NATIONAL OPEN UNIVERSITY OF NIGERIA

SCHOOL OF SCIENCE AND TECHNOLOGY

COURSE CODE: PHY130

COURSE TITLE: LABORATORY ORGANISATION AND MANAGEMENT

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Course Title LABORATORY ORGANISATION AND MANAGEMENT
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LABORATORY ORGANISATION AND MANAGEMENT

COURSE GUIDE

Course Introduction

Change is the nature of the scientific world! A laboratory design should conform to this reality. It is therefore important to keep provision for changes while designing a laboratory. Moreover, you must acquire the ability to judge whether or not a particular design is adequate. With this in mind, we begin the course by discussing the basic principles to be followed in the design of a laboratory. Next we proceed to specifics such as preparation room, balance room, instrumentation room and storeroom. The need for structural fittings and services (gas, water and electricity) in the main laboratory and in the specialised areas is also emphasised.

This course consists of ten units.

In the first unit, we discuss the approaches that are required for planning the overall design of a laboratory. Beginning with the fixed and flexible designs, we introduce you to the concept of a laboratory unit. It should enable you to estimate space requirements. Other essential features of the laboratory such as benching, surfaces and furniture, lighting, ventilation, heating and cooling, services, flooring, security and safety are also discussed in detail.

In Unit 2, we discuss the design and, the requirements of space, storage, lighting and services that need to be provided in the preparation room. Specific requirements of a microbiological preparation room are separately discussed.

In Unit 3, you will learn the basic principles followed in the design of stores and ways of keeping provision for storing various equipments and chemicals. Environmental and physical features, which are of prime importance in designing a store, are also considered. Two appendices on storage and disposal have also been included in this unit.

Organisation of practical work is the main responsibility of laboratory technicians. In Unit 4, you will learn about organisation of practical work, demonstration, clean up, maintenance, handling services, emergencies and securities.

In a laboratory, management of stock with particular emphasis on organisation of inventories is extremely important. Unit 5 deals with procedures to be followed in the purchase of equipment/instruments, glassware, chemicals etc. The unit also touches upon accounting aspects of expenditure, budget, petty cash etc.

In unit 6, we have discussed how basic skills in oral and written communication improve effective communication. You will agree that these are essential for efficient running of laboratories. In this unit, you will also learn to produce suitable written notes, letters and memos etc., and the channels through which these should be routed for necessary implementation.

Record keeping is another aspect of efficient communication. Though, it may be cumbersome, it aims at providing information about availability of stock so that laboratories operate smoothly. In Unit 7 on 'Files and Records' we discuss various systems used for filing equipment, chemicals, books, audio-visual aids, printed and written materials, worksheets, instruments, correspondence, supply orders and other miscellaneous items.

Reporting is an important part of any scientific endeavour. It involves accurate recording of facts and data, analysis and interpretation and presentation in a good scientific report. These need skills of various kinds. Unit-8 on "Scientific Reporting" discusses the basic skills and essential elements of report preparation. The use of various devices for effective presentation is illustrated through examples.

You may be aware that computers are gradually becoming part of every forward-looking work environment. Therefore, to provide you some training on the use of computers in organisation and management of science laboratories, in unit 9 we have discussed how you can work on a computerised system. You will be able to appreciate the advantages of using various computer software for handling and retrieving information about stocks, finance, personnel and technical data in a laboratory.

Information Distribution forms the subject matter of unit 10. To be able to take information to all concerned, we need to produce multiple copies of various documents, letters, reports etc., economically. In this context use of various kinds of typewriters, Xerox machines and duplicating machines are discussed in detail.

Objectives

After studying this block, you will be able to:

- appreciate the main features of design, organisation and management of laboratories including preparation room and store,
- suggest the ways for renovation and/or reorganization of a lab,
- identify the requirements in terms of benching, furniture and storage for a
- lab,
- suggest suitable arrangements for adequate light, ventilation, heating and
- cooling for a lab,
- outline methods of stock control, purchasing, accounting of expenditure,
- budgeting, maintenance of petty cash etc.,
- Draft communication related to laboratory work and outline procedures for sending these to concerned authorities,
- prepare a clear and effective scientific report,
- explain the importance of filing system and record keeping,
- state the advantages of using a computer system in laboratory organisation
- and management, and
- list various reprographic methods used for information distribution.

UNIT 1 ORGANISATION AND DESIGN OF LABORATORIES: INTRODUCTION

Structure

1.1 INTRODUCTION

You have some experience of working in the laboratories (abbr. singular- lab, plural -labs) of your School/College. They are meant to train students in practical work. Some of you may have visited private and public testing labs also. Can you recall how they were designed? Was one type of lab different from the other? Did you find them convenient and safe to work in or did you feel that there was scope for improvement?

In this first unit we will discuss the broad principles underlying the organisation and design of a good lab. This will be followed by units 2 and 3 which deal with design considerations with regard to preparation room and store.

In practice the task of lab design is given to the engineer or architect who may consult the faculty members on certain issues and finalise it. Nevertheless, we feel it is important that all personnel involved in organisation and maintenance of a lab should know the principles underlying good lab design. Quite likely, there may be occasions to apply this knowledge when labs are renovated, reorganised or services are improved or repaired.

The lab technicians assist in most of the lab activities and are responsible for lab maintenance. Therefore, they should also learn what all is required for a good lab design.
In this unit we will cover the following general topics:

1. The general features of atypical School/College lab.
2. Design considerations that apply to the lab and to the areas that directly support its operation.
3. Requirements of people in the lab together with how they should organise the lab and themselves.
4. Requirements of specialized rooms and services.

Objectives

After studying this unit you should be able to:

- list the desirable features of a good lab,
- use the principles underlying design of labs while planning new ones or renovating them,
- estimate minimum working space needed on the basis of the number of persons who will use the lab ,
- list the advantages and disadvantages of fixed and variable systems of lab layouts,
- suggest the various types of material available for benching and furniture and discuss their merits,
- state the need for efficient and safe services (mechanical, electrical, water and gas) in the lab and preparation room,
- describe the requirements of adequate lighting, ventilation, and heating of various lab areas,
- state the need for adequate circulating space, particularly in respect of safety,

- describe the various types of floors and flooring available and discuss their relative merits for types of working area,
- state the reason for the use of fume cupboards and other forms of mechanical ventilation,
- describe the need for and control of smoke doors, escape routes and general circulation,
- describe the need for security of both premises and the immediate work area.

1.2 THE ESSENTIAL REQUIREMENTS OF A TYPICAL LABORATORY

In this unit we will try to identify the essential requirements of a typical laboratory.

Here it would be interesting to consider the kind of lab a famous scientist "Herr Bunsen" used in the 19th century. In the summer of 1852 Bunsen first went to Heidelberg (Germany) to work in Gmelin's old lab. This is how he described the lab.

> "The lab was situated in the buildings of an ancient monastery, and there we all worked. It was roomy enough. The old refectory was the main lab, and the chapel was divided in two. One half became the lecture room and the other a storehouse and museum. Soon the number of students increased and we needed further extensions. So the cloisters were enclosed by windows and working benches placed below them. Beneath the store floors at our feet slept the dead monks, and on their tomb stones we threw out waste precipitates! There was no gas supply in Heidelberg in those days; nor any town's water supply. We worked with Bezelins' spirit lamps, made our combustion with charcoal, boiled down our wash-waters from silicate analysis in large glass globes over charcoal fires, and we went to fetch out water from the pump in the courtyard."

What we have reproduced above is actually based on an account published in a science magazine the *Journal oj the Chemical Society* in 1900.

SAQ 1

(a) From this account try to list below the essential requirements of a lab.

_____

_____

_____

_____

_____

_____

_____

_____

_____

Check your answer with ours at the end of the unit before continuing.

(b) Now try to recall the features of the labs you have worked in at school or college or in any other lab you may have visited sometime, and list them below.

_____

_____

_____

_____

_____

_____

_____

_____

_____

Now we will discuss how best the above features can be accommodated in the lab design so that the persons using it can work with ease and comfort.

Let us start with the requirement for space.

1.3 LABORATORY SPACE

A lab could just be a single room or a large building with provision for separate rooms for specific work. The size depends upon the purpose for which it is required. Single owner personal pathology or microbiology labs used for some routine tests are generally very small. The physics, chemistry, botany and zoology labs of school/college are larger in size. Public and private research institutions have several big labs. Labs are variously designed. For instance, the biology lab of a college is different from chemistry, physics or computer labs.

> According to the Oxford dictionary a laboratory is a room or building fitted out for scientific experiments, research, teaching or the manufacture of drugs and chemicals.

Before we discuss labs any further it is necessary that we become familiar with the usage of the term laboratory. The term could be used for a single room if it is equipped for performing experiments. In colleges, you will find botany, zoology, physiology and microbiology laboratories. In common parlance these together with other units and ancillaries are also referred to as laboratories. Therefore we find that the term laboratory is not used very specifically. While we are discussing the various units (rooms) of a lab, we shall use the term Main Lab instead of lab for the room/unit where experimental work is performed.

Often the main lab in a teaching institution is rectangular like the one illustrated in Fig. 1.1. The typical size is somewhere between 40 and 80 square metres.

It is of utmost importance that any lab has adequate space within which lab workers can work. Ample space is required for the safe conduct of lab work and for efficiency and maintenance. Therefore, it is necessary to decide how much space is ideal per lab worker?

Various suggestions have been made by different organizations as to the space that should be provided for each lab worker. The Laboratory Investigation Unit (LIU) of the Department of Education and Science (UK) introduced the concept of the Laboratory Unit **(Lab Unit).** *This is a self-contained area within a lab that supports the work of two or three workers.* The LIU suggests that in practice, it is unlikely that fewer people will be working together. Thus if all the requirements for this group of workers are provided in terms of space, services, storage, etc. any larger lab can be a multiple of the Lab Unit. This introduces the idea of modular lab design.

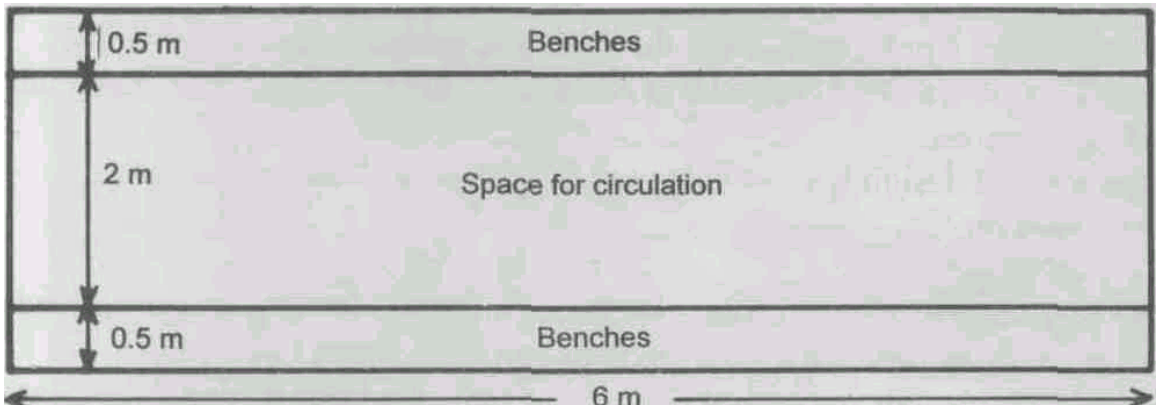

Fig. 1.1: One arrangement for the '**Lab Unit**'

The LIU suggests that some 12 m of bench space is needed for two to three workers. This includes space for sinks (and the dead space alongside each sink), and fume cupboards. This 12 m run would be best accommodated by two 6 m runs separated by about 2 m. Allowing 0.5m for the depth of benching, the dimensions of the Lab Unit will be $6\text{m} \times 3\text{m}$.

Even if unattainable in some situations, the idea of LIU is helpful for calculating the number of students that can be accommodated in a given lab. We can propose that a minimum of two metres bench space should be allotted per person. Whatever the condition be, sufficient space must be allowed for work and circulation.

SAQ 2

(a) What are the fundamental points that should be raised before deciding on the number of students/persons who will use a lab?

(i)

(ii)

(iii)

(b) When considering the size, of a lab, how much space should be planned for each worker?

_____

_____

_____

1.4 DESIGNS OF LABORATORIES

The overall philosophy of the design could be fixed or flexible.

1.4.1 Fixed Design Laboratories

Traditionally the labs are of fixed design i.e. all benches, cupboards and services are rigidly fixed. Let us first try to list the typical features of a traditionally designed lab below:

a. Benches are firmly attached to the floor and, perhaps also to the walls,
b. Services are usually screwed and clamped to bench legs and the underside of lab benches,

> Services means gas, water and electricity.

c. The general design approach is one of permanency and substantial construction.

The strength of the design lies in its physical strength. In certain circumstances this may be an important factor where, for example, many people carry out varied tasks in the lab, e.g. in a school. However, in a fixed design lab a change in lab layout would cause major disruption.

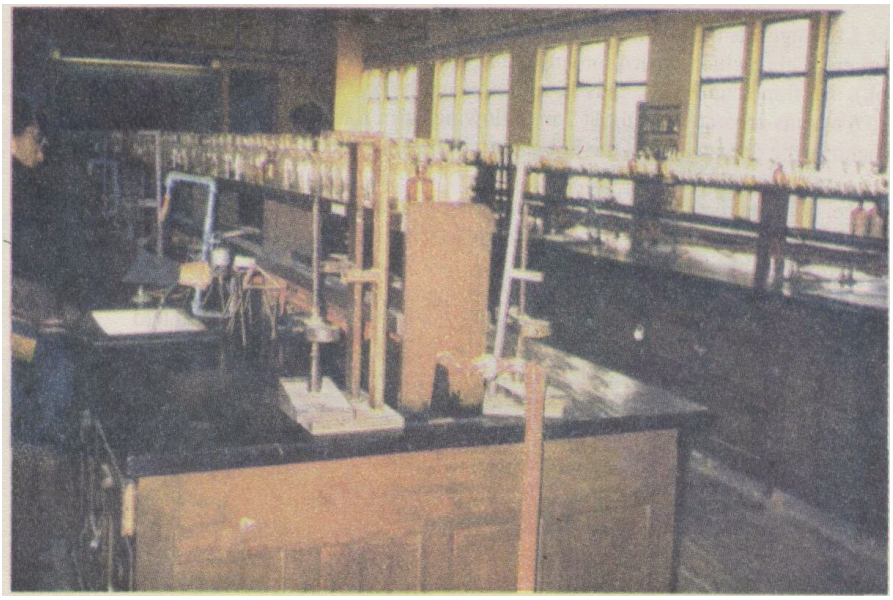

Fig. 1.2: A view of a fixed design laboratory

1.4.2 Flexible Design Laboratories

Flexible lab design adopts the strategy of keeping furniture, benches and services free-standing so that they can be easily moved. Many labs show a continual pattern of change in usage, and 'flexible' design helps to overcome the potential inherent disruption. Flexible design is quite suitable for private multipurpose labs.

In case one wants to build a lab there is no hard and fast rule. The choice of design depends on a real life need. To opt for a high degree of flexibility in every case or to be completely biased to the traditional approach would suggest that no account is taken of the real needs. The most important point as far as the approach to the design is concerned is to be able to answer the following question positively:

Fig. 1.4: A view of flexible design laboratory

Can the features incorporated in the design be justified? In other words, will the design meet requirements for the present as well as in the future?

Partition Walls

At times it may be necessary to divide the lab space in order to confine an area for specific work. Such matters as partition walls should be included in the plans. Either load-bearing walls or temporary partitions can create the division. Load bearing walls, for example offer little flexibility but can be used for permanent fixing. Although partition walls offer considerable flexibility in contrast to structural walls, this flexibility can easily be lost by fixing benches, shelves and services to a partition wall. If at some future stage a conversion is, undertaken, major work may be required to remove the fixtures, which have" been attached to the partition. Clearly, while you design the lab you should take this into account and avoid making permanent attachments to partition walls.

SAQ 3

(a) Try to recollect-the design of the lab you have worked in school or college. Describe its features, what kind of services were available to you and how they were fixed?

_____

_____

_____

(b) When designing a lab, what services should be planned for the lab and an associated preparation room?

_____

(c) 'Partition walls should be used wherever possible to attach services and benches firmly.' Do you have any comment to make about this statement?

Check your answers with those given at the end of the unit before continuing.

1.5 MAIN LABORATORY IN RELATION TO OTHER ROOMS

Suppose you wish to choose the location for the main lab (where students perform practicals) then you should think about whether the chosen room will be ideal and what its relationship to nearby rooms will be.

You should consider the use of adjacent rooms. If the proposed activities in the main lab will result in a lot of noise or vibration, it should not be located next to a rest room or library!

Of more importance is the relationship between a main lab and related accommodation. For example, a school has two biology labs. These should be located as near as possible to each other, perhaps separated only by a preparation room - see Fig. 2.1 (Unit 2).

Widely dispersed labs should be avoided as this leads to considerable difficulties for the technical staff. All the labs should be near each other and, ideally in a separate wing, which can be isolated in the case of fire.

SAQ 4

Why is it important that related labs and preparatory rooms should be located close to each other?

1.6 BENCHING, SURFACES, FURNITURE, AND STORAGE

Often labs are rectangular like the one illustrated in Fig. 1.5. Since in most cases benching is firmly fixed and drainage is only available along walls, this is what we shall assume for this lab also.

Fig. 1.4 a shows the basic lab - empty. Fig. 1.4 b, c and d show various possible arrangement for benching, each with advantages and disadvantages.

In the arrangement in Fig. 1.4 b, a mixture of perimeter and island benches is used. In this lab what could be the arrangement for drainage? The drainage might be restricted to the perimeter. This design may allow a large number of people to use the lab. Besides it provides a considerable quantity of under-bench storage. But in a school lab, the supervision of the pupils, particularly those with their backs to the teacher, may be a problem.

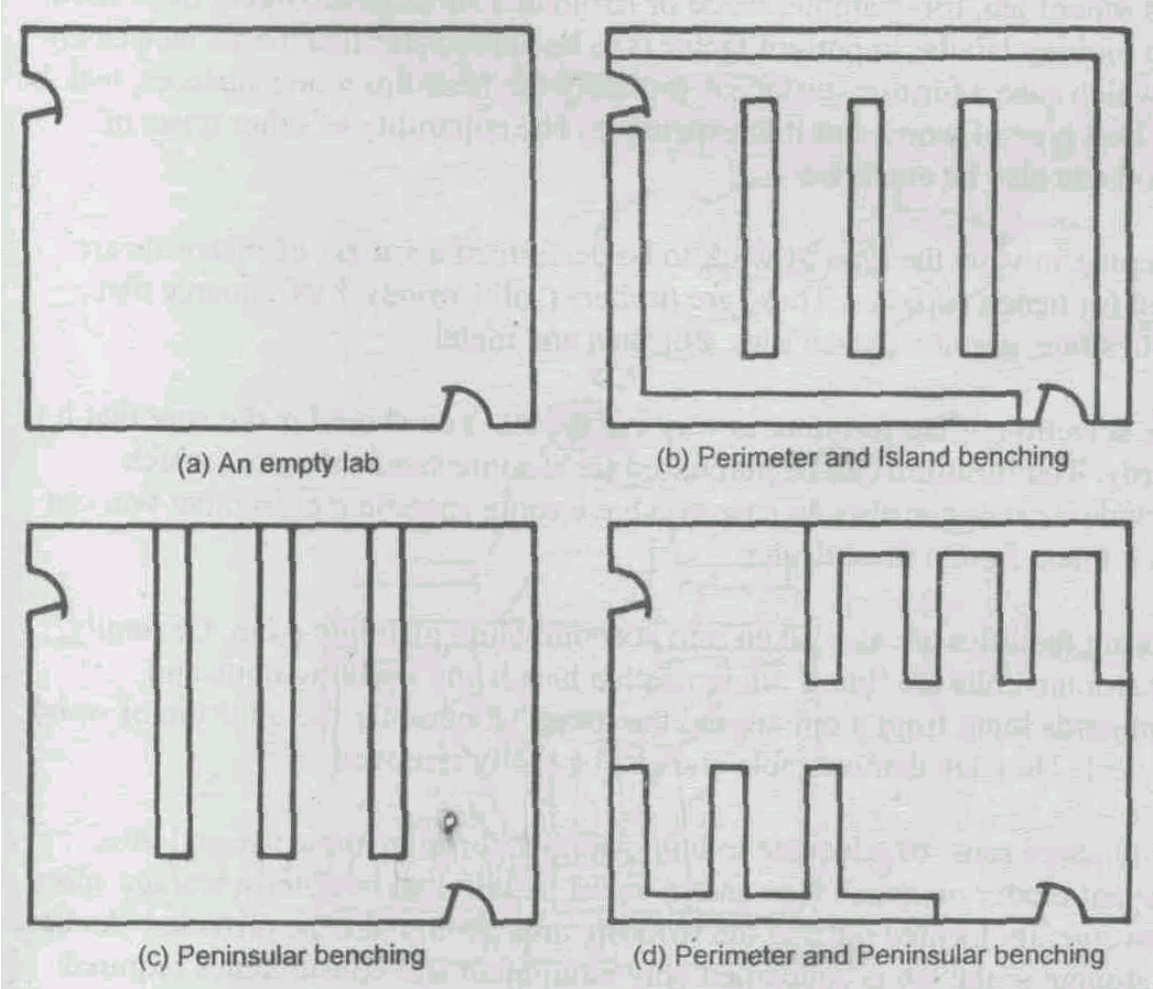

Fig. 1.4: Some laboratory layouts

Fig. 1.4 c shows a design with peninsular benching only. These benches would be rather long and sufficient distance would have to be allowed between each so that people at the ends nearest the wall could have safe access to their work area.

In Fig. 1.4 d, you can see a mixture of perimeter and peninsular benches. This is a typical modular approach with each U-section forming a module.

Many other designs could be devised, but before you decide, you must find out what your requirements are.

The dimension of the work surfaces- the height and width of benches is generally standard for a discipline though most people are of differing height and build.

Once the position of benches is decided one must consider suitable work tops, cupboards and other storage units, shelving and so on.

Bench tops should be sealed to the walls, impervious to water and resistant to disinfectants, acids, alkalis, organic solvents and moderate heat.

Two main factors in the choice of work tops to be considered are:

1. The cost of the material, and
2. The nature of the lab work.

In a school lab, for example, wood or laminated surfaces are likely to be used. In a biology lab the important factor is to be able to sterilize the surface easily in which case a formica surface is probably the best. For wood surfaces, teak is the best type of wood, but it is expensive. The suitability of other types of wood can also be explored.

Keeping in view the type of work to be performed a variety of materials are used for bench surfaces. These are timbers (solid wood), PVC, quarry tiles, Kota stone, granite, glazed tiles, Formica and metal.

The selection of lab furniture is very important. You should make sure that it is sturdy. The furniture can be purchased from some standard firms, which provide a catalogue also. In case you have some specific requirement you can get it made from a local dealer.

Storing facilities are also taken into account while planning a lab. Generally, the storage units are 'hung' underneath a bench and shelving units and cupboards hung from a rail around the room. Commonly the units are of wood or steel. They are demountable and can be easily removed.

Store space must be adequate to hold supplies for immediate use and thus prevent clutter on bench tops and in aisles. Additional long-term storage space conveniently located outside the working area should also be provided. As far as storage in the lab is concerned only equipment and consumables required for day-to-day use should be stored. Obviously an exception would be specialised large equipment, which may have to be housed in the lab even though it is used only occasionally.

Many labs have totally inadequate storage space. Here under-bench storage assumes a far greater importance. Indeed, it can become the major method of storage. Under-bench storage is inconvenient, with low shelves making access difficult (Figs. 1.5 and 1.6).

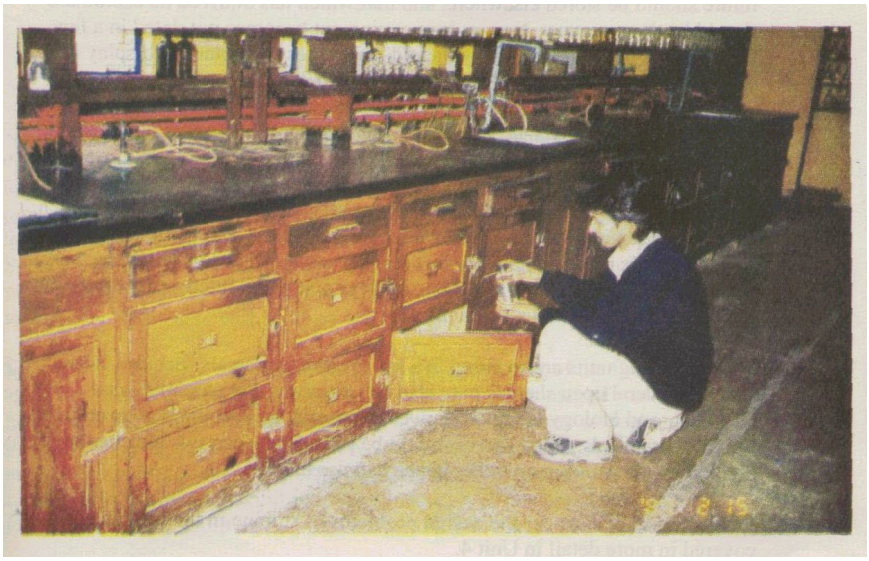

Fig. 1.5: Under **bench storage**

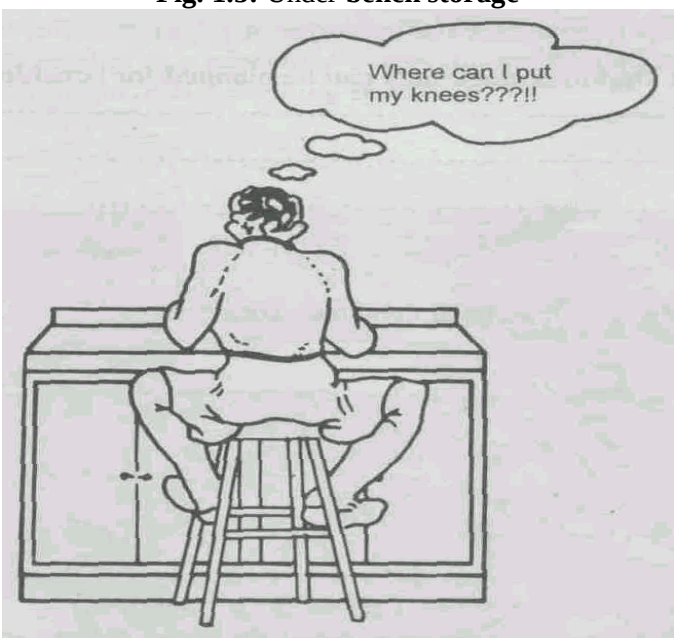

Fig. 1.6: Knees up while working

The insides of under-bench units are dark. They often get dirty and collect items that should have been thrown away years ago. Staff is often reluctant to throw away equipment and use the statement 'we used that back in, let me see 1975, we could still have a use for it'. You need to adopt an aggressive policy towards storage, stipulating that anything which is not needed in the very near future should be stored elsewhere, and that which has outlived its usefulness should be thrown away. Now-a-days equipment becomes outdated in a few years so it is best to throw away the old stuff unless one plans to display it in some exhibition.

If you want to use under-bench storage then some of these units will need to take trays, which slot into units or are fitted with movable shelves.

A more convenient way is to place a movable (wheeled) unit under the bench. Since a single unit would be quite large and difficult to move out, a few small units (each of approximately 1½ feet length) can be placed instead. Since each small unit has wheels they move like trolleys and when fitted under the bench give the appearance of a single unit.

Many shelving units are required in a lab to store chemicals. Besides closed shelves, several open shelves may also be necessary. For example in a chemistry and biology lab open shelves are useful for keeping bottles required for daily practicals. Open shelves could be placed between two benches so those students working on either bench can use them.

Finally we shall consider the design problems of storage in the lab. This is covered in more detail in Unit 4.

Now try the following SAQs.

SAQ5

(a) What kind of arrangement can be planned for benching in the lab?

_____

_____

_____

(b) List the materials used for bench surfaces.

_____

_____

_____

(c) In the following statements fill in the blank spaces with appropriate words,

(i) ..... units are convenient for under-bench storage.

(ii) Bench lops should be ..... to water, ... to disinfectants, acid alkali, organic solvents and moderate heat.

(iii) The items that have outlived their usefulness should be

_____

1.7 SERVICES

All labs require water, gas and electricity to be freely available as well as a drainage system. Some labs (such as chemistry) may also require specialized services such as steam, vacuum or compressed gases and fume extractors. The provision of these services has been the subject of much heart searching for they are the principal factors that limit the flexibility and adaptability of a lab. Suppose, for example, a lab is fitted with demountable partitions. If service pipes are then fixed to the partitions they immediately become fixed and immovable. This same will apply to benches.

Services, traditionally, are almost always provided by way of the floor and run along benches to outlets fixed to the benches, forming an integral part of the furniture. What other alternatives exist? The outside walls are undoubtedly fixed so they may be used to carry services. Some labs are equipped with movable service stations that are supplied via the floor but allow a considerable degree of flexibility in that the supply of services is no longer an integral part of the furniture.

Drainage points have to be set into the floor. The right choice of material for the pipe line is necessary. For example, in a polytechnic chemistry lab the drainage system consists of a network of borosilicate tubing set into the floor, with drainage points at intervals of 2.4 m set over the entire area of the floor. The borosilicate tube is used as it is particularly resistant to corrosion and is readily cleaned with a solution of hot washing soda.

Fig. 1.7: Services in a lab

Whichever system is chosen, the number of service outlets fitted should be as numerous as funds allow. Experience shows that the demand on services always increases and if they are not needed today, then they will be tomorrow. Nowadays, arguments could be put forward for limiting the number of services available in a particular lab. For example, is gas really needed in a physics lab? Small electric immersion heaters can fulfil most of the requirements for heating and steam production. If a need cannot be identified why have that particular service? Once again the importance of identifying requirements is demonstrated.

Safety should also be borne in mind when providing services. Services controlled from the back of the bench can be a positive hazard in the event of an accident (see Fig. 1.8 a) when it may be necessary to turn off the appropriate services.

An alternative would be to put the controls on the front edge of the bench (Fig, 1.8 b). However, this leads to the danger of lab coats (pockets, fastenings and buttons) catching on the knobs and switches.

With overhead services, the switches and outlets are away from the experimental area. The lab worker can, in the event of an accident step back and reach up to turn the services off.

One word of warning: when choosing overhead services, do check that they are of good sound construction and will stand up to heavy continuous usage.

Whatever we decide safety is of paramount importance.

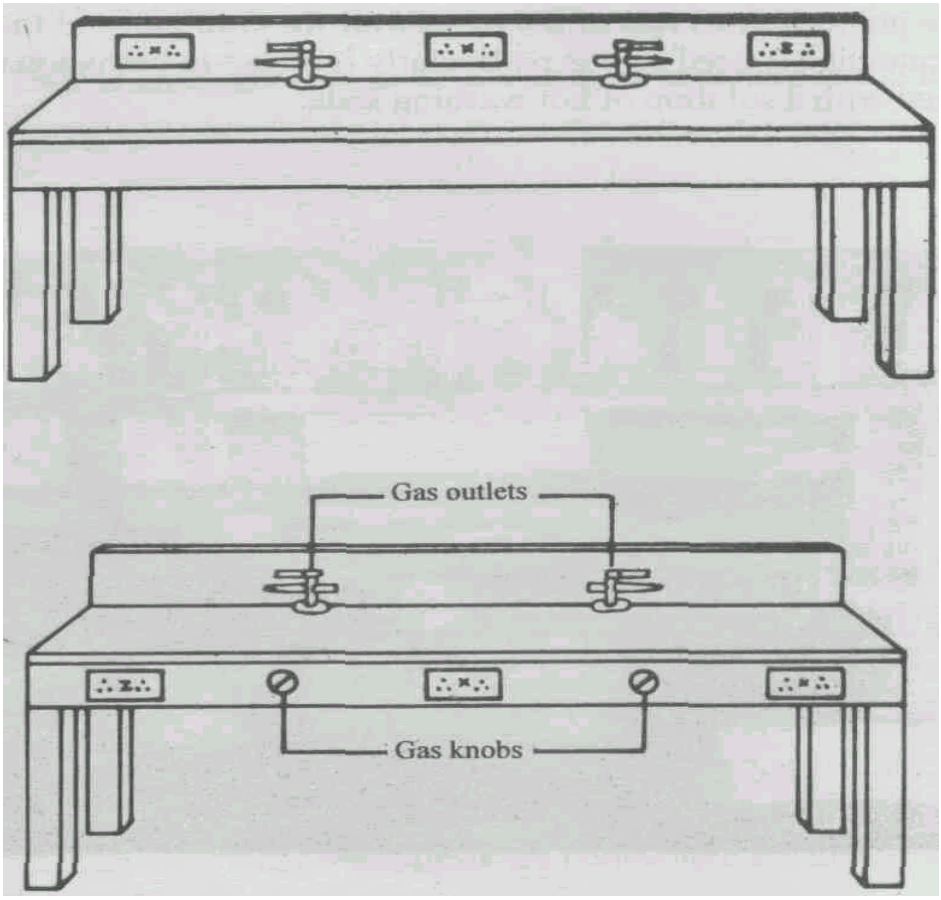

Fig. 1.8: (a) Poor positioning of service outlets, (b) services controlled from the front bench

SAQ 6

(a) Having spent time considering the various types of services, you should now complete the following table to compare advantages and disadvantages of fixed and flexible services. Plenty of 'clues' are given in the text, but do consult your counsellor if you have problems.

	Advantages	Disadvantages
Traditional fixed services		
Modern flexible services		

Discuss your completed list with your counsellor.

(b) Indicate which of the following statements are true or false? Write T for true and F for false in the given boxes.

(i) Gas, water and electricity are a must for any lab. ☐

(ii) For safety reasons services control in a lab should not be fitted at the back of benches. ☐

(iii) Service outlets should be limited in numbers. ☐

(c) In the following statements fill in the blank spaces with appropriate words.

(i) ..... tube is appropriate for the drainage pipeline of a chemistry lab.

(ii) ..... considerations are paramount when deciding on services.

1.8 VENTILATION, LIGHTING, HEATING AND COOLING

Ventilation, lighting, and heating are often treated as related and will be considered as such here. Proper ventilation in a lab is necessary for health and safety and for efficient working. Lighting which is too bright or too dull may lead to tired eyes, headaches, and again an increased incidence of accidents. Also, working conditions that are too hot or too cold, too, dry or too damp are unpleasant to work in and may result in accidents. Thus control of all these factors is important for a safe and comfortable working environment.

Let us consider these factors in detail.

1.8.1 Ventilation

The reasons for requiring ventilation are:

(a) Removal of excess heat due to ovens, hot plates, Bunsen burners, body heat, etc.

(b) Control of humidity from respiration, steam baths, etc. High humidity with high heat can be very uncomfortable.

(c) Reduction of fumes, odours. Usually taken care of by mechanical extractor systems. Ventilation can either be provided by natural or mechanical means.

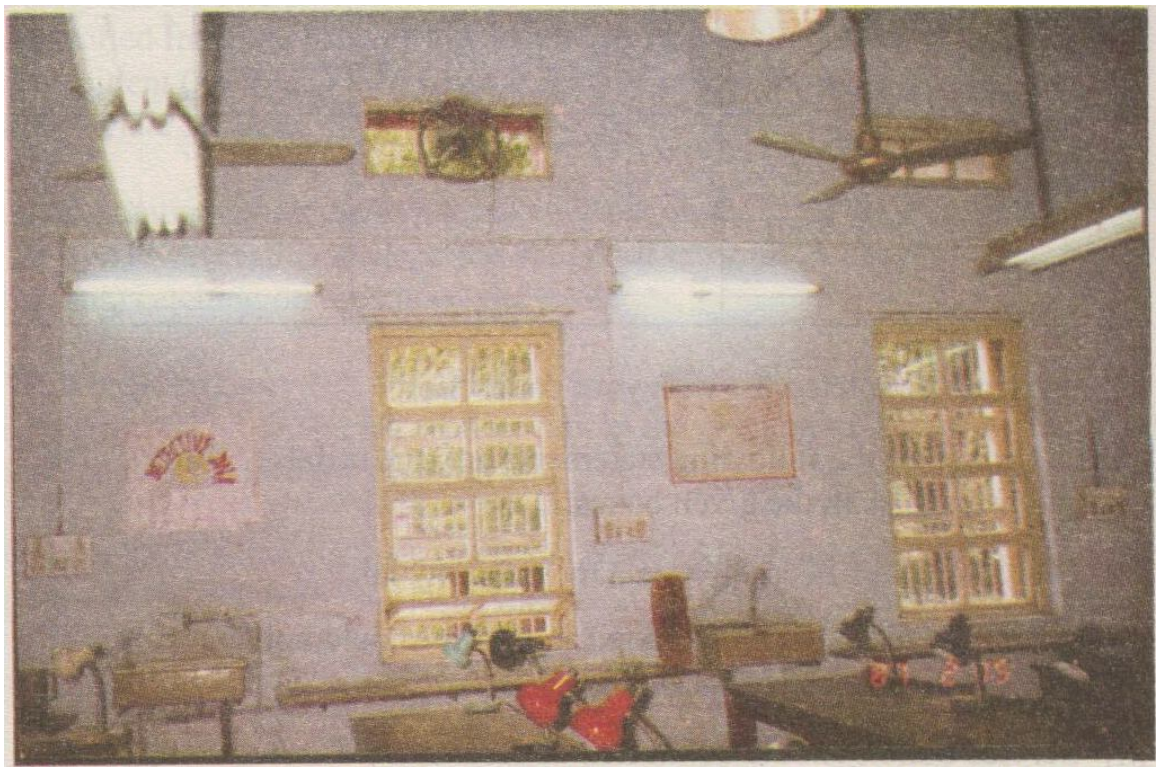

Fig. 1.9: Arrangement for ventilation, lighting and cooling in a laboratory

Windows provide an uncontrollable flow of air, and although louvered windows are better, they tend to be draughty. Excessive draughts must be avoided on safety grounds, as Bunsen burners may be extinguished or delicately poised apparatus disturbed.

Mechanical or forced ventilation can be provided by extractor fans, which at the time of installation can be set high up thereby reducing any draughts. Extractor fans provide a more constant flow of air and avoid the problems of open windows.

For general low level extraction, fans can be installed in windows or walls. If window fans are fitted it is a good idea for them to be reversible, so they can also be used to draw in fresh air.

Air conditioning units are considered in the following section on heating, and the use of fume cupboards, an example of forced ventilation, will also be discussed in section 1.10.

1.8.2 Lighting

Adequate lighting is necessary for any kind of work. Natural lighting is most acceptable to the lab worker. Fig. 1.10 shows two totally different approaches to natural lighting in the lab. In Fig. 1.10 a one of the long walls is virtually all glass and as there are also windows in the end wall very little artificial lighting will be required. This is known as a 'shallow[7] lab. The "deep" lab with windows in only one short wall will present a darker environment that will need *permanent supplementary artificial lighting* (PSAL) in all conditions: see Fig. 1.10b. However, a considerable amount of lab work takes place in labs, which by necessity will require PSAL.

Various types of lighting are available and the amount of light required will depend on the design of the lab. Illumination should be adequate for all kinds of activity. Undesirable reflections and glare should be avoided.

Artificial lighting is provided either by incandescent bulbs (heated tungsten filament) or by. fluorescent tubes. While light bulbs may give rise to light of a more acceptable 'colour' they do have the disadvantage of producing excessive shadows-see Fig. 1.11a. Although 'daylight[1] fluorescent tubes are available, the lighting provided by this means is often rather harsh and artificial. On the other hand it does give a good distribution of light – see Fig. 1.11b. Machinery in workshops may require individual lighting. Also individual lighting may be necessary for intense work, e.g., soldering intricate circuits; see Fig. 1.11c. Positioning of all lighting is important to give an effective distribution of light.

