO

Patent protection means that the invention cannot be commercially made, used, distributed or sold without the patent owner's consent. A patent provides the right to the patent owner to decide how the invention can be used by others. The owner can sell the right to the invention to someone else, who will then become the new owner of the patent. The term of every patent in India is 20 years from the date of filing of patent application. Once a patent expires, the protection ends and an invention can be used by the public freely. The details of the first patent filed for a zipper are given in Figure 12.10.

Trademark: A trademark is a distinctive sign that identifies certain goods or services produced or provided by an individual or a company. A trademark can be a name, logo, symbol, etc. that can be used to recognise a product or service. It provides protection to the owner of the trademark by ensuring the exclusive right to use it to



Fig. 12.11: Popular Indian trademarks

identify goods or services. It helps consumers to identify and purchase a product or service. A trademark must be registered. The initial term of registration is for 10 years. Thereafter it can be renewed. In order to determine whether any person or company is using a particular trademark, a trademark search can be conducted through the trademark registry maintained by Controller General of Patents Designs and Trademarks (<http://ipindiaonline.gov.in>). The effect of a trademark registration is limited to that country. Some popular trademarks in India are given in Figure 12.11.

Industrial designs: An industrial design refers to the ornamental or aesthetic aspects of an article. A design may consist of three-dimensional features such as the shape, surface of an article or two-dimensional features, such as patterns, lines or colour. An industrial design right protects the visual design of objects that are not purely functional. Industrial designs are applied to a wide variety of industrial products and handicrafts like medical instruments, watches, jewellery, vehicles, textile designs, etc. The registered designs of Coca-Cola bottle and iPhone are given in Figure 12.12.

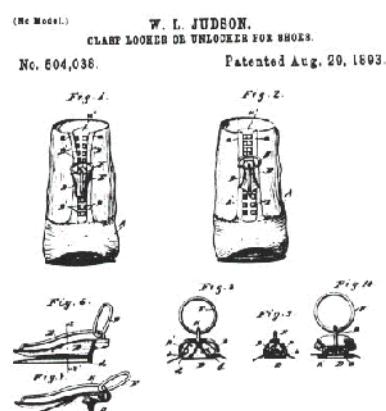


Fig. 12.10: The first patent for zipper

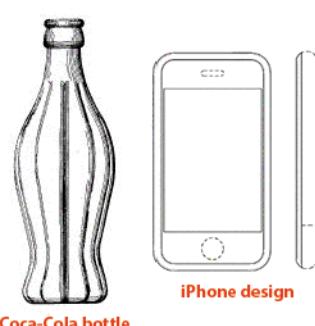


Fig. 12.12: Popular industrial designs

Geographical indications: Geographical indications are signs used on goods that have a specific geographical origin and possess qualities or a reputation that are due to that place of origin. Agricultural products typically have qualities that derive from their place of production and are influenced by factors like climate and soil. Place of origin may be a village or town, a region or a country. Some of the popular products with geographical indications related to Kerala are Aranmula Kannadi and Palakkadan Matta Rice (Figure 12.13).



Fig. 12.13:
Geographical
indications related to
Kerala

B. Copyright

A copyright is a legal right given to the creators for an original work, usually for a limited period of time. Copyright applies to a wide range of creative, intellectual or artistic forms of works which include books, music, painting, sculpture, films, advertisement and computer software. This covers rights for reproduction, communication to the public, adaptation and translation of the work.

In India, the Copyright Act, 1957 came into effect from January 1958. This Act has been amended five times. Some of the important amendments to the Copyright Act in 2012 are extension of copyright protection in the digital environment, liabilities of Internet Service Providers, ensuring right to receive royalties for music composers and exception of copyrights for physically disabled to access any work.

Under Indian Copyright Act, a work is automatically protected by copyright when it is created. The general rule is that the copyright lasts for 60 years after the death of the last surviving author. Registration of copyright gives a legal status to a creative work. This makes it an intellectual property, giving exclusive legal right over the creation. It should be noted that it is not necessary to register to get the copyright. Copyright registrations in India are handled by the Copyright Office under the Ministry of Human Resource Development. The logo of Indian Copyright Office is given in Figure 12.14.