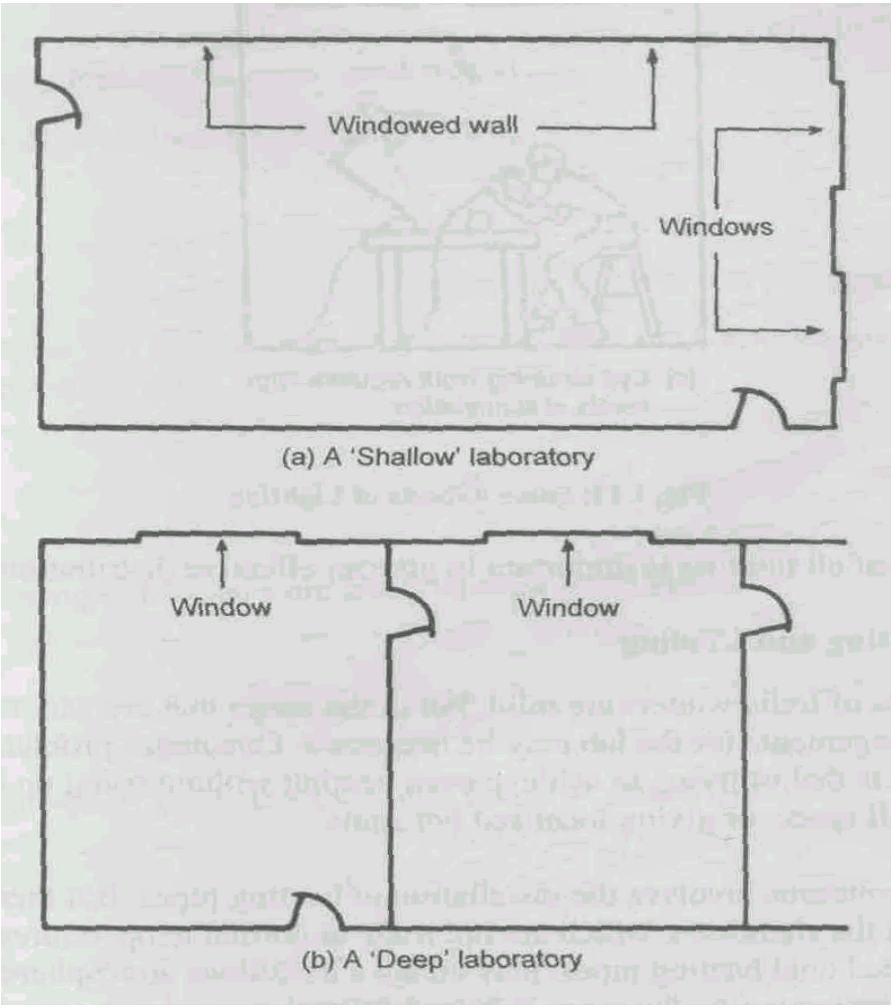

Fig. 1.10: Two different approaches to lighting in the lab

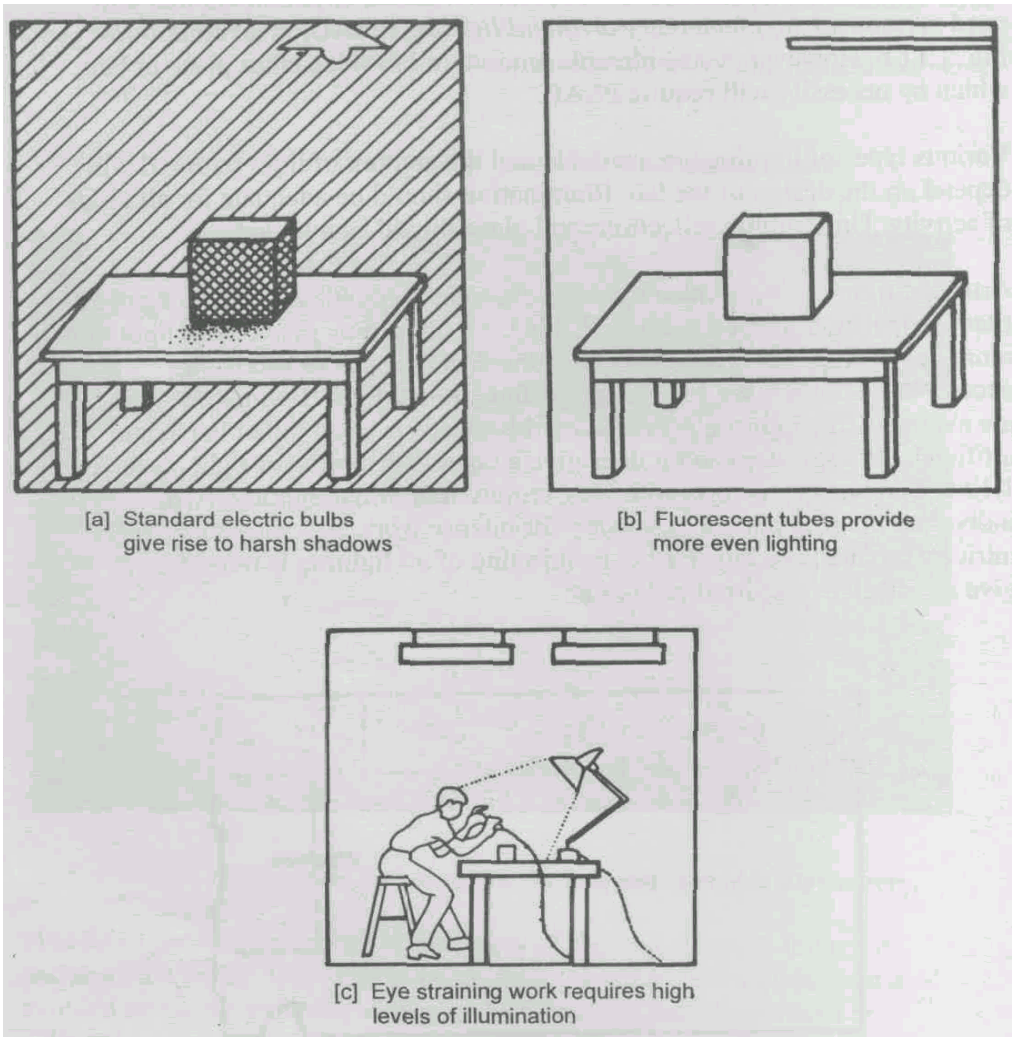

Fig. 1.11: Some Aspects of Lighting

Positioning of all lighting is important to give an effective distribution of light.

1.8.3 Heating and Cooling

In zones that are very cold, heating arrangements for the lab may be necessary. One major problem in laboratories is that of trying to achieve even heating without using up too much valuable wall space, or giving localised hot spots.

One of the solutions involves the installation of heating pipes. But there are chances that the chemicals, which are not toxic at normal temperatures when spilt unnoticed onto heating pipes, may create a hazardous atmosphere. A better solution is running the pipes in boxed-in sections under the window wall, with adjustable grilles below the window. Nothing can then be placed directly on the heating pipes nor can chemicals be easily spilt on to heated-surfaces.

The following are common heating systems:

(a) Radiators: Traditional radiators are too susceptible to corrosion from spills etc. to be of any great use in most labs, although they could be used in physics and biology labs. They are also dust traps and give only localised heating.

(b) Local heating: Local heating by electric fires is very expensive and highly dangerous. Even more hazardous are the fan-assisted heaters which can draw flammable vapours over a heated element.

(c) Air conditioning: Air conditioning units control both temperature and humidity by supplying air that has been heated/cooled, dried/dampened in a series of accurate processes. This form of control provides the most acceptable way of controlling the lab environment. However, for a school it is prohibitively expensive and its use is usually restricted to the industrial or research lab.

Now try the following SAQs.

SAQ 7

(a) In the following statements fill in the blank spaces with appropriate words,

(i) Ventilation removes excess of..... controls the level of ..... and reduces ..... and odours.

(ii) Very bright or dull light causes ..... and tired eyes and may lead to increased incidence of.....

(b) What do the letters PSAL stand for?

_____

_____

_____

(c) When do you think it is necessary to consider the use of an air-conditioning unit?

_____

_____

_____

(d) Which types of rooms are likely to require PSAL?

_____

_____

_____

(e) What type of work demands high levels of illumination?

_____

_____

_____

(f) List the two common heating systems.

_____

_____

_____

1.9 FLOORING

The floor should be smooth but slip-resistant. The choice of covering for the lab floor is governed by a number of considerations, which include:

1. Cost;
2. Safety;
3. Chemical resistance;
4. Wear; and
5. Environmental factors, e.g. comfort, ease of cleaning, noise reduction and warmth.

Most lab floors have a concrete base. Floors should include watertight upstands around all services that enter through floors, and along the walls, particularly floors above ground level.

Table 1.1 lists some of the materials used for flooring and includes the advantages/disadvantages of each.

Table 1.1: Types of Floor Coverings Suitable for Laboratories

Floor	Advantages	Disadvantages	Remarks
Concrete	(1) More acid resistant than mosaic or granolithic	(1) Hard (2) Cold (3) Noisy	(1) Must be sealed against dust (2) Poor in finish
Mosaic	(1) Resists solvents (2) Stands up to heavy traffic (3) Available in attractive designs	(1) Hard (2) Cold (3) Does not resist acids	With white or regular cement
Linoleum	(1) Warm (2) Quiet (3) Easily maintained	(1) Slippery (2) Marks easily (3) Not very resistant to solvents	(1) Must be sealed (2) Must be stuck down
Glazed tiles	As Mosaic (1) Very water resistant (2) Acid resistant	As Mosaic (1) Slippery	(1) Acid-proof cerment must be used for joints
PVC tiles	(1) Quiet (2) Variety (3) Easily maintained (4) More resistant to indentations	(1) Their resistance is variable and must be checked before use (2) Soft and marks easily (3) Indentations gather pockets of dirt, etc.	(1) It is best to use sheets with welded joints and edge the area with swept-up covers to contain spillage

Note: The table is provided for reference only. You are not expected to memorise it.

Table 1.2: Recommended flooring for various labs

Type of accommodation	Comments
Chemistry lab	Large scale rooms should be tiled on both floors and walls
Physics lab	PVC or thermoplastic tiles are suitable
Biology lab	PVC sheet or thermoplastic tiles are suitable
Workshops and stores	Concrete with surface hardening

SAQ 8

Match the floor coverings listed in column 1 with the disadvantages given in column 2.

	Column 1		Column 2
1.	Glazed tiles	(a)	poor in finish
2.	Linoleum	(b)	does not resist acids
3.	Mosaic	(c)	slippery
4.	Concrete	(d)	marks easily

1.10 FUME CUPBOARDS

Any work involving noxious fumes should be carried out in a fume cupboard. The design of fume cupboards is very important so as to ensure an adequate flow of air with the door either open or closed. A minimum rate of flow of 0.4 m/s should be produced across the work surface, 0.5 m/s being required when using highly toxic materials. Fig. 1.13 shows a simple fume cupboards. With the sash open draught at the work surface is considerably reduced, whilst with the sash closed, air near the top is virtually static.

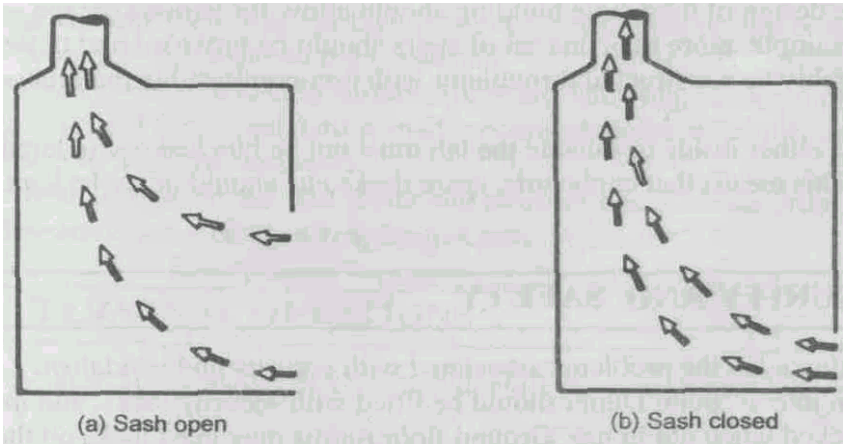

Fig. 1.12: Simple fume cupboard. A heavy duty fume cupboard (to get a photograph)

Addition of a baffle to a simple fume cupboard improves air flow and efficient purging is achieved with the sash open or closed.

Flexibility within the lab can easily be lost by installing a fume cupboard that is totally immobile. In schools, with the growing use of multi-disciplinary laboratories, flexibility may be of considerable importance. Therefore to continually tie space down for one specific function that will only be used occasionally is undesirable.

Factors to consider are:

1. Ease of movement
2. Connectibility to services
3. Visibility, e.g. for demonstrations
4. Connectibility to ducting

SAQ 9

What is the main function of a fume cupboard?

1.11 ACCESS TO AND FROM THE LABORATORY

Any lab design must take into account that the lab worker must be able to gain access to and from the experimental area. Sufficient distance must be allowed between benches for the safe movement of people, so that colleagues are not disturbed.

As even in the best run establishment accidents can happen, all laboratories and preparatory rooms should be provided with at least two escape routes as widely separated as possible. Note

that door positions in ideal lab arrangements by checking back with Figs. 1.10. If an accident occurred near one of these doors escape would still be possible using the other door.

Likewise, the design of the whole building should allow for various escape routes. For example, more than one set of stairs should be provided and these should preferably be constructed throughout with non-combustible materials.

Access routes either inside or outside the lab must not be blocked or hindered in any way. This means that cupboards, spare desks etc. should never be kept in corridors.

1.12 SECURITY AND SAFETY

When designing a lab the problems associated with security and vandalism must be taken into account. Doors should be fitted with security locks, and the room kept locked when not in use. Ground floor rooms may need locks on the windows. Fire doors must be provided and these should be fitted with crush bars or similar mechanisms.

Safety system should cover fire and electrical emergencies.

Now try the following SAQ.

SAQ 10

(a) Why should the design of a lab show at least two doors?

_____

_____

_____

1.13 SUMMARY

In this unit you have learnt:

- The various aspects concerned with the design and usage of a good lab. While designing a lab it is very important to consider the type of accommodation available, nature of work, and present and future requirements of the users.

- Some of the major aspects to be considered are space requirement per person, benching, furniture, storage, electricity, water and gas, ventilation, lighting, heating, flooring, provision for circulation, cupboards, access to and from the lab, security and safety.

- The Department of Education and Science (UK) introduced the concept of Lab Unit. It is the area defined that can support two to three workers.

- A lab can be of fixed or flexible design. Both designs carry certain merits and the one adopted should be according to the requirement.

- While drawing a map for a lab, it is necessary to make sure that the respective location of the main lab and accessory rooms is such that the access to and from them is convenient in terms of ease of working and efficiency for the users.

- There are different ways of laying out benches but the design is selected according to the cost and requirements.
- The selection of benching surface, furniture, shelving, storing units flooring and fume cupboard is made according to the suitability and available financial resources.
- Provision for services- gas, water and electricity is made according to the need.
- The safety and security arrangements must be made.

1.14 TERMINAL QUESTIONS

1. What features should be considered while planning a new lab?

   _____

   _____

   _____

2. For a particular space that is to become a lab, is it likely that there will be only one design that can be considered suitable?

   Yes No

   Reason

   _____

   _____

   _____

3. What points should be considered while planning storage?

   _____

   _____

   _____

4. Give two advantages that mechanical ventilation, for example using extractor fans has over ventilation via windows.

   _____

   _____

   _____

5. List the factors that help to determine the choice of flooring in a lab.

   _____

   _____

1.15 ANSWERS

Self-assessment Questions

1. (a) You should have identified the following:
   - (i) Main Lab, benches and other furniture
   - (ii) Lecture room
   - (iii) Store house
   - (iv) Museum
   - (v) Provision to include more persons (ability to meet changing demands)
   - (vi) Provision for disposal
   - (vii) Supply of water, gas and electricity
   - (vii) Office type accommodation for the people who work in the lab
   - (viii) Specific specialised accommodation, e.g. instrument, balance rooms, etc.
   - (ix) Storage space both within and outside of the lab.
   - (xi) Relationship to other rooms and lab.

(b) Some of the main features of School lab are:

(i) Main lab
(ii) Office type accommodation
(iii) Store
(iv) Instrument room
(v) Museum

Here we have listed features of a school lab only. You may expand the list according to your experience of different laboratories.

2. (a) (i) Space (ii) Purpose (iii) Cost
   (b) The dimensions of the lab unit, i.e. the self-contained area within a lab that will support the work of two or three workers, is 6 m × 3 m. For school and college labs 2 metres bench space per person should be planned.

3. (a) Most likely a fixed design lab. In services you can recall gas, water and electricity.
   (b) Basically, those for which a need is identified. Services may be fixed or flexible, depending on the type of lab.
   (c) The statement in incorrect. One should avoid this if possible as this will make any future alterations much more difficult to accomplish.

4. This arrangement is convenient for the teachers and technical staff who manage both labs at times when the number of students is large.

5. (a)
   - (i) Mixture of perimeter and island
   - (ii) Peninsular
   - (iii) Mixture of perimeter and peninsular

   (b)
   - (i) Timber
   - (ii) PVC
   - (iii) Quarry tiles
   - (iv) Kota stone

(v) Granite
(vi) Glazed tiles
(vii) Formica
(viii) Metal

c) (i) Movable
(iii) impervious, resistant, acid, moderate
(iii) discarded/thrown away

6. (a) See the text and consult your counsellor.
(b) F, the need has to be identified.
(ii) T, can be hazardous in the event of accidents
(iii) F, need always increases with passing year
(c) (i) borosilicate
(ii) safety

7. (a) (i) heat, humidity, fumes
(ii) headache, accidents
(b) Permanent Supplementary Artificial Lighting.
(c) When it is necessary to accurately control temperature and humidity while at the same time introducing fresh air (ventilation).
(d) Deep rooms that only have windows along one short wall.
(e) Work demanding concentrated vision, for example, soldering intricate circuits.
(f) (i) Radiators
(ii) Air conditioning

8. (1) c, (2) d, (3) b, (4) a.

9. A fume cupboard is used for safe removal of noxious fumes.

10. It is essential that more than one escape route is provided. If an accident blocks one exist, hopefully the other one will still be available.

Terminal Questions

1. You should have identified the following:
(i) Main Lab/working are with working benches.
(ii) Lecture room
(iii) Storehouse
(iv) Museum
(v) Provision to include more persons (ability to meet changing demands)
(vi) Provision for disposal
(vii) Supply of water, gas and electricity
(viii) Office type accommodation for the people who work in the lab.
(ix) Specific specialised accommodation, e.g. instrument, balance rooms, etc.
(x) Storage space both within and outside of the lab.
(xi) Relationship to other rooms and lab.

2. No. There are likely to be many designs that could be devised. Some may appear better than the rest. The real skill lies in producing a design, which meets the requirements that you have identified.
(c) (i) The articles that need to be stored,

(ii) Long-term and short term storage,
(iii) Convenience

(d) Your answer is correct if you have two of the following points:
(i) Draughts can be reduced by correct positioning of the fans
(ii) The rate of airflow can be controlled
(iii) If the fans are reversible they can also be used to draw in fresh air

(e) These are (i) cost (ii) safety (iii) chemical resistance
(iv) wear and tear (v) climate of the area

UNIT 2 ORGANISATION AND DESIGN OF LABORATORIES: PREPARATION ROOM

Structure

2.1 INTRODUCTION

In the previous unit (Unit 1) you have studied about the broad principles underlying good laboratory design which could be of fixed or flexible type. You were also familiarised with the various components of a standard laboratory and their ideal/standard placement within the lab. The kinds of facilities like water, gas, electricity etc. needed for a lab were also explained to you. In addition to this you learnt that the main laboratories usually have adjacent rooms or rooms close by called preparation rooms which function to provide service to these main laboratories and so these are built according to the type of laboratory and their requirements.

In the present unit we will discuss in greater detail the following aspects of preparation rooms:

(i) The need for a preparation room with a laboratory.
(ii) The role and function of preparation room.
(iii) Location of preparation room with respect to the main labs.
(iv) The basic design of a preparation room as well as variations in its design in accordance to the main lab, with which it is associated.
(v) The various types of items like equipment, apparatus etc. and their location in a standard preparation room.
(vi) Design of a microbial preparation room for bacteria and fungi and the methods used for sterilising materials and apparatus, associated with the culture.

Objectives

After studying this unit you should be able to:

- explain the need for a preparation room.
- state the need for controlled access to preparation rooms,
- explain the basic principles for the design of an efficient layout of the preparation room,
- list the essential components of a standard preparation room and describe how they should be located,
- state the problems of storage of equipments, chemicals, apparatus and
- paper in the preparation room and describe how they could be overcome by efficient storage methods,

- describe microbial preparation rooms for bacteria and fungi,
- give methods of control in the use of small scale bacterial mould culture,
- define an autoclave and hot air oven and give their basic function,
- list the basic precautions to be taken while operating an autoclave, and
- state the need for efficient and safe services (electrical, water and gas) in the preparation room.

2.2 IMPORTANCE OF A PREPARATION ROOM

Most of you have some experience of working at a private lab or at an education lab at School/College or University level. If so then you may be able to recall that the main laboratories usually have an adjacent room or a room close by called the preparation room that serves both as an extension of the main lab and as well as provides service to it.

All educational establishments because of the nature of work in the education sector require preparation rooms to be used in association with the main laboratory (Fig. 2.1). However, in the industrial research sector some preparation work is also conducted in the laboratory.

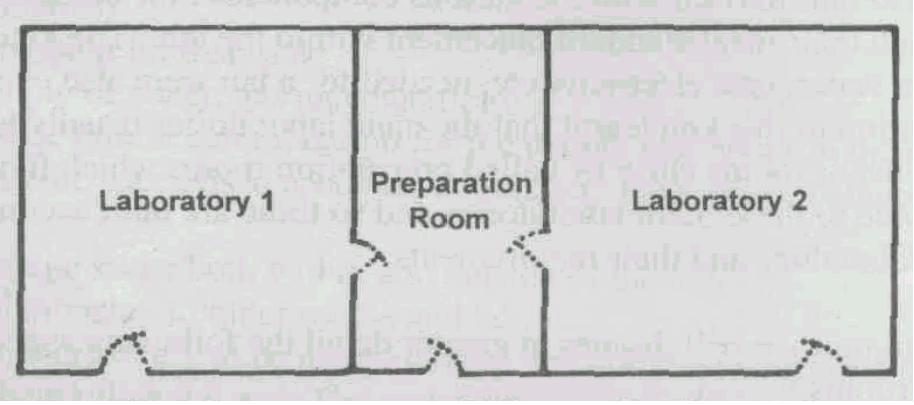

Fig. 2.1: Typical Relationship between the Preparation Room and Laboratories

Laboratories and preparation rooms which provide service to teaching/research and industrial labs have a very important role of storing a range of equipment and apparatus which are not in continuous use. They are also used for storage of extra quantities of chemicals and reagents. In addition to this administration work associated with labs are usually done here. These rooms should also be ideally used for most of the preparation work of the experiments and demonstrations that would be done in the main lab (Fig. 2.2). In many instances usually at school level a single room functions as a store and preparation room.

Fig. 2.2: A Zoology preparation room

SAQ 1
What is the function of a preparation room?

_____

_____

_____

2.3 REQUIREMENTS TO BE PROVIDED IN THE PREPARATION ROOM

The role of the preparation room as we have explained is extremely important and so it should be an essential feature of building plans of entire buildings that have labs of any kind.

As you will study later in the unit, the design of the preparation room as well as what it contains depends mainly on the type of main lab or labs it services. However, all preparation rooms need to contain certain basic items and facilities in order to function properly. Most preparation rooms should have:

(i) A wet bench with running water, and draining board.
(ii) A water distillation or deionizing plant.
(iii) Balance (preferably an accurate one and a rough one).
(iv) A large dry bench for dry work like constructing apparatus and for repair work.
(v) Vice (Refer Fig. 2.3) and small hand tools.
(vi) Adequate shelving and cupboards for storage of apparatus, equipment and chemicals as well as adequate storage space for a considerable quantity of paper.
(vii) A area for office work where the teacher or lab attendant could do paper work.
(viii) Adequate electrical outlet sockets.
(ix) Gas supply.

(x) An efficient waste disposal system.

A badly organized preparation room is rather like a badly organized kitchen. Time is often lost looking for items which should be easily at hand. In a kitchen this results in frustration. In a lab it leads to a loss in efficiency and effectiveness and this in turn results in waste of money. A badly organized kitchen may also produce poor quality food. A badly organized preparation room may produce inaccurate solutions which may give inaccurate or poor results causing loss of money.

In labs where accuracy in weight is of prime importance and where zero-vibration is essential, properly designed balance room may be built.

Some of these items are self explanatory while others need some elaborations.

Wet Bench: The wet bench could be a large preparation table with services for water, gas, electricity and waste disposal. A table of this type could be placed against the wall of the room.

The water distillation plant and balances: The water distillation plant as well as balance should be located on stable surfaces, where disturbance and to and fro traffic is minimum. Furthermore the table on which the distillation plant is placed should have electricity and water facility located close by or on it.

The most commonly used balance is the modern electric top pan balance since it is sufficiently accurate and can be used for many purposes. Modern electronic balances are so designed as to visually eliminate the need for vibration-free benching. However, you should be aware that many laboratories still have balances with knife-edge systems for which reduction of vibration is essential. The manner in which anti-vibration (zero-vibration) base is constructed for these types of balances is however not going to be dealt with in this unit as these types of balances are used in very specialised research labs.

Storage: Storage of equipment is always a very difficult problem for there always seems more equipment in use than there are cupboards to keep it in. Often under bench cupboards are used as storage space. This is bad practice as access to them is not easy and they are often used to store items that are rarely used and perhaps should have been thrown away long ago.

A laboratory should only contain the minimum amount of equipment required for its needs and no more. For example, a chemistry laboratory should contain only a selection of glassware in common use (flasks, beakers, burettes, etc.) plus balances, pH meter and other large items in common use. All other items must be kept in the preparation room.

In the preparation room it is recommended that metal adjustable shelving be used for glassware and other equipment and wooden shelves for chemicals (wood resists chemical attack very well). Figure 2.3 shows some ideas for adjustable shelves based on a framework of angle-irons drilled with holes at intervals of every inch and fitted with adjustable shelves, bins and cupboards. However, for storage of special materials used by teacher in preparatory and research activities, wall cabinets mounted above the work table prove useful.

In addition to this storage, it is necessary to store a considerable quantity of paperwork (lab scripts, manufacturer's catalogues, work roster (duties assigned), maintenance records, staff leave forms, stock control forms - the list can seem endless). Some means of storing all this information is required. Usually, a metal filing cabinet (Fig. 2.3) can be used for this purpose. The material within the cabinet must be stored in a clear and logical manner so that anyone coming into the preparatory room for the first time can understand the system. Further information about filing systems is given in Unit 7 of this course.

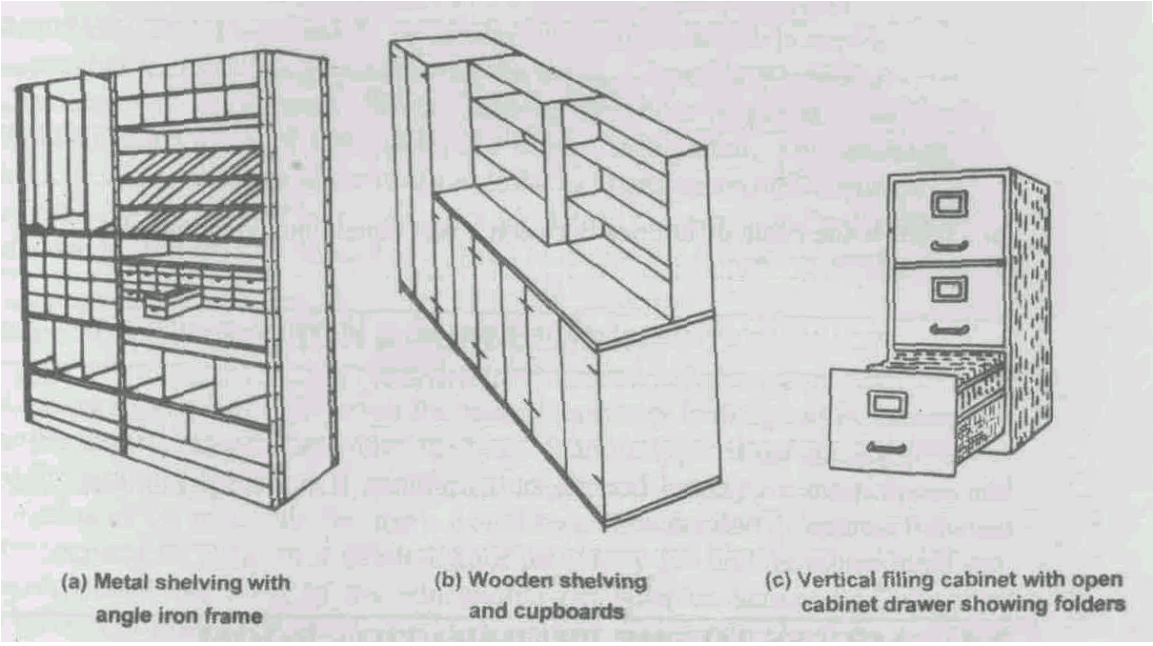

Fig. 2.3: Shelving and cupboard arrangements as well as a filing cabinet likely to be found in a preparation room. Preparation rooms are required to have a variety of different storage systems and some plan of work activities for effective operations.

Dry Bench: The dry work bench besides storage of hand tools may also serve to have the vice (Fig. 2.4).

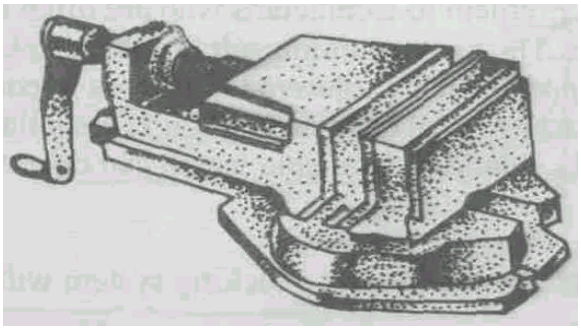

Fig. 2.4: A vice is a tool. It grips objects on which work is being done. Its grip is made tighter or looser by turning a lever at the same point. The lever is attached to a shaft which has a thread like bolt. For example the carpenter puts the pieces of wood in a vice so that it would not move around while he is planing it.

SAQ2

a. List the basic components of the standard preparation room.

_____

_____

_____

b. What is the basic difference between a wet bench and a dry bench?

_____

_____

_____

2.4 ACCESS TO THE PREPARATION ROOM

Access to and from the preparation room needs to be and usually is restricted since it is likely to contain expensive and dangerous materials and equipment within them. Doors that lead from labs or corridors are usually fitted with closures in order to comply with fire regulation. This is because doors are often installed to prevent the spread of smoke during fire. However, door closures pose a problem to technicians who are often moving equipment on trolleys or trays. The most common solution for this is to keep the door open with a door stopper. Such a solution however is in contravention of the fire regulation as we have explained and so if it is essential that the door remains open, other links should be available which can operate under emergency conditions.

In order to further restrict access a locking system with authorized key holders is also used.

SAQ 3

Why is it necessary to restrict access to preparation rooms?

_____

_____

_____

2.5 WORK FLOW

The most important principle when considering any design for a preparation room is to consider aspect of the work "flow" through the area. To understand this the operation or function of the preparation room should be examined and the components of such an operation should be identified. This is done by procuring advance information about the planned experiments and demonstrations. These should be displayed in a place which is readily accessible for checking when starting the work. Clean glassware and chemicals will be required. When solutions have been prepared, stock bottles will be needed together with trolleys or trays of equipment. The returning trolleys will have dirty glassware and leftover chemicals which require attention. An area will be required for glassware cleaning and finally this cleaned glassware will again be required to restart the laboratory exercise.

2.6 PREPARATION ROOM DESIGN

A preparation room that serves the main laboratory is designed in accordance to the lab it is associated with. Its size, location, type of design, the kinds of equipment and apparatus it

contains, thus depend largely on the purpose and function of the main lab. So, there would be a considerable difference between the preparation room of a single-owner pathology lab and an educational lab. Furthermore, the level of the educational lab whether School or College or University or purely research would also affect considerably both the design of the main lab and its preparation room. Fig. 2.5 shows a general plan of a preparation room area.

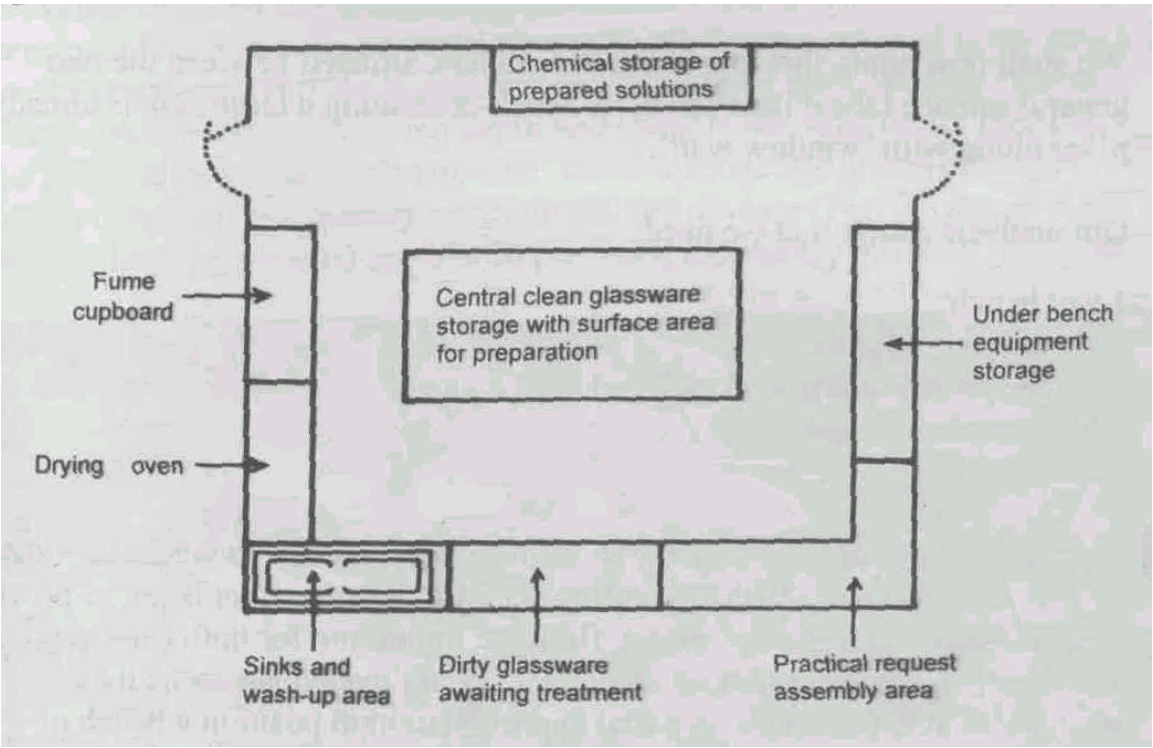

Fig. 2.5: A general plan of a preparation room area.

It is very important however before embarking on any design for a preparation room to consider carefully the use to which the room or groups of rooms are to be put to and how best this purpose can be achieved. The main points to consider are:

The type of activity to be carried out:

(i) The number of people involved.
(ii) Storage required.
(iii) Service requirements.
(iv) Access.
(v) Relationship to other rooms.
(vi) Special equipment required.
(vii) Cost.

If the purpose of the preparation room is to service laboratories used for general science then the main activity will be preparation for experiments, like preparation of solutions or media, assembling apparatus, washing up. Subsidiary activities are the repair and construction of equipment and apparatus. Requirements will include:

(i) Sufficient storage for materials for day to day use.
(ii) Services e.g. 2 gas outlets, 8 electric points, water supply for washing up.

(iii) Access for heavy pieces of equipment, methods to transfer goods between floors, and access for trolleys
(iv) Escape in case of fire.

Special equipment required would probably include a water distillation plant, top pan balance, vice, fume cupboard and a battery charger at level of School or B.Sc. lab.

Having determined the requirements of the preparation room, we are in a better position to able to plan the room itself. All that remains is to sensibly fit them in the space available. You must bear in mind that services may already be in place in which case they may represent a serious limiting factor.

We shall now apply this to a room, 8×6 meters, situated between the two general science labs it is to serve. A bench containing a large sink is already in place along with 'window wall'.

Our analysis shows that we need:

1 wet bench;
1 dry bench (at least);
1 work-bench (for repair work fitted with a vice);
1 fume cupboard; and
Storage space.

The wet bench is already in place so we have no choice as to where to situate it. It is now necessary to do a juggling act with the space that is left to provide adequate bench and storage space. Both are important, for both can lead to a potentially dangerous situation arising if they are inadequate or badly positioned. It is preferable as a first approximation to position a bench of reasonable proportions and then plan the storage space. Finally the remaining space should be used in the best way possible.

A reasonable 'dry bench' would be about 6 m in length (the width of a bench is pre-determined at about 600 mm). One way of placing it would be in one length along a wall, or in the form of islands, 1200 mm wide. Do remember that dry benches need not be confined to the walls alone.

There is no reason why the floor space should not be used provided it does not interfere with general movement around the room.

SAQ 4
List the main points that should be considered before designing a preparation room.

_____

_____

_____

_____

_____

_____

2.7 STORAGE IN THE PREPARATION ROOM

Many preparation rooms are used as store-rooms. Ideally a separate store (Refer Unit 3 - Organisation and Design of Laboratories: Store) should be provided for items that arc only needed occasionally and for the storage of bulk consumables. Since the preparation room has a diverse range of items which need to be stored, various storage systems have to be used. Storage system which have drawers of varying depth and strength are most useful (see Fig. 2.3). This allows segregation of 'like' materials together in sets or ranges which in turn allows quicker selection and distribution (Fig. 2.6 shows a Botany lab's preparation room with provision for storage as well).

Fig. 2.6: A preparation room showing storage.

When selecting storage systems, great care should be exercised that safety factors are not overlooked. The major risk apart from the dangers involved with chemicals comes from heavy objects. Drawer and shelf constructions which do not adequately support heavy objects are of little use. Serious damage can and has occurred when a tray on a high shelf has broken from its supports and crashed down onto the trays below in a 'domino effect'.

The items in the storage system should be arranged with some thought. The heaviest items should be stored at a height allowing easy removal and replacement. Do not be tempted to put the heaviest items on the floor or the lowest shelves since this can lead to a risk of back injury (See Fig. 2.7).

Small items such as lamps, corks, teats, bottle tops, etc. can be kept in trays with dividers. Most commercial systems do provide this feature. If the storage system is heavily used, open bins

suitable in engineering workshops and stores may be useful but do remember that these collect dust and dirt and therefore are not suitable for long term storage.

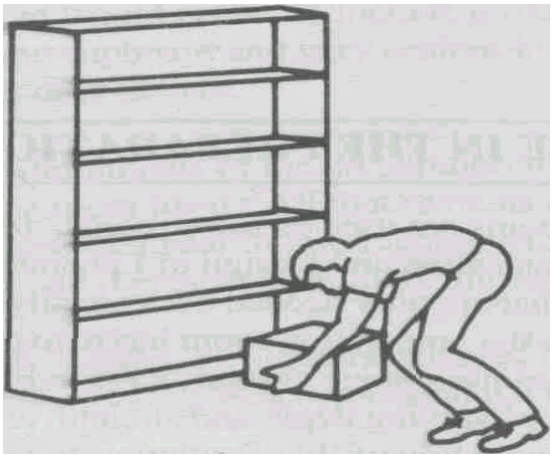

Fig. 2.7: Heavy objects should be placed at a convenient height to avoid back strains

Storage of Chemical Containers

The safe storage of chemicals is a major problem and has been dealt with in subsection 13.3 of Unit 13 of this course. However, here we shall examine the difficulties of storage of chemical containers. Preparation of chemical and biological solutions is one of the prime functions of the preparation room staff, so it is essential that the storage of these chemicals is designed to allow maximum availability to the technical staff and minimum availability to potential thieves.

1. Liquids

These chemicals are supplied in glass bottles and when considering their storage you should bear this point in mind. Most glass Winchester bottles, i.e. those which hold two or two-and-a-half litres, should be stored at a fairly low level but off the floor. Shelving with a lip is very useful to prevent bottles overlapping the edge of a shelf and running the risk of being knocked off. Flammable solvents may be kept in cabinets which are designed to minimize the risk of fire spread, or preferably in a solvent store.

2. Containers of solid chemicals

The largest of the laboratory chemical containers holds 3 kg. These should also be kept at a low level to avoid people stretching to reach the chemicals or from having to use steps to attain the right height to reach the required shelf.

3. Small bottles of chemicals and stains

Bottles holding quantities of less than 25 g present their own problems as far as storage is concerned. If they are kept with the routine sizes they will become hidden behind larger bottles and subsequently become 'lost.' Drawer units with dividers are one way to overcome this problem. Chemicals in each division can be stored alphabetically to facilitate the search.

4. Refrigerated samples

Samples requiring refrigeration either at 4°C or in a deep freeze condition can also be sub-divided. Polythene sandwich boxes are most useful here. They allow removal of a group of samples without letting the rest of the samples warm up.

5. Dispensed solutions

The most difficult storage problems however is that of solutions which have been made up ready for use and are waiting in the preparation rooms or which are to be kept for future occasions. There is no simple answer. However, the use of standard size containers will help as these are easier to store than bottles of differing shapes and sizes. A shelving system which is flexible will also help here.

SAQ 5

A certain amount of storage will probably have to be provided in a preparation room. Is a conflict likely to occur between its use as a preparation room and as a store?

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2.8 LIGHTING AND SERVICES

Lighting

Good lighting in the preparation area similar to the main laboratory is essential for safe and effective operations. Strip lights are most commonly found in these areas and their placing is important if shadows are not to be thrown on the work space.

Various recommendations are given in technical journals as to the amount of light which should be available. Whilst engineers may measure the amount of light available with meters, the person working in the area will soon know if the light is too dim or too bright by the frequency at which they experience distress whilst working.

> Many other factors affect the choice of lighting systems such as colour of walls, height of ceilings, amount of light available, nature of work operations. Work involving the use of revolving machinery should always be carried out under tungsten bulbs and not fluorescent tubes for safety reasons since certain stroboscopic effects may be set up. Some spectroscopic systems are also sensitive to fluorescent lighting.

If you find that you and your colleagues are getting headaches or eye strain, complain immediately to your superiors to rectify matters or if you have the authority, get the lighting changed on your own initiative.

Services

The range of services provided in the preparation room should be as good as those available in the lab. Refer to Unit 1 where services have been explained at length. With overhead services, these can be extended from the lab into the preparation room through the walls.

2.9 MICROBIOLOGICAL PREPARATION ROOMS

The microbiological preparation room is very different from the usual preparation rooms since an important and most fundamental part of microbiological preparation is sterilisation (of microbiological material, glassware and other apparatus), towards which such a room is clearly geared. Preparation rooms in large microbiology units may have a variety of sterilisation methods available. All materials have to be sterilised before and in some cases after use (Refer also to Unit 4 of this course).

2.9.1 Access to Preparation rooms for bacteria and fungi

Microbiological preparation rooms have their own security problems. The culture of micro-organisms concentrates the cells to huge numbers compared with the numbers found under normal working circumstances. It is therefore, most important that cultures are kept in restricted areas. Most educational and industrial laboratories are unlikely to have highly dangerous organisms although some of the less 'dangerous' bacteria will give rise to unpleasant symptoms if contamination is gross.

Restriction of access is the best method to prevent spread of potentially infective material. It is essential that all staff who have access to contaminated areas are vigilant and are aware of their responsibilities. When cultures are provided for examination they may be fixed prior to use.

2.9.2 Sterilizing equipment

The standard sterilising apparatus that are used in the microbiological preparation rooms are autoclaves and hot air oven.

Autoclaves

The autoclave is a large version of the domestic pressure cooker. It has controllable pressure and temperature facilities and may be used to sterilise media, equipment and other items. It is also used to sterilise waste material before disposal. Normal operation conditions for autoclaves are 121°C at 15 p.s.i. for 20 minutes.

The autoclave when in use generates a large amount of heat and steam and often unpleasant smells. Therefore when planning preparation areas involving autoclaves, ventilation systems which can cope with these problems must be installed. This can be effected by means of a simple extractor fan or by a highly sophisticated air treatment system. The arrangement of sterilisation facilities should he organised in such a way that the condition in the technician's work area is not detrimental to their health!

Hot air oven

Hot air ovens in addition to autoclaves, are also used for sterilisation. These arc used for dry sterilization and work at temperatures of] 60°C giving rise to the problem of additional heat in the room. Dry sterilisation methods are suitable for pipettes and other glassware not containing liquids.

SAQ 6

What is the main function of an autoclave?

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2.9.3 Preparation area

Preparation areas will require bench space for the assembly and treatment of the equipment and an area for the storage of sterilised materials. Storage of sterilised material is not normally a problem provided that seals marked 'sterile' are used and that the materials are used strictly in order of production.

Pipette canisters which are box-shaped in cross section are most suitable for storage purposes as they can be stacked in drawers with little loss of available space. The round canisters are most

likely to roll about and they produce waste space when stored together. Rooms which contain autoclaves should be fitted with a floor drain and sortie form of non-slip finish to the surface (see Fig. 2.8). Using an autoclave invariably leads to spillage of water on the floor and the drain offers the best method of keeping the risk of an accident to a minimum.

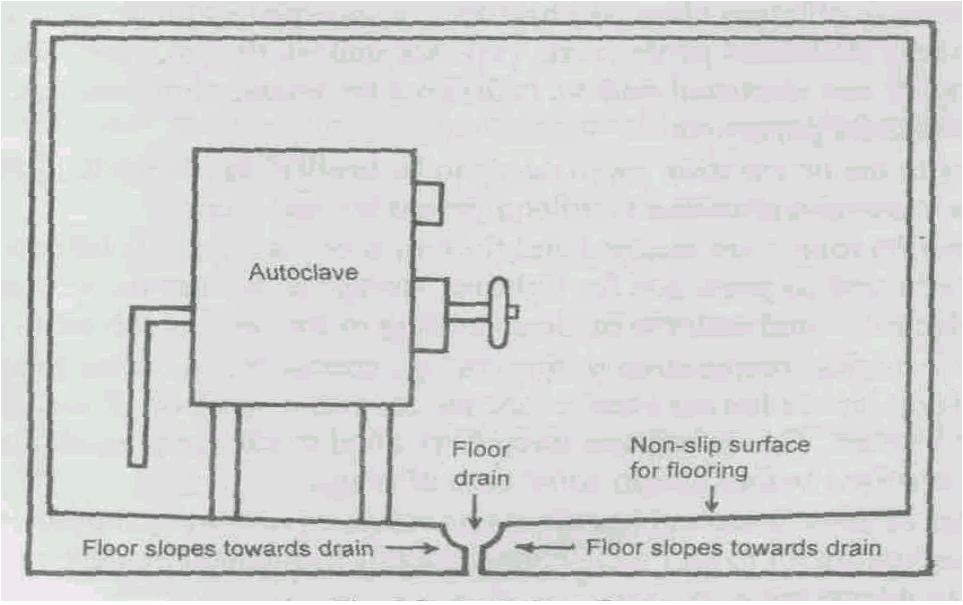

Fig. 2.8: Autoclave Room

SAQ7

Special precautions have to be taken in rooms used for the preparation of bacterial and fungal cultures. Can you state what precautions need to be taken?

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2.10 SUMMARY

In this unit you have learnt that:

- Preparation rooms should be an essential feature of the main lab of educational/ (School/College/University/Research) industrial or private institutions.
- The preparation rooms are usually close or adjacent to the main labs to which they provide service.

- The main role of the preparation room is to store (But not in such bulk as in a store) a range of equipment which are not in continuous use such as chemicals, reagents and quite often administrative paper work associated with the lab and preparation room.
- In most preparation rooms, specially those associated with educational labs, some preparation work like preparing solutions, cleaning glassware etc. is done prior to the experiment or demonstration to be conducted in the main lab.
- A standard preparation room should have (i) a wet bench (ii) a dry bench (iii) water distillation plant (iv) balances (v) adequate storage systems for chemicals, stains and paper work, (vi) vice and small tools, (vii) adequate gas supply and electrical outlets, (viii) area for preparation work and (ix) office area for paper work.
- Access to the preparation room needs to be limited due to the dangerous and/or expensive chemicals and equipment housed there.
- Preparation rooms are planned and built in accordance to the laboratories they serve and so provision for lighting, storage as well as for services like gas, electricity and water is made according to the need of the labs.
- Microbiological preparation rooms contain special sterilising apparatus like autoclaves and/or hot air ovens since an important function of such rooms is sterilisation. This is because microbiological studies require all materials to be sterilised before and in some case after use.
- The use of autoclaves and hot air ovens create environmental problems in the preparation room and these rooms should be planned in a such way that these problems are overcome.

2.11 TERMINAL QUESTIONS

1. Describe the basic requirements of a preparation room.

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2. Describe how various kinds of chemicals could be stored in the preparation room for easy availability.

3. How does the operation of autoclaves adversely affect the preparation room? How can this be rectified?

2.12 ANSWERS

Self Assessment Questions

1. The function of a preparation room is to provide service to the main labs. This involves storage of a range of equipment and apparatus which are not in continuous use as well as storage of extra quantities of chemicals and reagents. In addition to this administration work associated with labs are done here. Also much of the prior preparation of experiments and demonstration is conducted here.
2. a) The basic components of a standard preparation room are:
    1. A wet bench
    2. A water distillation plant
    3. A dry bench
    4. Balance (an accurate one and a rough one)
    5. Vice and small hand tools
    6. Adequate shelving and cupboards
    7. An area for office work
    8. Adequate electrical outlet sockets and gas supply
    9. An efficient waste disposal system

    b) The basic difference between a wet and a dry bench is that the wet bench has water connection with sink, draining board etc. while the dry bench does not.
3. It is necessary to restrict access to the preparation room because it is likely contain expensive and dangerous equipment.
4. A preparation room is designed in accordance with the lab it is associated with. Its design, size, location, the kinds of equipment and apparatus it will house all depend on the purpose and function of its associated lab. Thus before designing a preparation room these points should be considered:
    (i) Type of activity to be carried out.
    (ii) The number of people involved.
    (iii) Storage required.
    (iv) Service (gas, electricity, water etc) requirements.
    (v) Access
    (vi) Relationship to other rooms
    (vii) Special equipment required
    (viii) Cost required
5. Yes, however in most cases little can be done, except for finding alternative accommodation.
6. Autoclaves are used for sterilisation of a wide range of culture media and equipment.
7. (i) Cultures should be kept in special areas.
    (ii) Access to these areas should be restricted
    (iii) All materials should be sterilised before and generally after use.

Terminal Questions

1. Refer to Section 2.3.
2. Refer to Subsection 2.7.1.
3. The autoclave when used, generates a large amount of heat steam and often unpleasant smells. These problems can be minimized at the planning stage of the microbiological preparation room, by installing adequate ventilation systems which can cope with these problems. At a smaller scale a simple extractor fan will be adequate. However in bigger preparation rooms the installation of highly sophisticated air treatment system is better.

UNIT 3 ORGANISATION AND DESIGN OF LABORATORIES; STORE

Structure

3.1 INTRODUCTION

Storage is usually a necessity in most scientific establishments, with the provision of sufficient and appropriate storage space being the exception rather than the rule. In this unit, we will discuss the basic principles of the design of stores as well as typical ways of providing storage. You should bear in mind that the material in this unit inevitably has implications for other units dealing with the general subject of laboratory organisation. An important paragraph is included on the special problems encountered when storing particular items such as solvents, museum specimens and plants.

Stores cannot be considered in isolation, since the design of the laboratory and the store are related. A certain amount of storage will be provided in the laboratory - this aspect is considered in unit 1 of this course. In some cases, it is more important that you are aware of sources of information rather than precise details and, therefore, two appendices have been included on storage and disposal. If in doubt always seek advice.

Objectives

After studying this unit you should be able to:

- state the basic principles of the arrangement of stores,
- appreciate the interrelationship between the laboratory and the stores,
- state the requirements for areas in which goods are received or dispatched,
- recognize the need to control the environment of any store,
- appraise the necessity of identifying an establishment's requirements for storage of goods and materials,
- appreciate that there may be several designs that would meet the requirements identified above,
- recognize the difficulties encountered in producing an effective store in a school or in other institutions (as relevant).

3.2 THE FLOW OF MATERIALS

The volume of material that passes through a store and the nature of the material that has to be stored varies enormously from one lab to another. However, the same basic principles apply both to the requirements of the storage place and to the flow of materials.

Before considering the design of stores, it is important that you appreciate the pattern in which materials flow through or between stores. In an ideal situation, three separate stores need to be provided, as shown diagrammatically in Fig. 3.1

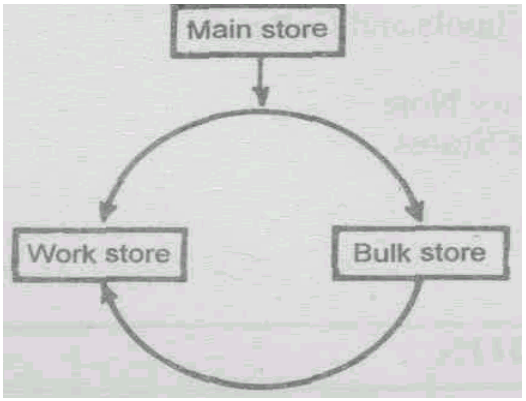

Fig. 3.1: The primary flow of materials

Even though three physically separate stores may not be provided in small institutions, the concept expressed in Fig. 3.1 can usually be easily recognized where just a single store exists. This concept is the way in which materials are moved before being distributed to the lab worker. Let us now consider these three stores individually.

1. Main store: This is the area in which goods are received and checked. They are then either unpacked for immediate use, in which case they will be moved directly to the laboratory or to the work store; or they are repacked and moved to the bulk store.

2. Bulk store: As its name implies, this is the store, or the area within a single store, in which materials are held for some time. Typically, unopened cases of glassware or chemicals are stored here for future use.

3. Work store: From this store materials will be drawn for day-to-day use, e.g., working solutions for chemistry work.

3.3 ARRANGEMENT OF STORES

In this section, you should gain an understanding of the basic principles involved in the design of stores. So the emphasis is on principles rather than on constructional diagrams of stores. Once you appreciate the basic principles you should be able to apply these principles to new or old stores under your supervision.

3.3.1 Environmental Considerations

Before we engross ourselves in a discussion on the design of stores, there are two points to bear in mind:

1. Many items will deteriorate if stored under the wrong conditions, such as extremes of temperature and dampness.
2. Hazards to health and safety must be considered. Dangerous materials are best stored away from the main building in a special store.

With a store which is located within the structure of a main building, physical dimensions of a store, while important, are probably secondary to what might be called 'environmental factors'. By this we mean factors such as:

1. Ventilation
2. Temperature
3. Lighting
4. Humidity

and so on.

For example, ventilation is required to maintain the clean air inside the store and to prevent dampness from affecting the material stored in old stores. It may be adequate to control temperature, i.e., for sufficient warmth in winter, and keeping the store cool in summer. However, if natural ventilation is inadequate, some form of air conditioning will be required. Another environmental factor that is often ill-considered is lighting. It ought to be obvious that a store should be well lit; and there are safety implications for stores that are poorly illuminated. Having said that, how often do you come across stores that are an afterthought, a hole-in-the-wall affair, where the lab technician has to grope around in a damp, dark space?

Having considered environmental requirements, we'll now think about physical considerations.

3.3.2 Physical Considerations

By physical considerations, we simply mean:

1. Shelving on which to place the stored materials,
2. Access or circulation space where one can safely reach the materials they require, and
3. The location of the store in relation to the outside world; if heavy goods are to be stored, direct access will be required,
4. Entry of the store - independent entry or from the laboratory itself.

1. Shelving

There are many forms of shelving and you need to decide which is most suitable. Wooden, metal, plastic-coated metal all have their uses. Strength is one important factor and in a chemical store, the material of the shelves should be inert. These two factors would probably lead you to choose wooden shelves.

Activity 1

1. Make a list of the types of shelving in your store and laboratory.
2. Look at suppliers' catalogues and publicity material to see what is available and then list here what you would like to see used where you work.

From Activity 1, you should appreciate another aspect of the design of the store: namely that a store must be designed and fitted out to meet the requirements of a particular establishment. Inevitably, this will relate closely to the design of the laboratory itself (Unit 1 of this course).

At this stage it is the concepts behind the design of a store or a laboratory that matter rather than a specific design. In all cases, compromise will be required as well as exercising the art of justifying an approach or design based upon the identified needs of your establishment.

2. Layout

There will be several ways in which you can arrange the layout of a store, but what matters is that you can justify the arrangements you have designed based on a statement of your requirements. In nearly all establishment the space provided for a store will be inadequate, and therefore your design must allow for access while at the same time providing the means for storage. In Fig. 3.2 you can see the plan of a fairly traditional layout with a regular array of shelving units.

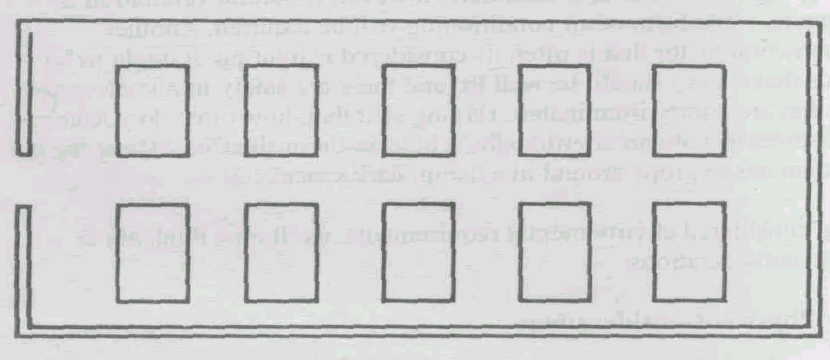

Fig. 3.2: A simple array of shelving units

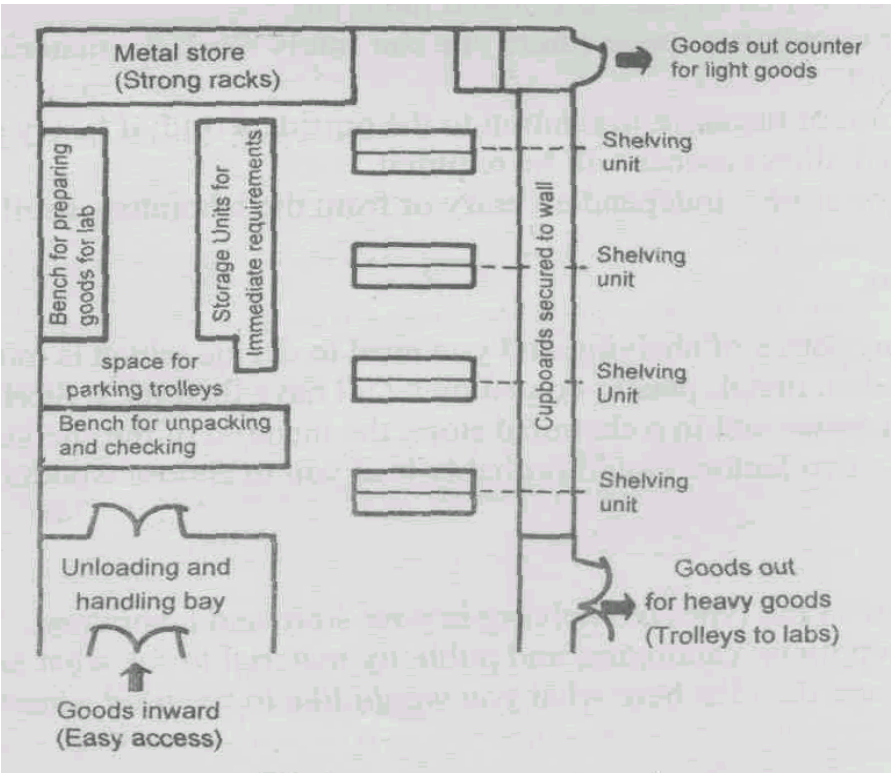

Fig. 3.3: A possible design for a store

With this approach, considerable space is used for access. In a large store, the space could be better utilized by mounting these units on wheels running in a trackway.

Most of the time the units could then be rolled together. They are then moved apart to gain access when required. Remember that the space required for access is not just for staff to walk between units but may be needed for trolleys.

In practice, the stores of most establishments will require a range of different types of units - shelving units, cupboards, racks, tray units, etc. It is up to each establishment to set its requirements. Fig. 3.3 shows an arrangement which embodies most of the ideas that we have developed so far.

3.4 FLEXIBILITY

Before proceeding further, you should appreciate two factors which were not specifically identified and which certainly cannot be ignored.

1. For a given space to be used as a store, more than one design could meet the requirements of the user. Each design will have its own merits or faults and each will have to be justified on its merits.
2. As factors change with different patterns of usage, the demand on the store will change. It is important that changes can be accommodated with the minimum of inconvenience. There is only one way in which this can be achieved, and that is to incorporate as much flexibility as possible.

Flexibility can be enhanced in many ways at little or no extra cost. Some examples are as follows:

1. Where possible, use free-standing storage units.
2. Use units which allow for easy repositioning of shelves, or use units where shelves can be replaced by trays or bins.
3. Avoid fixing units to walls and floors.

Now try the following SAQs.

SAQ 1

Write down three questions that need to be asked when designing.

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SAQ2
Do you think that a single arrangement or design can be expected to meet all storage requirements? Justify your answer.

Yes ☐ No ☐

Reasons:

_____

_____

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_____

_____

_____

SAQ 3
'It is necessary to control the environment within a store'.
Briefly comment on this statement and explain which particular factors are likely to require control.

_____

_____

SAQ 4
Imagine that you are arranging a store and wish to achieve a reasonable level of flexibility. List three features which you would incorporate to achieve the required flexibility.

3.5 SCIENCE STORES IN SCHOOLS AND COLLEGES

A store should be used solely for storing goods. However, in practice there are many science departments where this is not the case and the stores and preparation room are housed in a single room. Where space is allocated to both functions, within a single room, space for each function is often inadequate and a difficult working situation arises. The lab technician is expected to provide a 'first class' service to academic staff who are ignorant of the conditions under which the service is provided.

3.5.1 Ventilation

Adequate ventilation is imperative to avoid the risk of dangerous fumes accumulating. Ventilation can be achieved in the following ways:

1. Setting the roof slightly above the walls and filling the gap with bars or chain link 'fencing'.
2. Incorporating ventilators in the roof.
3. Placing ventilators high up in two or more walls.
4. In addition to features (1) (3), setting air bricks low in the walls.

3.5.2 Windows

Because of the danger of the sun shining through windows onto glassware containing flammable liquids, windows are *never* incorporated in any solvent store.

3.5.3 Containment

The design of an external store must provide for the containment of any spilt liquids caused, for example, by a container rupturing. Probably the simplest method is for the level of the floor to be set below ground level (see Fig. 3.4). A concrete door still is necessary to ensure containment. A rule of thumb when designing for containment is that containment should be twice the volume of liquid stored.

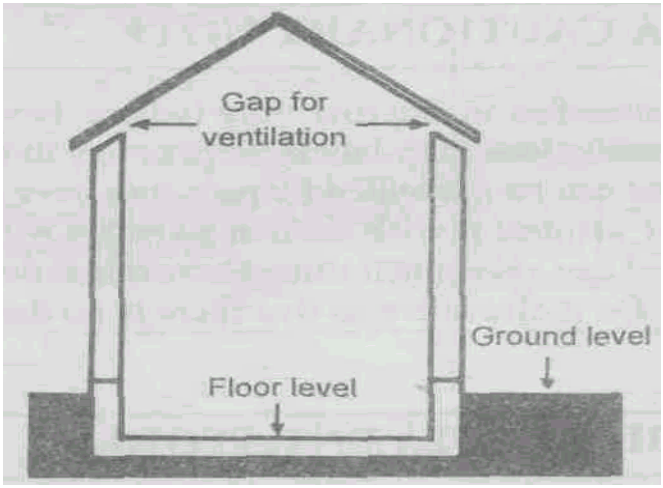

Fig. 3.4: Designing for containment and ventilation

3.5.4 Lighting

As windows are not provided, artificial lighting is essential. Both switches and light fittings must be spark proof and approved for this purpose.

3.6 SAFETY PROVISIONS

Besides the design of the store several other factors must be considered if you are involved in commissioning a new store or using an existing store. Briefly these factors are as follows:

1. *Fire-fighting equipment:* this should be housed outside the store.
2. *Smoking:* NO SMOKING signs must be prominently displayed.
3. *Furnishings:* the materials used in the store for shelves, etc. must be non-combustible.
4. *Access:* only authorized staff should be allowed to have access to the store.
5. *Transferring liquids:* liquids must not be poured from one container to another in the store. This activity should be performed elsewhere.

6. *Alcohol:* a locked cupboard must be provided for duty-free alcohol. This cupboard can only be used for this purpose. (A lockable cage would suffice and also provide ventilation.)
7. *Regulations and legislation:* it is more or less certain that one or more sets or regulations made under an Act of Parliament will apply to your external store. Advice must be sought from a competent authority safety officer at the design stage of a store:

- Regarding any regulations that may apply to the materials that may be stored;
- If you take over responsibility for such a store; or if the function of the store changes.

Activity 2
List any regulations relating to safety that apply to your establishment. These could be general or specific.

3.7 LABELS: A CAUTIONARY NOTE

Bottles of chemicals stored in an external store (where they might remain for some time) will eventually lose their labels. In practice, this can happen in quite a short time. This can be prevented by **painting over the label and for about one centimeter around it with molten paraffin wax.** This is a quick and simple process and can save much time. Remember, do not carry this out inside the store itself. Do it elsewhere so that there is no danger of explosion in the store.

3.8 METAL CHEST SOLVENT STORES

Some authorities arid institutions provide a metal chest to store solvents, with the intention of allowing dangerous solvents to be stored within a main building. Our recommendation is that you do not store solvents in this way.

WARNING: METAL CHEST SOLVENT STORES ARE POTENTIALLY DANGEROUS DUE TO LACK OF VENTILATION WITHIN THE CHEST WHICH CAN CAUSE THE CONCENTRATION OF EXPLOSIVE MIXTURES OF FUMES.

3.9 SUMMARY

- Materials flow through or between stores. Three separate stores i.e., **main store, bulk store and work store** are required to store the material in ideal situation.
- While arranging a store, environmental and physical considerations should be undertaken.
- Store can be designed according to the needs of the user. So, flexibility should be brought in the system.
- In a school, for a science store, there should be adequate ventilation, windows, containment and lighting.
- There should be safety provisions in a store i.e., fire fighting equipment, bottles should be properly labelled, solvents should be stored in metal chests.

3.10 TERMINAL QUESTIONS

1. Which important environmental factors should be taken into consideration while arranging for a store?

2. How can the labels on bottles of chemicals be kept for a longer time?

APPENDIX A
RECOMMENDED STORAGE PROCEDURES

Item	Recommended Storage Procedure	Comments
Perishable	Cold store	To reduce rate of decay.
Gas cylinders	Vertically-chained up Horizontally – specially designed racks	Must not be stored overnight in laboratory. Kept outside main building. Could be in solvent/ chemical store, as this is well ventilated. Check current legislative requirements.
Chemical	Inorganic – alphabetical order Organic – molecular formula. Store in well ventilated area.	Make sure that chemicals that react together are not stored alongside each other. Treat all chemicals as potentially hazardous. Check current legislative requirements.
Poisons	Secured place – cupboard	Antidotes must be available. Check current legislative requirements.
Animal foodstuffs	Dry, cool place.	Make sure stock does not deteriorate.
Glassware	Re-pack into boxes as supplied	Avoid breakages.
Delicate equipment	Re-pack into boxes as supplies	Avoid breakages.
Metal stock/ wood	On suitable racking	
Museum materials	In perspex or embalmed	
Herbarium	Dry cool conditions	Reduces deterioration of samples.
Radioactive sources	Stored under 'lock and key' preferable in safe.	Log book of all movements must be kept. Check current legislative requirements.

APPENDIX B

RECOMMENDED DISPOSAL PROCEDURES

Item	Recommended Disposal Procedure	Comments
Chemical	Each chemical needs to be considered separately. (a) Flammable liquids (i) Water miscible: dilute with copious quantities of water or allow to evaporate. (ii) Water immiscible: mix with surfactants. Dispose with plenty of water or mix with sand or allow to evaporate. (b) Acids: run to waste with copious quantities of water. (c) Compounds that react with water: unless you are skilled at disposing of this class of material, you should not attempt it. No instruction given here on purpose. Seek advice.	Seek advice as necessary from a Safety Officer. Consult specific publications on safety, and current legislative requirements. AS ABOVE
Biological	Macerate small quantities of animal remains. Use plenty of water when disposing.	
Animal house	All waste to be sterilized.	

3.11 ANSWERS

Self-Assessment Questions

1. (i) What are the specific requirements of the organisation?
   (ii) What environmental problems are there?
   (iii) Are there any safety implications?

2. No. No one design can be expected to meet all requirements within one establishment. The problems then multiply when considering the requirements of various institutions.
3. Control of the environment is most important. Lack of control can have serious safety implications which could in the worst case lead to an explosion. Also many stored materials may deteriorate unless stored under appropriate conditions. Particular factors requiring control are temperature, humidity, ventilation and lighting.
4. (a) Where possible, use free-standing storage units.
   (b) Use units which allow for easy repositioning of shelves, or use units where shelves can be replaced by trays or bins.
   (c) Avoid fixing units to floors and walls.

Terminal Questions

1. (a) Ventilation
   (b) Lighting
   (c) Containment
   (d) Windows.
2. Labels on bottles of chemicals can be kept for a longer time by painting over the label and for about one centimetre around it with molten paraffin wax.

UNIT 4 DAY-TO-DAY MANAGEMENT OF THE LABORATORIES

Structure

4.1 INTRODUCTION

In the previous units 1 and 2, you have learnt about the basic principles of laboratory and preparation room designs. You have also learnt about their functions. The laboratory is meant for conducting experiments and demonstrations while the preparation room, as the name suggests, is used for pre-experimental and pre-demonstration preparation. In this unit we will study how day to day management of the preparation room and laboratory can be carried out in an efficient manner.

Effective organization of the laboratory and preparation room is essential for efficient service to be provided. The factors involved are: planning for experiments and lecture cum demonstrations sessions; ordering of supplies and maintenance of stock control (Refer unit 5 - Stock Control and Supplies) maintenance of equipment; cleaning, etc. None of these need to be particularly difficult if tackled properly.

Human management is also an aspect of running laboratories which is beyond the scope of this unit.

Objectives

After going through this unit you should be able to:

- explain the essential aspects concerning organization of practical work and demonstrations,
- describe how to clean laboratories and preparation rooms,
- describe the colour codes for various laboratory services,

- describe the correct procedure to be carried out in the event of emergency situations with respect to laboratory services,
- describe the need for security of both premises and the immediate work area (i.e. the laboratory and preparation rooms),
- explain the problem of vandalism and state the measures that can be taken to prevent its occurrence and its effects,
- explain the dangers of theft of harmful substances such as potential explosives from the laboratory,
- state the need for adequate maintenance of laboratories, their various services and the equipment housed there,
- explain the procedure for proper maintenance of laboratories and their preparation rooms.
- describe the method for organizing the laboratory work,
- explain the merits of various laboratory designs, and
- describe the necessity and problems of providing for cleaning laboratories and preparation rooms, etc.

4.2 ORGANIZATION OF PRACTICAL WORK/ DEMOSTRATIONS

In order to run a lab efficiently, good planning is essential. The following is concerned only with teaching labs. The requirements in industry and research laboratories tend to be different.

In a teaching lab most lab work involves preparation of solutions or arranging for equipment or specimens for practical classes and lecture cum demonstration sessions. Neither of these tasks can be done in a hurry. It is not advisable to start a practical or demonstration session without

- proper planning
- essential solutions or equipment or samples, and
- correct choice of materials or concentration of solutions etc.

For lab work to be carried out efficiently and satisfactorily it is essential that there is good cooperation between the laboratory staff and academic staff. This is because prior information about the demonstration/experiments to be conducted is necessary for the planning and preparation of the experiment. For the proper conduct of the experiment the academic staff would usually ensure that:

(1) a reasonable amount of time to be allowed for pre-laboratory preparation,
(2) full details of what is required are given to lab staff,
(3) details of any special requirements are also given, preferably in consultation with concerned lab technician, especially if special pieces of equipment are needed.

4.2.1 Day-to-Day Organization

For good organisation the day-to-day requirements for practical classes are usually entered into a diary/register/note book kept solely for that purpose, and the academic staff would give advance (at least two days) notice to the lab technician for the preparation of the practical. You should therefore expect the academic or the teaching staff to enter into the diary the following details at least two days before it is required.

1. Number of students, time of class and room number
2. List of equipment required
3. List of solutions required
4. List of chemicals required, and

5. Note by academic staff for any special requirements or hazards.

The routine becomes quite simple; each day check the diary for the requirements, not only for that day but also for the next two days. Also find out if there is anything to be prepared at the last moment or anything that may take a long time to prepare. Ensure that preparation for all the practicals for that particular day and the next day is completed.

Decide what solutions have to be prepared during the course of the day, and be sure that you know the correct concentration and volume to make up. It is a good idea to keep a stock of 5-10 litres of certain solutions (e.g. 2 M sodium hydroxide, hydrochloric acid, sulphuric acid, nitric acid and ammonia solution) that are in common use as lab reagents.

Check that the volume of solution required is adequate. For example, for a titration allow no more than 100 cc of solution for each student, while for simple 'test-tube[7] tests allow 10-20 cc per student. This prevents waste and does not allow students to get into wasteful habits.

Once the solutions are prepared, they should be put into bottles of the correct size, and labelled with the date, name and concentration of the solution. For this purpose it is a good idea to keep a stock of clean bottles of all sizes, especially Winchesters.

The same sort of routine can be applied to the provision of procuring of animals/plants materials as well as preparing culture medium in order to make sure that there is sufficient quantity of the correct for preparing material for class use.

Also assemble whatever other equipment is required. If all the apparatus for the practical is placed on a trolley, it can then be moved to the lab from the preparation room with minimum difficulty. Lecture demonstrations should be set up prior to the experiment so that everything is at hand when it is required.

It is very important that demonstrations proceed smoothly; therefore they should be tried out first to check that everything works. Physics practicals may present a different problem in that the same equipment may be required a number of times. In order to avoid unnecessary work, it is suggested that materials for a particular experiment be assembled and kept in a plastic tray. These trays may fit conveniently into cupboards specially designed to hold them.

4.2.2 Day-to-Day Cleaning Up

When a practical is finished remove all equipment and chemicals and ensure that the lab is clean and tidy. DO NOT keep small volumes of solutions in the hope that they might come in handy; discard them safely. Ensure that all equipment and apparatus is clean before putting it away: this particularly applies to pipettes and burettes, which must be thoroughly cleaned after use. Pipettes are best cleaned by placing them in a 2 litre measuring cylinder filled with a detergent, or chromic acid.

WARNING: CHROMIC ACID IS CORROSIVE

SAQ 1

Why should the technician have advance information about the practicals to be conducted?

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4.2.3 Sterilisation

It is necessary for instruments, culture media, and glassware to be sterilized for experiments involving micro-organisms, live embryos, tissue culture, etc.

Sterilisation as we have explained in Unit 2 of this course is most efficiently and conveniently carried out in an autoclave or, failing that, in a pressure cooker. For most purposes it is sufficient to sterilize at 6.7 kg. pressure for 20 minutes.

Instruments, pipettes, syringes, etc., should be wrapped in paper or metal foil before being autoclaved and left wrapped afterwards until required. Test tubes should be plugged with cotton wool beforehand and the caps of screw-topped bottles should be loose. After unsealing, instruments can be quickly re-sterilised by heating in the flame of a Bunsen burner or spirit lamp, or by dipping in 50-70 per cent ethanol (ethyl alcohol).

Bench tops should be washed with an antiseptic, e.g. three per cent solution of lysol, before experiments are started.

For sterilisation of skin, swab the skin with cotton wool soaked in e.g. 70 per cent ethanol. Alternatively use a pre-packaged medical swab obtainable from suppliers.

4.2.4 Disposal of Wastes

The disposal of wastes presents a real problem in a large laboratory with many students. Wastes should be disposed off promptly and not allowed to accumulate. Many institutions have specific regulations regarding disposal of wastes, and these should be followed. If however, no such regulations exist, the following suggestions may be helpful:

Acids and bases may usually be discarded in the sink with a quantity of water. If a concentrated solution is involved, pour this into a large volume of water and then discard the diluted solution with a good flow of water.

Alcohols of 70 per cent or more, which are not contaminated with xylol, toluol, etc. should be saved in a separate container for use in alcohol lamps.

Alcohols below 70 **per cent,** and those which are contaminated with other reagents may be discarded in the sink along with a good flow of water.

Cultures must be sterilized before disposal.

Biological Material

Animal tissue or any other biological material must also be safely disposed. Animal remains should always be placed in a separate container. The only completely safe way to dispose of biological material is to incinerate it, but if this is not possible, care *MUST be* taken to sterilize the material adequately before disposing of it. Simply placing the material in a plastic bag and putting it in the dustbin is NOT good enough. Go through Units 14 and 15 to learn about disposal of biological and chemical wastes.

The two day routine suggested here is not the only appropriate system. Each establishment should and usually does devise a system to suit its particular needs. A period of one week may be convenient as it is relatively easy for academic staff to know what they will be doing in a week time and help you to prepare in advance, especially if you have to order for live biological materials from the dealer.

In all efficiently run labs, the academic staff does plan the practical work and gives instructions to laboratory staff well in advance. This enables the lab staff to function efficiently.

4.3 ROUTINE INSPECTION AND MAINTENANCE OF LABORATORY

A regular schedule of maintenance will help ensure that the lab runs efficiently. In order to ensure that regular checks are made it is a good idea to compile a series of check-lists detailing the things that must be checked on a daily, weekly or monthly basis. In this way one can be sure that checks are made and nothing is left to memory. Some things have to be done more frequently than others as is indicated below. (This is not an exhaustive list, merely a catalogue of the more important points).

1. ***Daily.*** Ensure that labs are clean and tidy.

2. ***Daily:*** Ensure that the sinks are cleaned properly, that the drains are not blocked and that the grill over the waste water pipe is clean and in place.

3. ***Monthly:*** Every month clean the chemical stains in the sink. Check to see that there are no leaks in the sinks or drains.

WARNING: ELECTRICAL FAULTS CAN BE FATAL AND MUST BE RECTIFIED IMMEDIATELY

4. *Weekly:* Clean the fume cupboards since they rapidly become a repository of dirty apparatus and bottles of harmful chemicals. Every week make sure that all unwanted equipment and apparatus is removed from the fume cupboard. Clean the bench and ensure that the sink is free of obstructions.
5. *Monthly:* Every month cleaning of fume cupboard windows on the inside is essential. Check also that the exhaust fan works properly and removes air rather than just stirring it up. Check also that the front door of the fume cupboard opens and closes easily. If necessary, the cords (strings or thin ropes) used for moving the front door may be replaced.
6. *Monthly:* Every month check lab services like the supply of water, gas and electricity to labs since these are essential. Ensure that all gas taps are easy to operate, i.e. can be turned on and off without undue effort, and that the outlets are not blocked. Inspect electrical fittings to make sure they are not corroded or burnt in any way. If they show signs of being burnt or corroded, have them replaced. A burnt socket indicates that the point has been overloaded, so check that the equipment connected to that socket is correctly fused and in good working order. Keep a constant check on all electrical apparatus to ensure that it is attached to the correct fuse and, it is in good condition and connecting wires are not damaged.

7. *Annual* White-washing of walls, painting, varnishing of furniture and recoating table tops need to be taken care of once in a year or two. This will maintain and enhance the look of the laboratory (also refer subsection 4.4.7).
8. *Maintenance of register:* If you find defects in wiring, faulty equipment etc. it is essential that they are reported so that they can be rectified; therefore a suitable system of reporting faults is usually devised. It is suggested that a maintenance register is used for this purpose and that it is signed by the lab incharge whenever a complaint is entered. In this way, no-one can deny responsibility when something goes wrong.

SAQ 2

The efficiency of a lab can be adversely affected by poor maintenance of services and equipment. Make a list of the checks that should be taken.

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4.4 MAINTENANCE OF EQUIPMENT, APPARATUS AND FURNITURE

The amount of servicing and repair of equipment which can be undertaken by a laboratory technician in a school/college is limited. However, to ensure satisfactory performance of various equipment, attention should be given to the type of environment and the manner of use that the equipment is subjected to. Protection from the avoidance of dust, vibrations, corrosion and excessive heat will enhance the maintenance of the equipment. Use of instruction manuals in operation of equipment reduces tear and wear as well as damage to equipment,

4.4.1 Prevention of Dust

Routine cleaning and dusting of equipment removes a lot of the visible dust. The effectiveness of the process depends on the amount of dust and the rate of accumulation of dust. Certain environments are likely to encourage rapid accumulation of dust on equipment. Long, dry periods cause the winds to carry a lot of dust from the neighbouring countryside. This calls for the following measures:

(i) Dust barriers on windows in the form of fine wire mesh or (installation of air conditioner if affordable).
(ii) Keeping the doors closed most of time.
(iii) Covering equipment with dust covers when not in use.

In case where laboratory surroundings and path to the compound are not covered (paved, grass) a lot of mud is brought into the labs during the rainy periods which after a while dries up forming dust. The measures to reduce such dust should include:

(i) Provision of dust or door mats at the entrances
(ii) Mopping the floors instead of dry broom sweeping several times in a day
(iii) Covering equipment with dust covers while not in use

4.4.2 Reduction of Vibration

Constant vibration no matter how minor causes undesirable loosening and movement of various component of equipment which results in loss of alignment, precision and accuracy. The common sources of vibrations are:

(i) Moving equipment when needed from place to place without care or without the use of trolleys
(ii) Hammering on walls, benches and floors
(iii) Banging doors, windows
(iv) Heavy traffic close to the lab
(v) Loud noises

SAQ 3

Why should constant vibration be prevented in a laboratory?

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4.4.3 Prevention of Corrosion and Rust

Majority of the lab equipment is constructed of metals and plastics that would be affected and corroded by fumes and spillages of mineral acids and certain organic solvents.

The laboratory should have an efficient ventilation system and those experiments likely to produce fumes should be carried out in the fume cupboards. Equipment should be wiped after use in order to remove any droplets of liquids and chemical dust. Furthermore, covering equipment or storing them into cupboards reduces chances of corrosion due to spillages.

4.4.4 Protection of Equipment from Excessive Heating

Equipment which are not meant for heating would be adversely affected by high temperature. Certain plastic or rubber components would harden and crack due to heat. It is therefore advisable to ensure that electrically operated equipments are switched off after use. Also heating operations or equipments should not be kept too close to other equipment and direct sunlight should be prevented into the lab.

4.4.5 Correct usage of Instructional Manuals

Laboratory equipment should always be operated in the manner recommended by the manufacturers. The technician should ensure that a copy of instruction manual is available to the users who may be students, research scholars or academic staff. Sometimes a list of operational steps could be copied from the manual and can be hung or stuck on the equipment to assist the users. The originals of instruction manuals should be filed under the custody of the lab in-charge. They may contain useful information for guarantee, servicing and repair.

4.4.6 Servicing of Equipment

Some servicing of laboratory equipment is simple enough to be undertaken by the lab technician. This includes:

(i) Internal cleaning by use of certain solvents, blow brushes, vacuum, compressed air
(ii) Lubrication
(iii) Replacement of bulbs, belts, nuts, bolts and screws
(iv) Tightening of nuts, bolts and screws

4.4.7 Servicing of Furniture

Bench tops and tables in the laboratory require constant care. The type of care depends on the materials used for construction. Where wood tops are used, care must be taken to avoid long contact with water and chemicals. Hence immediate mopping of spillages prevents damage. Occasional application of wax polish makes the surfaces more resistant.

If the surface is highly stained and dented, renovation by a carpenter is recommended. Renovation of wooden bench tops if highly dented is done by sanding or first planing down the surface and then by application of several coats of a good clear varnish (polyurethane forms a more durable and impervious coating but is quite expensive) and routinely polishing with wax. Also renovation of formica laminated bench can also be carried out by a carpenter. This would require replacement of the formica by use of appropriate glue. Before the new formica sheet is laid the surface must be thoroughly cleaned and dried.

Other furniture in the laboratory i.e. cupboards, drawers, shelves, and blackboards are usually painted. A schedule of painting (yearly or biannually) should be established which may include the painting of walls and ceiling.

SAQ 4

List the types of simple servicing of equipment that the lab staff can undertake.

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4.5 CLEANING OF LABORATORIES AND PREPARATION ROOMS

Cleaning staff, who are usually not scientifically qualified, often perform their tasks early in the morning or late in the afternoon. As a result much of the time they work unsupervised. Clearly, in laboratories and preparation rooms they can be in danger if chemicals, glassware, and equipment are not placed properly. Equipment and containers that are not to be disturbed by cleaning must be clearly identified with *'DO NOT TOUCH'* or similar notices.

One further point is worth mentioning here, and it relates to laboratory design. Cleaning of floors (in particular) and benches is often much easier with the newer styles of laboratory design (which as you will recall from Unit 1 is free standing). Brooms and mops can more easily be used to get at the dirt that collects at the backs of units or along walls. With the more traditional designs, access for cleaning can be particularly difficult.

SAQ 5

Briefly explain as to how free-standing lab furniture makes life easier for cleaning staff.

4.6 COLOUR CODING OF SERVICES

In state of art laboratories and preparation rooms, the service pipes of water, electricity and gas have colour codings which is essential especially in case of emergency. The preparation room of your lab may or may not have such a system. However if the service pipes in the preparation room are not coded you should try as far as possible to get them coded. In any case you should be aware of the procedure of coding, which is as follows.

All service pipes should have the appropriate colour band of approx. 150 mm marked on them at:

(1) the point where they enter a room,
(2) any point where they change direction, e.g. at island benches or turns at wall benches,
(3) any stopcock or tap, and
(4) any visible lengths of conduit or pipe.

SAQ 6

Why should service pipes in the lab and preparation room be colour coded?

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4.7 EMERGENCIES WITH SERVICES

In order to deal with any emergency involving services, it is essential that you know where all the stopcocks and mains switches are located. Labs should have emergency electrical cut-outs located near demonstration benches and near the doors in all labs, preparation room and workshops. However, the important point is that the main switches or stopcocks should all be clearly labelled and the labels mounted between waist and eye level, e.g.

WATER STOPCOCK BELOW

It is no use if a stopcock is marked with a tag tied to it in some obscure place, such as behind or under a bench cupboard.

4.7.1 Emergency Procedure

In an emergency that requires all the lab services to be cut off, turn them off in the following order:

(1) Local electrical cut-outs.
(2) Gas supplies.
(3) Water.
(4) Remote electrical cut-outs, e.g. the main lighting switch which may be outside or in the basement of a large block.

4.7.2 Flooding

Water flooding is the most common emergency in science labs. It can be more dangerous in multi-storey buildings as rooms below may also be affected. Use the following procedure:

(1) If the flood is severe, follow the procedure outlined in subsection 4.7.1.
(2) If the flood is minor, e.g., a leaky tap, turn off the water at the source of the failure.

> The emergency procedure suggested in this Subsection 4.7.1 is valid for flooding situations also.

(3) Check the rooms (if any) immediately beneath the scene of the accident (flooding) as well.
(4) If water is coming through the ceiling, cover all electrical equipment with polythene or plastic sheets. By supporting them and tying them up, you could create a slope so that it is possible for the water to run off it into a sink or a bucket. Keep an eye on the light fittings as they may get filled up with water!
(5) Clear up the flood water as best as you can. In case of a sophisticated lab you may find that one of the machines used by the caretakers or cleaners will be useful for this.
(6) Get an electrician to check all electrical apparatus, so that he can ensure that the insulation has not broken down and that pockets of water causing a short circuit are not present.

SAQ 7

Imagine that it is the start of your working day. You enter the lab and find that it is flooded with water. What action would you take?