Table 12.4 shows the different symbols used to specify the registration status of intellectual property.

The copyright holders of a work can authorise or prohibit

- its reproduction in all forms, including print form and sound recording;
- its public performance and communication to the public;



Copyright Office
Government of India

Fig. 12.14: Logo of
Copyright Office, India

- its broadcasting;
- its translation into other languages;
- its adaptation, such as from a novel to a screenplay for a film.

Creators often sell the rights of their works to individuals or companies for financial benefit.

Computer software (source code, databases, web sites, etc.) can be copyrighted as a literary work. Even though computer software is protected under copyright, nowadays they are

increasingly getting patented. This is because software development is considered as an industry and patents provide better protection when compared to copyright. It should be noted that the criteria required for obtaining patent protection is more stringent.

Table 12.5 displays the rights and the related intellectual property. The differences in the registration of rights of intellectual property are shown in Table 12.6.

INTELLECTUAL PROPERTY	
Registered trademark	®
Unregistered trademark	TM
Copyright	©
Sound-recording copyright	!

Table 12.4: Symbols used for intellectual property

Intellect	Property	Right
Idea	Invention/innovation	Patent
Idea	Quality + identity	Trademark
Idea	Appearance	Design
Goods	Geographical origin	Geographical Indication
Idea	Expression	Copyright

Table 12.5: Rights related to intellectual property

	Patent	Trademark	Copyright
Refers to	Product, Process	Name, Logo, Symbols	Creative, intellectual or artistic forms of work
Registration	Required	Required	Automatic, can be registered
Duration	20 years	10 years	Until 60 years after the death of the last surviving author
Renewable	No	Yes	

Table 12.6: Differences in the registration of rights for intellectual property

12.2.2 Infringement

Unauthorised use of intellectual property rights such as patents, copyrights and trademarks are called intellectual property infringement. It may be a violation of civil law or criminal law, depending on the type of intellectual property, jurisdiction (countries) and the nature of the action.

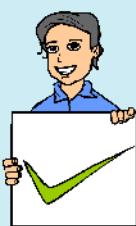
Patent infringement is caused by using or selling a patented invention without permission from the patent holder. Many countries allow using patented inventions for research purpose. The legal dispute between Apple and Samsung over their mobile phone technologies is an example of patent infringement.

Trademark infringement occurs when one party uses a trademark that is identical to a trademark owned by another party, where both the parties use it for similar products or services. It is better to register the trademarks to get the legal advantages. An example of trademark infringement is the legal suit where a small company manufactured toffees under the trademark 'HORLIKS'. This violated the trademark rights enjoyed by 'HORLICKS'.

Copyright infringement is reproducing, distributing, displaying or adapting a work without permission from the copyright holder. It is often called piracy. Software piracy is the illegal copying, distribution, or use of software. Music piracy is the copying and distributing of a piece of music without the consent of the composer, artist or the copyright holding music company. Enforcement of copyright is generally the responsibility of the copyright holder.

Know your progress

1. Creation of the mind is known as _____.
2. Expand WIPO.
3. Intellectual property rights are categorised into _____ and _____.
4. Patents are exclusive rights given to _____.
5. _____ is a sign used to recognise a product or service.
6. What is industrial design?
7. What is the importance of geographical indicators?



12.2.3 Cyber space

Cyber space is a virtual environment created by computer systems connected to the Internet. It is the term used to refer to a simulated world, where we can do many things at one place. Let us now discuss various instances where cyberspace has influenced our lives.

Formerly, communication was mainly dependent on postal service. Now a days e-mail has gained wide acceptance and legal validity for communication. In the Department of Higher Secondary Education (DHSE), all communications to higher secondary schools related to admissions, examinations, National Service Scheme, administration, etc. are done through *website/e-mail*. Today, Internet has become a popular medium for communication among common people.

In December 2012, a girl student was subjected to inhuman physical torture in a moving bus in a metro city in India. After a few days the girl succumbed to her injuries. This incident invoked protests among people from various walks of life. Social media like facebook, twitter, etc. became a platform for the protest. These people organised a movement in support of the girl through messages over the social media. Thousands of people gathered in the streets of Delhi with lighted candles as a protest. Taking this incident into account, the Lok Sabha passed 'The Criminal Law (Amendment) Act, 2013', which strictly deals with sexual assault cases. Such movements organised over *social media*, show its influence on society.