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4.7.3 Gas Leaks

For gas leakage first if possible, open all doors and windows. Also all the electricity supply to power and lighting circuits for the whole block must be turned off immediately, because gas can

travel along ducts and collect in pockets. Even if the emergency occurs at night, never turn on the lights as the spark from the light switch may be sufficient to ignite flammable gases. The gas supply must be turned off as soon as a leak is observed. If the source of the leak is not obvious, or if it can't easily be repaired, the local gas supplier must be contacted immediately. Remember to get all services checked and reconnected by a professional person before using the gas facilities.

4.8 SECURITY AND VANDALISM

Security and vandalism is a problem not only for the buildings as a whole, but for the labs in particular. The security staff like watchman are usually responsible for the overall security, but the technician who has a more specialized knowledge should be responsible for the lab area.

This particular point should be borne in mind as the caretaker will be the person normally called to attend to any emergencies. His lack of knowledge may lay him open to more danger than already exists, e.g. vandalism involving the smashing of containers of toxic and highly flammable material. He could quite well switch on the lights in a lab with a high concentration of flammable vapours without realizing the danger. Fluorescent light switches usually spark causing ignition with a flash fire or an explosion. The security staff for emergency purposes should have the telephone number of a member of the science staff he can call for advice or help; or a list of telephone numbers of the science staff should be available with him at an accessible place.

4.8.1 Security of Premises and the Immediate Working Area

A good system of locks for both internal and external doors is essential for secure premises, as locked doors are the first line of defence in security. A locked door is an effective way of delaying intruders. You should never forget to shut and lock the lab door when it is unoccupied. The type of lock is very important. It should be such that duplicate key of it cannot be made easily and it should not be easy to break into either the labs and preparation room due to it.

It is most important that a record be kept of all keys issued, including the date they are issued and returned. A much more detailed record should be kept of keys to places such as poisons' cupboards, radioactive stores, and stores. There should be only one key in use, held by a responsible person who keeps the record of the key's usage. This record should give the issue date, the person's name, reason for use (if no other record is kept), date returned, and user's signature.

In establishments where people work out of normal hours, the provision of a signing-in book is important. In the event of an emergency this provides a rapid means of checking if anyone is present in the building.

WARNING: ONE OF THE RULES OF ALL ESTABLISHMENTS SHOULD BE THAT NO ONE SHOULD WORK ALONE WITHOUT INFORMING SOMEONE ELSE.

Security in your immediate working area should involve the equipments as well as the building. Many items are attractive to thieves, and these must be on the inventory records. To deter the theft of the more obviously saleable items such as computers these should be marked not only with security paint but should be engraved with the name of the establishment and its inventory number in a visible position. The item is less likely to be stolen if it is easily identified and therefore difficult to sell.

Furthermore, we can add that if your lab, preparation room or store is on the ground floor, then perhaps it would be better if you cover those windows through which most people can look in. This simple action can help remove the temptation of pilferage.

Items such as computers, video recorders, slide and cine projectors should be ideally fixed in position (on a trolley if they have to be used in differing locations) to prevent theft. You could survey the market in order to find security systems for these valuable items and if available, get them installed.

SAQ 8
What basic measures should be taken to ensure a reasonable level of security in labs and the surrounding areas, as well as for the equipment contained therein?

4.8.2 Protection from Vandalism

Vandalism and theft have other implications beside the destruction of the building and the theft of saleable items such as TVs, tapes, etc. The entry into the lab may be to obtain simple chemicals to make explosives e.g. ammonia nitrate, mercury, nitric acid, etc. or solvents for sniffing for drug abuse.

There are other aspects of vandalism and theft besides the destruction of property and theft of resaleable items.

In one university lab, illicit drugs were being produced in the open lab for months before anyone realized what was occurring. This may have been the first time that something of this nature has occurred but unfortunately it probably won't be the last. However, it does raise another issue, and that is the misuse of equipment and materials by employees. This really is just another form of vandalism. The problem may be overcome by the adoption of an effective stock control system which can help identify excessive use of a particular material. The problem also calls for more effective supervision of staff

Other items which could be of serious consequences if stolen items are hypodermic syringes and needles. Not only is there the problem of syringes being used for the misuse of drugs but also there have been cases of children finding them and using them to play doctor. Remember it only needs a tiny bubble of air to kill a person. To prevent the theft of syringes they should be issued only under the strictest controls and signed for by a responsible person. On return they should be kept in the preparation room rather than in a drawer in the lab.

SAQ 9
Hypodermic syringes and needles present specific problems these days. What are these problems and how can they be prevented?

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4.9 SUMMARY

In this unit you have learnt that:

- In order to run a lab efficiently, good planning is required which involves cooperation of teaching staff and technicians.

- Organization of practical work/demonstration requires advance information to be given by the teaching or academic staff (2 days or a week) to the laboratory technician about the particular practical or demonstration to be conducted and full details about requirements and equipment.
- Day to day organization requires that the technicians should be informed by the teaching staff in advance about: (1) number of students (2) list of. equipment (3) List of solutions to be prepared (4) list of chemicals needed (5) note of any special requirements or hazards. All this will ensure that proper preparation can be made before the start of experiment/demonstration.
- Daily cleaning of the lab should be done routinely and after practical/demonstration. The used and unused materials (chemicals, stain, animal or plant tissues) should be disposed off safely.
- The maintenance of the preparation room as well as lab should be done ' both on a daily, weekly monthly as well as annual or biannual basis to ensure cleanliness of the lab as well to provide uninterrupted supply of services like water, gas and electricity.
- The avoidance of dust, vibrations, corrosion, rust and excessive heat in the lab and preparation room will ensure the maintenance of equipments, apparatus and furniture for a longer period of time. Servicing of equipments and furniture will ensure their satisfactory and long term use.
- The colour coding of service pipes, electricity, water and gas as far as possible should be done as this will prove useful during service emergencies like flooding or gas leaks.
- In case of emergency that requires all lab services to be cut off, the services should be turned off in the following sequence. (1) Local electrical cut outs. (2) Gas supplies (3) Water supply (4) The main light switch which may be housed elsewhere.
- It is important that the labs and preparation rooms are secured and guarded both from thieves as well as vandals because these rooms have both expensive as well as dangerous materials.

4.10 TERMINAL QUESTIONS

1. Describe the method of disposal of wastes such as chemical solution and biological material that accumulate in the laboratory.
2. Describe the method of cleaning the fume cupboard.
3. List the main sources of dust in a lab and suggest measures you would take to minimise entry of dust in the lab.
4. List step-wise, the procedure you would follow in case of leakage.
5. Describe the security measures you would take to prevent theft and vandalism.

4.11 ANSWERS

Self Assessment Questions

1. It is important for the technicians to have advance information so that they can have everything prepared and ready before the practicals or lecture cum demonstrations are held.
2. Compare your list with that in Section 4.3. The list in section 4.3 provides only the most important points. It would be impossible to give an exhaustive list as each lab and preparation room will have its own specific requirement.
3. Constant vibration should be prevented in the laboratory area because they adversely affect the equipment kept there. The vibrations cause undesirable loosening and movement of the various components of the equipment. This results in loss of adjustment, precision and accuracy of the equipment.
4. The lab technician can undertake the following servicing of equipment. He can

(i) Clean the internal components of the equipment by using certain solvents, blow brushes, vacuum and compressed air.
(ii) Lubricate components of the equipment.
(iii) Replace bulbs, belts, nuts, bolts and screws of equipments, if necessary.
(iv) Tighten nuts, bolts and screws when needed.

5. Access to floors and walls is easier.
6. Colour coded services are instantly recognizable. This is particularly important in the event of an emergency.
7. You should follow the procedure given in section 4.7.2.
8. Your answer should include the following points.
   (1) Good quality locks should be used.
   (2) Doors should be locked when the lab/preparation room is not in use.
   (3) Access should be restricted to authorized personnel. Other people should only be allowed to enter under supervision.
   (4) Items which can be easily stolen or misused should, if possible, be kept out of sight.
   (5) Inventory number/name of institution engraved on equipment in a position which is clear for all to see in order to deter the thief.
9. The main problem these days is the use of hypodermic syringes for drug abuse. Hypodermics should only be issued under the strictest controls and signed for. They should be kept in the preparation room rather than in an open drawer in the lab.

Terminal Questions

1. Consult subsection 4.2.3 for the answer.
2. Consult subsection 4.3 for the answer
3. Consult subsection 4.4.1 for the answer
4. Base your answer on subsection 4.7.3.
5. Base your answer on section 4.8.

UNIT 5 STOCK CONTROL AND PURCHASE

Structure

5.1 INTRODUCTION

In this unit, you will study about management of stock which includes organisation of stock within the stores, inventories etc. You will study how orders arc placed for purchasing equipment/instrument, glassware, chemicals etc. You will learn how the equipment to be purchased is selected. You will learn that the purchase of alcohol, poisons etc. is regulated by legislation. As a matter of fact purchasing is an important job of lab assistants or technicians because it is related to use of financial resources and effectiveness of lab functioning. It is important for a lab technician/assistant to know whether the company with which he/she is dealing is a reliable only. Reliable companies can only supply goods of good quality at a reasonable price and without undue delay.

Objectives

After you have read this unit you should be able to:

- state the necessity of organising stores in an orderly and systematic manner,
- describe the methods by which list of requirement of a lab can be prepared,
- outline the two methods of stock control i.e. two bin system and constant
- cycle system,
- explain the functions of stock control system,
- understand the use of terms such as re-order quantity and re-order levels,
- state the method of inviting quotations,
- explain the factors deciding the purchase,

- discuss the method of placement of order for purchase,
- define the terms-order books, inventory and service register,
- explain the procedure for taking delivery and processing bill,
- state the significance of Sale of Goods Act (1930),
- discuss the principles involved in accounting for major and minor expenditure
- appreciate the necessity for record keeping in stores,
- recognise a stock control card of bin card, and
- use a stock control card, and
- explain or differentiate between stock control and inventory.

5.2 ARRANGING STOCK

You would like to know the problems of organising the store and the factors affecting the running of it. A store is a place where materials and equipment are kept often for an unspecified period. Now the question arises, after having kept an item in a store, how can it be found?

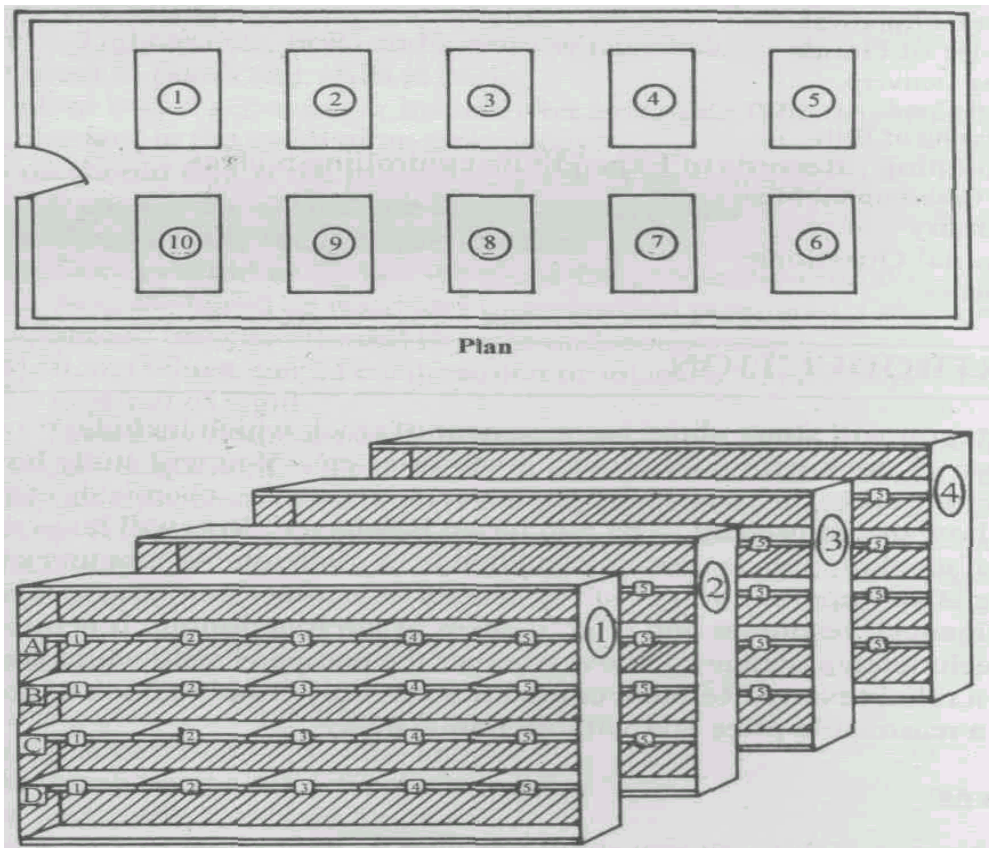

Fig. 5.1: Sub-division and referencing of shelving units

Generally, when a person is asked to place an item in store, he/she will place the item in the shelf where there is any gap. But in doing so the chances of getting it later on are not too good. Therefore, the item should be placed in a known position so that it can be located easily.

5.2.1 Locating and Referencing

Most of the stores are provided with racks of shelving units, (i) Usually a number is allocated to each rack, (ii) A letter is assigned to each shelf and (iii) the shelves are in turn sub-divided using

numbers as shown in figure 5.1. In practice the chosen arrangement should be such that that the stores can be managed easily.

5.2.2 Shelf Arrangement of Stock by Nomenclature

After having developed a method of classifying storage space, there arises the problem of arranging items on a shelf in a store. In practice, there are more than one ways to do it.

In Figure 5.2 an example of a shelf from a physics store is shown to demonstrate the use of alphabetical system. This system seems to be easy to understand as it shows that various items starting with the letter 'M' are arranged in a shelf of a store. There is a possibility that this shelf is full and then problem arises as to where you will store a new item such as digital Meters? In that case the shelf needs to be rearranged and, if still space is insufficient, adjacent shelves would be occupied for arranging the new items. In a nut shell this is how items are arranged on a shelf in a store.

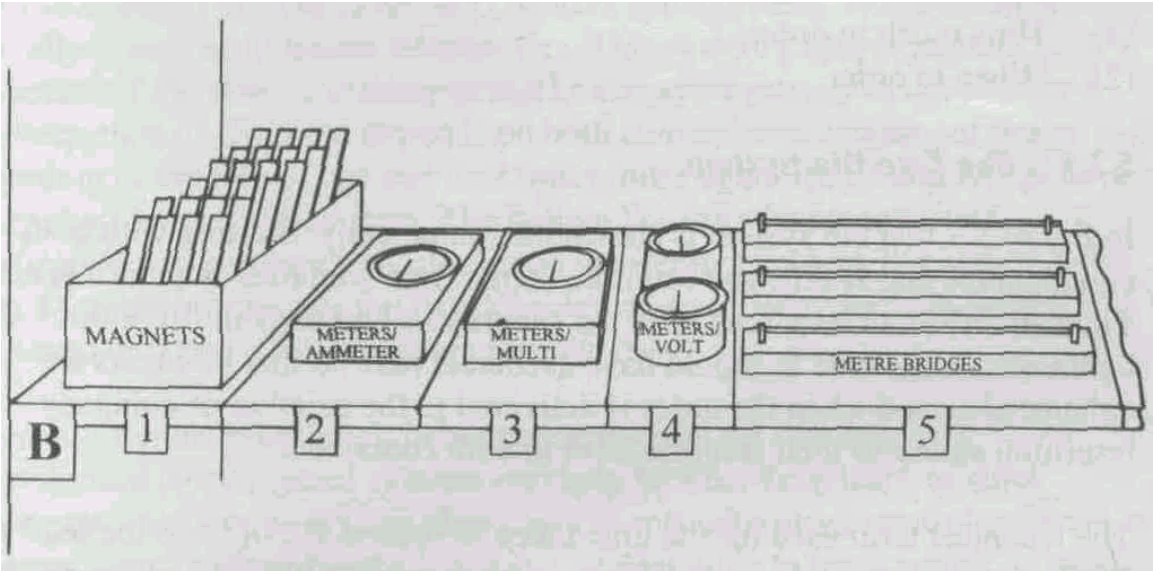

Fig. 5.2: Stock arranged alphabetically

SAQ 1

Mr. Adamu has taken delivery of equipment for a physics lab. After moving around the store, he has managed to squeeze the items into various spaces on a shelf. Comment on whether Mr. Adamu has been logical in his approach. If not, how he could have tackled the arrangement?

_____

_____

_____

5.3 STOCK CONTROL

In the previous section, you have studied how items should be arranged within a store. In this section, you will study about the supply of goods. Besides, you will deal with ordering quantities of materials. Here we will only discuss consumable items rather than the purchase of specific pieces of equipment. Factors that influence the purchase of equipment will also be discussed in section 5.5. There are two main systems used for stock control mentioned as under.

(1) The two-bin system and
(2) The constant cycle system.

Of above two which system is to be used depends on the circumstances and arrangements in a particular store. Both the systems or a hybrid of the two may be found useful in the store. The system chosen should be convenient to operate and be capable of being easily understood. A sophisticated system may be useless if staff does not use it. A stock control system should make it clear as to:

(1) How much to order
(2) When to order

5.3.1 The Two Bin System

In figure 5.3 two bin system is shown diagramatically. Starting with both containers A and B full, you can draw items from container A until it is empty. Then an order can be placed with the supplier or company to fill both containers. Container B should have sufficient item so that its stocks are exhausted as and when the order is delivered to the supplier or company, returning stocks to their original level in both containers.

The technical term used for the time taken to receive the order is the **lead time.** While the quantity ordered is called re-order quantity (ROQ) and the quantity of stock in container B is called the re-order level (ROL).

In practice it is not necessary to have two containers. A simple container with a mark on the side will be as ideal for liquids whereas the ROL marked on the container will be ideal for solid items such as nuts and bolts. At the same time ROL information should appear on a stock card or bin card and this should serve the purpose of reordering.

The relative size of A and B will depend on the lead time as shown in figure 5.3. If the lead time is short, the capacity of B will be small and vice versa. A small additional stock what you call buffer stock should be maintained to safeguard against fluctuation in both supply and demand. In this system stock itself is used to trigger the placing of an order. In the other system of stock control - the constant cycle system-time rather than stock is used to control the system.

5.3.2 The Constant Cycle System

There is a second system called the constant cycle system. This system requires regular inspection of the store, checking of stocks and appropriate placing of orders. The frequency of checking depends on both convenience and rate of usage. According to the role of use and lead times, once again ROLs and ROQs have to be set up for each stock item. The system has the advantage of self rectification and consequently stocks are frequently checked. It could be either every Monday morning or the first Monday of the month, the third Friday of the month or it could be on any appropriate day.

Where a lot of different stock items are carried out by a technician, computerised stock control systems can help him/her keep track of stock movements and purchasing. In places where specialist stock control software is not appropriate such as in small labs etc. it is possible to use a simple spreadsheet to 'flagup' the requirement for reordering in the desired amounts. Computer stock records can easily be accessed whenever you would like to check them. However, like any other system they rely on accurate, up-to-date input of information.

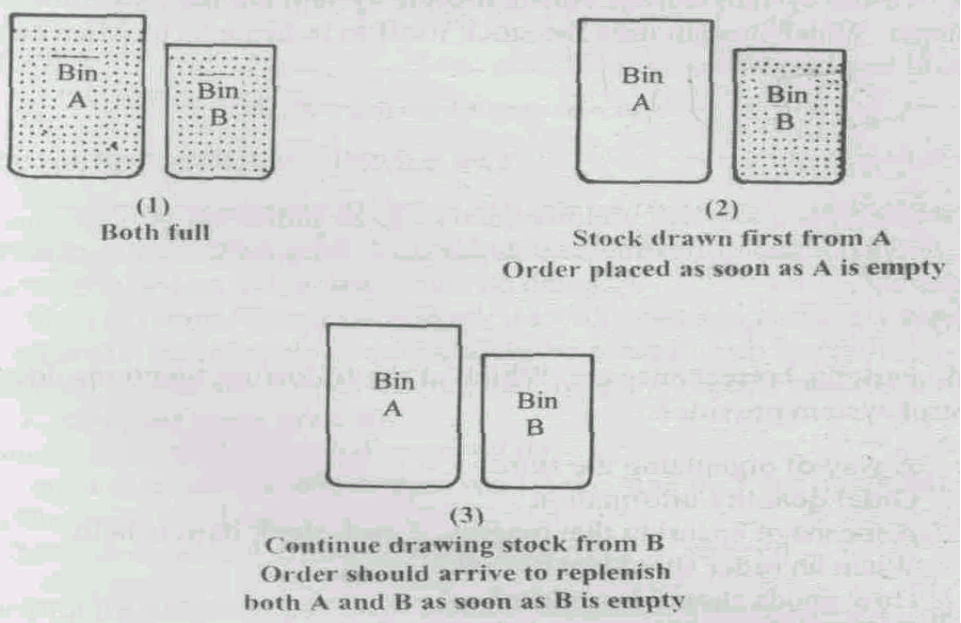

Fig. 5.3: Two Bin Stock Control System.

The re-order quantity should be within the economical amount. This should not be too small causing orders to be placed frequently. At the same time the stock should not be excessive with ordering at long intervals. This involves money and technician should use his/her common sense or judgement or experience. For example, in some cases such as conical flasks, it could be more appropriate to make purchases for a year's supply. Whereas in other cases such as chemicals, regular order would be more appropriate.

SAQ 2

The two-bin system and the constant cycle system are the two stock control systems. Which system uses the stock itself to indicate as to when an order should be placed?

_____

_____

_____

SAQ 3

Tick mark the correct answers. Which of the following functions does a stock control system provide?

(i) A way of organizing the store
(ii) Order quantity information
(iii) A means of ensuring that masses of each stock item is held
(iv) When an order should be placed
(v) How goods should be ordered
(vi) Training for staff to operate the system

5.4 RECORD KEEPING

Whatever system is used in any lab, you will find that maintenance or records of the stock held and quantities ordered are necessary. We will discuss here the manual system. However, the computerised systems are based on similar principles.

You may refer to unit 7 of this course for detailed information on record keeping.

5.4.1 Bin Cards

In common practice, bin cards are used for recording information for consumable stocks held and on order. Specially printed cards can be used for this purpose. Index cards are also quite satisfactory or else the desired information can be stored in computer. An example of a bin card is illustrated in figure 5.4.

Item	**Beaker 500 ml**		**ROL**	**14**	**ROQ 30**
Date	Ordered	Order No.	Received	Issued	In hand
13.5.96	Stock	Take			40
27.5.96				14	26
01.6.96				10	16
02.6.96	30	SOS 109			
04.6.96				10	06
06.6.96			30		36

Fig. 5.4: Bin card for stock control

Bin cards can be used in the following way:

(i) You must enter the initial stock in hand either when stock-taking or when continuing into a fresh card. You should remember to enter any outstanding orders. All entries must be dated.
(ii) You must enter any quantity ordered, the order number and the date of the order.
(iii) An order for fresh supply should always be placed when the ROL is reached (two-bin system) or when performing the regular stock control check (constant cycle system).
(iv) Quantities should be ordered as per ROQ.
(v) You must enter all quantities removed (at the time they are removed) together with the date.
(vi) At the time of arrival all the new supplies must be entered.

By following the above steps it will be easy for you to know:

(a) What stock is in hand.
(b) What has been ordered and
(c) the rate at which items are being used.

The Points mentioned above are important as what is it? Finds out re-order quantity (ROQ) and sets the re-order level (ROL). Say for example, if an item is being used 10 per month and the delivery time is three months. Then the ROL must permit for enough stock to be held until new supplies are made, besides a little extra is required in case of delay. So you could fix the ROL of four months supply instead of three. In a similar condition with a long, delivery time, an order can be placed for a year's supply at a time. It can be borne in mind that placing an order costs money and so small orders can be avoided. After all it is a question of balance.

5.4.2 Order books

To trace the progress of purchase orders, an order book is quite useful. In an order book order for items of equipment as well as consumables are recorded. Entries are kept of the amount of money committed with orders. This can be done by any one who controls budget for lab. In Fig. 5.5 an extract from a typical order book is illustrated for you to know how an order book is maintained

Date	Order No.	Supplier	Item(s)	Estimate Price	Delivery Note No.	Remarks
27.5.96	SOS09	Borosil Ltd. Lagos	200 Watch glasses 30 × 250 m Beakers	₦ 500.00	54	Order complex 9.6.96
27.5.96	SOS 10		5 Kg Nacl 50 g $AgN0_3$ 3 × 500 ml HC1	₦ 400.00	72	NaCl returned as damaged Rest Ok

Fig. 5.5: Showing an extract from an order book

The principle of recording the progress of orders need to be done through a book. You may have special forms for purchasing or requisitioning items and copies of these forms can act as an 'Order Book'. However, this information also can be maintained on the computer.

It has to be kept in mind that official purchase order forms must be completed and authorised by a designated person. All staff should be aware of procedures adopted for purchasing.

5.4.3 Inventory

After having gone through the record keeping you should know the requirement for keeping an inventory. An inventory is a record of all items, both materials and equipment, stocked at a particular time, in a lab and a store. In other words an inventory is a list of all non-consumable items. In common practice, official inventory books are issued by the institutional authorities and, other employees are supposed to follow these practices. In the absence of an official inventory book, a loose-leaf ledger with numbered pages will be adequate for the purpose. An inventory book is shown in figure 5.6.

Name of lab
Division
Section

Serial No.	Details of Item	Balance on	Addition	Discard	Balance on 31.3.2000	Initial of checking officer

Fig. 5.6: The Extract of an Inventory Book

The inventory book needs to be kept up to date all the time. Updating will take place when stock taking occurs. A complete stock taking must take place at least once a year when a complete accounting of all items of equipment (major or minor) is made. Account of all items used or disposed of has to be made.
Inventories of non-consumable items are of considerable importance. In all institutions, it is a set practice to stamp all such items with an inventory number to help the identification of equipment in the light of inventory. While auditing, the stock auditors demand to see an inventory so that appropriate checks can be made against each item (equipment).

5.4.4 Service Register

A service register is not part of a stock control system, but we would like to mention here that much of the equipment logged in the register is kept in the store. Some equipment will require regular servicing under contract whereas other equipment will need occasional service and repairs. A record of the work carried out must be maintained and, for such purpose a service register is required.

The service register contains the names of equipment, inventory numbers, serial numbers, details of servicing of-repairs and the name of the person or contract who carries out-repairs. In figure 5.7, an example of service register is illustrated.

Name of instrument		**Serial No.** **Inventory No.**
Date	**Service/repair details**	**By which agency**

Fig. 5.7: Extract of a Service Register

Now you can try some SAQs and check your answer at the end of the unit.

SAQ 4

What information is entered on a bin card?

_____

_____

_____

SAQ 5

Where are entries of equipment held in a lab?

_____

_____

_____

5.5 ORDERING PROCEDURE

We shall discuss here various procedures adopted for ordering or placing an order towards acquiring non-consumable and consumable items for the lab.

5.5.1 Preparation of List of Requirements

For making purchases for your laboratory you are supposed to know the requirements and the prices of various items you want to buy. First of all you have to prepare a list of consumable (chemicals, soaps, detergents etc) and non-consumable (instruments/equipment items). For knowing your requirements you have to see the stock register regularly so that you are aware of your current stock position. Some time some new items are required by the persons working in the lab. For this you have to ask these persons periodically to update the list of requirements.

5.5.2 Inviting Quotations

After you have prepared the list of items required for your laboratory you work enquire the prices of these items for placing an order towards purchase with the suppliers/firms/manufacturing agencies. You would write the various firms (not less that three) to quote the prices of the items which you want to buy from them. For doing this institutions have their own printed forms (proforma for inviting quotations). Below is given an example of a quotation form (Fig. 5.8).

NATIONAL OPEN UNIVERSITY OF NIGERIA
Victoria Island, Lagos

To No:

_____ **Date**:

_____

_____

Sub:

NOUN-INVITATION FOR QUOTATION FOR SUPPLY OF

Dear Sirs,

Please quote your lowest rates for supply of following items:

S. No.	Description of Items	Remarks

1. You are requested to attach samples of the items wherever required. Please furnish the following information also:

(a) Validity of the quotation.
(b) Your Sales Tax Registration No.
(c) Are you a manufacturer or a supplier?
(d) Delivery period.

2. The quotation in double sealed cover with superscription "Quotation for supply of ....." against Tender Enquiry No. ..... should reach the ..... and shall be received up to 3.00 p.m. on ..... The same will be opened at 4.00 p.m. on the same day in the presence of the tenderers whomsoever are present. Late tenders will not be considered.

3. Specifications: stores offered should strictly conform to your specifications. Deviations, if any. should be clearly indicated by tenderers in their quotation. The tenderer should also indicate the Make/Type, number of the stores offered and provide catalogues, technical literature and samples, wherever necessary along with the quotations. Test certificates wherever necessary should be forwarded along with supplies. Wherever options are called for in respect of specifications, the tenderer should induct all such options. Wherever specifically mentioned by us the tenderer could suggest changes to specifications with appropriate response for the same.

4. Corrections, if any must be attested. All amounts shall be indicated both in words as well as in figure. Where there is a difference between amount quoted in words and figures, the amount quoted in words shall prevail.

5. If the supplies are not made within the stipulated period and the lime is not extended, the supplier will be liable to pay compensation equal to one percent or such small amount of the total amount of contract as the Registrar may decide for every day that the quantity remains incomplete, provided that the entire amount of compensation shall not exceed 10% of the total amount of the contract. In addition the Registrar reserves the right to cancel the order at the supplier's risk and cost.

6. The purchaser shall be under no obligation to accept the lowest or any tender and reserves the right of acceptance of the whole or any part of the tender or portion of the quantity offered and the Purchase tenderers shall supply the same at the rates quoted.

Yours faithfully

Deputy Registrar/Asset. Registrar (CPU)

Fig. 5.8: An extract of the quotation format

You would fill up the forms with the list of your requirements and post them to the firms. A definite time is given by which you want them to submit the price list of items you require because these quotations are to be placed on a fixed date before a committee called **Purchase Committee.** These quotations are only opened before the committee members. After opening the envelope these quotations are signed by the members of the committee. Once these quotations are signed, a comparative chart of various quotations of the prices is prepared by which you can make out which firm/supplier/agency has quoted the lowest price for a particular item. After the chart is ready, you would place it once again before the purchase committee for getting approval for making the purchase against the lowest price quoted items.

5.5.3 Factors Deciding Purchases

Before deciding what specific type of equipment needs to be purchased, various factors are taken into consideration. Common sense should be applied which equipment is most important for a particular occasion.

Factors that influence purchasing of equipment are:

(i) Cost
(ii) Duplication - availability of a similar kind of equipment in the lab.
(iii) Specifications
(iv) Quality

(v) Servicing
(vi) Availability of spares
(vii) References - experiences of others
(viii) Competition between suppliers
(ix) Training and other staff implications

For purchasing of consumable items, the factors are:
(i) Cost
(ii) Minimum order size - standard packages
(iii) Delivery time
(iv) Quality
(v) Delivery Service/collection of containers, etc.

5.5.4 Propriety Items

Propriety items means goods/equipments/instruments/chemicals/ glassware which are particularly manufactured by a particular firms which have the sole propriety of the items to sell them either through their approved agencies or by themselves. For making purchases of the propriety items you need not invite quotations and what you have to do you have to ask the firm which manufacture the propriety items to furnish the price of the same. This step is taken only when you want to buy a standard quality items of a firm.

5.5.5 Role of Purchase Committee

A committee is formed to facilitate, regulate and monitor the purchases of an organisation/institution/department/lab. The purchase committee members are nominated by the head of an organisation/institute/lab for the fixed tenure of 2-3 years and after the expiry of the term either the same members may renominated or they may be replaced by the new members. There are no fixed numbers for the purchase committee. As per practice, the senior most member becomes the convenor of the meeting or as decided by the Head of an organisation.
Different functions are assigned to the committee:

1. To formalise the purchases
2. To monitor the discrepancy if any in inviting quotations
3. To sign the quotations on a specified date
4. To grant approval for the purchase

Besides the above said functions the purchase committee from time to time formulates procedures for the purchases to be made by the organisation. If some irregularities are committed the committee itself sorts out the problem or refers the matter to the notice of competent authority for its resolution.

5.5.6 Purchase of Alcohol

Alcohol/rectified spirit is a controlled item as such it is not sold in the open market. The sale of alcohol/rectified spirit is controlled by the permit issued by excise department of district/city. If you want to buy alcohol for your lab you will have to make a written request through your head of the department to the excise department. This request will contain the quantity of alcohol needed indicating its purpose. On getting the permit from the excise department, you would go to the Distillery with the container to collect the alcohol. In the permit itself the name and the place of the distillery is mentioned from where you would be lifting the consignment.

5.5.7 Placing an order

Procedure adopted for placing an order varies from one organisation to another. In most of the organisations the order for the supply of equipment is placed on an official order form. In many organisations the copies of orders are required for supplying information regarding purchase to different sections as follows.

(i) Original copy - to the supplier
(ii) First copy - to the accounts section
(iii) Second copy - to the lab file.

The order to be placed must contain full details of items being purchased as shown in figure 5.9. Besides, it must contain certain information that are legally required. For example, a limited company must give its company details. Autonomous bodies like educational institutions will have official order forms showing different details. Whatever the case may be, only an authorised person can sign an order form and this sort of form can serve as the basis for a contract.

You are supposed to know how to prepare an order form for making purchases form supplier. While doing so you should keep following two points in your mind.

(a) You should never use 'home-made[1] order forms as you would make your employer legally liable.
(b) You should ensure that whoever signs order forms is an authorised signatory. It should also be ensured that the form is checked occasionally.

A model format of order form is given below:

NATIONAL OPEN UNIVERSITY OF NIGERIA
Victoria Island, Lagos

P.O. No.
Dated
DVN Code

To

_____

_____

Sub: Supply of goods

Dear Sir,

With reference to you quotation No..... dated ..... please supply the following articles on or before …….

S. No.	Description/Specification	Qty. 3	Rate 4	Cost 5

The above purchase is subjected to the following terms and conditions:

TERMS AND CONDITIONS

1. The material may be supplied to the ....., Lagos by .....
   All correspondence regarding the order should be addressed to the consignee.
2. 100% payment will be made when the material/goods have been received by the University and have been inspected by its inspection unit and accepted by it.

   OR

   90% payment will he made through Alpha Bank, Lagos, if the documents are received through a bank.
3. Balance payment of 10% will be made on receipt of material/goods and their inspection by the University inspection Unit. This payment is subject to the acceptance of goods by the inspection Unit.
4. The goods which are not according to specification and are thus not accepted shall be lifted by the Supplier at his own cost.
5. If the supplies are not made within the stipulated period and the time is not extended the supplier will be liable to pay compensation equal to one percent or such small amount of the total amount of contract as the Registrar may decide for every day that the quantity remains incomplete, provided that the entire amount of compensation shall not exceed 10% of the total amount of contract. In addition, the Registrar reserves the right to cancel the order at the supplier's risk and cost.
6. In case the supplier backs out of his contract, his earnest money if any shall be forfeited and such other action will be taken as deemed proper.
7. The supply shall be increased/decreased within ..... day of placement of this supply order.
8. The bill in triplicate may be sent to the Registrar, National Open University of Nigeria, Lagos, for payment.
9. An extra amount as Sales Tax/Excise Duty will be paid as applicable under Government Rules if so quoted by the supplier/contractor in the tender/quotation subject to the certificate in the bill of costs as follow.

   Certified that the Sales Tax/Excise duty charges
   in this bill is leviable under Government Rules.
10. Other material should be packed in a strong case so as to avoid any damage, theft or pilferage in transit, in which case the responsibility shall be that of the supplier.
11. Other terms and conditions are as per terms and conditions specified in the notice inviting tenders.
12. All disparities/disputes arising out of the order are subject to the jurisdiction of courts at Delhi.
13. Every packing case should contain a packing note mentioning details of the material packed with complete reference to our order. Our address must be superscribed on the side of the packages.
14. The claim for freight charges if admissible in terms of your quotation should be made in your bill.
15. Prices are fixed and are not subject to any variation.

Yours faithfully.

Deputy Registrar/Asst. Registrar (CPU)

C.C.: Finance & Accounts
Div. Indentor
PS to VC

Fig. 5.9: An extract official order for purchase

5.5.8 Importing

Importing goods from overseas might be a complicated and time consuming process and it will be better to utilise the services of an agency which deals with importing goods. For importing items from overseas there are two approaches which you can undertake.

(1) Firstly wherever possible purchase can be made through an agent. The agent will furnish all the required documents for you. Most of the agents provide break-down or maintenance service to their customers. Before placing order you must satisfy yourself that there are adequate arrangements for after sales service. Particularly you will have to be extra careful in case where agent does not provide servicing arrangement.

(2) Secondly when you don't find an agent, you will have to make all necessary arrangements. The arrangement includes making application to the appropriate government department by completing necessary formalities. You have to check whether import duty can be waived for research and educational establishment. In some cases import duty will be paid but it can be claimed later.

5.5.9 Value Added Tax (VAT)

Educational and research establishments and some companies are zero rated for value added tax (VAT). Therefore, these establishments can reclaim any VAT if they have been charged either for goods or service. It is essential to find out whether VAT has been charged. On checking if it is found that VAT has been charged, then the finance and accounts office of your establishment should be informed as it will be their duty to reclaim VAT. For your information VAT is paid to custom and excise departments and reclaimed from them on quarterly basis.

5.5.10 Discounts and Bargaining

While making purchases, the job of a lab assistant or technician is to obtain the best value for the money. Bargaining with the suppliers is one such way through which it is possible to buy goods at a lower price. On limited occasions, bargaining and playing one supplier against another is an exercise that can be practiced. Certainly one can not bargain every time when a purchase is made. Usually one can bargain when a supplier is new or if another supplier is found who charges less.
Often suppliers offer an educational discount typically to educational and research institutions. Sometimes, suppliers offer large discounts e.g., on supplying consumables or service contracts. If you work in an educational laboratory you can enquire whether an educational discount is available. By doing so there is everything to be gained.

5.5.11 Goods on Approval

There is a keen competition amongst some suppliers and in some sectors of the market e.g., the market of microcomputer. A request to a supplier to retain equipment on approval to judge its performance can often be arranged. Many suppliers will be willing to do so. In some cases it is good to avail of this facility.

SAQ6

Discuss briefly as to why it is necessary to use both official order forms and an order book.

_____

_____

_____

5.6 RECEIPT OF GOODS

In 5.5, we have discussed the purchase of goods and the various problems related to it. Now we will discuss the procedure to be adopted when goods arrive from a supplier.

5.6.1 Taking Delivery

After the supplies have been made, you have to carry out the following jobs:

(1) Check the condition of all items to see that none of them are damaged.
(2) Check the items received against the delivery note. If any difference is found, note it.
(3) Check the list of goods on the delivery note against your order to ensure that the goods received have actually been ordered.
(4) Enter details of receipts in the order book or purchase records.
(5) Inform the supplier against any discrepancies or damages. Keep in mind that there is often a time limit for notifying deficiencies to the supplier. This time limit is in fact printed on the delivery note.
(6) Therefore, Endorse the delivery note with the condition and accuracy of the goods received and then, send it to the Accounts department to make for payment, and
(7) Repack the goods and place them in store in bulk, if not required for immediate use.

5.6.2 Processing of Bills

After taking the delivery of the items supplied by the firms, entries of supplied items are made in the stock/inventory register. Once the proper entries have been made the bills are processed for payment. In processing the bill you will tick mark only those items which have been supplied as per your specifications as you would like to make payment to the firm only for the ordered items.

Delete the prices of those items not desired or supplied as per your specifications. Write on the bill that the bill is passed for payment for this much amount of money and write on the bill the page number of stock/inventory book on which the supplied items have been entered. Then this bill will be countersigned by the controlling authority. He may be Head of lab/department/school. After the bill is duly signed by the controlling authority, it is sent to the Finance Division for payment.

5.7 ACCOUNTING: RECORDS OF EXPENDITURE

As a lab technician you may not be involved in the exercise of obtaining funds by which your department or lab runs. You will definitely be involved in looking after the funds being spent. This process can loosely be described as accounting; though a proper accountant would apply more rigorous methods in controlling the flow of funds and also in ensuring value for money.

5.7.1 Controlling Budget

Money is usually obtained and allocated under various heads. These heads include such items as minor equipment, furniture, consumables, and a separate account has to be maintained for each head. In most organisations major items of equipment are obtained by a different process whereby funds are requested for the purchase of a specific piece of equipment.

Of the various heads under which money is accountable there are two more important heads - consumable and minor equipment. For example, in some schools, there is little freedom to make orders for items from anywhere from a except local authority such as Central Store or Super Market. In such cases accounting becomes easier as prices will be known and can be entered on an appropriate form or book. However, situation remains the same whether the items are purchased either through central stores or on open market. In the open market it is common practice to obtain an 'estimate' or and approximate idea of the price of an item.

Now we will discuss a practical approach to the problem of controlling expenditure.

In Fig. 5.10 you can see an extract of some accounts towards expenditure incurred towards minor technical equipment. You will notice from the top of the accounts that they refer to one particular financial year 1995/96. The account applies to minor technical equipment for which the money allocated is ₦400,000.00.

In the first two columns the date of the order and the order number are taken straight from the order form. Whereas in the 3[r] column just the name of the item that has been ordered, is recorded. No further details of the items are required as these information are already available on the copy of order form. These details may also find entries in the order book.

Next there are four columns of figures. You can consider the first lists of prices of the items obtained, say over the phone. The price may not include account of any recent price rise or postage and package. In the second column a running total of expenditure is calculated as per the estimate at the time of the latest order. So these first two columns refer to what you visualise about the situation based on intelligent guess work, telephone calls and so on.

National College, Otukpo		Science Department				
Financial Year 1995/96		Expenditure Head - Minor technical equipment				Amount Allocated: ₦400,000.00
Date	Order No.	Items	Est. Price	Est. Expenditure	Invoice Price	Actual Expenditure
10.4.95 13.4.95 17.4.95 19.4.95 4.2.95	101 102 103 104 105	Spectre photo meter Colorimeter pH meter Glassware Skull/bones	20,000 6,000 5,000 5,000 200	20,000 6,000 5,000 5,000 200	20,000 6,000 5,000 5,000 200	20,000 6,000 5,000 5,000 200

Fig. 5.10: Accounting for a Lab/Dept funds

The last two columns are based on the actual costs that are shown on the invoices received from suppliers. These two columns are similar to the previous columns but they can only be completed when you know the exact invoiced costs of items. You will not be able to keep these columns up-to-date as you will keep yourself waiting until invoices arrive. So the best what you can do you mention actual expenditure with pencil and await further information.

Invoices are presented before the end of a particular month of the year; otherwise payment may not be made to suppliers. Once all the invoices have arrived, the accounts can be totalled, handed over to the Head of the department and, forwarded to the concerned accounts section for making payment to the parties. You will have to explain any underspent or overspent amount.

5.7.2 Petty Cash/Imprest Money

In the preceding sections we have discussed problems related to accounting for major expenditure within a department. Petty cash as the name itself suggests is concerned with minor expenditure. However, keeping of records is quite important as all money must be accounted for.