People purchase mobile phones, shoes, apparels, etc. by visiting showrooms. Today, many people prefer to purchase these goods online from e-commerce websites. The *e-commerce* sites provide catalogs which display different search options like price range, brands, etc. about the product. This made shopping easier from the comfort of home and saves time too. E-commerce requires payments through credit cards, debit cards, Internet banking, etc. Nowadays more and more people are attracted to online buying and selling. Figure 12.15 shows e-commerce websites.

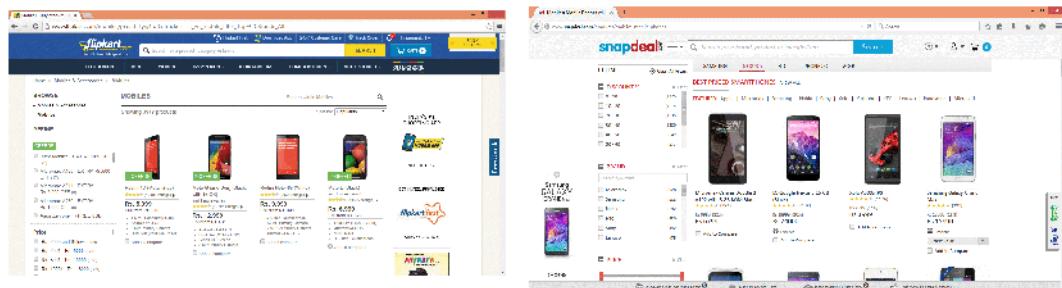


Fig. 12.15 : Sample e-Commerce websites

Almost all banks offer *Internet banking* facilities to its customers. Through this facility we can transfer funds, pay telephone bills, electricity bills, payments for online purchases, train tickets, cinema tickets, etc. This saves a lot of time and effort when compared to performing these activities by actually visiting the respective offices. Hence banking is also a popular service over Internet. An Internet banking website is displayed in Figure 12.16.

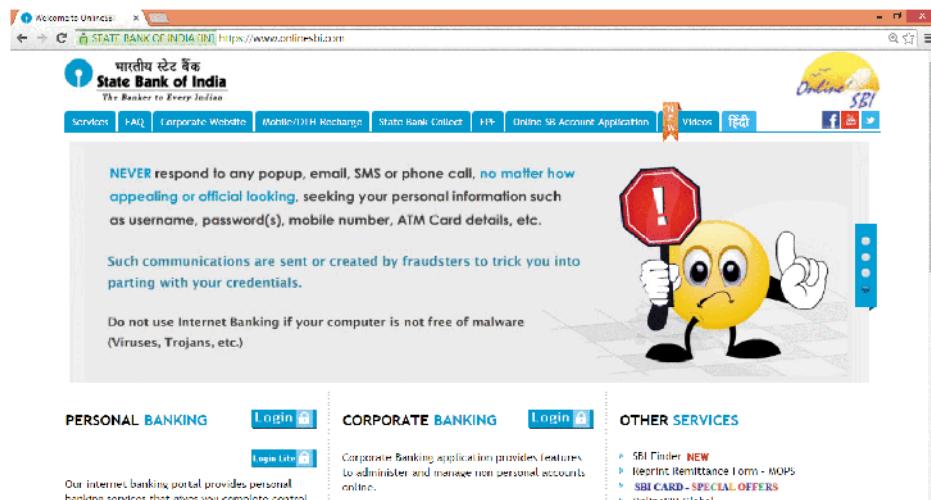


Fig. 12.16: An Internet banking website

With the passage of time, more services are going online. Many people spend a considerable amount of time surfing the Internet to avail of various services in the web. Internet is often referred to as cyberspace. Figure 12.17 shows a symbolic representation of cyberspace.

Cyberspace is an unreal world in which communication over computer networks occurs. It is an information superhighway where individuals gather information, interact, exchange ideas, provide social support, conduct business, play games, engage in discussions and so on.

Cyberspace is a space where social interactions dominate. Some people consider cyberspace as an uncontrolled and unregulated electronic space where anyone is free to do anything as they wish and express themselves freely. Such acts of people affect or negatively influence many others. Hence, when an individual works on the Internet, they have to follow some rules and ethics which are beneficial to all users.

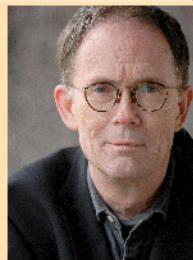
This unregulated space also provides room for criminals. Since activities like communication, financial transactions, etc. in the cyberspace increase day by day, it has opened a new medium for criminal activities. Today cyberspace security has become a serious concern.



Fig. 12.17 : Symbolic representation of cyberspace



'Cyberspace' is a term coined by William Gibson, a Canadian science fiction writer, in his short story 'Burning Chrome' (1982). He used it to represent a world where events or transactions occur that are not in real world. He believed that cyberspace is a consensual hallucination. According to Gibson, consensual hallucination is the nature of existence within cyberspace.



12.2.4 Cyber Crimes

We know that the Internet has opened new opportunities in entertainment, business, communication education, sports, etc. At the same time, it is a reality that some people use the Internet for committing illegal activities.

The increasing use of the Internet through smart phones and tablets for online banking and other financial transactions has increased the risk. Rising Internet penetration and online banking provides opportunities for cyber criminals to target online financial transactions, using malicious software (malware) or through illegal hacking. The statistics of cyber crime committed in the recent years according to National Crime Records Bureau is given in the graph shown in Figure 12.18. This graph shows the significant rise of cyber crimes in India through the years.

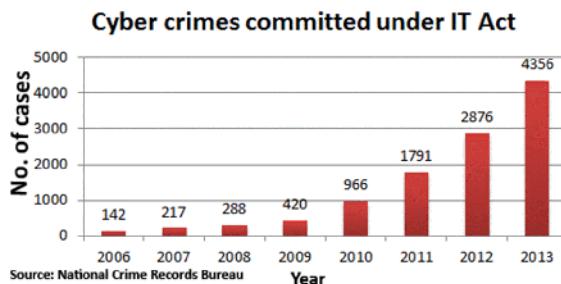


Fig. 12.18: Cyber crime statistics in India

Cyber Crime is defined as a criminal activity in which computers or computer networks are used as a tool, target or a place of criminal activity. The victims of cyber crime lose money, reputation and face mental trauma.

An important aspect of cybercrime is its nonlocal character. A crime can occur in jurisdictions separated by vast distances. That is an attacker may operate from a country and attack a destination in some other country. So the investigating team and the judiciary of different countries must keep hand in hand. Due to the anonymous nature of the Internet, it is possible for people to engage in a variety of criminal activities. People commit cyber crimes knowingly or unknowingly.

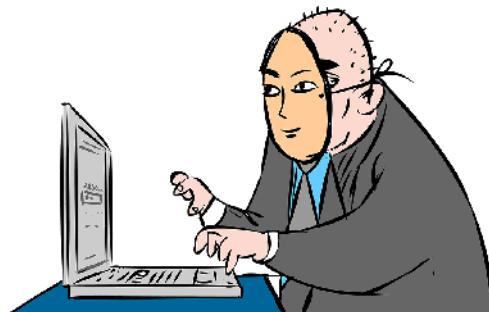
Cyber crimes include phishing, hacking, denial of service attacks, etc. which we have learned in Chapter 12 of Class XI. Computer crime mainly consists of unauthorised access to computer systems, credit card frauds, illegal downloading, child pornography, cyber terrorism, creation and/or distribution of viruses, spam and so on.

Cyber crimes can be basically divided into 3 major categories: They are cyber crimes against individuals, against property and against government.

A. Cyber crimes against individuals

The popularity of broadband Internet increased the dependence of Internet for daily activities. This increased the risk of online crimes. An act of a person in cyberspace that causes physical or mental trouble to an individual is referred to as cyber crime. Harassment, assuming someone's identity, impersonation and violation of privacy are some examples of cyber crimes.

i. **Identity theft:** Identity theft occurs when someone uses another person's identifying information, like their name, credit card number, etc. without their permission to commit fraud or other crimes. It is a form of stealing a person's identity, by which someone pretends to be someone else, to gain access to resources like bank account, social media accounts, etc. This is done with the intention of transferring money from the victim's bank account, payments for purchases, defaming the person through social media, etc. This is done with the intention of obtaining credit from financial institutions or gaining benefits in that person's name.