Generally with petty cash, small local purchases are made in order to keep the lab running smoothly. Receipts of the purchases made must be obtained in all cases as these are proof of purchase. Formal orders are not required. A receipt should also be given when money is obtained from accounts section to be used as petty cash. This receipt indicates that money has been issued to the keeper of the petty cash.

The most frequently used system of accounting is the *'imprest method*', whereby a fixed float is available from which purchases are made from time to time. The maximum value of the float is called the imprest.

In Fig. 5.11 an imprest system for petty cash is shown and in this case imprest is ₦ 200.00. By the end of the month a total of ₦125.00 has been spent leaving a balance of ₦ 75.00, which is judged to be adequate for the time being. But by the end of second week of the next month a further ₦ 50.00 has been spent leaving a balance of only ₦ 25.00. At this stage ₦ 175.00 is obtained to make the balance to the imprest amounting ₦ 200.00 and so on.

It should be borne in mind that petty cash should not be overused. They should only be used for minor purchases made and all other expenditure should be through the main accounts.

End of month	Description	Expenditure	IMPREST	Balance
1.4.96 5.4.96 10.4.96 16.4.96	Postage Stamp Paper (for typing) Carbon paper	50.00 25.00 50.00	₦ 200.00	₦ 200,00
End of month 3.5.96 8.5.96	Screw Driver Postage Stamp	Sub Total of April 25.00 25.00	₦ 125.00	₦ 125.00 ₦ 200.00
10.5.96 21.5.96 29.5.96	Imprest Soldering Iron Nails	50.00 15.00 10.00		
End of month		Sub Total of May = ₦ 25.00		₦ 175.00

Fig. 5.11: Shows an example of a petty cash account

SAQ 7

How far is bargaining with a supplier justifiable? Support your answer with reasons.

_____

_____

_____

SAQ 8

Why is petty cash dealt with in a simplified accounting form as compared to the one used for other expenditure?

_____

_____

_____

You can check your answer with the one given at the end of the unit.

5.8 SUMMARY

Let us summarise what you have learnt so far.

- You have studied the organisation of stock within the store, maintenance of inventories etc.
- The problems of organising the store and the factors affecting the running of it.
- The procedure related to supply of goods, ordering quantities of materials; two major systems used for stock control: (1) the two bin system and (2) the constant cycle system.
- The maintenance of records of stock held and quantities ordered; two main systems i.e. manual systems and computerised systems.
- The factors influencing purchase of equipment.
- The procedures adopted for placing an order to the supplier.
- The procedures to be adopted when goods arrive from a supplier.
- The process involved in looking after the funds being spent.

5.9 TERMINAL QUESTIONS

1. What are conditions under which import duty is likely to be waived on imported items?

_____

_____

_____

2. What is it not always possible to state precisely how much money has been spent under a particular budget head? How should you attempt to make allowance for this?

_____

_____

_____

5.10 ANSWER

Self Assessment Questions

1. Mr. Adamu's approach does not seem to be systematic. A much more organised and systematic approach is required to locate where specific items have been stored.
2. The two-bin system uses the stock to indicate as to when an order should be placed.
3. A stock control system tells you (2) how much to order and (4) when to place an order.
4. Bin cards are used for recording information on stocks held and on order.

5. Inventory is used for recording the list of equipment purchased.
6. Order forms are used for placing an order. An order book is used to maintain a record of what orders have been placed and their progress and, to provide an idea of how much money is to be spent towards orders placed. Official order forms are necessary because they help to reduce fraud by ensuring that only authorised people can place order for purchases.
7. Yes, on occasion, It is not a process what you can always undertake. Having done it once with a supplier, this is likely to set the price for the time being. (Sometimes some sort of relationship with supplier is also required to bargain)
8. Petty cash is only for minor amount of purchases. So a simplified system can be used.

Terminal Questions

1. Import duty may be waived on items imported for use in education and research provided similar equipment is not manufactured in Nigeria.
2. The price may not be exact for a number of reasons such as VAT has not been included, allowances have not been made for discounts. No allowance for VAT should be made, because VAT can be reclaimed. You can, however, make adjustments for discounts.

UNIT 6 EFFICIENT COMMUNICATION

Structure

6.1 INTRODUCTION

Communication is essentially to-and-fro transfer of information between individuals, departments as well as between organisations. Therefore, it is an important aspect of the functions of any organisation. At the heart of any well-run department will be a good system of communication. In order to be effective, communication must take place at the proper time, must be accurate and must occur speedily.

In this unit we will discuss three means of communication - oral, written and by using computer. Of these, oral and written are the old and common means of communication, whereas computer is not that common but it is becoming increasingly important.

Objectives

After reading this unit you should be able to:

- list means of communication stating when each would be appropriate,
- recognize and produce suitable written communications in given circumstances,
- list some of the uses of the computer for filing and keeping records together with any drawback,
- identify different channels of communication at the workplace and recognize their use, and
- recognize your place in the work-team and be aware of the areas of responsibility.

6.2 WHAT IS COMMUNICATION?

Communication is a process of exchange of messages, facts, ideas, opinions, feelings between two or more persons. In any organization various people are linked together for common purposes. Mutual understanding and effective relationship among such people can be established by meaningful transfer of information from one person to another. Any department can be successfully run if it has a good system of communication. Communication system involves sending of information, receiving the information as well as response or reaction to the

information. Transmission of information from communicator to receiver is carried out by certain means. In the following sections we will consider some of the means of communication available to you and when and how you should use them. It is necessary than you should select the most appropriate means of communication for the benefit of the people with whom you communicate. It is also required that you should use correct level of language and terminology. This will avoid misunderstandings, mistakes and breaches of protocol. Let us now try the following SAQ.

SAQ1
Two things you should consider while communicating with others are:

_____

_____

6.3 ORAL COMMUNICATION

Oral communication between the people occurs with the use of spoken words. You should keep in mind the following points while communicating orally with your colleagues or other people.

1. Listening is as important as talking.
2. Accuracy and precision in what you say avoids confusion.
3. Be careful how you use jargons. However, science is reckoned to be an exact subject so use the correct names for apparatus, quantities etc. when discussing science.

Oral communication can occur face to face or with the help of the telephone. Face to face communication is most natural and easiest means of oral communication that occurs daily between co-workers during work. Telephone is most commonly and widely used mechanical device for oral communication.

Oral communication obviously has advantages and a disadvantage compared to written communication. While oral communication is quick, easy and personalised, it suffers from one major disadvantage. When finished, there is no record of what has actually been said. It can be important to have a written record of a conversation. For example, it you receive some goods which are broken or incomplete, you will need to notify the supplier and, in some instances, the transporter/carrier. The easiest way to do this is to use the phone and there is no reason why you should not do so, provided you follow up your phone call with a confirmatory letter (of which you should keep a copy). If you receive an oral request for some apparatus, ask for the request in writing (or write it down yourself, immediately)-then there is less chance that you will forget. No doubt you can think of many other instances from your working life where the written word is essential. Let us try the following SAQ before we proceed further.

SAQ 2

1. Can you think of two advantages that written communication can have over oral communication?
   (i)
   _____
   (ii)
   _____

2. Can you write down one advantage that oral communication can have over written communication?
   _____

6.4 WRITTEN COMMUNICATION

The communication process that involves written media, i.e. paper is called written communication. It involves distribution and delivery of papers. Two basic aspect of written communication are information received and information sent.

6.4.1 Information Received

You must always read the information you receive. After reading through the information you can decide what needs to be read in depth, what can be scanned and what can be safely thrown away. With experience you will learn how to do this. All the incoming information that are important need to be filed. In the next unit you will study about filing system. Probably the most important written communication which you will receive concerns requests for apparatus and materials.

6.4.2 Information Sent

This is the aspect of written communication where your skill of using appropriate language, precision, accuracy and thoughtful words is exercised. In the following sections we will discuss some types of written communication, but before that try the following SAQ.

SAQ3

Which of the following (from a to d) would you use in a written communication to:

1. an equipment supplier, and
2. a friend?

a) Please would you dispatch to me at the above address and at your earliest convenience a box often double-sided high-density three-and-a-half inch microfloppy data disks, as described in your equipment list of 12 February 1999.

b) Re: yours of 12[1] Feb, send another box.

c) I refer to your list dated 12-02.99. Please supply 1 box of 10 DS DD 3½" disks.

d) Regarding your list (12 Feb), can you please send me a box often 3½ floppies?

6.5 MEMORANDA

Memoranda (though some prefer "memorandums" and others refer to "memos") are commonly used for written communications within a workplace, within departments, etc. They are much like letters in general layout and content but differ in certain specific details. They all have similar headings which are illustrated in Fig. 6.1.

MEMORANDUM

To:
From: Date:
Subject:

Fig. 6.1: Memo Headings

Memos dispense with the need for giving instructions, salutations, greetings and a complimentary close. A signature is not necessary in a memo, although it may be initialled. While it is not true that memos are always brief, they are essentially an aid to quick and direct internal communications. They should therefore, be written in clear, concise English, and in continuous prose rather than in note form. It is a good idea to number or letter each topic for clarity. Try also to plan the contents of your memo so that they follow some sort of logical sequence, instead of presenting statements as they occur to you. You should not forget the usual words of courtesy and politeness, too. These belong as much in a memo as in conversation or letters.

6.6 LETTERS

There are conventions established by bodies covering the way that letters are set out and every letter has certain components in common. It might be interesting for you to see how far you are aware of these.

Let us now look at the example of a letter by a equipment firm to the chief technician in an organization.

Science Equipment Ltd.
50, Onikoko,
Abeokuta Road
Lagos.

Chemical Industries Ltd
Okpala Industrial Estate
Ilupeju
Lagos.

For the attention of the Chief Technician

Your ref. Our ref. DRS Date. 4lh April 2000

Dear Sir,

Re. Your order no. E023904

We must apologize for the delay of the above order which is due to nil stock of this item. As this situation was unforeseen at the time of your order, we now find we are unable to invoice you for March. We would be grateful if you could notify us as to whether you wish to cancel this order and re-order for April invoicing, or if you would like the order to stand.

We hope to have sufficient stock to cover your order within the next 21 days.

Yours faithfully,
D.R. Abubakar
Sales Office

SAQ4

Read the above letter carefully list the mistakes and rewrite the letter in the correct form.

6.6.1 Official and Personal Communications

We are going to draw your attention to a point of procedure concerning letter-writing. Your workplace will have a supply of headed writing paper and it may well have a policy concerning who can use it and who can sign letters written on it. Two points arise from this:

1. The quality of the letter reflects the standards of the sender and his or her place of employment. Therefore, letters on headed paper should be typed and laid out correctly. Correct spelling, grammar and punctuation are equally important.
2. A typewritten letter on headed paper represents an official communication from an establishment, and whoever signs the letter must have authority to represent the establishment.

It is unlikely that you will send out official letters in your own right. It is more likely that you could be required to draft letters which are then typed and signed by one of your superiors. Bear this in mind when reading this section, and remember the distinction between official and personal communications. For personal communications you can make your own draft and can send handwritten as well undersigned by you.

Incidentally, beware of signing letters with *p.p. (per procurationem)* in someone's absence, even if it is a letter that you have drafted. The use of *p.p.* implies a legal responsibility for the contents of the letter.

SAQ 5

In each of the following circumstances, whom would you contact? There may be more than one person/group, in which case put your answers in order, starting with your first choice.

1. A piece of apparatus is delivered broken, although the packaging had not been undone when delivered to you

_____

_____

2. A sink in the lab is blocked

_____

_____

_____

3. You require financial assistance for travelling to a study centre for a distance learning course

_____

_____

_____

6.7 REPORTS

There are two kinds of report that you may be called on to write in connection with your work. The first may concern an investigation or enquiry that you have been making, e.g., an experiment, and the second may arise because you have some information that you wish, or have been instructed, to pass on, e.g. after an accident or other mishap.

Scientific reporting is covered in unit 8. Accurate reporting of experiments allows them to be repeated as a verification. Other kinds of reports may be either informal or formal and often concern a particular set of circumstances that may need action or decisions from someone in authority, e.g. a head of department.

In this text it is impossible to work through all the cases in which you communicate with people at work but this section will have introduced the basic ground so that the underlying principles and procedures are apparent to you.

6.7.1 Informal Reports

Many of the comments that we have made about other forms of written communications apply to informal reports. They should contain only facts, presented in a succinct and logical way. Important features to include are the date, the title and the name (and status) of the person making the report. They should begin with a simple statement of the relevant facts and/or circumstances. It can be helpful to number or letter each item.

If there are circumstances in which your opinion has been requested, your opinions would then form the second half of this report. If data and/or diagrams would help the reader, they should be included. The same criteria apply to these diagrams as apply in reports of experiments.

6.7.2 Formal Reports

Formal reports are often produced as the result of an investigation or request for information required by management. A formal report can be similar in layout and content to the informal report but may contain five sections instead of two. Each section might require a heading. Examples of these headings could include:

1. *Terms of reference.* These outline: who gave the instructions for the investigation or whatever, the nature of the investigation, the extent of the enquiries and the nature of the information required. This helps you to clarify in your own mind exactly what you are meant to be considering.
2. *Proceedings, Procedure or Action Taken.* This should consist of a list of actions, with dates and times, when they took place. Actions could include examination of sites, equipment and processes and visits to other places, etc. No information is given at this stage.
3. *Findings.* In this section, all the facts are listed - as in the first section of the informal report. If more than one item or situation is being investigated, this section can be divided up by appropriate sub-headings with numbered or lettered details.
4. *Conclusion.* This section is for the writer to express his/her conclusions and/or opinions and must refer to the findings. They should express the result of logical reasoning and deduction from the facts.
5. *Recommendations.* You might not be asked to make suggestions as to what action should be taken but, if you are, there are some do's and don'ts to be considered:
    a) DO be practical. Consider the effect your recommendations could have on your colleagues if they were adopted. Be precise.
    b) DON'T suggest that further investigations should be made (unless there are good reasons why your investigations were not adequate or sufficient).
    c) DON'T let your wishes dictate your recommendations when all the facts point to a course of action that you would find unwelcome. Be anxious about making important recommendations.

Major decision are not likely to be made on the basis of your report alone!

Writing a report after collecting facts and drawing conclusions ought to be at least a two-day process. Once your report is written, keep it for twenty-four hours and then read it again. It is surprising how many alterations and/or corrections you will wish to make after you have "slept on it".

Finally, as with the informal report, the final draft of your formal report should be signed and your status added, with the date that you produced the report. Let us now try the following SAQ.

SAQ 6

1. If you witnessed an accident, what facts/circumstances concerning the accident would be appropriate for you to include in the introductory paragraph of a written accident report? (Use only as many numbers as you require).

_____

_____

_____

_____

_____

_____

2. Which of the following could you include in an informal report?
   (i) The date on which the report was written,
   (ii) The name of the author.
   (iii) The title of the report.
   (iv) The terms of reference of the report.
   (v) A statement of facts/circumstances.
   (vi) Data and/or diagrams.
   (vii) Conclusions.
   (viii) Recommendations.

Till now we have briefly reviewed different types of written communication. Now we will study another mode of communication which can be used to produce all the forms that we have mentioned above and much, much more.

6.8 THE COMPUTER

You must be aware that the computer is now a powerful tool in communications. Indeed, this unit was written and produced with the assistance of modern communications technology. The units were typed and stored on disk. You can also use a microcomputer as a word processor if you have the right programme available. As a word processor you can use a computer to generate all the written communications we've discussed in this unit.

Microcomputers are an indispensable tool in the modern working environment and you may also have access to a mini or mainframe computer. There are many software packages available for use in stock control and in keeping records of the kind we have discussed. There are packages which link stock control with accounts, and these are particularly useful if you bear financial responsibilities. Of the three basic types of propriety computer programmes available (namely word processing, database and spreadsheet), the database is the most useful for stock control.

You will also find spreadsheet programmes useful, particularly if you are involved on the accounting side. Needless to say, a printer to produce "hard copy" is essential for this kind of work so that you have a permanent record of your reports.

Some basic hints in using computers this way are:

1. Always try and enter data in the form that you want to see it printed out. For example if you type in "kbr", don't expect the computer to print out "beaker".
2. Be consistent in the way that you enter data. Using the example in (1) enter either "bkr" or enter "beaker" for all beakers. If you enter a beaker as "bkr", and then ask the computer to list all "beaker's", don't be surprised if it misses out the "bkr".
3. Item (2) is allied to the GIGO principle. This is a universal and self-explanatory principle which simply states "Garbage In - Garbage Out"!
4. Try and retain printouts (hard copy) of all your work as they invariably provide a useful reference. .
5. Ensure that you have back-up copies of all of your data and programme disks (or tapes), and that your working data disks are copied onto your back-up disks regularly.

SAQ 7

Give three uses of the computer/microcomputer in a science department.

6.9 CHANNELS OF COMMUNICATION

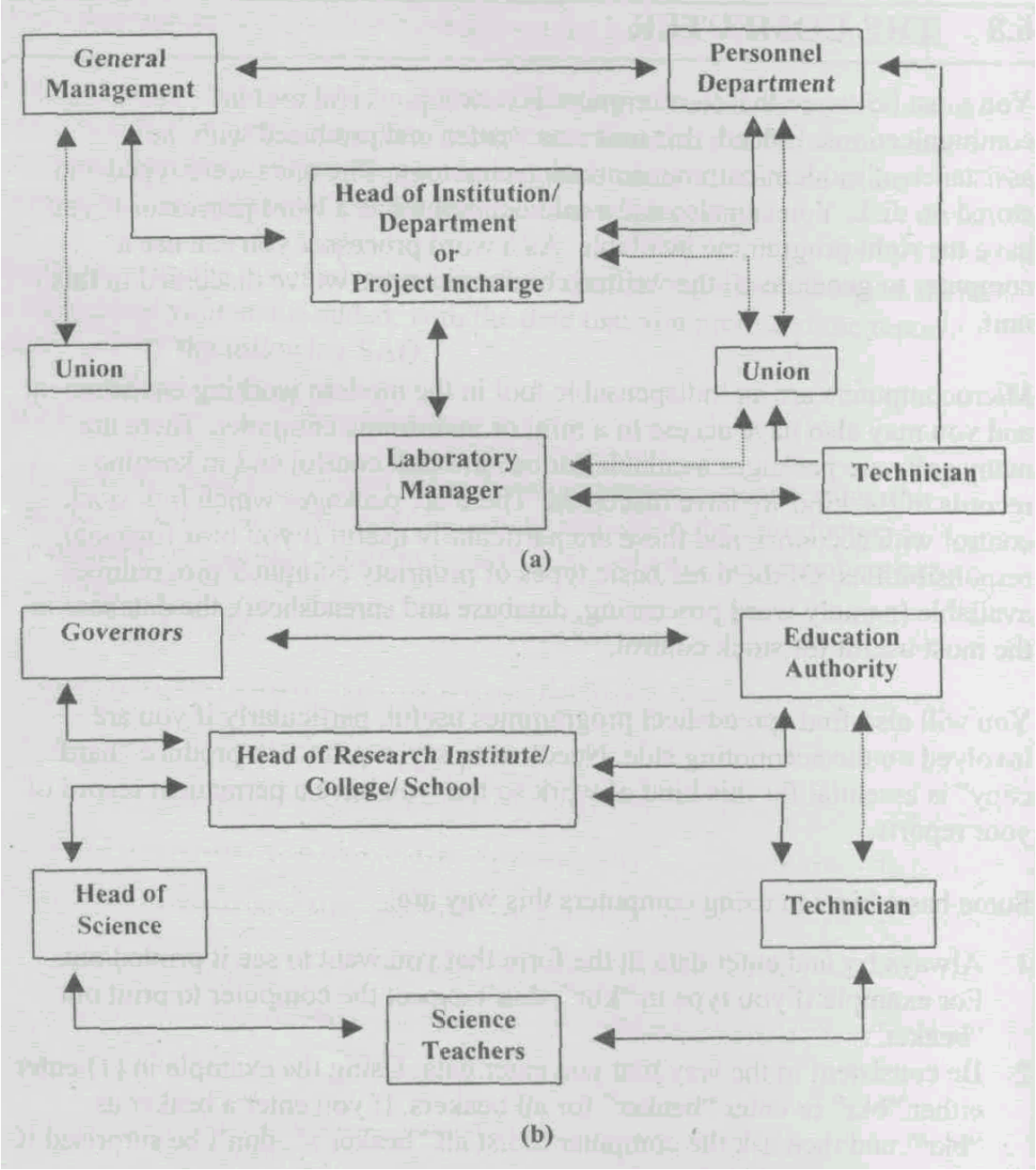

Fig. 6.2: (a) A general example, (b) Example in an education lab.

Note: _____ unrestricted path of communication.
…….... restricted path of communication.

Having discussed how to communicate with people, let us now consider the people with whom we need to communicate and the ways of communication that are most appropriate. After all, you might be an extremely effective communicator, but if you don't use the correct channels of

communication your efforts will be wasted. Worse still you could easily provoke an adverse reaction from some "links" in the chain! Fig. 6.2 illustrates two typical chains of communication. You will appreciate that there are variations possible, e.g. a lab might have trainee technicians working under supervision. In this case, there would be slightly different channels of communication.

First, consider Fig. 6.2. The main channel of communication for a lab technician is to the lab manager or, in a school for example, the head of the science department. It is likely that the responsibility for the employment of lab technician is part of this person's (Head's) duties. This means that, in theory anyway, he or she is the person who directs the technician's activities. Here, the line of communication is an unrestricted two-way channel and the formality inherent in it depends on the relationships at work. Both parts of Fig. 6.2 could be represented in general as shown in Fig. 6.3.

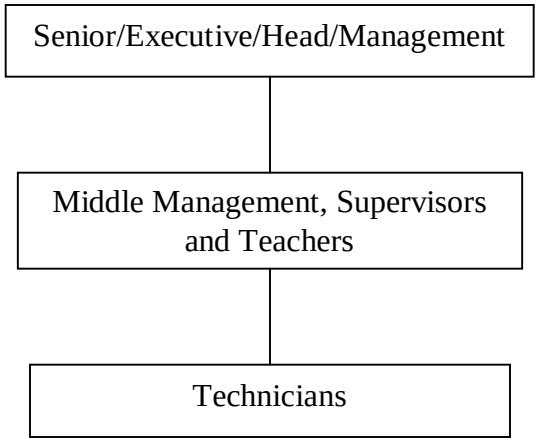

Fig. 6.3: General lines of communications

This figure shows fairly limited view of organizational structure and communications, and there are of course many other possibilities. Now try the following SAQ to test what you have learned in this section.

SAQ 8

Consider Fig. 6.2 and Fig. 6.3 together. We said that Fig. 6.3 is a general summary of the two situations illustrated in Fig. 6.2. In fact there are also two important links in the chains of communication that are missing. One link is that of the personnel/advisory office. What is the other?

_____

_____

6.10 SUMMARY

Let us now summarise what we have studied in this unit.

- Communication is a two-way process whereby transmission of messages or exchange of ideas, facts or opinions occur between the persons as well as between the systems.
- Oral, written and use of computers are the three ways by which
- communication can be carried out effectively. It is important to choose the most suitable means of communication at an appropriate occasion.

- Written communications can be personal or official. Official
- communication can be in the form of letters, memoranda etc. Reports are made to write about any event.
- In the present day computer is a powerful tool in the communications. Infact it is increasingly becoming an essential tool for communications and other purposes such as for filing and keeping records.
- Along with what to communicate and how to communicate it is also important to know whom to communicate. In any organisational set-up there is a channel through which the communication should travel.

6.11 TERMINAL QUESTIONS

1. On which of the following occasions do you think the telephone would be the most suitable sole means of communication?
   (i) Checking train times at the nearby railway station
   (ii) Ordering food for livestock
   (iii) Asking for details of a training course
   (iv) Booking a place on a training course

   _____

2. List three examples from your working life when written communications are essential.

   _____

   _____

   _____

3. Recall the three situations outlined in SAQ 5. For each, how would you contact the person/organization concerned? Include all the means that you would use, in chronological order, and mention any other person/people who might be involved with the communication process.

   _____

   _____

   _____

4. Which of the following words could be used to describe a well-presented memo? (Select as many as you wish)
   (i) Polite
   (ii) Concise
   (iii) Signed
   (iv) Brief
   (v) In note form
   (vi) Detailed

5. Below is a letter that a technician drafted to a supplier to complain about an item of defective equipment. What, if anything, is wrong with this letter? Correct the letter by rewriting it in the space given below (using your imagination to insert any missing information).

Dear Sirs

We have received a delivery from you containing 10 porcelain crucibles, 3 of which wer broken. I demand that you replace the broken ones immediately.

Yours sincerely

_____

_____

_____

6.12 ANSWERS

Self Assessment Questions

1. (i) Appropriate means of communications
   (ii) Language
2. (i) (1) You can always retain a copy.
   (2) You have the time to identify the precise words needed for any situation. In other words you have time to write exactly what you mean,
   (ii) You might be able to obtain an immediate reply or response. For example, if you request "urgent action" in a letter, you would expect some sort of action within a working day of receipt of your letter – this could mean a delay of days. However, if you requested "urgent action" in an oral communication, you could reasonably expect within minutes.
3. (a) It is verbose, and while it is correct, it is badly written and difficult to understand easily.
   (b) It is too abbreviated to be either courteous or concise.
   (c) This would be appropriate for (1) - a supplier. There is sufficient information for the supplier to identify the product; the use of the word "please" incorporates some courtesy; and the abbreviations are acceptable.
   (d) This would be appropriate for (2) as it is polite and contains sufficient information.
4. (1) Addresses - Sender's address block should be located top right not left, unless the letter is on printed note paper. It is better if the addressee's address is set below the last line of the sender's address, but set left as shown.
   (2) Date and references - These are better grouped below the sender's address.
   (3) Style - While this letter conveys its meaning, it could be structured better and expressed in a more business - like fashion. For example, the first sentence would be better put as "I apologize for the delay in fulfilling the above mentioned order. This is because this item is out of stock". Note the use of "I" and not "we" - if you sign a letter personally then you should be direct in what you say. The other sentences could be tidied up in a similar way. This letter is an example of the use of clinches i.e. shortened form of the expression, e.g. "nil stock", "unable to invoice you".
   (4) There is no indication of the title of the writer - Mr. Miss, Mrs., or Ms. Also the signature block would normally be ranged left.

Science Equipment Ltd.
50, Onikoko,
Abeokuta Road
Lagos.
4th April 2000
Our ref: DRS
Your ref:

The Chief Technician
Chemical Industries Ltd
Okpala Industrial Estate
Ilupeju
Lagos.

Dear Sir,

Re. Your order no. E023904

I apologise for the delay in fulfilling the above mentioned order. This is because this item is out of stock, but new stocks are expected within twenty-one days. Do you wish to cancel this order and re-order for April invoicing, or do you require the order to stand?

Yours faithfully,

D.R. Abubakar
Sales Office

5. (1) The supplier and, possibly, the carrier.
   (2) Caretakers, or perhaps the lab manager or Head of the Science Department. This depends on your channel of communication for reporting faults of the buildings, fittings and services at your workplace. Usually there will be a set procedure which may eventually lead to the works manager or works department.
   (3) If you are employed by an education authority you would need clearance from your head of science, (science adviser, inspector and personnel officer). If you are employed by, say, a company, you would contact your lab manager and personnel and training officers.
6. (1) 1. Date.
   2. Approximate time
   3. Place
4. Name(s) of person/people directly involved.
5. Whether there were other people in the area (as possible witnesses).
6. Brief description (one sentence) of nature of incident. The next part of the report would contain a detailed description of the incident as you saw it and what action was taken by you and other people.
   (2) (i),(ii),(iii),(v),(vi)and(vii)
7. (1) For simulations of experiments and educational use.
   (2) For keeping records of stock, etc.

(3) For keeping and printing copies of worksheets, etc.

8. The trade unions are the missing link. Just as you will be in direct communication with the personnel office, in relation to your pay and conditions of employment, so you may be in direct contact with a trade union in the form of a safety representative, local representative, or even local secretary. Both trade unions and personnel offices are available for the discussion of employment-related matters and advise managers through appropriate committees and groups, independent of the usual channels of communication.

Terminal Questions

1. (i) (iii).
2. Your list could include
   (1) Your employer[1] s statement of safety policy.
   (2) Your pay slip.
   (3) Orders for goods.
   (4) Requests for building repairs and maintenance, etc.
   (5) Requests for leave.
   (6) Accident/incident reports.
3. (1) To the supplier: telephone followed by letter. To the carrier: letter (sent immediately as there is a time limit for complaints). (These letters would be signed by the head of department or other person with sufficient authority).
   (2) To the caretaker: oral. To the head of science or lab manager: oral, and then a memo.
   (3) To the head of science or your personnel/training officer: oral and, perhaps a letter. To the Area Education Office (if applicable): a letter. (If your head of school is supportive, he/she might write on your behalf).
   4. (i), (ii)
   (v) is wrong.
   (iii), (iv) and (vi) could apply, depending on the nature and amount of information that is being given.
5. The letter lacks:
   (1) date of delivery
   (2) delivery note number
   (3) order number
   (4) catalogue number
   In addition, the second sentence is much too abrupt and "Yours sincerely" is incorrect. It would be better written as follows.

Dear Sir

On 10 January 2000, we received some goods from you (with delivery note No. Z1234) in response to our order no. A5678. Unfortunately three porcelain crucibles (cat. No. L1112) were broken.

Please would you replace these at your earliest convenience?

Yours faithfully,

V. Olowonla
Lab Manager

UNIT 7 FILES AND RECORDS

Structure

7.1 INTRODUCTION

In modern days an office acts as information centre. It is a place where information is collected, processed, stored and made available for the conduct of various activities of an organisation. In these modern times there is lot of written communication which generates large amount of papers. Thus the filing, its system and methods become highly important. Filing constitutes the core of record keeping. It serves as important aid to office persons because we cannot rely on memory alone. In order to run the laboratory work we all need to refer some person or to a variety

of publications and papers. The problem is where to go and find the proper papers. The correct and efficient filing is answer to the above raised questions. In this unit you will study about various filing systems, their function, types of records, filing procedure, way of cataloguing and record maintenance.

These records become handy in case of emergency. If you are keeping the records of instruments, chemicals, glassware, instructions given from time to time, etc. you will be able to do work and monitor it in a better way. These records can be kept in files, record books and computer files. In this unit you are going to study various filing system, types of records and how the records are kept.

Objectives

After studying this unit you will be able to:

- understand the importance of filing and filing systems,
- describe suitable system for filing science stock and paperwork using some examples,
- describe ways of cataloguing,
- state what records should be kept and what information should be recorded (including abnormal incidents), and
- maintain a record of breakages and report them periodically to the persons concerned.

7.2 SOURCE OF INFORMATION

In the last few years there has been a vast growth in the development of information system and the generation of information. Along with this development comes the real problem of finding out relevant information quickly and easily. This problem can be solved by proper filing system and record keeping.

In general there are three principal sources of scientific information:

1. Original papers published in learned journals (primary sources).
2. Compilation of data on specific subjects (secondary sources)
3. Text books (tertiary sources)

7.2.1 Classifying Secondary and Tertiary Information Sources

Secondary and tertiary sources are usually in the form of books or recorded material which are commonly stored in libraries. In an attempt to overcome the problem of locating information, libraries have adopted a standard method of arranging publications so that information can be readily found. An example of a standard system is the Dewey Decimal Classification System. This consists of assigning an arbitrary number to broad areas of human knowledge. These large areas are then subdivided again and again so that the more subdivisions there are, the more precise is the definition of the subject.

In the Dewey Decimal System, the number 5 is ascribed to scientific subjects. The system is then progressively sub-divided as shown in Fig. 7.1.

Books in libraries, therefore, are arranged in a numerical order. However, the great disadvantage is that the Dewey Classification number is assigned by a librarian who may be guided by the title rather than the content and thus assign an inappropriate number. If this happens it can be very difficult to find a particular book.

The Dewey Decimal System could be applied to some types of equipment classification. For example, a large collection of microscopes could be effectively indexed using the Dewey Decimal System.

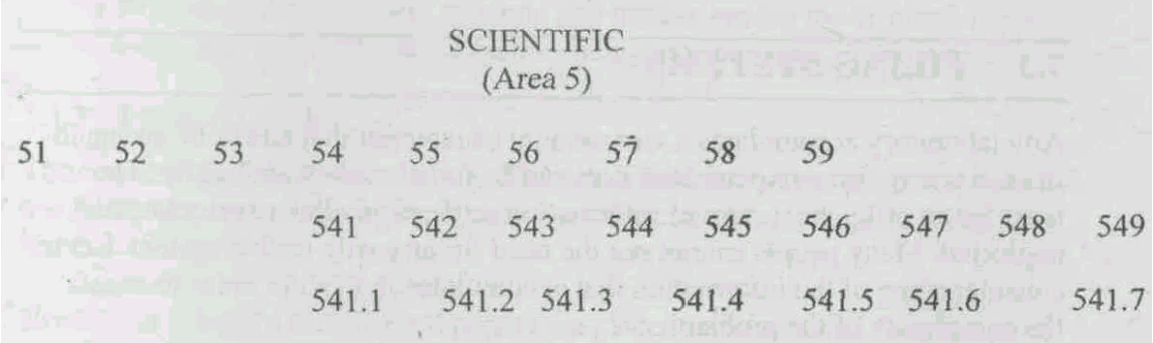

Fig. 7.1: Dewey Decimal System for Science

7.2.2 Sources of Information in the Lab or Prep. Room

Every lab ought to contain two or three reference books of information for everyday use, such as:

- Essentials of plant techniques, scientific publishing, Enugu, Nigeria.

There are other sources of information which are valuable and might not be found in the library such as trade catalogues, e.g., the Catalogue from various manufacturer and exporters, technical specifications, articles from periodicals of interest to technicians such as *Laboratory News* or *Laboratory Digest*, and so on. Again some method of cataloguing and accessing these must be devised.

The following is atypical list of sources of information:
(1) Reference books
(2) Catalogues
(3) Card indexes
(4) Computer databases
(5) Personal experience

As you can see, information sources are widespread and various, and to locate precisely the material you require can be a formidable task without expert advice. To simplify matters, most sources of information have a reference/index system, which enable large quantities of information to be examined quite quickly. The aim of constructing such an indexing system is to enable relevant information to be stored and accessed quickly.

Essentially, the manager of each lab must decide on the sources of information that are required and then stock and store these, if these are appropriate. (Some reference books are expensive and it may make economic sense to use local library for these).

7.3 FILING SYSTEMS

Any laboratory accumulates a vast amount of material that has to be arranged in such a way that any particular item can be found readily and easily. The need for an efficient system of information retrieval is often overlooked and neglected. Many people cannot see the need for an

easily usable system. Let us consider some of the information that accumulates in a lab in order to assess the complexity of the problem.

> File: Information located forever. Not more than 200 pages should be accommodated in one file. Always use tag for filing papers. Always number your file papers.

(1) Correspondence and related materials
(2) Literature references
(3) Indexes for slide and film libraries, samples, general stock, etc.
(4) Manufacturers' catalogues and specifications

None of this information can be ignored if it is required in a lab's work. At some stage someone will need to gain access to the material quickly and easily. The test is 'is it relevant to the lab's work?' If it is, it is worth keeping. If not it can be thrown away. Filing is often a job to be delegated to the most junior member of staff because it is considered to be too boring a work.

7.3.1 Aims of Filing System

A filing system aims to keep information in its proper place so that it can be easily retrieved when needed. Bearing this in mind, it might be useful to outline what makes for a good filing system:

(a) It should be clear and easily understood.
(b) It should be accessible.
(c) It should be adaptable and easily updated.

All of these are made easier by some kind of indexing of each group of items by some kind of "key" e.g. alphabetical or numerical ordering, or colour coding.

7.3.2 Classification of Files

You can classify the files in different ways. Some important ways are given below:

(i) **Alphabetical classification:** This is the simplest method of classification in which files are arranged strictly in alphabetical orders.
(ii) **Numerical classification:** Under this method you can give supplier or subject a number and all the papers are placed in one folder bearing distinctive number as allotted. The folders are arranged in cabinet in the numerical sequence and guide cards are used to divide them into suitable groups of 10 or 20. The numerical filing may be combined with alphabetical system e.g. A-l, A-2, A-3 and so on and files are kept in this order. It is called 'Alpha-numerical filing' which is more flexible than the alphabetical or numerical filing.
(iii) **Chronological classification:** In this method the papers are filed date wise in a sequence as and when correspondence has taken place. It is suitable for filing correspondence.
(iv) **Subject wise classification:** Under this method, records are classified according to subject matters of papers. For example there may be one folder for the main subject Botany (general), Chemistry, Physics, Electronics, Zoology, and separate sub folders having lower plant, higher plants, physical chemistry, organic chemistry, inorganic chemistry etc.

7.3.3 Filing methods

The conventional methods of filing (like metal holders, bound or guard books, box filing) are not of much use. Nowadays there are: (1) Horizontal filing (2) Vertical filing.

Horizontal filing: In this method papers are placed in folders and folders are kept in horizontal position. Folders or files are kept one upon the other and the papers are inserted in the order of date on which received or despatched. Naturally, the latest papers are found at the top. An index prepared allotting number to the files.

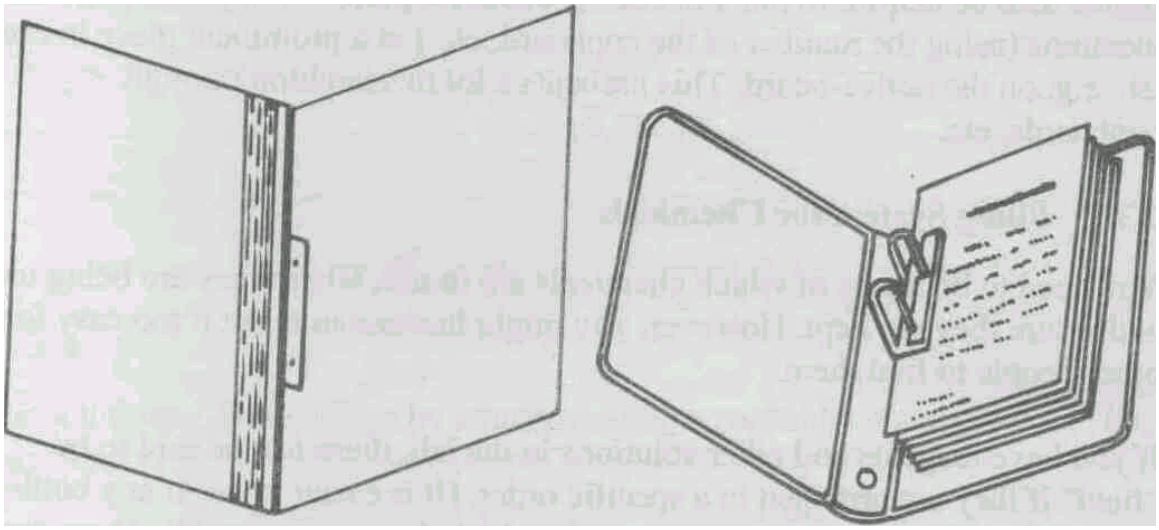

Fig. 7.2: (a) Flat tile, (b) Arch lever file

Vertical filing: Under this method all the papers, folders and files are kept in a vertical or standing upright positions. We will show you some equipment required in vertical filing by figure only.

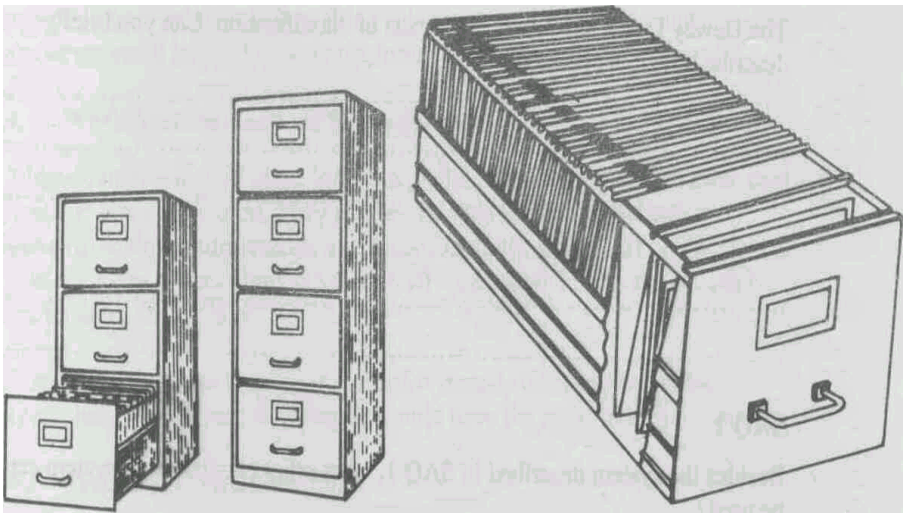

Fig. 7.3: (a) Vertical filing cabinets, (b) Cabinet with drawer and folders

7.3.4 Filing System for Equipment

You may have thought that our description of the storage of apparatus and equipment as a filing system was inappropriate. Yet this is not entirely farfetched. For example, retrieval of specific items is aided by the clear numbering and labelling of cupboards, drawers, shelves, etc. Plastic embossing tape can be used but if vandalism is a problem, white, plastic drafting or artists' tape (which can be written on with spirit-based felt-tip pen) is very useful. Using a stencil to paint the name of the contents of the cupboard, etc. on the door can create problems if you decide to move things round!

If you find that glassware and other small pieces of apparatus tend to "wander" from lab to lab, you can "colour-code" each lab's contents using a spot of paint of the appropriate colour on each item in a lab (selecting a site where the paint will not be burnt off during heating).

It may also be helpful to put a list of the common pieces of apparatus and their locations (using the number of the cupboard, etc.) in a prominent place in each lab, e.g. on the notice-board. This prevents a lot of searching through cupboards, etc.

7.3.5 Filing System for Chemicals

You need to be aware of which chemicals are in use, where they are being used and where they are kept. However, you might hesitate to make it too easy for other people to find them.

If you have reagents and other solutions in the lab, these can be said to be "filed" if they are arranged in a specific order. (It is easier to see if any bottles are missing if you have a set sequence in which they are arranged). There are several ways in which solutions can be arranged, e.g. alphabetical order, sets for particular experiments (such as staining slides or food tests), in order of oxidizing power (for bench acids), in order of strength (for bench alkalis), etc. If you use plastic embossing tape for "permanent" labels, you have the opportunity to incorporate a system of colour-coding.

SAQ 1

The Dewey Decimal System is a means of classification. Can you briefly describe how it is operated?

_____

_____

_____

_____

SAQ 2

Besides the system described in SAQ 1, what other classification system can be used?

_____

_____

_____

_____

SAQ 3
What sources of information do you think should be held in the lab/prep, room?

_____

_____

_____

_____

SAQ 4
Can you think of three ways by which locating a particular chemical could be made easier?
1.
2.
3.

7.4 FILING PRINTED AND WRITTEN MATERIAL

It is important not to let printed and written material accumulate, otherwise filing becomes a monumental task. There are a variety of headings under which paperwork can be filed and a variety of places in which it can be filed. Boxes, folders, varieties of files, filing cabinets, card index boxes and computers can all be used to store the information recorded.

7.4.1 Worksheet/Instructions for Experiments

A filing cabinet is a good place for these. Failing that, a cardboard storage case or suitable box can be used. They can be arranged in a variety of ways depending on the circumstances, e.g. according to the group/s of people that would use them or according to topic. In all cases, an indexing system can be used, together with a "key".

Incidentally, if you are keeping ink or spirit stencils that have been used to prepare these worksheets, the stencils should have the same indexing systems.

7.4.2 Technical Communications

These are notes, diagrams, etc. that are produced to provide theoretical scientific information. A filing cabinet is the best place to keep them, but of course, the originator concerned may wish to keep them. Once again, if an indexing system is used for these hand-outs, the same system should be applied to any stencils prepared.

7.4.3 Instructions for use of Apparatus

One or more box-files or lever-arch files are suitable for these [see Fig. 7.2 (b)]. If you have more than one set of instructions for a particular piece of apparatus you must decide whether to file them all in the same file, create a back-up file with the spares or throw them away.

Alphabetical order is as good a way to file them as any other. You could file them according to manufacturer/supplier wise and then in alphabetical order. It is a good idea to keep guarantees and service or maintenance agreements with the instructions, although you could create special files for these. There is also a case to be made out for keeping guarantees with the instructions. The alternative is to create a special file for guarantees. The same can be said for service/maintenance agreements. Either file them with the instructions for use of the apparatus to which they refer or create a file specially for service/maintenance agreements.

7.4.4 Correspondence

The widespread use of the telephone seems to have reduced the volume of correspondence that is generated. But for now, there will still be some level correspondence. If the volume of this is small, a lever-arch file is suitable: file incoming letters in the front, and copies of outgoing letters in the back. Incoming letters can be numbered whilst outgoing letters can be filed by alphabetical order of the addressee and put in date order. It might be useful to keep a brief summary of each letter at the front of the file; an example is shown in Fig. 7.4.

No.	*Date*	*Sender*	*Subject*
1	11.11.99	Ashaye John	Quotation for electronic balance
2	14.11.99	Job & Company	Will send replacement prism
3	21.11.99	Haruna-Chigbo	4 mm spade adapters discontinued

Fig. 7.4: Index for File of Incoming Correspondence.

These letters are also kept in date wise order and with the most recant one having the highest number.

7.4.5 Orders

If you are involved in ordering materials or equipment for your lab, you will require a file to house copies of orders that have been sent and possibly delivery notes on which you have written the date of the goods arrived. You may also keep accounts.

Even if, you don't keep copies of the actual orders, you might choose to keep copies of the requests for apparatus, materials, etc. that you have made.

7.4.6 Requests for Equipment

Your main function is to provide equipment for experiment and investigations. The first stage in this process is for someone to ask you for certain items. It is not enough to have an oral request; to avoid confusion, a written requisition is vital, and it should be made available to you some time in advance. It is also possible that the same requests will be made year after year or by different people. It can save your effort, therefore, if you keep the written requests together with the list of equipment and materials that you supplied. You should also have a file containing requests that you have not yet fulfilled.

SAQ 5

Imagine that you are working in a school laboratory, and a biology teacher hands you a scrap of paper with the following written on it. "A dissection tray and animal for demonstration". You assume that this is a request for practical work but what further information would you need before you could provide the necessary apparatus and materials? (List the items of information below).

1.
2.
3.
4.
5.
6.

7.

7.5 SPECIAL FILES

As a lab technician some very important files are kept in labs under your direct supervision. We are going to describe such files in this section.

7.5.1 Safety File

Now we will describe what a safety file should contain.

Every now and again hazard warnings are issued. They originate from manufacturers/ suppliers, from your employer, from the scientific press and from union safety offices in case of factories, these should be filed in the Safety File. You might choose to include copies of memos reporting hazards and your subsequent actions, as well as any communications from safety representatives and management concerning safety. You can also keep the statement of health and safety policy of your employer if available in a safety file.

Any regulations concerning the use of a Lab's Safety instructions for the treatment of spillage, basic first aid and other information that is "safety" related should also be included in the safety file. If you have a Safety Check List, this, together with the records of such checks made from time to time, should also be kept in the Safety File.

With all this information, this file constitutes a useful package for new members of staff to read. In some establishments, new staff are required to sign a document confirming that they have read the Safety File.

7.5.2 Technician's File

Technician file is for you to keep any information that might be of use to you or your successor in the future. The form that it takes is a matter of personal preference. You could use any of the systems we have mentioned.

The file may include the following information:

1. *Names and addresses:* suppliers, sources of information, useful contacts, etc.
2. *Recipes:* for all the solutions, stains etc. that you have to prepare.
3. *Sources of specific items and materials,* e.g. fertile hens' eggs, hearts, insects, mouse, various chemicals, various instruments, glassware etc.

Technician's file must include asset's register, which include all the received chemicals, equipment, glassware etc. from time to time. In case of audit, you will be able to locate any particular item and place it for audit. This register or stock book should be passed to your successor in future.

No doubt you can think of many more things as file entries - especially if you are new to the job! In this case, there must be several things that you wish you could ask someone about. The technician's file would solve this problem.

SAQ 6

You have decided that, as there are now 25 slide sets and filmstrips (some with a taped commentary) in the biology section, the time has come to catalogue them.

1. What sort of indexing system would you use?
2. What information would you record for the catalogue? (Write you answers below.)

1.

2.

SAQ 7
From the list given below which items do you think should be placed in the Safety File?

(1) The employer's Statement of Health and Safety Policy.
(2) Lab Safety Regulations.
(3) Instructions for use of apparatus.
(4) Procedure when the fire alarm sounds.
(5) Employer's advice about hazards.
(6) List of chemicals in stock.
(7) Names and addresses of suppliers.
(8) Accident report forms.

(1), (2), (3), (4), (5), (6), (7), (8) - delete as appropriate.

SAQ 8
Give two reasons why it can be helpful to keep the previous year's requests for equipment, materials, etc. from your colleagues. (Write your answers below.)
(1) _____

(2) _____

7.6 RECORDS

Records means "any written matter or document prepared for possible future uses". It may be in the form of a letter, notice, circular, invoice, voucher, picture, chart, report, registers, books of accounts etc.

A record provides a summary of information. For example, if you want to know how many beakers you have in stock, you have at least two ways of obtaining this information. You can count the beakers in each lab and store or you can consult the stock record, (the accuracy that is required and when you last took stock will be relevant here).

If your lab had the misfortune to catch fire or suffer a major disaster, how could an accurate claim be presented to the insurance company? How can the number of accidents/near misses and incidences of bad practice, etc. be assessed and monitored? How can Excise department monitor the use of alcohol? How can you make sure that you know where specific pieces of equipment, etc. are? The answer to all these questions is not by relying on your memory, but is that you need to keep records. These can be kept on record cards, in record books, or on computer files.

Principles of record keeping

(i) Safety
(ii) Period
(iii) Economy
(iv) Flexibility
(v) Classification
(vi) Justification
(vii) Verification
(viii) Accessibility

(ix) Simplicity

7.7 STOCK RECORDS

As far as record-keeping is concerned, recording stock levels is likely to be most time-consuming. There are three kinds of record that are required. First is acquisition register where all purchases are entered. The second is stock register which reflect purchase, issue and active stock and the third one is laboratory indent register. The stock registers are maintained in stores. **One of the most important things to remember when you make a stock register is to count the pages and sign it.** Here we have an example of stock level records of biology lab. If you are following numerical classification then you may have register no. 1 for chemicals, Register No. 2 for glassware, Register No. 3 for apparatus, Register No. 4 for biological material, Register No. 5 alcohol etc. Now each year you can have a fresh register but again in the next year you will have Register No. 1 for chemicals and so on.

Whichever system you use, you should keep a list detailing stock kept in each lab, preparation room etc; from this you can draw up a "master" stock list of overall stock levels. Stock arriving or departing should be noted on both lists.

A separate register may be maintained for stock of rectified spirit, alcohol, lab animal, radio active material, poisons etc.

The time of year when you take stock will vary with your workplace. However, it is likely that the official inventory will need to be made up at the end of each financial year, e.g. 31st March.

The departmental stock records are probably best made up during a holiday or slack period. It is easier if two persons can take stock - one to count and one to record. Either file cards or a stock-book can be used to record stock levels in each lab/prep room/ storage area. File cards have the advantage that they are easier to keep in alphabetical order.

STOCK BOOK

ARTICLE _____

Month and Date		Particulars	Receipt			Issued Quantity	Balance Stock	Remarks
			Quantity	Rate	Amount			

Fig. 7.5: Illustrate stock-book entries

7.8 LOCATION

This is essential piece of information for anyone trying to find a particular piece of apparatus, etc. We mentioned that cupboards, drawers, etc. should be numbered and labelled with their contents. The location specified for each piece of apparatus should be unique.

A plan of the lab showing the siting of numbered cupboards together with a list of the contents of each numbered site pinned on the notice-board or stuck on a wall in the preparation room will provide a useful reference.

Location of people is also important. To this end, you need to know who is using and in which lab during the day and where each member of the department would normally expect to be working. You should know and, if necessary, have evidence to show where the people are working at any time in science department. To facilitate this, you need to know who has borrowed what and where he is using it.

7.9 RECORDING LOANS

All loans of stock, both apparatus and books, should be recorded in writing, no matter what time-scale is involved. In the case of apparatus and equipment, you need to know the name of the person concerned, what he/she is borrowing (and possibly why), where he/she is going to use it and when you can expect it to be returned. Items that feature in the official inventory should not be removed from the premises unless written permission has been given. In this situation, you could record this written permission with the loan details. "Borrowing" stock is not the same as using stock that you provide for experimental work.

In an educational establishment, it is necessary to record loans of textbooks to students. This is made easier if sets of books are numbered so that individual books can be identified. If an exercise book is ruled appropriately, it makes a useful loan record.

7.10 RECORDING STOCK USED AND MISUSED

On an hourly basis you should know what is being used, by whom and where it is being used. You will know this from the requests that have been made by other staff. There are three specific instances where you need to record the use of some materials in a little more detail:

1. Use of listed poisons;
2. Use of radioactive sources; and
3. Use of alcohol.

7.10.1 Record of Use of Listed Poisons

This should apply, to the substances that are locked in the poison cupboard, taking care that the same top and liner are in place. Your record should state the date, the substance withdrawn, the person responsible, for what it is required, the mass of substance used and your initials to denote that it was returned to the poisons cupboard. The mass of substance used is most easily determined by weighing the bottle when it is issued and again when it is returned. A book is most

useful for recording these "before use" and "after use" masses and a specimen entry is shown in Table 7.1.

Table 7.1: Specimen entry in a Poisons Book

Date	*Name of User/ Supervisor*	*Group*	*Substance*	*Mass on Issue*	*Mass on Return*	*Used*
5.11.99	Mr. Jalingo	A1	Barium carbonate	541.8 g	536.1 g	5.7 g
8.11.99	Mr. Ram	(C22)	Barium nitrate	235.5 g	215.5 g	20.0 g

7.10.2 Record of use of Alcohol (Industrial methylated spirit absolute and ethanol)

As far as record-keeping is concerned, there are two aspects involved. First, you should keep a copy of the letter which is sent to the supplier of methylated spirits when you wish to buy alcohol. Secondly, it is considered to be good practice to keep a record of all the alcohol that is issued and new stocks that are received. A book is useful for this and specimen entries are shown in Table 7.2 which indicates stock positions of methylated spirit.

Table 7.2: Specimen entries in stock book for methylated spirit

Date	*Volume Issued*	*Area of Work*	*Cumulative Addition*	*Stock Remaining*	*New Stock*
4.11.99	100ml	R&D	100ml	2.4 litre	
5.11.99	250ml	Microbiology	350 ml	2. 15 litre	
8.11.99	50ml	Workshop	400ml	2. 10 litre	
8.11.99					2.5 litre
11.11.99	100ml	Quality Assurance	500ml	4.5 litre	

7.10.3 Record of Breakages

Misuse of stock is generally concerned with breakages and these usually involve glassware although all types of stock can be included. A book is useful for recording breakages and each lab should have its own "Breakage Book". The entry should include the date, name of person responsible, article broken and member of staff in charge. Whether or not you include a column for the cost of the article (for you to fill in afterwards) is a matter of policy.

There are one or two more details about equipment that we need to mention but which have not fitted in with our classification so far.

7.11 INFORMATION ABOUT EQUIPMENT

Equipment, in this context, is being taken to mean items that need a power supply of some kind and which are likely to be enclosed by a metal or hard plastic case.

7.11.1 Serial Numbers

Most of the expensive pieces of equipment have a serial number engraved on the name plate that tells you the operating voltage and current used/power consumption. It is important that the serial number should be recorded so that the equipment can be identified when stock is checked, insured specifically and identified by the supplier/manufacturer in the event of a fault or complaint. If you keep a card index file of stock, the cards make an ideal place to record the relevant serial numbers. If you record stock location and serial number on a record card, you will have cards similar to the one illustrated in Fig. 7.6 or you can keep a separate record for this purpose.

Details of Item	*Inventory Kef.*
e.g. Make, Reg./Cat. No. Serial No. Location details	

Front

Date	No. in stock

Reverse

Fig. 7.6: Specimen Record Card

7.11.2 Maintenance Record

Your workplace may have a service contract covering such things as balances. This means that they should be checked (and repaired, if necessary) by a visiting engineer. If you don't have a service contract or if it is not possible to have one, you may choose to maintain some pieces of apparatus and equipment yourself, e.g. microscopes. It may also be necessary to send a piece of equipment back to the supplier for repair. In all these cases, you should keep a record.

7.11.3 Electrical Checks

Each piece of equipment that uses mains electricity should have its plug, cable, and fuse checked at least once a year, and you must keep a record of the checks that you make. Once again, a card index system can be useful. Each piece should have its own card. If you have several similar items with no serial numbers you must allocate each with a means of identification so that you can distinguish between them. A simple record card is shown in Fig. 7.7.

ITEM: Balance No: 2
MAKE: Torbal MODEL: PL400
SERIAL NO: 502186 POWER RATING: 400 W

Fuse		Plug	Earth	Date
Rating	Comment	Comment	Comment	
2A	OK	OK	Good	21.7.99

Fig. 7.7: Record Card Showing Details of Electrical Check.

7.12 MISCELLANEOUS

We are now left with three types of record that we cannot classify by any stretch of the imagination. The only way is to present them "as they come"!

7.12.1 Accident/Incident Record

All accidents, however minor, should be reported through appropriate channels. Most workplaces have an accident reporting procedure based on written reports which comply with statutory requirements and recommendations. However, it might also be appropriate to keep a record in your department. Certainly, a record of "incidents" should be kept. In both cases a book can be used. These provide a more permanent record than a loose-leaf file from which pages can easily be removed and mislaid.

7.12.2 Orders and Accounts

This is a topic that we mentioned in section 7.4.5. As far as a record is concerned, this will only apply if you handle orders. If you file orders, it can save time to have a list at the beginning of the file, showing date, order number, supplier and expected cost. In order to keep track of the expenditure, you will need to record the prices paid for goods, etc. If you handle petty cash, you will also, naturally, need to keep a record of income and expenditure.

7.12.3 Key to Unknown

In Chemistry, it is often the practice in educational establishments to give students unknown substances (unknown by them, that is!) to analyse. If you keep such a set of substances for use each year, it is important that you keep a record of the identity of each substance! It is also important that you keep this record in a safe place and that you remember where you put it.

Well, we have covered a number of records in this section and we acknowledge that it is quite possible that you might keep a record that we have not considered. Before we leave records, however, there are just a few general points to be made. Where to keep your records deserves some thought.

For records to be of any use in an emergency, they need to survive. Therefore, you should try to keep them in a relatively safe place.

For information useful for the day-to-day work in the labs, don't neglect the notice-board as a useful place to keep records. Records such as timetables, lists of batches of students, student number, etc. can well be displayed on a notice-board in the preparation room.

Finally, you should give some thought to the security of your records. If you handle any confidential information, this must be kept under lock and key, within the preparation room. This makes a lockable filing cabinet almost essential (although lockable desk drawers can be used).

SAQ 9

Would it be a good idea to keep your chemical stock records in the chemical store? (Explain your answer in one or two sentences.)

_____

_____

_____

SAQ10
Give three examples when up-to-date records could be useful. (Write your answer below.)

_____

_____

_____

_____

_____

_____

SAQ 11
List all the information that might need to be recorded about (Write your answer below).
(1) Top-pan balances,
(2) A video tape, and
(3) Chemicals.

(1) _____

_____

(2) _____

_____

(3) _____

_____

SAQ 12
Name three materials whose withdrawal from stock should be recorded. (Write your answer below)
(1) _____

_____

(2) _____

_____

(3) _____

_____

SAQ 13
Suggest how a record of breakages could be set out. (Write your answer below)

_____

_____

_____

_____

_____

SAQ 14

Give two reasons why it can be useful to keep a record of "incidents" and/or "near-misses". (Write your answer below)

(1) _____

_____

(2) _____

_____

7.13 SUMMARY

A filing system is necessary for smooth running of any office, school and laboratory. All the information about experiment, chemical, stock books and correspondence should be clear, accessible, adaptable and easily understood in a good filing system. There are various systems of filing for science stock, paperwork and for practical. The catalogue filing can be done in different ways. The record of information about abnormal incidents is also to be kept for being reported to proper authority. Another important aspect is the recording of listed poisons and alcohol used. Record keeping is an important aspect of laboratory safety.

7.14 TERMINAL QUESTIONS

1. In the space below, write a list of items found in your lab that require filing. (Use only as many lines as you find necessary).

1)
2)
3)
4)
5)
6)
7)

2. Write a list of records that need to be kept in your lab. Describe each group of records from the point of view of the information that the record gives rather than listing specific details. An example of this would be "stock levels". (Use only as many lines as you find necessary).

1)
2)
3)
4)
5)
6)

7)
8)

3. Imagine that you have just taken a job as a sole technician in a science lab. You find that there is no technician's file. Write a list of headings that you would use in preparing such a file and give a few details about the contents under each heading.

4. Describe, in your own words (not exceeding 200), why you think that filing and record-keeping systems are necessary.

5. Write down in the space provided brief definitions for the following terms. Channels of Communication

Inventory

Requisitions

Stock Level

7.15 ANSWERS

Self Assessment Questions

1. The Dewey Decimal System involves assigning arbitrary numbers to broad areas of knowledge. These large areas are then subdivided again and again so that the more subdivisions there are, the more precise is the definition of the subject. See para 1.1.2.
2. Alphabetic. This system is used where only a simple system is required, e.g. filing of catalogues.
3. Every lab ought to contain two or three reference books of information for everyday use. Trade catalogues and articles of interest to technicians from periodicals should also be held in the lab.
4. You may have given any of the following three ways, all of which help in locating chemicals:
   (1) Labels on shelves;
   (2) A chart; and
   (3) A plan on the door of the store room.
5. (1) Date
   (2) Time and duration of class
   (3) Room/lab
   (4) Class set/demonstration
   (5) Which method of preparation
   (6) Which animals
   (7) Any other chemical, e.g. chloroform
6. (1) You have a choice. If they fall into definite categories, e.g. botany, histology, etc., you could give each category a prefix letter and then use numbers (this means that some would have the same numbers but different letters) or you could just use consecutive numbers. You should not use letters only since would run out of letters quite soon in future!
   (2) Title and whether or not there was a taped commentary. If you include the number of slides in the set or frames in the filmstrip, this could give some indication of the time they would take to be shown.
7. All could go in the Safety File except (3) and (7).
8. (1) So that you can get back to see what you provided when a similar request came in the previous year.
   (2) So that you can demonstrate the amount of work that you did in a given period of time!
9. No, for three reasons.
   (1) In order to refer to them, you would have to go to the store.
   (2) The atmosphere inside the store will not facilitate preservations of records.
   (3) In the event of a fire or explosion in the store, the records would be lost.
10. Choose from the following:
   (1) after a fire,
   (2) after a theft,
   (3) when reordering, or
   (4) when tracing down a specific item.
11. (1) Make and model
   Date of purchase
   Serial number
   Service/repair history
   (2) Title

Running time
Type of cassette, e.g. VHS.

(3) Name Grade
Catalogue number
Date of receipt/transfer (from store to use)
Hazard/s
Stock level

12. (1) Radioactive sources
(2) Industrial Methylated spirits/Ethanol
(3) Poisons

13. One possible way would be as shown in below – using an exercise book for each lab;

Date	*Name of the person responsible for breakage*	*Group*	*Article broken*	*Cost*	*Initials of Supervisor*

14. (1) To identify a commonly-occurring type of incident, e.g. a chemical reaction which often behaves unpredictably.
(2) To identify a faulty technique, experiment or procedure.

Terminal Questions

1. The headings that we came up with are:
(1) Equipment {including apparatus and glassware).
(2) Chemicals (including radioactive sources).
(3) Books.
(4) Audio-visual aids.
(5) Printed and written material.
(6) Safety notes.
(7) Technician's file

2. Your list could include:
Stock levels of apparatus and chemicals Locations of apparatus and chemicals Book loans - text and reference
Equipment on loan
Service/maintenance information
Accidents/incidents
Electrical checks
Apparatus and materials requested by colleagues
Experiments performed
Alcohol used
Radioactive sources - stock and use
Use of poisons
Orders placed and expenditure

3. If you don't find the technician file then you should go through the previous correspondence file and would be able to make a list of following
1. Supplier - names and their addresses.
2. Useful contacts - name and their addresses
3. Any useful information

4. All the recipes of stains and solution that you have to make.
5. Sources of specific items
6. Sources of materials
7. Record of files - you will like to see what is on file records.

4. See summary 7.13.

_____

_____

_____

5. Channels of Communication
Formal lines or chains of communication throughout the organization.

Inventory Stock levels.
Requisitions

Written documentation of stock items in your charge, which is provided by the user, giving details of what is being used, by whom and where.

Stock Levels
A continuously updated record of all items for which you are responsible in your working environment.

UNIT 8 SCIENTIFIC REPORTING

Structure

8.l INTRODUCTION

Experimental investigation is one of the corner stones of scientific study – which is why many educational establishments have science labs. However, an experiment alone is quite useless without accompanying written reports for explanation, verification and hypothesis. For instance, what use would it be conducting an experiment in which you measured the time taken for a 100 g apple to fall 3.2 m from the top of a tree to the ground once? Even if you did write up this experiment in detail, it is unlikely that your conclusions would cause any excitement. But if your experiment was repeated many times for different masses of apples and different heights of trees; and your report included details of method, errors and observations; and the data was appropriately presented; your experiment would begin to have some scientific value. This unit will show that there are many concepts to be understood, apart from communication, when reporting experimental results. Accuracy, honesty and clarity of presentation are all important in determining the validity of a scientific experiment. We will be considering the implications of all these aspects in this unit.

Objectives

After studying this unit you should be able to:

- state the importance of accurate, and consistent reporting of experimental results;
- record all your experimental observations and figures precisely in a permanent note book;
- comment on the importance of reporting the experimental results obtained, without any preconceived bias;
- explain the need for repeated results;
- describe the importance of the range of results and standard deviation;
- choose the appropriate forms for presentation of experimental results; and
- use an appropriate writing style for effective scientific reporting.

8.2 WRITING UP AN EXPERIMENT

Any scientific investigation remains incomplete and often inconclusive without experimental component. Experiments make scientific knowledge testable and repeatable by other scientists. It is therefore essential that all experiments be described fully, clearly and correctly, and their details be available in some form of record for use whenever required.

8.2.1 Keeping a Notebook

Firstly, we need to consider the accuracy of recording results. It is here that keeping an accurate practical notebook is of vital importance. It will prevent loss of valuable information if all your observations are recorded *immediately* into a practical notebook, and are not left until later or jotted down on bits and pieces of paper. You may also need to use your notebook at a later date say when you want to refer to an actual experiment, or for revision purposes. Here are some guidelines for keeping of such a notebook:

(i) A bound notebook is preferable to a loose leaved one.
(ii) We suggest labelling the front of the notebook very carefully so that if lost it returns to you!
(iii) You may also find it useful to leave the first few pages blank so that you can prepare a list of contents on these pages at a later date.
(iv) In this connection, we suggest that you number all your pages.
(v) Use ink rather than pencil, as pencil written material smudges fast and often becomes illegible after a few days.
(vi) It is a good idea to use a fresh page to begin each experiment, giving it a title and recording the date.
(vii) The experiment should be written up under standard headings such as Date, Title, Introduction, Apparatus and Materials, Methods, Results, Calculations, Conclusions, and References.

All the observations should be recorded *directly* into the notebook. You should also record all partial and intermediate results so that any calculations can be double-checked.

The notes that you record should allow for the experiment to be repeated *exactly* by any other scientist - repeatability is an important test of scientific validity.

Final presentation of results is discussed in Section 8.3. Now you may try the following SAQ.

SAQ 1

Why do you think it is important to record experimental results immediately into your notebook? (Write your answer below).

_____

_____

_____

The importance of honesty when recording your observations need not be Scientific stressed too highly. It is important to be honest even when the results do not seem to produce a clear pattern, or when an observation appears to contradict what you already know. We will touch on this point again in Section 8.3. Apart from inadvertent human error, there are many other sources of error which can creep in as you record your observations. Let's look at some of these.

8.2.2 Error

Some sources of error are connected with the use of instruments, and can be summarized as:

(i) *Instrumental error,* arising from the accuracy of the measuring instrument itself.

(ii) *Observational* or *reading error,* arising from the precision with which that instrument may be read.
(iii) *Setting* or *adjustment error,* arising from the accuracy to which it is possible to set the instrument. It is also partly dependent on the skill and experience of the operator.

When writing up an experiment one usually estimates the maximum expected error. Sometimes worst-case errors are known from specifications on a piece of measuring equipment; sometimes the errors have to estimated as they cannot be known absolutely, e.g., misreading a dial where the pointer lies between two marks on a scale. In this last case, percentage error cannot be known absolutely.

Percentage error can be obtained as:

$$\frac{\text{Estimated error}}{\text{Actual measurement}} \times 100$$

8.2.3 Recording of Figures

Accuracy can also be affected by the way you record figures. This should be done as precisely as possible. Figures recorded should show all the *certain* digits, and add also *the final estimated* or *uncertain* digit. For example, suppose a voltmeter has a guaranteed specification of ± 1%. A measurement is taken and the voltmeter reading is 125.11 V. From the known accuracy (+ 1%) it is therefore obvious that the actual voltage lies between 125.11 + 1% = 126.3611 and 125.11 - 1% = 123.87128 volts. It can be seen that the only *certain* digits are the 100 and the 20. We know it is one hundred and twenty something! The 5 is the final estimated or uncertain digit, and all the others are meaningless, given the accuracy of the instrumentation.

As a rule of thumb guide the following might be useful:

- If your estimated error is between 50% and 5%, record 2 significant digits.
- If your estimated error is between 4.09% and 0.5%, record 3 significant digits.
- If your estimated error is between 0.49% and 0.05%, record 4 significant digits.

Another point that you should keep in mind is, for scientific reporting large numbers should be shown by index notation.

e.g., 4,230,000 as 4.23×10^6.

Now try the following SAQ.

SAQ 2

Imagine that you are conducting an experiment in which ionising radiation is being measured from various sources with a Geiger counter. Would you:

(i) Record only the meter reading?
(ii) Record the meter reading and the background count?
(iii) Record only the net reading?

From (i) (ii) (iii) – delete as appropriate, and explain in the space provided below.

_____

_____

_____

_____

_____

_____

_____

_____

_____

8.3 RESULTS

Results – the total outcome of a scientific investigation, either validate a hypothesis as a testable knowledge, or reject it altogether, or bring out any deficiencies/shortcomings in a hypothesis. It is therefore a crucial component in the generation of knowledge.

8.3.1 Recording Results

We have already mentioned the importance *of honesty* in scientific reporting. It is a temptation to leave out or disregard unexpected results because they do not fit in with ideas which you already hold. Unexpected results may be the outcome of faults in instruments, procedure, etc. but it isn't safe to assume this. It could be that by ignoring such results an important new discovery is overlooked. Another point worth noting, of course, is that once someone is known to have falsified results, his or her professional standing is compromised.

Now try the following SAQ before you proceed further.

SAQ 3

Figure 8.1 is an illustration of the apparatus used in an experiment to establish the relationship between the frequency of a tuning fork and the length (L) of a resonance tube. The apparatus includes a water-filled resonance tube, a measuring scale, and three tuning forks of 256 Hz, 419 Hz and 512 Hz frequencies. When conducting this experiment in the usual way, you set a tuning fork vibrating and adjust the water level in the resonance tube until the tube makes a "booming" sound, indicating that the tube had attained a resonant length. The resonant lengths of the three tuning forks were recorded as follows:

Tuning Fork Frequency (Hz)	**Resonant Length (L) cm**
512	50.3
419	20.2
256	32.75

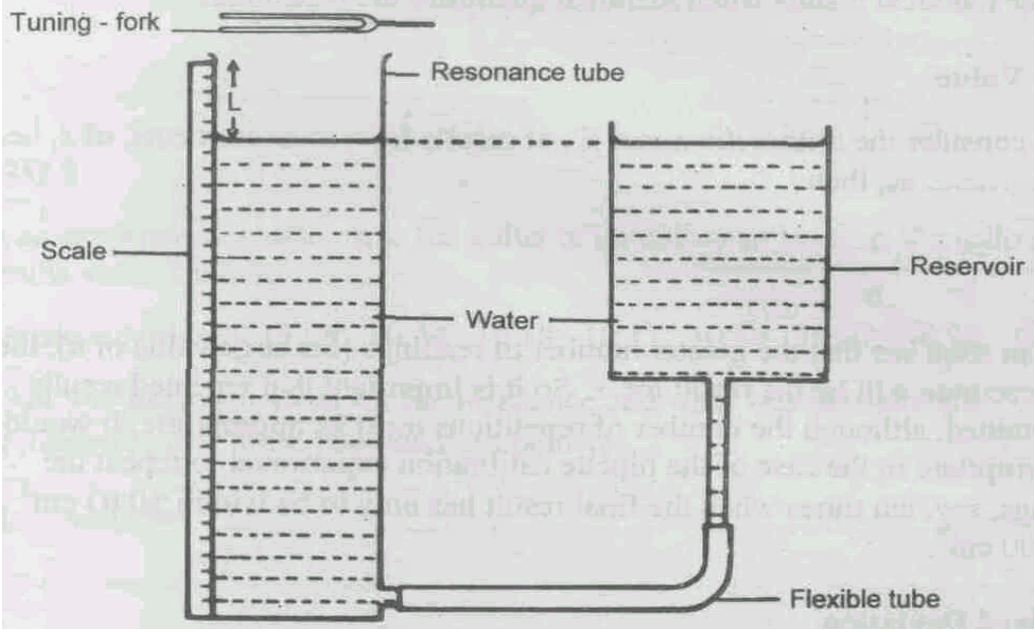

Fig.8.1: An experiment to establish the relationship between frequency of a tuning fork and the length of a resonance tube

Now you as the experimenter know that:

$$\text{Resonant length of tube } (L) = \frac{\lambda}{4}$$

(where λ, is the wavelength of the tuning fork's sound waves.) You also know that it is possible to achieve resonance when:

$$L = \frac{3\lambda}{4}$$

The inconsistency of your three readings shows you that your first resonant length was achieved at:

$\frac{3\lambda}{4}$, and not at $\frac{\lambda}{4}$ as you had intended.

The following three courses of action are open to you: which one will you take and why?

(i) Work out what X is from your measurements of $\frac{3\lambda}{4}$

(ii) Delete the result for 512 Hz from your records.

(iii) Note the suspected cause of the faulty result and obtain another result for 512 Hz.

From (i) (ii) (iii) select as appropriate. Check your answer with those given at the end of the unit.

8.3.2 Repeated Results

If investigations yield identical results in identical conditions, then the results may be accepted as valid. To put it in other words, the validity of results involves obtaining repeated readings of an

experimental procedure. The number of readings taken also affects the accuracy of the results, as you will see a little later. Remember that the requirement for repeated results demands that your measuring technique is repeatable too, i.e., your technique would produce identical results when identical quantities are measured.

Mean Value

If you consider the arithmetic mean, $\bar{x}$, of results for n measurements, of x, i.e., x_1, x_2, …, x_n, then:

$$\bar{x} = \frac{x_1 + x_2 + ... + x_n}{n}$$

You can soon see that the greater number of readings (for large value of n), the more accurate will be the result for x. So it is important that repeated results are obtained, although the number of repetitions must be appropriate. It would be appropriate in the case of the pipette calibration experiment to repeat the readings, say, ten times when the final result has only to be within ±0.03 cm^3 of 25.00 cm^3.

Standard Deviation

Standard deviation *(SD)* is the average amount by which results deviate from the mean value. *SD* simply gives an indication of how much the data is spread.

Arithmetically, *SD*, σ_{n-1}, is found as follows:

$$SD = \sqrt{\frac{(x_1 - \bar{x})^2 + (x_2 - \bar{x}) + ... + (x_n - \bar{x})^2}{n-1}}$$

Where $\bar{x}$ = mean value
and n = total number of results of x.

Most scientific calculators now-a-days have an *SD* function built in. s_n is the symbol used for the *SD* of large number of results, i.e., hundreds or more. s_{n-1} is used for a few results – and this is the one you should use.

Now try the following SAQs.

SAQ 4

An experiment to determine Young's Modulus (coefficient of elasticity) for a steel spring involved hanging the spring from a fixed hook, adding weights in 50 g amounts to a carrier on the spring, and measuring the length of the spring for each weight to a maximum of 300 g. One technician took his zero reading, added 50 g weights to the spring and recorded the length of the spring at 50 g intervals. When he reached 300 g, he removed the weights and began to analyse his results. A second technician recorded the length of the spring as he increased the weight by 50 g increments to 300 g. Then he unloaded the weights 50 g at a time and again recorded the length of the spring at each interval.

Whose method was scientific and most rigorous? Why? (Write your answer below.)

SAQ 5
In an experiment to determine the value of an unknown resistor, the following results were obtained:

Resistance (ohms): 10.05, 10.24, 10.18, 10.11, 10.19, 10.07, 10.20, 10.19.

What was the mean value for the resistance and what was the standard deviation (σ_{n-1})? (Write your answers below.)

Mean value = _____

_____

_____

Standard deviation = _____

_____

_____

Check your answers from Section 8.7 before continuing.

8.3.3 Range of Results

In an experiment to determine the freezing point of octadecanoic (stearic) acid by cooling, some of the acid was melted in a small test-tube and a 100°C thermometer was placed in the test-tube. The thermometer was packed in the test-tube with cotton wool and the test-tube was mounted in a flask, thus preventing cooling. The experimental set up is illustrated in Fig. 8.2.

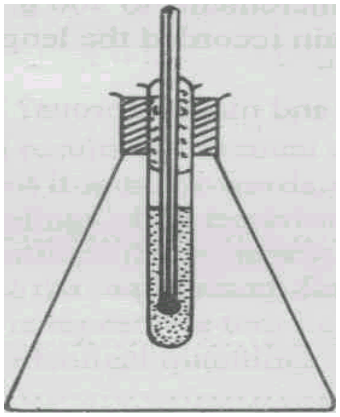

Fig. 8.2: An experimental set up for determining the freezing point of octadeconic acid

The temperature was noted every 30 seconds and a graph plotted of temperature against time. The graph is illustrated in Fig. 8.3.

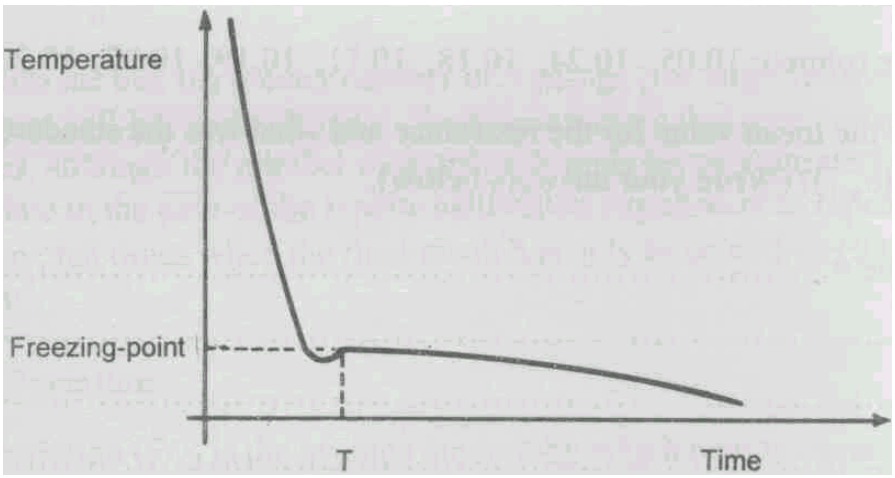

Fig.8.3: A temperature/time graph with a 30 seconds gap between readings

Looking at the graph, you can see that if the temperature was recorded every 30 seconds only up to time *T*, it would be impossible to establish where the freezing point of octadecanoic acid was. Similarly, if the temperature was only recorded after time *T*, you could not be certain exactly where the freezing point was. Thus time must be recorded for a wide range of values in order to be able to determine the freezing point accurately. However, appropriate time intervals must also be used. Consider what would happen if you recorded the temperature every 5 minutes instead of every 30 seconds. You would probably end up with a graph like the one shown in Fig. 8.4. Not only would you have trouble judging where the freezing point was from this graph, you would entirely miss the unexpected shape of the curve in Fig. 8.3 just before time *T*.

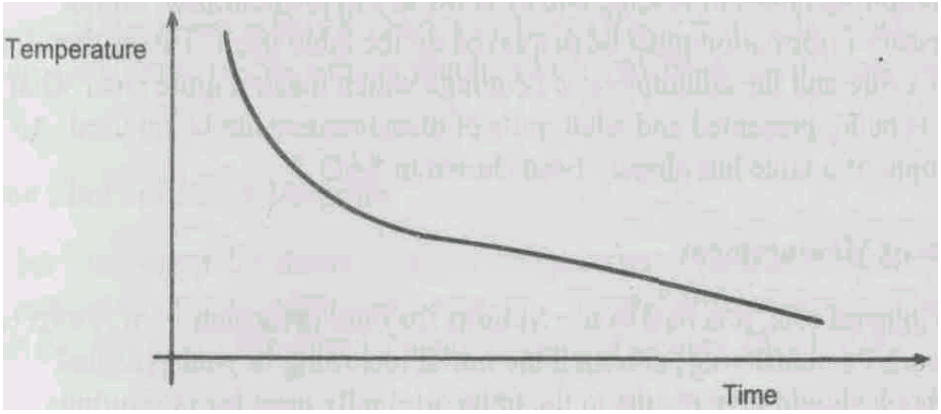

Fig. 8.4: A temperature/time graph using a 5-minute gap between successive readings

Conversely, it would be impracticable to record the temperature every 10 seconds, and it would certainly be pointless beyond time *T*. However, it might be beneficial to obtain more results before time *T* by more frequent measurement in order to obtain a more accurate plot of the cooling and supercooling curve.

You will see that a similar argument applies to the range of the temperature results. There would be little point heating the acid to, say 250°C, because this will not help you in your study of the freezing point of octadecanoic acid (70°C); and in any case the 100°C thermometer would not be

of much use at this high temperature. Similarly there is also no point in making elaborate arrangements to cool the acid to –30°C.

It is important, then, that you ensure that the range of results recorded in an experiment ensures that results are:

1. *Accurate:* within the practical limits of experimentation and instrumentation.
2. *Useful:* covering the areas fundamental to the final analysis of the experiment.
3. *Complete:* not so inadequate in one part of an experiment as to prevent you making more than a partial analysis of results.

Consideration of these points is essential at the planning stage of an experiment. The range of results dictates, to a large extent, the apparatus you would use in an experiment. In our example, for instance, you would not use a thermocouple for measuring the temperature, and you would ensure that whatever timepiece was used indicated seconds and minutes.

8.3.4 Presentation of Results

Presentation of results of an experiment is an essential feature both for analysis and any conclusions drawn from that experiment. Results are mostly recorded in tabular form whenever some measurements are made and presentation of results into, say, reciprocals or logs is invariably presented in tabular form. A useful analysis of results can rarely be made from an unprocessed table of raw results. You have to consider what the aim of an experiment is. For instance, are you trying to establish a certain kind of relationship between two variables, or you want to show the relative magnitude of certain quantities?

You will generally find that most of your results will need to be summarized first of all in a table, although a diagram or graph may be more appropriate for your final presentation.

Use of Tables

In compiling tables of results, *clarity is the key to presentation;* alt the necessary information must be displayed on the table itself. Tables therefore need a title and the columns need headings which make it quite clear what data is being presented and what units of measurement are being used. An example of a table has already been shown in SAQ 3.

Units of Measurement

As a general rule, it is best to use SI units *for final* presentation of results {e.g. pressure/Pa, density/kg) although the initial recording in your practical notebook should give results in the units originally used for measuring. Conversions, etc. can thus be double checked later.

8.3.5 Use of Graphs

You may find it more appropriate to use graphs to present your results. You may refer to Box 8.1, that tells about the procedure for plotting a graph. Graphs are particularly useful in showing the *relationship between* quantities rather than the actual quantities themselves. As an example, refer back to Fig. 8.3 which shows the relationship between temperature and time in the experiment to determine the freezing point of octadecanoic acid. This is a *linear* or straight line graph.

Box 8.1: Procedure for Plotting a Simple Graph

In case you have any difficulty with elementary graphs and graph plotting, we have included some information to help you, although this material does not require learning for this unit.

When plotting graphs, use a sharp, fine pencil - grade HB or H. Do not use ink or felt-tipped pens on your graph, and ensure that you place your graph paper on a hard flat surface.

Imagine that you have a table of figures connecting two variables and you want to express them as a graph. Follow this procedure as an easy guide.

1. Count the squares on the graph paper along the two adjacent sides. Note the two ranges of values of the variables to be plotted. The range is obtained from the maximum minus the minimum values.
2. Fit two ranges to the numbers of squares by choosing a scale for each variable, i.e., work out how much of each variable there will be to each square. This should be as simple a value as possible, e.g., 0.1, 100 or some round number. Your scale should be such that you use up more than half the graph side.
3. Draw two lines (the axes) at right angles on the graph paper lines, near the sides. If possible, your lines should be ten small squares in from both sides and, for preassurance, include the values zero for each axis. The "co-ordinates" of this point are 0,0 - *the first* value is the *horizontal* value, preferably the measurement you alter.
4. Every point in the rectangle of the graph represents a possible pair of values (or set of co-ordinates). You have to mark the points representing each pair of values -horizontally from 0,0 for the measurement that was altered and then vertically up to the measurement that resulted. Use either dots, or crosses, or circles to mark the point.
5. Draw the best single line you can through the points. If you think or know it should be a straight line but can't see where to draw it, try this:
   (a) Using a transparent straight edge, *draw faintly* the most and least steep lines which seem satisfactory.
   (b) Then bisect the angle between the lines.
   (c) Draw this line in as your final line or curve.
6. The slope of the line can then be measured.
7. Label the axes of the graph and write your name and the date on the graph paper.