Before transferring money from bank accounts, the thief may change the mailing address of the account so that the victim will not be able to realize that money is withdrawn. The stolen personal information may be used to open new accounts, open new credit card accounts, to apply for a mobile phone connection and more.

ii. **Harassment:** Posting humiliating comments focusing on gender, race, religion, nationality at specific individuals in chat rooms, social media, e-mail, etc. is harassment. The use of vulgar or indecent language, threatening any illegal or immoral act through a computer or a computer network is considered as harassment.

The use of the Internet, to harass someone is called cyber stalking. You might have read about statements from celebrities that the Facebook accounts in their names are fake. This is because such accounts may contain pictures or posts with defaming content. These profiles might be created using the photographs and personal information of the celebrity by people with criminal intentions. There are people who defame others by sending humiliating e-mails, Facebook posts, etc. All these amount to harassment. Common characteristics of cyber stalking include threats, false accusations, monitoring, identity theft and data destruction or manipulation. Cyber

stalking also includes sexual or other exploitation of minors. It can destroy friendships, careers, self-image and confidence.

iii. Impersonation and cheating: Impersonation is an act of pretending to be another person for the purpose of harming the victim. There are people who utilise the anonymity of the Internet to commit impersonation online.

Sometimes we may receive e-mails seeking help for transferring large amounts of money from a distant country to India. Usually, the sender states that this money is in the form of an asset (land, gold, etc.) that is to be sold. To dispose the asset and complete the legal formalities, the sender requires some amount of money. The mail requests us to share a portion of the expenses and offers us up to 50% of the value of the asset. After receiving the cheque or money order, the sender tells that due to some complications more money is required. In this way the victim may lose large amounts. We often receive similar mails with a different story. Mailing scams like this are examples of Internet fraud/cheating.

Similar crimes occur in online auction also. In some cases, individuals announce products for sale on Internet auction sites. They demand money before the delivery of the item and never carry out their order.

iv. Violation of privacy: Violation of privacy is the intrusion into the personal life of another, without a valid reason. This gives the person whose privacy has been invaded, the right to file a lawsuit for damages against the person/organisation that intruded. It consists of distributing private information like personal data, photography, workplace monitoring videos, etc.

You might have heard of issues regarding the use of hidden cameras, mobile cameras, etc. to capture images of women in public places. Photography of any person (men or women) without his/her permission amounts to violation of privacy. Posting images of others in social media, transferring them to others through e-mail/copying, etc. without their permission are considered as violation of privacy.

v. Dissemination of obscene material: The Internet has provided a medium for the facilitation of crimes like pornography. The distribution and posting of obscene material is one of the important cyber crimes today. Pornography on Internet may take various forms. It may include hosting website containing prohibited materials, use of computers for producing obscene material, downloading obscene materials through the Internet, etc. These obscene content may misguide adolescents.

Most of the cyber crimes occur without the knowledge of the victim, whereas in some others, the victim also takes part in crime to become rich easily. It should be noted that various types of preventive mechanisms have been installed to avoid such crimes.

E-mail service providers use spam filter that filters unwanted mails. Different types of authentication mechanisms that exist for online financial transactions prevent fraud to a certain extent. Above all, an individual has to be careful while using Internet.

B. Cyber crimes against property

Cyber crimes against all forms of property like credit cards, intellectual property, etc. are termed as cyber crime against property. These crimes include hacking, piracy, computer vandalism (destruction of others property), unauthorised intrusion through cyberspace, unauthorised possession of information stored in computers, etc. Some classifications of cyber crimes against property are given below.

i. Credit card fraud: Credit card fraud involves an unauthorised usage of another person's credit card information for the purpose of payments for purchases or transferring funds from it. There are instances where the web servers of large organisations are hacked and credit card information of a large number of people is stolen by Internet thieves. They use this information to make payments or they sell this information to other fraudsters over Internet for a small price.

ii. Intellectual property theft: The infringement of IPRs come under this category. Violation of copyright, patent, trademark, etc. are intrusions against property.

Recently an Indian IT company developed a software for correcting errors in program code. One of the employees of this company copied this software in a CD and tried to sell it to a competitor for a big price. This led to huge financial and property loss to the company. This is considered as theft of intellectual property. Software piracy is also a crime under cyber law.



Nowadays intellectual property theft has become common. Information about any topic is now freely available on the Internet. Copying of another person's language, thoughts, ideas or expressions and presenting them as one's own original work is called plagiarism. There are stringent copyright laws available in India which protect the intellectual property rights. Plagiarism can be easily detected through various tools available online.

iii. Internet time theft: Today almost all modems/routers have wireless Internet facility. They provide sharing of Internet at homes, schools, business establishments, etc. If this is not properly secured using passwords, other people may use our Internet. The usage of the Internet time by unauthorised persons, without the permission of the person who pays for it is called Internet time theft. This leads to loss of Internet

time and money. Above this, others may use our Internet account for committing crimes, for which we may also be held responsible.

The different types of attacks like viruses, worms, man in the middle attack, etc., discussed in Chapter 12 of Class XI also fall under cyber crimes against property.

C. Cyber crimes against government

Increasing popularity of e-governance has made governments vulnerable to cyber attacks. The various governmental computer networks and websites are vulnerable to risks and threats of cyber crimes. The different categories of cyber attacks against government are cyber terrorism, website defacement and e-governance denial attack.

i. Cyber terrorism: Cyber terrorism is a cyber attack against sensitive computer networks like nuclear power plants, air traffic controls, gas line controls, telecom, etc. These types of attacks against governments are increasing globally. Cyber terrorism focuses on the use of the Internet by anti nationals to affect a nation's economic and technological infrastructure.



In 2010 a computer virus called tuxnet was used to carry out an invisible attack on Iran's secret nuclear programme. This virus was aimed at disabling Iran's Uranium enrichment programme. This virus infected a large number of nuclear controls and gave false instructions leading to nuclear malfunctions and break down.

Cyber terrorism may prove to be very costly to a country. Therefore governments provide very powerful security mechanisms for their servers.

ii. Website defacement: This is a common cyber attack against a government. Defacement of websites includes hacking of government websites and posting derogatory comments about a government in those websites.

iii. Attacks against e-governance websites: These types of attacks deny a particular online government service. This is done using a Distributed Denial of Service (DDoS) attack which we discussed in Chapter 12 of Class XI. In another case the website may be hacked and controlled by the hackers. They gain access to website administration through content management system and destroy the data. This causes huge loss to the government.

Cyber terrorism has increased in the modern world because of the anonymous nature of cyberspace. The availability of a variety of targets that affect a large number of people, and the fact that attacks can be conducted from a distance have increased terrorism through cyberspace.

12.2.5 Cyber ethics

The available statistics shows that the volume of cyber crimes is increasing rapidly all over the world. Internet crime has many faces and is committed in diverse ways. Awareness is the first step in protecting ourselves, our family and our business. We should ensure that our actions in the cyberspace do not harm others. We should also remember that our actions over the Internet are being monitored by several others.

Suggestions given below can be considered as ethical practices over the Internet.

- Use anti-virus, firewall, and spam blocking software for your PC.
- Ensure security of websites ([https](https://) and padlock) while conducting online cash transactions.
- Do not respond or act on e-mails sent from unknown sources.
- Use unique and complex passwords for accounts and change your passwords on a regular basis. (Should have a minimum of 8 characters, contain alphabets, numbers and special characters)
- Do not select the check boxes or click OK button before reading the contents of any agreement/message.
- Avoid the use of unauthorised software.
- Do not hide your identity and fool others.
- Do not use bad or rude language in social media and e-mails.
- Remove the check mark against 'Remember me' before logging into your account using computers other than your personal ones.



- Conduct an awareness program about various cyber crimes.
Prepare a chart listing how we can protect ourselves in cyber space.

Let us do

Know your progress



1. What do you mean by cyberspace?
2. Criminal activity using computer, mobile phone and Internet is termed as _____.
3. What is cyber crime against a person?
4. Cyber terrorism is a type of cyber crime against _____.
5. Stealing one's information such as username and password is _____.