Other Types of Graph

The information given in Box 8.1 above relates to *linear* graphs: however, there are other types of diagrams or graphs which may be useful in presenting results:

1. Bar Chart or Block Diagram

A bar chart generally shows the relationship between various *quantities,* and is particularly useful when *comparing* data. Several different kinds of data can be shown on a bar chart by using shading or colours. (See Fig. 8.5)

Balance of payment of a firm over a ten-month period

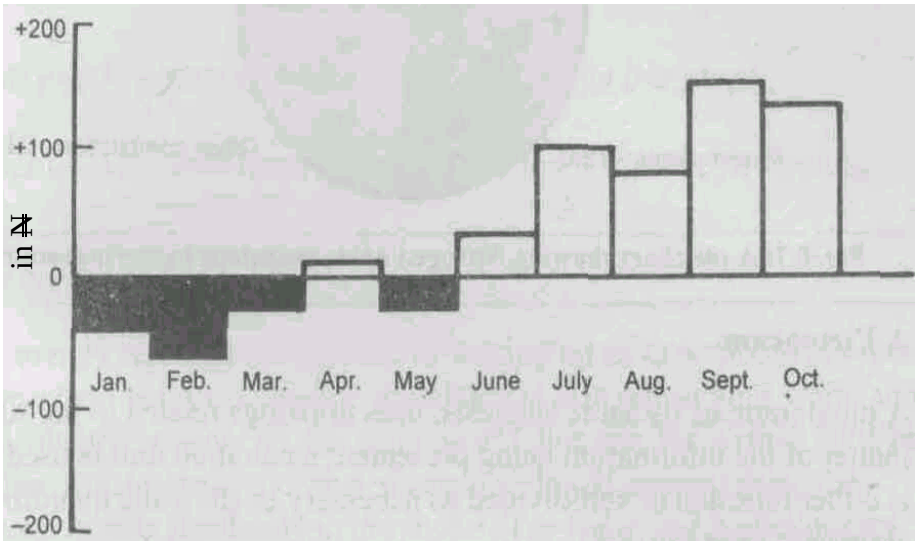

Fig. 8.5: A bar chart

2. A Histogram

A histogram looks rather like a bar chart, but shows the frequency distribution of a single variable rather than comparing different kinds of information (see Fig. 8.6).

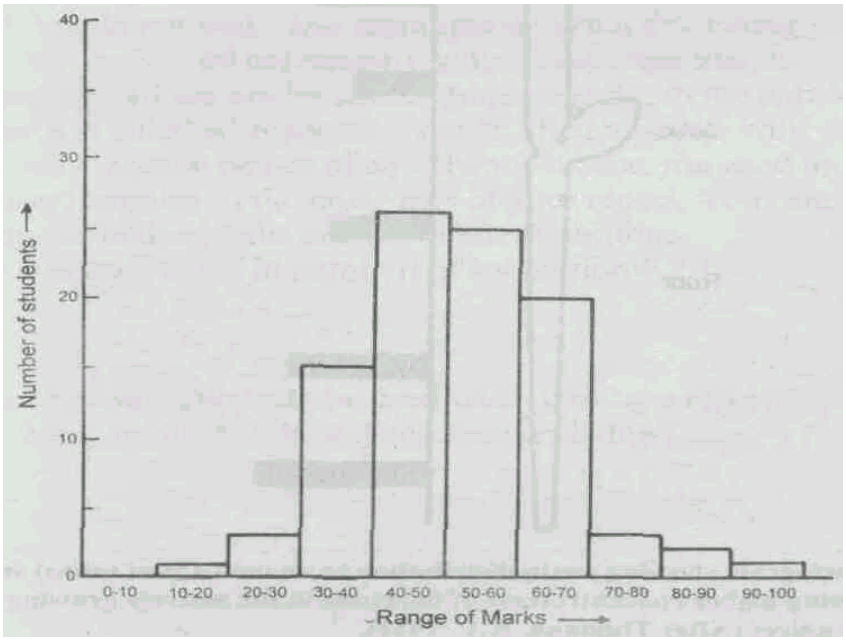

Fig. 8.6: A Histogram

3. A Pie Chart

A pie chart shows how a total is broken down into sub-units; for example, percentages may be shown as "slices of cake". Each "slice" represents a proportion of the total (100%). As a guide to compiling such a chart, each 1% is represented by 3.6° of the circle (see Fig. 8.7).

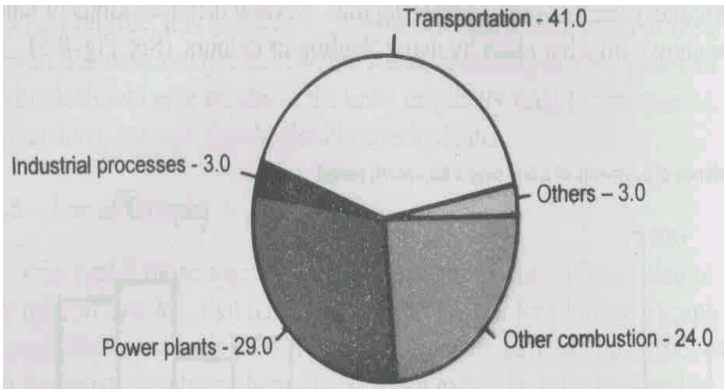

Fig. 8.7: A pie chart showing Nitrogen oxide emissions by various sources

4. A Pictogram

A pictogram, as its name suggests, uses drawings related to the subject matter of the information being presented; a common unit is used and this is either repeated or sub-divided as necessary to show the quantities being compared (See Fig. 8.8).

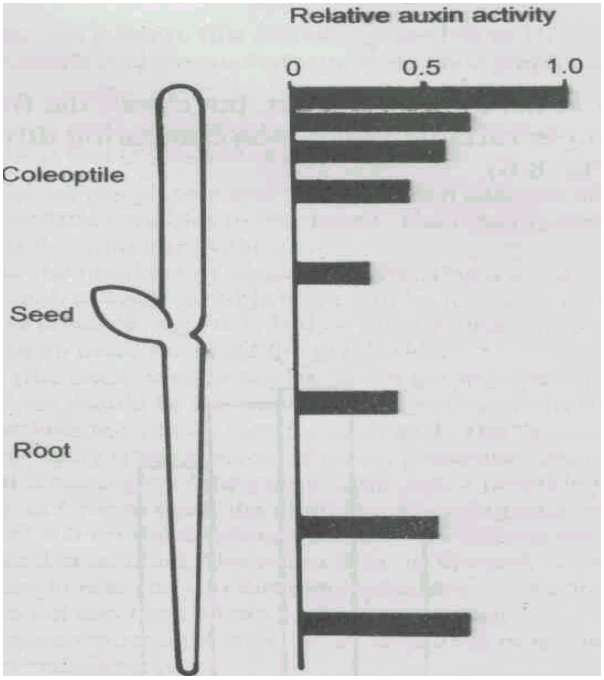

Fig. 8.8: A pictogram showing auxin distribution in an oat *(Avena sativa)* seedling, showing higher concentrations of hormone in the actively growing coleoptile and root apices (After Thimann, K.V. 1934).

SAQ 6

Complete the following sentences using the appropriate words from the list provided below.

(i) A ..... is used when results are recorded in an experiment.

(ii) A ..... is used when examining the relationship between quantities.

(iii) To show that two variables are directly proportional to one another (linear relationship), experimental results are used to draw a .....

(iv) A ..... is used to illustrate increases or decreases in the magnitude of results.
(v) A ..... is used to show how a total is broken down into sub-units.

histogram; graph, piechart; bar chart; table; straight line graph.

Check your answers with those written in Section 8.7 before continuing.

8.4 WRITTEN STYLE

We have already said that the purpose of writing up an experiment or other piece of practical work is to enable somebody else to repeat your work, and hopefully, obtain the same results that you did. For this, the written style has an important role to play. The written account should communicate the experimental details flawlessly to the reader. The following guidelines on written style should help you to communicate clearly, your practical work to others:

(i) You can assume, unless you have any reason or instructions to do otherwise, that the person reading your report is familiar with basic techniques used in practical work.
(ii) You should describe, in detail, any unusual or more advanced procedures. You can assume that your reader has the same scientific knowledge as yourself, but do not make any assumptions when describing your actions -after all, the reader did not actually witness the experiment.
(iii) The report should always be written impersonally, in the past tense, e.g., "a beaker was filled with water" – not "I filled a beaker with water".
(iv) Always write out the names of any chemicals that you used in full.
(v) Do not use formulae in the prose part of your report. You can, however, use formulae in the results and calculations sections.
(vi) Use the headings listed in point vii of subsection 8.2.1.

SAQ 7

There are nine headings that can be used when writing a report of an experiment. What are they? (Write your answers below).

(i) _____

(ii) _____

(iii) _____

(iv) _____

(v) _____

(vi) _____

(vii) _____

(viii) _____

(ix) _____

SAQ 8

Which of the following would you use to draw a diagram or a graph?

(i) A felt pen
(ii) An HB pencil

(iii) A fountain pen and black ink

From (i) (ii) (iii) - choose the appropriate one.

8.5 SUMMARY

In this unit the essentials of scientific reporting with particular reference to writing up experimental work have been dealt with. In this context the following aspects have been elaborated in the unit:

- importance of keeping a note book;
- necessity of accurate documentation of observations;
- meaning and significance of scientific validity of results;
- basic statistical techniques;
- different ways of presenting results; and
- the appropriate writing style.

We hope that after studying this unit you will now be of the opinion that a clear, accurate and honest scientific reporting is vital to the study of science and scientific experiment. For this it is essential that first the experiment be planned well before selecting or assembling the apparatus. It is also important that prior thought be given to the kind of results desired and their intended use.

8.6 TERMINAL QUESTIONS

1. A manufacturer of a new continuous flow liquid analyser published a glossy advertising leaflet about the instrument's performance. One of the statements in the leaflet said:

   "_____ and the measurement system has excellent repeatability".

   Given that you understand repeatability in scientific terms means "capacity for measurements to be repeated in the same way", state briefly why the manufacturer thinks that excellent repeatability would be a good selling point for an analytical instrument? Your answer should be based on the material contained in this unit and your knowledge of scientific methodology.

   _____

   _____

   _____

   _____

   _____

   _____

2. Write down in the space provided, brief definitions for the following terms.
   (i) Estimated Error

   _____

(ii) Mean Value

(iii) Repeatability

(iv) Significant Figures

(vi) Standard Deviation

(vii) Validity

3. Perform an experiment and write a brief report of this experiment. In your write-up, you should:
   (i) Explain the aim of the experiment;
   (ii) Describe your method;
   (iii) Record all experimental observations;
   (iv) Choose the most appropriate form to present experimental results. For instance, tabular, graphical, pictorial or in some other form;
   (v) Discuss your results with your peers or the counsellor and write your conclusions.
4. Comment on the utility of making a notebook for jotting down the details of an experiment.
5. What aspects should be ensured while recording a range of results of an experiment?

8.7 ANSWERS

Self Assessment Questions

1. Your answer should make it clear that you are aware that important information may get lost unless your observations are carefully recorded at the time the experiment is conducted.
2. i, iii; Hint: You must consider all significant raw data, such as background count, distances, type of instrument used, units, etc. There are no short cuts to this.
3. To say it in a lighter way - 'Results cook' would choose (i) as the answer. If you opted for (ii) you have ignored the paramount importance of recording ALL the results of the experiment. Remember, one mustn't just record the results one expects.

4. The second technician's. His/her final results will be the mean of the two readings and will be more accurate than the first technician's result. In this particular experiment, it would be important to check that the initial and final zero readings were the same.

5. Mean value $= \frac{1}{8}(10.05 + 10.24 + 10.18 + 10.11 + 10.19 + 10.07 + 10.20 + 10.19)$

$= \frac{1}{8} \times 81.23$

$= 10.15\,\Omega$

$$\text{SD} = \sqrt{\frac{1}{8-1}}[(10.05-10.15)^2 + (10.24-10.15)^2 + (10.18-10.15)^2 + (10.11-10.15)^2 + (10.19-10.15)^2 + (10.07-10.15)^2 + (10.20-10.15)^2 + (10.19-10.15)^2]$$

$= 0.068$

6. (i) table
   (ii) graph
   (iii) straight-line graph
   (iv) bar chart
   (v) pie chart
7. (i) Date
   (ii) Title
   (iii) Introduction
   (iv) Apparatus and materials required
   (v) Method
   (vi) Results
   (vii) Calculations
   (viii) Conclusions
   (ix) References
8. (ii) An HB pencil

Terminal Questions

1. You may refer to Section 8.3, and particularly subsection 8.3.2.
2. (i) The maximum degree of error expected in an experiment estimated as a%.
   (ii) The mean (a kind of average) taken from repeated readings.
   (iii) Refers to the degree to which an experiment can be repeated exactly to give the same results by different researchers, i.e., it is a test of scientific validity.
   (iv) Only significant or meaningful figures are meant to be recorded. This depends on the accuracy of the instruments used for measuring. One should record all the *certain digits* plus the final *uncertain* digit.
   (v) Also abbreviated as SD. It is the average amount by which results differ from the mean value.
   (vi) If an experiment is to be scientifically valid, all relevant details must be documented so that other researchers may be able to repeat the experiment exactly.
3. Write an experiment of your choice. In case you need some clarification you should discuss with your counsellor.
4. See Subsection 8.2.1.
5. Refer to Subsection 8.3.3.
   Hint: Ensure the following three aspects: (i) accuracy, (ii) usefulness, and (iii) the complete range.

UNIT 9 THE USE OF COMPUTERS IN LABORATORY ORGANISATION AND MANAGEMENT

Structure

9.1 INTRODUCTION

In the earlier units of this block you learnt the importance of proper filing and record keeping. You are also aware that in laboratory organisation and management, work related to filing, records and stocks is generally maintained manually/typed on paper. In this unit, you will become familiar with the use of computers as a tool for laboratory organisation and management.

Most of you must have seen a personal computer, PC as it is popularly called. Some of you may already be familiar with its use. Often schools and colleges that have science education have computers for the student's use and in the office for administrative use. You would realise that computers are becoming a necessity in all spheres of life and there will hardly be any laboratory, office or institution of the future that will not use the computer at some level for manipulating and organising information. Therefore, it would be in your interest to learn its use in laboratory organisation and management

In this unit you will become familiar with the basic components of a personal computer, the terminology used in computerised systems and the various possibilities of their uses in laboratory organisation and management. For instance, computing systems can handle large amounts of information with far greater facility than humans can. Time consuming activities like filing, record keeping, stock controls and their link with accounts can be adapted and managed better with computerised systems.

Objectives

When you have completed all the work in this unit you should be able to:

- List the basic components of a personal computer system,
- describe the use of computers in laboratory organisation and management,
- state the advantages of using a computer system in laboratory organisation and management.

COMPONENTS OF A COMPUTER

We use a computing system basically to feed in some data that is processed by the computer and some information is generated as a result.. For this we need **input devices,** to feed in some data into a **central processing unit (CPU)** and the results of the processing are displayed through **output devices..** Let us first describe the parts of a personal computer very briefly for those of you who have not had a chance to work with a computer before. The input devices, the CPU, and the output devices that you see in Figure 9.1 form the **hardware.** These are the physical parts that you can see and feel. The instructions given to the computer to perform a task are known as a programme, A set of programmes is known as the software of the computing system. Software is usually prepared in advance and stored on magnetic disc and compact disc. These are then loaded into the computer when somebody is ready to use it.

Computers can be large enough to fill up a whole room. These are known as the mainframe computers, forming powerful systems used by large businesses and government departments etc. You will mostly have to deal with smaller computers the micro computers or personal computers (PCs) that can fit on a table or desk and accomplish all the tasks that a mainframe does.

Let us first talk about the hardware of computing systems.

9.2.1 The Central Processing Unit

Central Processing Unit (CPU) is the brain of the computer. The intricate electronic circuitry of the CPU performs the computer's tasks of handling data. It is composed of:

(i) The Arithmetic Logic Unit or ALU, which computes mathematical functions, like addition, subtraction, multiplication and division

(ii) The control unit which carries out the computations and coordinates the movement of data and executes the instruction given to the computer.

The CPU receives programs and data through input devices, processes it and gives out the result through output devices.

9.2.2 Memory

Computers store information internally as well as externally.

Linked to CPU is an internal memory unit where all the instructions and data are stored. It contains the computer operating instructions or **programme.** The memory of the computer is of two kinds; **RAM** and **ROM.** Random Access Memory (RAM) is the computer's short term working space. During it's working life, a computer's RAM may be overwritten with new information millions of times. RAM is more like a blank cassette which can be recorded, wiped clean and recorded again. The computer can get to or access any part of the RAM memory 'at random'.

ROM is the Read Only Memory that is, one can read from it but cannot written on it. It is used to store software which will always be needed. ROM software is a permanent part of the machine, unlike the RAM which is forgotten each time the machine is switched off.

The external memory of the computer are the 'floppy discs', the compact discs (CDs) and the more recent flash (USB) discs. They need special **disc drives** to read and write the information on them. CDs and USB discs can hold an enormous amount of information. Infact, entire encyclopaedias can be stored on one CD or a USB disc.

9.2.3 Input and Output Devices

The most common input devices that you will see in your PC are the **keyboard** and the **mouse.** The keyboard of the computer looks like the keyboard of a typewriter with a few additional keys. One of the most common uses of the computer is as a word processor – basically a sophisticated typewriter that is capable of storing and manipulating text. With a few key strokes the writer can add or delete words and move entire similar sequences or paragraphs from one place to another in the text. Entire books can be written, edited, and printed with the use of computer discs without the manuscript even being committed to paper.

The mouse is a pointing device which is used while working with a display based computer system. It points or selects some area of display on the screen of the monitor and can be moved to another area of the screen. There are several other input devices like scanners, optical pens, joy-sticks that you may see associated with computing systems depending on the kind of requirements.

The output devices of the computer present the results of its work to users. The most common output device is the **monitor** which looks like a TV screen and the **printer.**

The input and output devices are so closely related that they are referred to as **input/output or I/O.** The most common I/O devices are floppy discs, compact discs, USB discs, modem (MOdulator-DEModulator) that connect to telephone lines. There are several other devices that can be connected to the computer. These are called **peripherals.** I/O peripherals are XY plotters to print graphs, devices that recognise and produce sounds, optical scanners to see text.

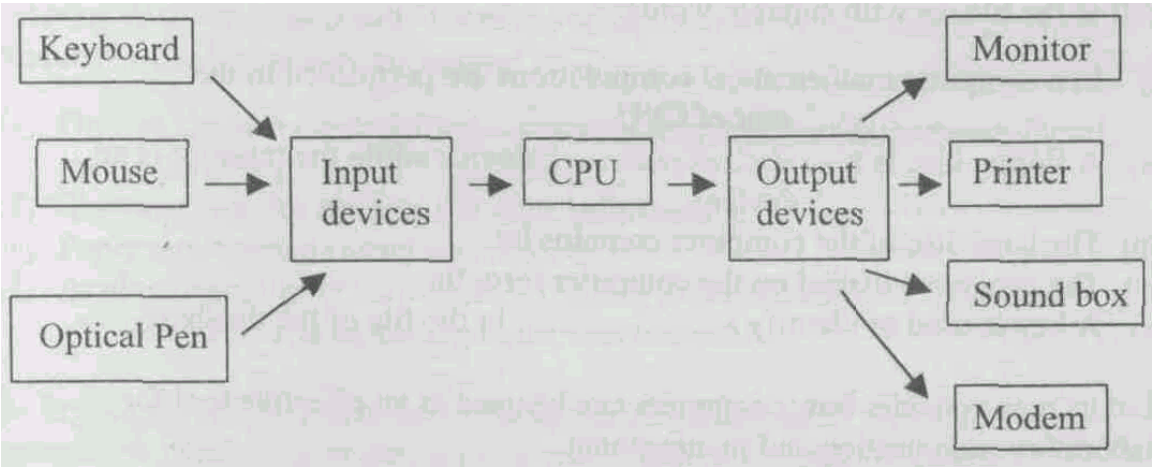

Fig. 9.1: Components of a Computing System.

9.2.4 Computerised Systems

You would have realized by now that computing systems are most useful for manipulating information. Any organisation and management of information basically involves 3 steps:

1. Information input
2. Information processing
3. Information output.

Information is usually in the form of data. Can you think of items which could form the data in a laboratory set-up?

Data could be any of the following: information about stocks, equipment, finances, personnel, technical data, student records etc. You could add more to this list according to your own situation. This data is normally stored, processed or analysed and then we get final results based on it. Sorting information fed into the computer is one of the most important operations it performs. The computer is able to arrange similar data items in a particular order, be it, numerical, alphabetical or some other sequence. On command the computer can compare any two data items and determine which is the next one in that sequence.

A collection of similar data is known as a **file** and each item is a **record**. In a file on students for example, each record contains data about one student such as the registration number, name, date of birth etc. of a student and sorting can be done according to the type of required information.

Once data has been sorted it is stored internally on the hard disc of the computer or on a floppy or a CD and can be printed out on paper. This information in a computer can be logically organised into files with separate records within files and individual items within records. When files are arranged in a database, each record contains identification labels known as keys. A key could be a code number, a name or perhaps data. When looking for particular data, the computer calls up each item from memory and checks to see if it contains the suitable key. Therefore, when a key is entered into a record, the computer scans its memory and displays that record.

SAQ 1
Fill in the blanks with suitable words:

(i) In a computer mathematical computations are performed in the ..... unit of CPU.
(ii) A floppy disc is a ..... device while the monitor is an ..... device.
(iii) The hard disc of the computer contains its .....
(iv) The programs loaded on the computer form the .....
(v) A key is used to identify a ..... in the file of the database.

Let us now consider how computers can be used as an effective tool for laboratory organisation and management.

9.3 OVERALL FUNCTIONS

There are three points that must be borne firmly in mind when considering the use of computers in laboratory management.

1. Overall Function

This includes the three steps we highlighted earlier, namely:

(a) Data input
(b) Data processing
(c) Data output

2. The G1GO Principle

This is a simple principle with a clear message and universal application – Garbage In – Garbage out!

Always try and enter any data in the form you want to see it printed out. For example, if you type in 'bkr' don't expect the computer to print out 'beaker'! Secondly be consistent in the way you enter your data. Using the same example, enter either 'bkr' or enter 'beaker'. Don't enter both because if you ask the computer to list all beakers, don't be surprised if it misses out the 'bkr'.

3. Paper System

When setting up a computer system you need to ask yourself 'Does the system you plan to operate work manually, i.e., on paper?' It is a popular misconception that to computerize a system that does not work will remedy the system's faults. Nothing could be further from the truth. If a system does not work, no amount of computing equipment will make it work. On the contrary, the system is likely to fall apart! It is always better to set up a system manually before attempting computerization.

Let us discuss overall functions in detail.

9.3.1 Data Input

There are several aspects of data input that need careful consideration. We shall assume that in a laboratory environment you are mainly concerned with entering data via a keyboard. There are other methods which, although not frequently used, you may encounter:

(1) Optical character recognition – scanners that read text from paper directly into a computer;
(2) Scanners, e.g. for reading bar code information;
(3) Paper tape systems – old equipment;
(4) Analogue-to-digital converters – reading experimental data from photoelectric cells in, for example, spectrometers.

At first sight, entering data into a computer might not seem problematical. Indeed, the mechanics of data entry are well tried and straightforward. However, from a management point of view there are several considerations.

First of all, there is the problem of access. This is often an acute problem in educational establishments where there might be an abundant supply of computers for teaching but a desperate shortage for management and administration. Sharing a computer terminal does not really work satisfactorily, and if a computer is to be a really useful management tool, it must be on hand at all times.

Another point to consider is that of training. Whoever enters data into your system, must know what they are up to. Otherwise it will not be long before the GIGO principle is brought into play. Adequate training is the cornerstone of good computer systems.

Coupled to both access and training is the problem of the time taken to 'key in' data. Consider the case of card index system being transferred to a computer system. At some stage, every character in the card index needs to be keyed into the computer. The computer system will not be any use until the transfer is complete and it may take months of time for keying- in the data. Even then there will be a need to update the data regularly which will require more time at the keyboard. **Never underestimate 'keying-in' time**.

Working conditions are especially important in computer work, particularly if it is for protracted periods. You cannot, for example, put a computer on someone's desk one day and expect everything to run smoothly. Operating computers can be particularly tiring and stressful and

hence it is worthwhile investing in proper furniture, ensuring that lighting conditions are suitable, and that noise and heat levels are kept under review.

9.3.2 Data Processing

Processing data is the most complex function of a computer system. It is where the computer itself (as opposed to a peripheral, e.g. a visual display unit or a printer) is brought into play together with suitable programs. We will discuss programs, or software, later; so here let us consider what kind of management decisions need to be taken in relation to the hardware - the computer itself. In practice, when you choose a computer system, you decide:

(1) What your aims are;
(2) What programs (software) will meet those aims; and
(3) What machines (hardware) will support the programs.

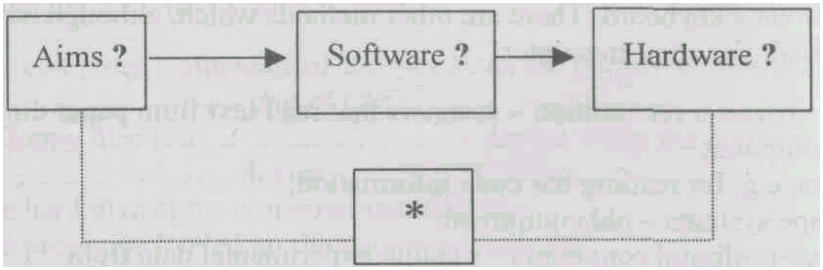

Fig. 9.2: Choosing a Computer System

Sometimes your aims affect the choice of hardware directly. For example, you require more than one person to gain access to the system at a time, you will need a multi-user system.

In defining your aims, you will define what data processing needs to take place and this will lead to a number of options - choices of programs. Once you have chosen a program for your task you will usually have a range of options, and a set of parameters for choosing hardware you may ask:

- Will you require a stand-alone workstation, a network, or a full multi-user system?
- What size RAM (the computer's own working memory) is required to support the program?
- What size hard disk (data store) is required?
- What data storage method will you use for backing up information?
- What is the cost of the computer and its subsequent maintenance?

9.3.3 Data Output

Processed data is no use to you if you cannot use it. Once data has been processed, you will either:

(1) Send it as a data file to another system, e.g. write a file to disk, transmit a file over a phone link via a modem, etc. For example as e-mail.
(2) Send it to a peripheral where it is decoded into information that can be readily understood. The most common peripherals are visual display units (VDUs) or printers.

SAQ 2

Can you remember from the previous paragraph what were the THREE steps to be decided when choosing a computer system? Write them down in order here.
(1)

(2)
(3)

Check your answer with ours at the end of the unit before continuing.

9.4 APPLICATION PACKAGES

In relation to item (2) in SAQ 2, there are two options. You can either write your own program or buy an applications package, i.e. a proprietary program, 'off-the-shelf. ' The former option is time-consuming and is a science in its own right and you have to be a computer programmer to do so.

There are applications package to suit almost any requirement, including:

- Database Management Software(data storage/retrieval)
- Spreadsheet Software (arithmetical calculations)
- Word processing Software
- Computer Aided Design (CAD)
- Accounts
- Stock control

We will look at some common types of applications software in more detail.

9.4.1 Database Management Software

For storage of large amounts of varied data, and rapid retrieval and interpretations of data, the database is the ideal tool. It is most useful for stock control.

Generally it tells a computer to behave just like a card index system. In computing terms the entire card index is called a file, each card is called a record, and each line of information on the card is called a file. Good database software will allow you to store information in exactly the same way as your index card.

A relational database is a type of computer program that allows you to store different information on a similar format for many different items. It also enables you to retrieve that information rapidly in a variety of ways. It can be used for applications like maintaining personnel records or student records, preparation of mailing lists and many other operations of a similar nature.

Figure 9.3 is an example of how a stock control data file might look for a database program. The concept is similar to a conventional card index system. The master file (your stock control file) contains many 'records'. Each 'record' relates in this case to a different stock item uniquely identified by its stock number. For each record there are several 'fields' or sections of information. In this case, the field descriptions are shown - stock number, description, etc.

The advantage that the computer has over a card index system is space. It can store thousands of records on many master files. That is the equivalent of many large card index systems. Also in a matter of a few seconds, the program could, in the case of the example in Fig. 9.3, list, say, all records for which a re-order was due.

It would do this by comparing the data in the 'requirement' field with the data in the "current holding' field and list all stock items where the 'current holding' is less than 'requirement'. This program would print the address labels of the supplier for you.

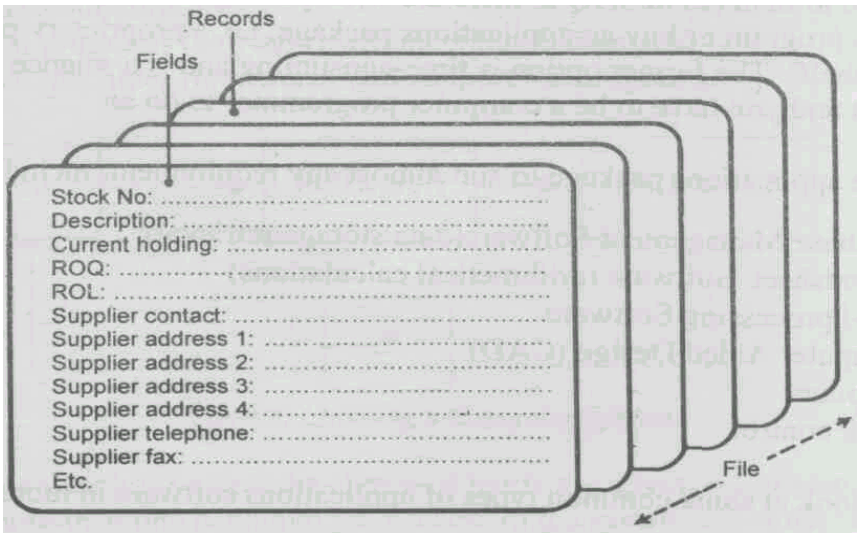

Fig. 9.3: Pictorial Representation of a Data File

When purchasing a database program, you must have a clear idea of what you need it for. Ask yourself the following questions.

(1) *Will it perform all the operations necessary for my system ?*

Many programs will manage 90% of what you want, but only a few will manage 100%. Your computer system will be a waste of time and money if it is a "ninety percenter", because you will have to operate a paper system in parallel. For example, can the program:

(a) Carry out batch processing, e.g. updating an entire file?
(b) Manipulate alpha, numeric and data information?
(c) Select records on matching or mismatching the contents of more than one field?
(d) Sort the data file into ascending or descending order on the contents of one or more fields?
(e) Produce useful reports to both a visual display unit and a printer?
(f) Link to another program, e.g. store a file of address data which can be used with a word-processing program for a mail merger?

(2) *Is it large enough?*

In this context beware of a common mistake, i.e., do not buy an educational program and expect it to carry out a business function. Check the possible:

(a) Number of files
(b) Number of records per file
(c) Number of fields per record
(d) Number of characters per field.

These features are interdependent to a certain extent but it is important to ascertain upper limits.

(3) *Is its cost justified?*

'You do not get what you do not pay for' in the computing world. However, it always pays to shop around. Some suppliers will adhere to a heavily marked-up tariff while

others will offer massive discounts, particularly in the education sector. Make sure that if you accept a large discount, you do not lose out on training.

Activity 1
List in the space below any activities at your workplace that you think could be usefully managed with a relational database?

We've listed some at the end of the unit for comparison.

9.4.2 Spreadsheet Software

Consider the grid in Fig. 9.4. It is split into rows and columns and is a pictorial representation of a typical spreadsheet program.

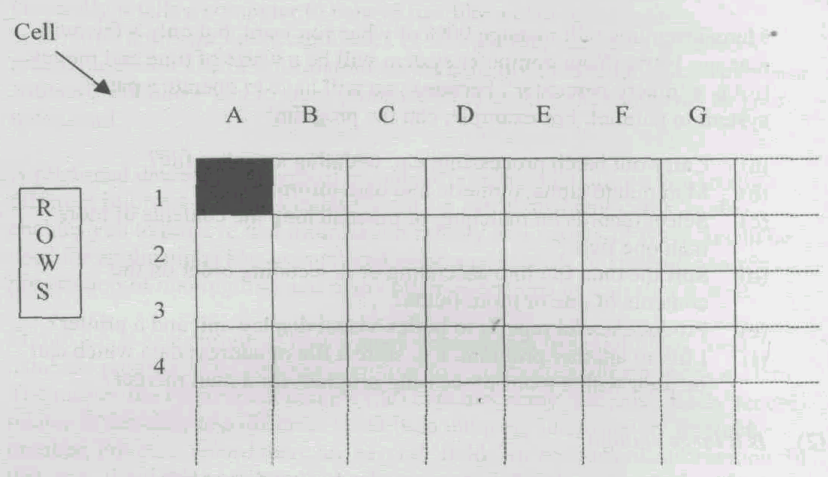

Fig. 9.4: Spreadsheet Cells

You can enter data in any 'cell', e.g. Al, Z53, etc. and, for example, perform arithmetic operations on that data and then 'post' the result to another cell. Take the following example. If you wanted to maintain a record of lab expenditure, you could set up a spreadsheet in the following way:

Column A
Date

Column B
Order No.

Column C
Item

Column D
Net Cost

Column E
VAT/Sales Tax
(Value added tax)

Column F
Total Cost

If all items in column D had VAT or sales tax chargeable at 17.5%, then

$$E = D \times 0.175$$

Column G
TOTAL of
net expenditure

Column H
Total sales tax
paid

In a separate cell you could show the balance outstanding on your annual budget.

You should be able to see the possibilities of such a program. Figure 9.5 shows an example of a printout from a spreadsheet.

	A	B	C	D	E	F	G
1	CASH FLOW ANALYSIS						
2							
3		TOTALS	MAY	JUN	JUL	AUG	SEPT
4							
5	INCOME						
6	Lab budget	3750	750	750	750	750	750
7	Grants	1500	1500				
8	Capital grants	500					500
9	Miscellaneous	150	50		50		50
10							
11	TOTAL	5900	2300	750	1000	1000	1600
12							
13							
14	EXPENDITURE						
15	Insurance & maintenance	175	35	35	35	35	35
16	Books, etc.	200				100	100
17	Phone	500	250			250	
18	Postage	150	30	30	30	30	30
19	Stationery	215		95	95		25
20	Replacements	635	45	45	500		45
21	Chemicals, etc.	700	100	200	200		200
22	Print & copying	350			250		100
23	Miscellaneous	250	50	50	50	50	50
24	Contingency (10%)	352	57	51	129	52	65
25							
26	TOTAL COSTS	3527	567	506	1289	571	650
27	CAPITAL EXPENDITURE	1250			1250		
28							
29	INCOME-COSTS-CAP.EXP.		1733	244	-1539	483	950
30							
31	CASH FLOW		1733	1978	439	922	1872

Fig. 9.5: Example Printout from Spreadsheet

You still need to ask yourself the same general questions as we listed for database as follows:

(1) *Performance*

For example, can the program:

(a) Carry out all arithmetic functions?
(b) Accept full character data and editing?
(c) Allow title lock and windowing?
(d) Allow easy cursor movement?
(e) Allow copying of blocks of cells?
(f) Allow alternative screen displays of formulae/data?

(2) *Size*
The size of the spreadsheet may be limited by the program itself or the size of the computer's RAM (Random access memory). A useful working size is 50 columns × 250 rows.

(3) *Cost*
The same criteria apply as for databases.

Activity 2
List in the space below any activities at your workplace that you think could be usefully managed with a spreadsheet.

Compare your answer with some activities listed at the end of the unit.

9.4.3 Communications Programs

By communications programs, we mean those programs which allow a computer to communicate via a transmission cable to another electronic device. Here we do not include multi-user system or small networks. We are mainly interested in communications for rapid data input and retrieval, and so we consider the telephone network as the transmission medium. Computer communications are most easily explained in Fig.9.6.

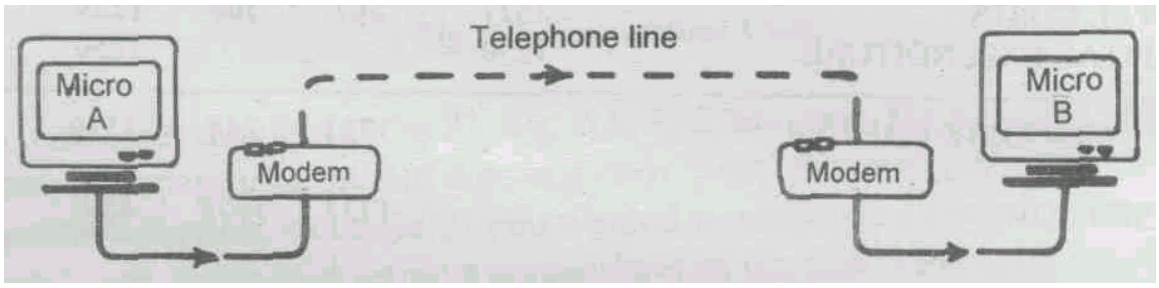

Fig. 9.6: Computer Communications

This shows one personal computer 'talking' to another. PC A reads a data file, say, from its floppy disk and sends it to a modem (Modulator -DEModulator). Here, PC A's electronic signal (the data file) is converted into a signal that can be transmitted over a telephone line. B can only read PC A's signal by receiving the signal via its own modem which translates the signal back into a computer signal. In fact, this example is typical for most computer communications over telephone lines:

(1) Between mainframe computers, or
(2) Between PCs and mainframes.

This situation is illustrated in Fig. 9.7 and is the basis on which PC users can communicate with the outside world.

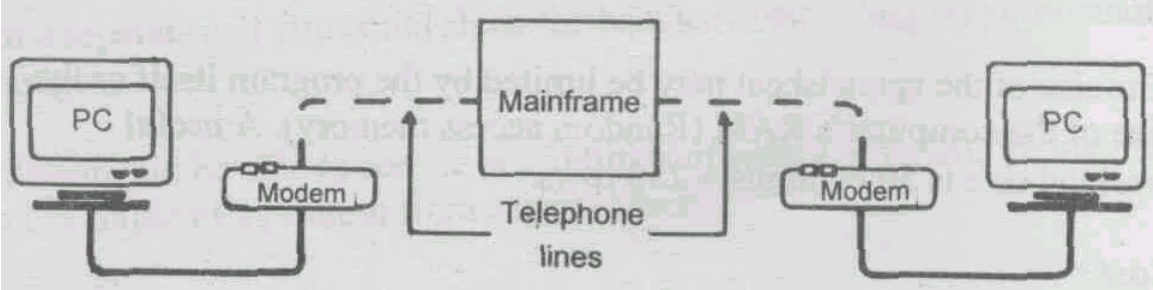

Fig. 9.7: PC/Mainframe Communicates

There are two main uses of PC to mainframe communications which may assist you in the management of your work. The first is accessing national databases and the second is electronic mail.

There are many databases for which you can become a subscriber and which your computer can access more or less at the touch of a button to obtain specialist information. **The Internet or the World Wide Web** is the most familiar and popular example. These databases hold vast amounts of information, for example, on companies. By obtaining details in this way, you do not need to hold large stocks of reference books, or spend time journeying to your local library and thumbing through weighty volumes. You obtain only the information you want, when you want it. In the education world, there are databases whose users not only draw data out, but put their own data in thus providing a dynamic data exchange, for example, web sites of companies which have information about their products and how to obtain them.

Electronic mail is another PC to PC and PC to mainframe data exchange. If .you subscribe to an electronic mail service, it will enable your PC to gain access to a 'mailbox' on a mainframe somewhere. You can either post data to the mailbox for someone else's PC to read later; or your PC can interrogate the mail box to see if anyone has left any data for you.

This system is now widely used for stock ordering, and many of your suppliers will have an electronic mailbox. The most competitive companies equip their salesmen with computers. Once a sale is made, the salesman sends exact ordering details to his distribution manager's mailbox. The distributor interrogates his mailbox every few hours, and should be able to despatch and invoice the sale within hours.

If you have to consider the installation of communications packages, the same questions have to be asked.

(1) *Performance*
- (a) Does the software and the modem support the necessary transmission rates?
- (b) Is the software secure? Telephone lines are often 'noisy' and unless there are sufficient data checks and error messages, you may end up with garbage instead of useful data.
- (c) Is the software 'user friendly'? Some packages do not allow much operator control.
- (d) Is the modem reliable? They can be susceptible to 'noise' and cause trouble. Generally, the more you pay for a modem, the more control you have over its operation and the more reliable it is. Internal modems are usually reliable.

(2) *Capacity*
This is not really a feature of communications packages. Just make sure that you are not locked in to slow transmission rates which can produce high telephone charges.

(3) *Cost*
You need to work this out carefully as costs mount up and may be difficult to justify. The elements are:

(a) Software for your PC.
(b) A modem for your PC.
(c) Subscription charges for database/mail service.
(d) Access charges to a database or mail box.
(e) Telephone call charges.

Activity 3
Are there any national databases that you think could be of assistance to you in your work? If so write down their names here.

Do any of your suppliers have an electronic mail facility? Write down their names here.
Can you see a use for data communications in the management of your work?

Yes No

Be prepared to discuss your answers with your tutor or mentor.

9.4.4 Word Processing Software

The main use for word processing is found in secretarial offices and small publishing companies. However, if you are involved in generating your own correspondence, or you are lucky enough to have your own secretarial support, you might find word processing programs useful. They are useful if you need to generate a large number of standard items of correspondence with small adaptations. Since we are mainly concerned here with information and management we will not dwell on word processing programs further except for one point and that is the use of word processing files to hold data in records.

You may recall that in the paragraph on databases, we spoke of the need to link details out of a database to a word processing program to enable mail merger to be carried out by a computer 'merging' two text files. One will be a letter, or address label layout; and the other will contain the variable details, e.g. the salutation, name and address and so on. If you are involved in carrying out mail mergers or circulars, it might well be worth your while maintaining a 'details' file of all the names and addresses of your correspondents. This file can be edited like any other text file.
Nowadays you can find integrated software which combine several of the capabilities of packages listed in earlier subsections. Microsoft Windows is the most popular such software.

9.5 DATA OUTPUT

Whatever, data or information that you feed into a computer will be the data output from a computer system and will be a data file sent from the computer to a peripheral unit. It may take the form of:

(1) A file written on to a floppy disk,
(2) A file sent to a VDU and displayed on a screen, or
(3) A file sent to a printer and printed onto paper (hard copy).