12.2.6 Cyber laws

The term cyber law in general refers to the legal and regulatory aspects of the Internet. Cyber law can be defined as a law governing the use of computers and Internet.

We have already discussed that there are different kinds of cyber crimes. Criminal activities such as theft, fraud, forgery and defamation are traditional in nature and are subject to the Indian Penal Code. The abuse of computers (cyber crime) has become wide spread in India which is addressed by the Information Technology Act, 2000 and IT Act Amendment Bill 2008.

Cyber law is important because it touches almost all aspects of transactions and activities using Internet. Whether we realise it or not, every action and every reaction in cyberspace has some legal perspectives.

12.2.7 Information Technology Act 2000 (Amended in 2008)

The Information Technology Act, 2000 is India's legislation regulating the use of computer, servers, computer networks, data and information in electronic format. The legislation has touched various aspects related to authentication, digital signature, cyber crime and liability of network service provider. The acts aim to provide legal recognition for transactions carried out by means of electronic data interchange and other means of electronic communication. IT Act allows using alternatives to paper based communication and facilitates electronic filing of documents with government agencies. It gives legal acceptance for electronic communication. It also addresses offenses and disputes in the cyberspace and provides justice to victims of cyber crimes.

IT Act aims to provide legal infrastructure for e-commerce in India. This Act was developed to promote IT industry, regulate e-commerce, facilitate e-governance and prevent cyber crimes. It promotes security practices within India that would serve the country in a global context. Under the Act certain violations are treated as serious crimes and offenders are liable to penal actions. Therefore it is important to understand the various perspectives of the IT Act, 2000 and what it offers.

In May 2000, the Indian Parliament passed the Information Technology Bill and it is known as the Information Technology Act, 2000. The Act was amended by the Information Technology Amendment Bill 2008, which was passed in December 2008. This amendment accommodates further development of IT and related security concerns, since IT Act 2000 was passed. Compensation has to be given to affected persons if damage is done to the computer system or computer network by the introduction of virus, denial of service, etc. Sections 65 - 74 of the Act specifically deals with cyber crimes.



SOME COMMON OFFENCES AND THEIR PUNISHMENTS NOTED IN IT ACT 2000 AND IT AMENDMENT 2008

Section	Offences	Punishments
65	Tampering with computer source code	Imprisonment up to three years, or with fine which may extend up to two lakh rupees, or with both.
66	Computer related offences	Imprisonment for a term which may extend to two three years or with fine which may extend to five lakh rupees or with both.
66B	Punishment for dishonestly receiving stolen computer resource or communication device.	Imprisonment for a term which may extend to three years or with fine which may extend to rupees one lakh or with both.
66C	Punishment for identity theft.	Imprisonment for a term which may extend to three years and shall also be liable to fine which may extend to rupees one lakh.
66D	Punishment for cheating by personation by using computer resource.	Imprisonment for a term which may extend to three years and shall also be liable to fine which may extend to one lakh rupees.
66E	Punishment for violation of privacy.	Imprisonment which may extend to three years or with fine not exceeding two lakh rupees, or with both.
66F	Punishment for cyber terrorism.	Imprisonment which may extend to imprisonment for life.
67	Punishment for publishing or transmitting obscene material in electronic form.	Imprisonment for a term which may extend to two to three years and with fine which may extend to five lakh rupees. In the event of a second or subsequent conviction with imprisonment for a term which may extend to five years and also with fine which may extend to ten lakh rupees.
67A	Punishment for publishing or transmitting of material containing sexually explicit act, etc. in electronic form.	Imprisonment for a term which may extend to five years and with fine which may extend to ten lakh rupees.

Section	Offences	Punishments
67B	Punishment for publishing or transmitting of material depicting children in sexually explicit act, etc. in electronic form.	Imprisonment for a term which may extend to five years and with a fine which may extend to ten lakh rupees. In the event of second or subsequent conviction with imprisonment for a term which may extend to seven years and also with fine which may extend to ten lakh rupees.
Punishment for sending offensive messages through online communication services like e-mail, social media, SMS, etc. will be according to the sections in Indian Penal Code (IPC).		

12.2.8 Cyber Forensics

The increase in computer crimes affects our daily lives and national security. Internet and digital technologies bring us a lot of convenience. But at the same time they also provide criminals more chance to commit crimes. Traditional law enforcement tools and methodologies do not successfully address the detection, investigation and prosecution of cyber crime.

Forensics is the process of using scientific knowledge for identifying, collecting, preserving, analyzing and presenting evidence to the courts. Cyber forensics can be defined as the discipline that combines elements of law and computer science to collect and analyze data from computer systems, networks, communication systems and storage devices in a way that is admissible as evidence in a court of law. The goal of computer forensics is to analyse data in a way that preserves the integrity of the evidence collected so that it can be used effectively in a legal case.

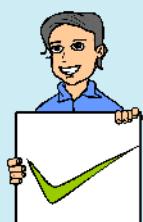
12.2.9 Infomania

Information is considered as the key to success. It has to be collected, managed and processed well. But what happens if a person gets overloaded with information? Infomania is the state of getting exhausted with excess information. It occurs due to accumulation of information from many sources like Internet, e-mail and cell phones, but cannot be processed. While collecting information, its quality and relevance are also to be considered. Infomania is the excessive enthusiasm for acquiring knowledge. This may result in neglecting the more important things like duties, family, etc. We may see people browsing for information during dinner. It is now treated as a psychological problem. Constantly checking e-mails, social networking sites, online news, etc. are the symptoms of infomania. Many people do this to keep themselves up to date with the fear of being out of the group.

Studies prove that people addicted to infomania lose concentration and sleep. Excessive use of technology reduces intelligence. Some people give high priority to respond to incoming messages through mail and social media. These people may skip or interrupt their important family or professional engagements to answer an e-mail or a social media post.

To get away from such situations, users must learn to log off social media, online news and discussion groups while they are at work or spending time with family.

Know your progress



1. The year in which IT Act came into existence in India is _____.
2. What is the purpose of IT Act?
3. What do you mean by cyber forensics?
4. _____ is the excessive enthusiasm for acquiring knowledge.



Let us conclude

Information Technology is a fast growing field. It is widely used in our day today activities. Business transactions, government activities, learning processes, etc. are some of the major areas where IT is substantially utilised. The advancements in the development of communication owes much to information technology. ICT is another term often used as an extended synonym for IT. Hence IT and ICT enabled services have become inseparable part of modern society. In the techno savvy world of 21st century, more people are engaged in Internet through social networks, net-banking, mobile applications, e-shopping, etc. It is a reality that Internet has made life easier. A person can do a variety of jobs through cyberspace. Due to its anonymous nature, cyber space has became a venue for criminals. Crimes can be against a person, property or government. The best way to be safe is to be aware of the traps in the Internet. The rights of creator or owner of music, software, artistic works, inventions, etc. are protected by Intellectual Property Rights. There are cyber laws which provide the framework for a secure environment in cyberspace. India has a robust IT Act. It addresses the different crimes committed using computers, Internet and mobile phones. Cyber forensics has emerged as a part of legal proceedings of almost all civil and criminal cases. Any crime committed using IT infrastructure leaves a digital evidence that makes it easily detectable. While using the Internet, ensure that our actions do not harm others. The term infomania is used for addressing the problems created by information overloading.

Let us assess

1. Name an electronic device used to read e-Text.
2. Name any two e-Learning tools.
3. List out different types of interactions in e-Governance.
4. What are the advantages of e-Governance?
5. What are the duties of Akshaya?
6. What are the major challenges faced in the implementation of e-Learning?
7. Compare the advantages and disadvantages of implementing e-Business?
8. What is cyberspace?
9. Why is cyberspace called a virtual world?
10. Phishing is an example for _____.
11. Explain different categories of cyber crimes in detail.
12. "Awareness is the best way to protect ourselves in cyberspace". Comment.
13. How do trademark and industrial design differ?
14. What is copyright? How does it differ from patent?
15. Explain the exclusive right given to the owner by IPR?
16. What is piracy?
17. What do you meant by infringement?
18. Why is a cyber law important?
19. "Non-local nature of cyber crime creates problems to the investigators". Explain.
20. "Infomania has become a psychological problem". Write your opinion.



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