A file may even be sent first to a VDU and then to a printer.

The consequences from an organisational point of view can be summarised as follows:

(1) *Disk output*
You will already have decided whether to use a hard disk or floppies for storing data. An important point of disk management is to ensure a secure method of keeping copies of your (valuable) data. The method shown in Fig. 9.8 is suggested

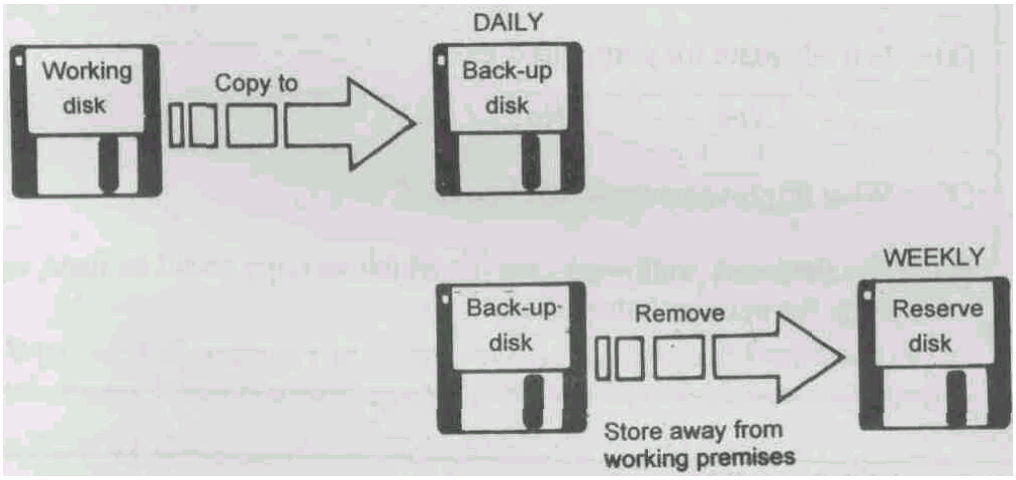

Fig. 9.8: Backing Up Data

This can be expensive in terms of time and disks. Those who economize usually learn the hard way!

(2) *VDU (Visual Display Unit) output*
Make sure that VDUs are of an appropriate type. They can cause severe eyestrain and tension if you do not check:
(a) Colour
(b) Resolution and screen size
(c) Flicker rate
(d) Viewing angle adjustment.

(3) *Printer output*
Consider what is required here. Do you just require management information on the one hand or camera copy for reprographic purposes?

InkJet — Very quiet. Cheaper than laser printer. Quality can be very good, and colour printing is a real option with inkjets. They are slower than laser printers, but their technology is changing rapidly.

Laser — Have graphics capability. Printouts give camera copy. Best choice for quality work. Speed varies from 4 pages per minute to 20 pages per minute. Some print double sided.

Resolution of printers is measured in d.p.i. (dots per inch) with 600 d.p.i. being relatively high resolution. A good laser printer may be capable of 600 + d.p.i.

Activity 4
If you have a computer printer at your workplace:

(1) What general type is it:
- Laser?
- InkJet?

(2) Is it adequate for your purposes? Yes No

(3) What improvements would you like?

9.6 SUMMARY

You have learnt in this unit that:

- Computers can be used for better and more efficient management and organisation of laboratories. A computer like the human brain receives information, stores and processes it and then displays the results. It receives information through input devices and stores it in its memory, processes that information in the central processing unit and displays it on an out put device like a monitor or through a printer. The physical parts of the computer form its hardware and the instructions given to the computer to process the information form the software.
- Software can be of two kinds, system software that controls the actual working of the computer and applications software that are the programs written to achieve the desired results for the user. The most important categories of applications software useful for laboratory organisation and management are: database, spreadsheet^ communications programs and word processing.
- Any organisation and management of information basically involves three steps. Data input, Data processing and Data output.
- Before using computerised systems it is important to understand and decide what the aims are what software/programs will meet those aims and what hardware will support the programs. It is also important to work out the costs of using a computerised system.

9.7 TERMINAL QUESTIONS

(1) What sources of information are there that you can think of that you could access with a computer to help you in your work in a lab?

_____

_____

_____

(2) List the following sources of information in order of speed, of retrieval. Start with the slowest.

(i) Subscription database
(ii) Catalogue
(iii) Card index
(iv) Own database

_____

(3) What kind of computer program would you choose to keep track of laboratory budgets over the year? (Tick the correct answer.)

(i) Word processor
(ii) Spreadsheet
(iii) Database
(iv) Stock control software

(4) What advantages do computers offer when used for information retrieval or for stock control?

A Cautionary Word

A final cautionary word on computing systems. It is imperative that any computer-based information system is backed up by a sound paper-based system. For example, can you imagine a petty cash ledger on a spreadsheet where invoices and orders were not numbered and filed properly? The spreadsheet would soon become meaningless and an auditor would have a fit!

9.8 ANSWERS

Self-assessment Questions

1. (i) ALU
   (ii) I/O, output
   (iii) Permanent memory
   (iv) System software
   (v) Record
2. (i) Decide on the aims of the system.
   (ii) Decide what programs will achieve the aims.
   (iii) Decide what hardware will support the progress. Computer salesman would like you to believe that these items are in reverse order! You will probably not have to look far to find a system running at fifty per cent efficiency as a result of this simple discipline being ignored!

Activity 1

Typical examples are:

(1) Stock control
(2) Inventory
(3) Library records

(4) Personnel records. You may need to register under the Data Protection Act if you hold personnel details on a computer system.

Activity 2

(1) Inventory. Although you cannot find particular details quickly in the same way as with a database, you can more readily ascertain asset values, written down values, etc.

(2) Ledgers. More or less any accounting ledgers are suitable for putting on spreadsheets, although there are dedicated accounts packages designed for the purpose.

(3) Budgeting and forecasting. A spreadsheet could help in monitoring a budget. However, in setting up a forecast of, say, cash requirement for a year, a spreadsheet is invaluable and will save much time with a calculator. It also enables you to see the effects of 'What if questions.

Terminal Questions

1. Subscription databases, your own database, bought-in disk-based data (e.g. dictionaries), electronic mail, other computers (via a communication network).
2. (ii) You might have to go to the library for this.
   (iii) Although this depends on its efficiency, it could be as quick as (4).
   (i) Access times vary.
   (iv) If you've set it up well, this should be quickest.
3. (ii) would be best, although you can also get more specialist software.
4. Computing systems can handle large amounts of information with far greater facility than people. They are speedier and more reliable.

UNIT 10 INFORMATION DISTRIBUTION

Structure

10.1 INTRODUCTION

Like any other office we need equipment to provide for information distribution in the laboratory office also. For information distribution we require multiple copies of various letters and document which can be handed over personally or mailed to the concerned persons. A variety of office machines and equipment's are now available for preparing documents and making multiple copies.

In this unit we will cover the following:

(i) various kinds of typewriters and their uses,
(ii) various reprographic processes for information distribution.

Objectives

After studying this unit you should be able to;

- list various types of reprographic methods,
- describe uses of various kinds of typewriters,
- explain duplicating and copying processes and describe materials and machines required for the purpose,
- compare the advantages and disadvantages of spirit, stencil and litho duplication, and
- describe the uses of microfiche and facsimile.

10.2 INFORMATION DISTRIBUTION

The organization and management of any institution, be it an isolated lab or a large site with many labs, requires that information is managed. Methods of managing information - selecting it and distributing it to the right people - are the subject of separate study, usually under the heading of 'Information Technology'. Here we will restrict ourselves to information distribution.

In unit 9 we discussed some of the most efficient ways of managing information with the use of computers. However, if a computer in a lab receives information, it is only available to those with immediate access to it. The information is not widely available. In order to disseminate information widely, machines and equipment are used in all types of offices. The common examples of such machines are typewriters, duplicators, photocopying and Xerox machines.

These labour saving devices are an integral part of any office. Therefore, it is important that you get familiar with them.

Office mechanisation should be considered a must for all laboratory organisation and management. You may not have come across this term before. Office mechanisation is the process of introducing the use of machines and equipment in place of manual operation of office work with a view to increase efficiency and output, and reduce office cost. It is preferred mainly to improve quality and efficiency of work and ensure accuracy. Introduction of the latest devices in lab offices from time to time facilitates handling of information and its distribution effectively.

Reprography

In order to disseminate information widely some method of reprography is invariably used. Reprography is the science and practice of copying documents by photography or xerography. You may have used a Xerox machine for making copies of your degree, grade card, application forms etc.

The scope of reprography is wide, covering areas such as duplicating, document reproduction and copying, including photographic copying.

The wide range of methods can be divided into two basic techniques.

(1) Duplicating, and
(2) Copying.

Though the terms appear to imply the same process, technically they are different. One of the fundamental differences is that *in duplicating a special master has to be prepared from which copies are made.* The duplicating process will often eventually expend the master. With copying however, *copies are made directly from the original which remains intact for further use.* The choice of method will depend on the facilities that are available in an office, the number and quality of the copies required, and cost.

Here we will consider some of the more usual processes from the point of view of convenience, copy quality and cost. The knowledge of those processes is essential because you will certainly require to use them sometime in the lab office.

Before we discuss duplicating processes and requirement of material and machine, we must consider various kinds of typewriters commonly available in labs and their uses. Besides routine work typewriters are also used for cutting stencils about which you will learn in section 10.4.

SAQ 1

(a) Indicate which of the following statements are true or false? Write T for true and F for false in the given boxes.

(i) Reprography includes duplicating and copying processes ☐

(ii) Duplication and copying are the same process. ☐

(iii) In duplicating the multiple copies are obtained directly from the original. ☐

(iv) Reprography methods are used in order to disseminate information widely. ☐

(b) In the following statements fill in the blank spaces with the appropriate words.

(i) ..... are used for managing information in the most efficient way but they are costly.

(ii) The common machines used in the offices for making multiple copies of a document are ..... and

10.3 TYPEWRITERS

Typewritten letters are attractive in appearance as compared to handwritten ones. The same matter can be typed in lesser space on writing paper along with carbon copies. Thus, use of a typewriter helps to bring about speed and efficiency in written communication and lab management. Many other advantages such as quick tabulation, storage of data, typing of formulae, etc., may also be obtained by the use of special purpose typewriters.

There are a variety of typewriters available in the market. Each of them has some specific features and uses. The details of some commonly used typewriters are given below:

Standard typewriter

You must have seen this manually operated machine. Standard typewriters of various makes such as Remington, Facit, Godrej, etc., are available in the market. A standard typewriter can type ten characters to the inch horizontally and six lines to the inch vertically with single spacing. Moreover, a number of carbon copies can also be obtained depending upon the quality of typing and carbon papers used.

Electric typewriter

Electric typewriters are similar to standard typewriters but with-an electronic motor taking the place of human energy. It is much faster than the standard model. They can produce up to 20 copies of a document if paper of appropriate thickness is used. The slightest touch of fingers sets the keys in motion and the impressions produced are uniform and perfect. Electric typewriters are commonly preferred because of the speed of typing, fineness and uniform quality of the print. Besides they are good for cutting stencils, typing invoices and preparing material for printing.

Automatic typewriter

It is a power-driven machine, which automatically types a standard pro forma from a previously punched or stencilled master (Ref. to section 10.4). When the master is placed on the machine and the machine is switched on, the matter is automatically typed on the paper at a speed of about 150 words per minute. Non-standard information like names, addresses, etc., may be inserted at appropriate places by manual typing. Thus, it is suitable when letters or circulars bearing routine messages have to be reproduced in large numbers.

Electronic typewriter

An electronic typewriter has a 'memory' or 'electronic brain' which enables it to recall the whole document at a time and type it automatically at the press of a button. A small display panel reads out the memory and permits editing and modification of drafts on the typewriter itself prior to final print-out. An electronic typewriter is shown in Figure 10.1.

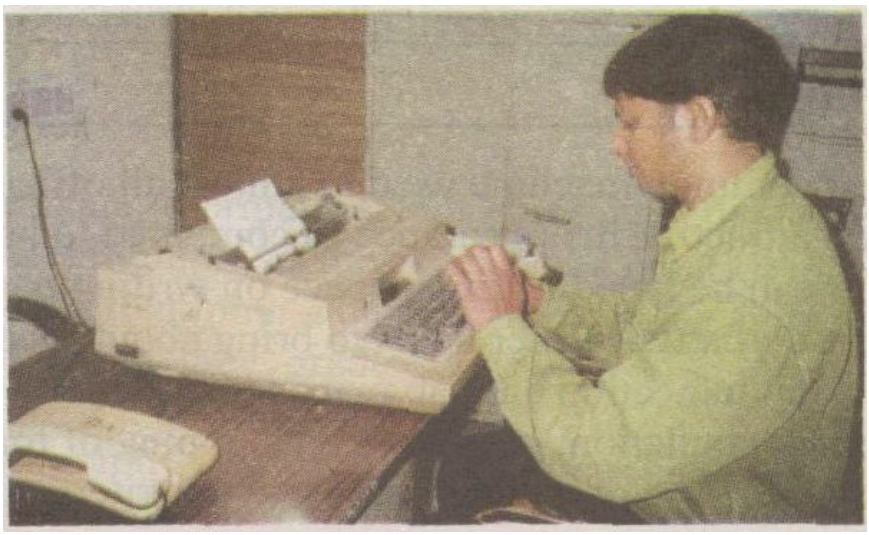

Fig. 10.1: Electronic Typewriter

Typewriters with special attachments
Certain special attachments can be used to the typewriter for typing work of a special nature. These are:

The continuous stationery device - It is used for typing continuous strips of office forms.
The front feed device - It enables insertion and typing of cheques and receipts.
Card-holding attachment - It enables small stiff cards or labels to be fed and curved round the roller.

Use of Typewriters for Multiple Copies
Offices frequently require copies of various letters and documents. The simplest method is to make the copies at the same time along with the original letter or document. Carbons, carbon-coated sheets or carbonless copy papers are often used to get a small number of legible copies. A standard typewriter can produce up to six carbon copies, whereas an electric typewriter can produce up to 20 copies as compared to four legible copies by handwriting. But where the number of copies required is more than 20, a duplicator may be used for the purpose.

In the following section we will discuss the duplicating process. But before moving further try the following SAQ.

SAQ 2
(a) List the various kinds of typewriters.
(b) In the following statements fill in the blank spaces with appropriate words.
   (i) An..... typewriter automatically types a standard pro forma from a previously stencilled master.
   (ii) An..... typewriter has a memory and can automatically type a whole document on command.
   (iii) Approximately twenty copies can be produced by an..... typewriter.
   (iv) With ..... device the standard typewriter can type cheques, receipt etc.

Check your answers with ours before continuing.

10.4 DUPLICATING PROCESSES

As we mentioned earlier duplicating is a process whereby a master copy is prepared from which a large number of other copies are obtained with the help of a duplicating machine. It is a substitute for printing. It is used when the number of copies required is more than the capacity of a typewriter and yet not large enough to justify printing.
There are three main duplicating processes. These are listed in increasing order of cost and copy quality.

1. Spirit duplicating
2. Stencil duplicating
3. Offset litho duplicating

These three processes require duplicator and special material for making copies. Thus there are spirit duplicators, stencil duplicators and offset litho duplicators. Besides you may come across others such as electronic stencil duplicators and type set duplicators.

The duplicating machines available in the market can produce 200 to 500 legible copies of letters, circulars, notices, reports, forms, price lists, etc.

Let us now consider equipment, materials, master preparation and making of copies in each of the processes listed above.

10.4.1 Spirit Duplicating

Equipment Required

Spirit Duplicator (also known as hectograph) Thermal copier (optional)

Materials

Masters
Hectographic carbon Copy paper Duplicating spirit

Method

Master Preparation

By hand, typing or thermal.
Line drawings possible.

The master from which the copies will be taken is first prepared from a special non-absorbent glazed sheet of paper and special carbon paper which acts as the reproducing medium. This carbon paper is known as *hectographic carbon* and contains aniline based dye. These carbons are available in different colours, typically purple, red, green, black, blue, brown and yellow.

To construct a master the glazed surface of the master paper is placed in direct contact with tne coated surface of the hectocarbon. The required information is then drawn, typed or written onto the surface of the master paper, causing a mirror image to be developed on the glazed side.

If a thermal copier is available it can also be used to prepare a hectographic master. This is a quicker and cleaner method.

Duplication

Once the master is ready it is attached to the drum of the duplicator with the carbon image outward. The copy paper is then fed into the machine. The function of the machine is to impregnate the copy paper with spirit in its passage through the machine so that it is moistened immediately before it comes into contact with the master on the drum. Since the contact of paper with master is brought about by a pressure wheel, the reaction of the spirit with the carbon causes an image to be transferred to duplicating paper.

Use

Mainly in educational establishments, that is class handouts.

Individual duplicating copies are relatively cheap to produce, the duplicator itself is simple and easily maintained.

Copy Quality
Poor - satisfactory

Multiple colours available simultaneously

Economic Run 10-100

- Both carbon and master paper are cheaply available.
- Master copy can be prepared easily.
- The process is simple.
- Good quality paper is used for copies.
- Many colours can be duplicated simultaneously.

Disadvantages

- The copies are inferior in quality because the dye tends to spread and ink on the copies tends to fade with time.
- The clarity of the image becomes progressively weaker as the copies are rolled out.
- It is difficult to alter the master copy if there are mistakes in the master.

10.4.2 Stencil Duplicating

Equipment Required

Stencil Duplicator
Thermal copier (optional)
or
Electronic stencil cutter

Materials

Stencil Copy paper Ink Cleaning Fluid

Method

Master Preparation

By hand, typing, thermal or electronic cutter.
Line drawings possible.

The master in this case is a sheet of fibrous, porous material which has a plastic coating. Such stencils are often referred to as 'skins'. An image is cut into the coating either by:

A typewriter,
By hand using special styli,
By thermal copier
Electronically by use of electronic scanner.

Duplication
After preparation, the master is attached to the drum of the duplicator. Once in position, the paper backing sheet is removed from the stencil and the stencil 'inked'. As the machine is operated; the semi-absorbent copy paper is fed in and bought into contact with the rotating copy via a pressure roller.

The stencil duplicator is commonly used in offices where a large number of notices, circulars, price lists etc., are to be reproduced quite often. Such duplicators can be manually-operated or power-driven. They are available in the market under different brand names.

Use

In offices and educational institutions for bulletins, circulars, notices, etc.
Again, it is relatively inexpensive to produce individual copies, and the equipment is basic and easily maintained.

Copy Quality

Satisfactory

Colour

Multiple colours possible so long as machine rollers, etc. changed.

Economic Run 10-100

Advantages

- This duplicating process is cheaper as compared to printing or other processes.
- Graphs, diagrams, etc., can be prepared easily on the stencil .by using a stylus pen.
- Stencil can be altered easily by using correcting fluid.

- A good number of copies can be obtained within a short period of time.
- Photographic reproduction is possible with electronic stencils.
- Stencils can be stored and used again for more copies when required.

Disadvantages

- The main disadvantage of stencil duplicating is that separate runs are required for two or more colours. However, complicated duplicators have been developed for impression in multiple colours simultaneously.
- Stencil duplicating proves quite costly if only a few copies (say up to 25) are required.

10.4.3 Offset Litho Duplicating

Equipment Required Duplicator

Plate-making equipment (not always, essential), e.g. printing box and processing unit

Materials
Plates
Paper
Ink
Plate making materials

Method

This process is far more complex than the previous two methods of duplicating. In fact, it is more like printing than a duplicating process, and ' gives a much better overall quality to the finished copy, including illustrations.

Master Preparation

By hand, typing, electrostatic copying, or photographic copying.

Line drawings and contrasting photographs possible.

Duplication

In lithographic process the plates can be either paper, plastic, or metal. Paper plates for short runs are cheaper and easier to prepare than metal plates (for longer runs). Cost increases with quality. Paper plates are usually used once, whereas metal plates have an almost indefinite life. Paper plates can be prepared directly by the use of special grease-based pencils, ink or ribbons. Alternatively, the image of an original can be produced by means of an electrostatic copier, or by photo-transfer.

The plate is attached to the drum of the duplicator and a supply of grease-based ink and a watery fluid are applied to it simultaneously. The inked image is not transferred directly to the copy paper, but is brought into contact with another drum which transfers the mirror image created on this drum to the copy paper.

Use

Offices, educational institutions and purpose-built reprograpahic facilities e.g. bulletins, promotional literature etc.

This is a more expensive option in terms of equipment and maintenance but may be economic where longer runs (see 'economic runs') are required.

Copy Quality

Good - excellent

Colour

Multiple colours possible so long as machine rollers, ink fountain, etc. changed. Accurate registration possible

Economic Run
50-10,000

Advantages

- The process is well-suited to the production of office forms, particularly those with complex rulings.
- A very large number of copies can be obtained.
- It is a cheap form of printing. Compared with normal printing, cost of printing is lower by 30% to 40% in offset litho printing.
- The quality of production is much better as compared to stencil duplicators.
- Master can be stored for an indefinite period. Copies can be obtained with the help of master whenever required.

Disadvantages

- Separate runs are required for printing in different colours.
- It can be run only by trained operators.
- It is costlier than other duplicating machines.
- It requires sufficient office space for storing chemicals, plates, and paper etc.

SAQ 3
In the following statements fill in the blank spaces with appropriate words.

(i) The carbon used for spirit duplication is called .....
(ii) In Lithography ..... and ..... plates are also used.
(iii) The quality of print of lithography is superior than ..... and ..... duplication.
(iv) The process of..... is more like printing.

10.5 COPYING

There are basically two methods of copying:

Photocopying
This is a modified development of photography. It is quite expensive and slow and is not often used for routine reprographic work these days.

Electrostatic copying
This method is often incorrectly called photocopying.
The electrostatic copying machine or xerography helps in getting exact copies of the original at a very fast speed. This eliminates the need for preparing a master copy.

Equipment Required

Copier

Usually copiers are available on lease. Outright purchase is possible, but may not be cost effective. For the lease the following should be inquired and checked.

(i) The period of lease
(ii) Conditions to which the lease can be terminated and a new copier used

(iii) The method of charging for copies
(iv) Charges for ancillary items, e.g. document handler, paper feed trays, sorter, standing cabinet, etc.
(v) Maintenance.

Materials

Toner: may be supplied under a lease agreement
Paper

Economic Run

This depends on leasing arrangements. Generally there is a flat rate cost for every copy made up of:
Machine cost + Paper cost + Toner + Maintenance

Master Preparation

There is no master to be prepared. The original may be in virtually any form, but certain colours, e.g. light blue, light yellow, etc. will not reproduce.

Copy Quality

Good - excellent

Colour

Usually one colour, multicoloured copiers are also available but they are very expensive.

Use

Almost any reprographic use.

Xerox machines are relatively expensive to run and to maintain (maintenance contracts allow serving from time to time). Because they are easy to use, normally everyone is allowed to use them. As a result they can suffer inexpert handling. You may find that some sort of control is required.

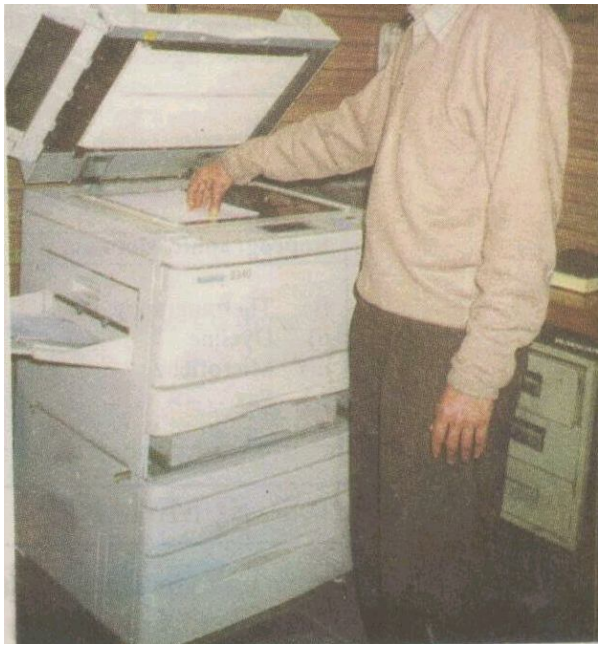

Fig. 10.2: Xerox machine

10.6 AUXILIARY METHODS

There are other reprographic methods which although commonly used earlier, are now mainly used for specific purposes. We think you should be aware of these methods also.

Thermography

Used mainly for preparation of reprographic masters, e.g. hecto, stencil, etc.

Dyeline

A cheap method ideal for large originals, e.g. circuit diagrams, engineering drawings, construction plans, etc. (Blue prints)

Microfiche

This is a standardized form of microfilm storage of information. Such a system allows the storage of approximately seventy-two pages of A4 per slide. The slide is viewed by placing it into a viewer, which projects enlarged sections of the slide onto a screen.

Microfiche systems allow high density storage of any material which can be photographed.

10.7 FACSIMILE

This is often known as 'fax' and it represents the interface between reprographic and computer technology. By using fax, the contents of a sheet of paper (text or illustration) can be transmitted over a telephone line. A typical example of the use of this method would be to send a schedule to the various speakers for a conference and to receive a reply and finalise accordingly.

Locally, urgent documents can be faxed from one end of the country to the other in less time that it takes to walk to the nearest post box! Fax terminals are expensive, but if you do not have immediate access to one, there is bound to be a local fax agency.

SAQ4

Complete the following table:

Reprographic Methods		Used for
(i)	Thermography	
(ii)	Dyeline	
(iii)	Microfiche	
(iv)	Fax	

10.8 SUMMARY

In this unit you have learnt that:

- Methods of reprography are used for the distribution of information.
- Typewriters are the most commonly used copying machines. They produce written matter on paper in type similar to the printer's type, along with 3 to 4 carbon copies. Standard typewriter, electric typewriter, electronic typewriter and typewriters with special attachments are commonly used.
- Duplicating is a process whereby a large number of copies can be obtained from a master copy with the help of a duplicating machine. A duplicating machine is used when the number of copies required is more than the capacity of a typewriter and yet not large enough to justify printing.
- Various makes of duplicating machines are available which can produce 200 to 500 legible copies from the same master copy. Some of the important kinds of duplicating machines used are: spirit duplicator, stencil duplicator, offset litho machine.
- Thermography is also used for preparing reprographic masters.
- The choice of method of duplication is made according to the required quality, number of copies and the cost involved.
- In present times copying machines are widely popular because they are easy to use, several copies can be obtained within minutes and the original remains intact for further use.
- Microfiche can be used for storing large information.
- Facsimile or fax is revolutionary for information distribution. The content or illustration on a paper can be transmitted over a telephone line.

10.9 TERMINAL QUESTIONS

1. List the advantages of an electric typewriter.

_____

_____

_____

_____

2. Is there a difference between duplicating and copying? If yes, what is it?

_____

_____

_____

_____

3. In duplicating and copying quality is of considerable importance. Of these systems described in the text, how does the quality vary?

_____

_____

_____

_____

10.10 ANSWERS

Self-assessment Questions

1. (a) (i) T, (ii) F, (iii) F, (iv) T
   b) (i) Computers
   (ii) duplicators, photocopier or Xerox machine
2. (a) See section 10.3.
   (b) (i) automatic
   (ii) electronic
   (iii) electric
   (iv) front feed
3. (i) hectographic carbon
   (ii) metal, plastic, paper
   (iii) spirit, stencil
   (iv) lithography
4. (i) Preparation of masters for hecto and stencil.
   (ii) Blue prints for engineering drawing.
   (iv) Storage of large information.
   (v) Quick transmission of information on paper via telephone lines.

Terminal Questions

1. (i) Much faster than standard typewriters.
   (ii) Require much less energy in processing the keys
   (iii) Provide uniform and perfect impressions
   (iv) High speed
   (v) Uniform quality and print
2. In duplicating a special master has to be prepared from which copies are made. While in copying copies are made directly from the original.
3. The offset litho duplicating process gives the best quality copies, as good if not better than those produced by photocopying. Although both stencil and spirit duplication give satisfactory copies on the whole, stencil duplication is preferable.

BLOCK 2 LABORATORY ORGANISATION AND MANAGEMENT-II

In Block 1 you have learnt about the design, organisation and management of the main lab, preparation room and store as well as various aspects related to purchase and stock maintenance. In this block we have discussed different communication methods within and across departments/organisations. As a member of a science laboratory you are part of a team working within a much larger organisation. Therefore, for improved efficiency you need skills, which are required for record keeping, report writing, efficient communication, and information handling and distribution.

In unit 6, we have discussed how basic skills in oral and written communication improve effective communication. You will agree that these are essential for efficient running of laboratories. In this unit, you will also learn to produce suitable written notes, letters and memos etc., and the channels through which these should be routed for necessary implementation.

Record keeping is another aspect of efficient communication. Though, it may be cumbersome, it aims at providing information about availability of stock so that laboratories operate smoothly. In Unit 7 on 'Files and Records' we discuss various systems used for filing equipment, chemicals, books, audio-visual aids, printed and written materials, worksheets, instruments, correspondence, supply orders and other miscellaneous items.

Reporting is an important part of any scientific endeavour. It involves accurate recording of facts and data, analysis and interpretation and presentation in a . good scientific report. These need skills of various kinds. Unit-8 on "Scientific Reporting" discusses the basic skills and essential elements of report preparation. The use of various devices for effective presentation is illustrated through examples.

You may be aware that computers are gradually becoming part of every forward-looking work environment. Therefore, to provide you some training on the use of computers in organisation and management of science laboratories, in unit 9 we have discussed how you can work on a computerised system. You will be able to appreciate the advantages of using various computer software for handling and retrieving information about stocks, finance, personnel and technical data in a laboratory.

Information Distribution forms the subject matter of unit 10. To be able to take information to all concerned, we need to produce multiple copies of various documents, letters, reports etc., economically. In this context use of various kinds of typewriters, Xerox machines and duplicating machines are discussed in detail.

Objectives

After reading this block, you should be able to:

- Draft communication related to laboratory work and outline procedures for sending these to concerned authorities,
- prepare a clear and effective scientific report,
- explain the importance of filing system and record keeping,
- state the advantages of using a computer system in laboratory organisation
- and management, and
- list various reprographic methods used for information distribution.

UNIT 6 EFFICIENT COMMUNICATION

Structure

6.1 INTRODUCTION

Communication is essentially to-and-fro transfer of information between individuals, departments as well as between organisations. Therefore, it is an important aspect of the functions of any organisation. At the heart of any well-run department will be a good system of communication. In order to be effective, communication must take place at the proper time, must be accurate and must occur speedily.

In this unit we will discuss three means of communication - oral, written and by using computer. Of these, oral and written are the old and common means of communication, whereas computer is not that common but it is becoming increasingly important.

Objectives

After reading this unit you should be able to:

- list means of communication stating when each would be appropriate,
- recognize and produce suitable written communications in given circumstances,
- list some of the uses of the computer for filing and keeping records together with any drawback,
- identify different channels of communication at the workplace and recognize their use, and
- recognize your place in the work-team and be aware of the areas of responsibility.

6.2 WHAT IS COMMUNICATION?

Communication is a process of exchange of messages, facts, ideas, opinions, feelings between two or more persons. In any organization various people are linked together for common purposes. Mutual understanding and effective relationship among such people can be established by meaningful transfer of information from one person to another. Any department can be successfully run if it has a good system of communication. Communication system involves sending of information, receiving the information as well as response or reaction to the

information. Transmission of information from communicator to receiver is carried out by certain means. In the following sections we will consider some of the means of communication available to you and when and how you should use them. It is necessary than you should select the most appropriate means of communication for the benefit of the people with whom you communicate. It is also required that you should use correct level of language and terminology. This will avoid misunderstandings, mistakes and breaches of protocol. Let us now try the following SAQ.

SAQ1
Two things you should consider while communicating with others are:

_____

_____

6.3 ORAL COMMUNICATION

Oral communication between the people occurs with the use of spoken words. You should keep in mind the following points while communicating orally with your colleagues or other people.

1. Listening is as important as talking.
2. Accuracy and precision in what you say avoids confusion.
3. Be careful how you use jargons. However, science is reckoned to be an exact subject so use the correct names for apparatus, quantities etc. when discussing science.

Oral communication can occur face to face or with the help of the telephone. Face to face communication is most natural and easiest means of oral communication that occurs daily between co-workers during work. Telephone is most commonly and widely used mechanical device for oral communication.

Oral communication obviously has advantages and a disadvantage compared to written communication. While oral communication is quick, easy and personalised, it suffers from one major disadvantage. When finished, there is no record of what has actually been said. It can be important to have a written record of a conversation. For example, it you receive some goods which are broken or incomplete, you will need to notify the supplier and, in some instances, the transporter/carrier. The easiest way to do this is to use the phone and there is no reason why you should not do so, provided you follow up your phone call with a confirmatory letter (of which you should keep a copy). If you receive an oral request for some apparatus, ask for the request in writing (or write it down yourself, immediately)-then there is less chance that you will forget. No doubt you can think of many other instances from your working life where the written word is essential. Let us try the following SAQ before we proceed further.

SAQ 2

1. Can you think of two advantages that written communication can have over oral communication?
   (i)
   _____
   (ii)
   _____

2. Can you write down one advantage that oral communication can have over written communication?
   _____

6.4 WRITTEN COMMUNICATION

The communication process that involves written media, i.e. paper is called written communication. It involves distribution and delivery of papers. Two basic aspect of written communication are information received and information sent.

6.4.1 Information Received

You must always read the information you receive. After reading through the information you can decide what needs to be read in depth, what can be scanned and what can be safely thrown away. With experience you will learn how to do this. All the incoming information that are important need to be filed. In the next unit you will study about filing system. Probably the most important written communication which you will receive concerns requests for apparatus and materials.

6.4.2 Information Sent

This is the aspect of written communication where your skill of using appropriate language, precision, accuracy and thoughtful words is exercised. In the following sections we will discuss some types of written communication, but before that try the following SAQ.

SAQ3

Which of the following (from a to d) would you use in a written communication to:

1. an equipment supplier, and
2. a friend?

b) Please would you dispatch to me at the above address and at your earliest convenience a box often double-sided high-density three-and-a-half inch microfloppy data disks, as described in your equipment list of 12 February 1999.

b) Re: yours of 12[1] Feb, send another box.

c) I refer to your list dated 12-02.99. Please supply 1 box of 10 DS DD 3½" disks.

d) Regarding your list (12 Feb), can you please send me a box often 3½ floppies?

6.5 MEMORANDA

Memoranda (though some prefer "memorandums" and others refer to "memos") are commonly used for written communications within a workplace, within departments, etc. They are much like letters in general layout and content but differ in certain specific details. They all have similar headings which are illustrated in Fig. 6.1.

MEMORANDUM

To:
From: Date:
Subject:

Fig. 6.1: Memo Headings

Memos dispense with the need for giving instructions, salutations, greetings and a complimentary close. A signature is not necessary in a memo, although it may be initialled. While it is not true that memos are always brief, they are essentially an aid to quick and direct internal communications. They should therefore, be written in clear, concise English, and in continuous prose rather than in note form. It is a good idea to number or letter each topic for clarity. Try also to plan the contents of your memo so that they follow some sort of logical sequence, instead of presenting statements as they occur to you. You should not forget the usual words of courtesy and politeness, too. These belong as much in a memo as in conversation or letters.

6.6 LETTERS

There are conventions established by bodies covering the way that letters are set out and every letter has certain components in common. It might be interesting for you to see how far you are aware of these.

Let us now look at the example of a letter by a equipment firm to the chief technician in an organization.

Science Equipment Ltd.
50, Onikoko,
Abeokuta Road
Lagos.

Chemical Industries Ltd
Okpala Industrial Estate
Ilupeju
Lagos.

For the attention of the Chief Technician

Your ref. Our ref. DRS Date. 4lh April 2000

Dear Sir,

Re. Your order no. E023904

We must apologize for the delay of the above order which is due to nil stock of this item. As this situation was unforeseen at the time of your order, we now find we are unable to invoice you for March. We would be grateful if you could notify us as to whether you wish to cancel this order and re-order for April invoicing, or if you would like the order to stand.

We hope to have sufficient stock to cover your order within the next 21 days.

Yours faithfully,
D.R. Abubakar
Sales Office

SAQ4

Read the above letter carefully list the mistakes and rewrite the letter in the correct form.

6.6.1 Official and Personal Communications

We are going to draw your attention to a point of procedure concerning letter-writing. Your workplace will have a supply of headed writing paper and it may well have a policy concerning who can use it and who can sign letters written on it. Two points arise from this:

1. The quality of the letter reflects the standards of the sender and his or her place of employment. Therefore, letters on headed paper should be typed and laid out correctly. Correct spelling, grammar and punctuation are equally important.
2. A typewritten letter on headed paper represents an official communication from an establishment, and whoever signs the letter must have authority to represent the establishment.

It is unlikely that you will send out official letters in your own right. It is more likely that you could be required to draft letters which are then typed and signed by one of your superiors. Bear this in mind when reading this section, and remember the distinction between official and personal communications. For personal communications you can make your own draft and can send handwritten as well undersigned by you.

Incidentally, beware of signing letters with *p.p. (per procurationem)* in someone's absence, even if it is a letter that you have drafted. The use of *p.p.* implies a legal responsibility for the contents of the letter.

SAQ 5

In each of the following circumstances, whom would you contact? There may be more than one person/group, in which case put your answers in order, starting with your first choice.

1. A piece of apparatus is delivered broken, although the packaging had not been undone when delivered to you

_____

_____

2. A sink in the lab is blocked

_____

_____

_____

3. You require financial assistance for travelling to a study centre for a distance learning course

_____

_____

_____

6.7 REPORTS

There are two kinds of report that you may be called on to write in connection with your work. The first may concern an investigation or enquiry that you have been making, e.g., an experiment, and the second may arise because you have some information that you wish, or have been instructed, to pass on, e.g. after an accident or other mishap.

Scientific reporting is covered in unit 8. Accurate reporting of experiments allows them to be repeated as a verification. Other kinds of reports may be either informal or formal and often concern a particular set of circumstances that may need action or decisions from someone in authority, e.g. a head of department.

In this text it is impossible to work through all the cases in which you communicate with people at work but this section will have introduced the basic ground so that the underlying principles and procedures are apparent to you.

6.7.1 Informal Reports

Many of the comments that we have made about other forms of written communications apply to informal reports. They should contain only facts, presented in a succinct and logical way. Important features to include are the date, the title and the name (and status) of the person making the report. They should begin with a simple statement of the relevant facts and/or circumstances. It can be helpful to number or letter each item.

If there are circumstances in which your opinion has been requested, your opinions would then form the second half of this report. If data and/or diagrams would help the reader, they should be included. The same criteria apply to these diagrams as apply in reports of experiments.

6.7.2 Formal Reports

Formal reports are often produced as the result of an investigation or request for information required by management. A formal report can be similar in layout and content to the informal report but may contain five sections instead of two. Each section might require a heading. Examples of these headings could include:

1. *Terms of reference.* These outline: who gave the instructions for the investigation or whatever, the nature of the investigation, the extent of the enquiries and the nature of the information required. This helps you to clarify in your own mind exactly what you are meant to be considering.
2. *Proceedings, Procedure or Action Taken.* This should consist of a list of actions, with dates and times, when they took place. Actions could include examination of sites, equipment and processes and visits to other places, etc. No information is given at this stage.
3. *Findings.* In this section, all the facts are listed - as in the first section of the informal report. If more than one item or situation is being investigated, this section can be divided up by appropriate sub-headings with numbered or lettered details.
4. *Conclusion.* This section is for the writer to express his/her conclusions and/or opinions and must refer to the findings. They should express the result of logical reasoning and deduction from the facts.
5. *Recommendations.* You might not be asked to make suggestions as to what action should be taken but, if you are, there are some do's and don'ts to be considered:
    a) DO be practical. Consider the effect your recommendations could have on your colleagues if they were adopted. Be precise.
    b) DON'T suggest that further investigations should be made (unless there are good reasons why your investigations were not adequate or sufficient).
    c) DON'T let your wishes dictate your recommendations when all the facts point to a course of action that you would find unwelcome. Be anxious about making important recommendations.

Major decision are not likely to be made on the basis of your report alone!

Writing a report after collecting facts and drawing conclusions ought to be at least a two-day process. Once your report is written, keep it for twenty-four hours and then read it again. It is surprising how many alterations and/or corrections you will wish to make after you have "slept on it".

Finally, as with the informal report, the final draft of your formal report should be signed and your status added, with the date that you produced the report. Let us now try the following SAQ.

SAQ 6

1. If you witnessed an accident, what facts/circumstances concerning the accident would be appropriate for you to include in the introductory paragraph of a written accident report? (Use only as many numbers as you require).

_____

_____

_____

_____

_____

_____

2. Which of the following could you include in an informal report?
   (i) The date on which the report was written,
   (ii) The name of the author.
   (iii) The title of the report.
   (ix) The terms of reference of the report.
   (x) A statement of facts/circumstances.
   (xi) Data and/or diagrams.
   (xii) Conclusions.
   (xiii) Recommendations.

Till now we have briefly reviewed different types of written communication. Now we will study another mode of communication which can be used to produce all the forms that we have mentioned above and much, much more.

6.8 THE COMPUTER

You must be aware that the computer is now a powerful tool in communications. Indeed, this unit was written and produced with the assistance of modern communications technology. The units were typed and stored on disk. You can also use a microcomputer as a word processor if you have the right programme available. As a word processor you can use a computer to generate all the written communications we've discussed in this unit.

Microcomputers are an indispensable tool in the modern working environment and you may also have access to a mini or mainframe computer. There are many software packages available for use in stock control and in keeping records of the kind we have discussed. There are packages which link stock control with accounts, and these are particularly useful if you bear financial responsibilities. Of the three basic types of propriety computer programmes available (namely word processing, database and spreadsheet), the database is the most useful for stock control.

You will also find spreadsheet programmes useful, particularly if you are involved on the accounting side. Needless to say, a printer to produce "hard copy" is essential for this kind of work so that you have a permanent record of your reports.

Some basic hints in using computers this way are:

1. Always try and enter data in the form that you want to see it printed out. For example if you type in "kbr", don't expect the computer to print out "beaker".
2. Be consistent in the way that you enter data. Using the example in (1) enter either "bkr" or enter "beaker" for all beakers. If you enter a beaker as "bkr", and then ask the computer to list all "beaker's", don't be surprised if it misses out the "bkr".
3. Item (2) is allied to the GIGO principle. This is a universal and self-explanatory principle which simply states "Garbage In - Garbage Out"!
4. Try and retain printouts (hard copy) of all your work as they invariably provide a useful reference. .
5. Ensure that you have back-up copies of all of your data and programme disks (or tapes), and that your working data disks are copied onto your back-up disks regularly.

SAQ 7

Give three uses of the computer/microcomputer in a science department.

6.9 CHANNELS OF COMMUNICATION

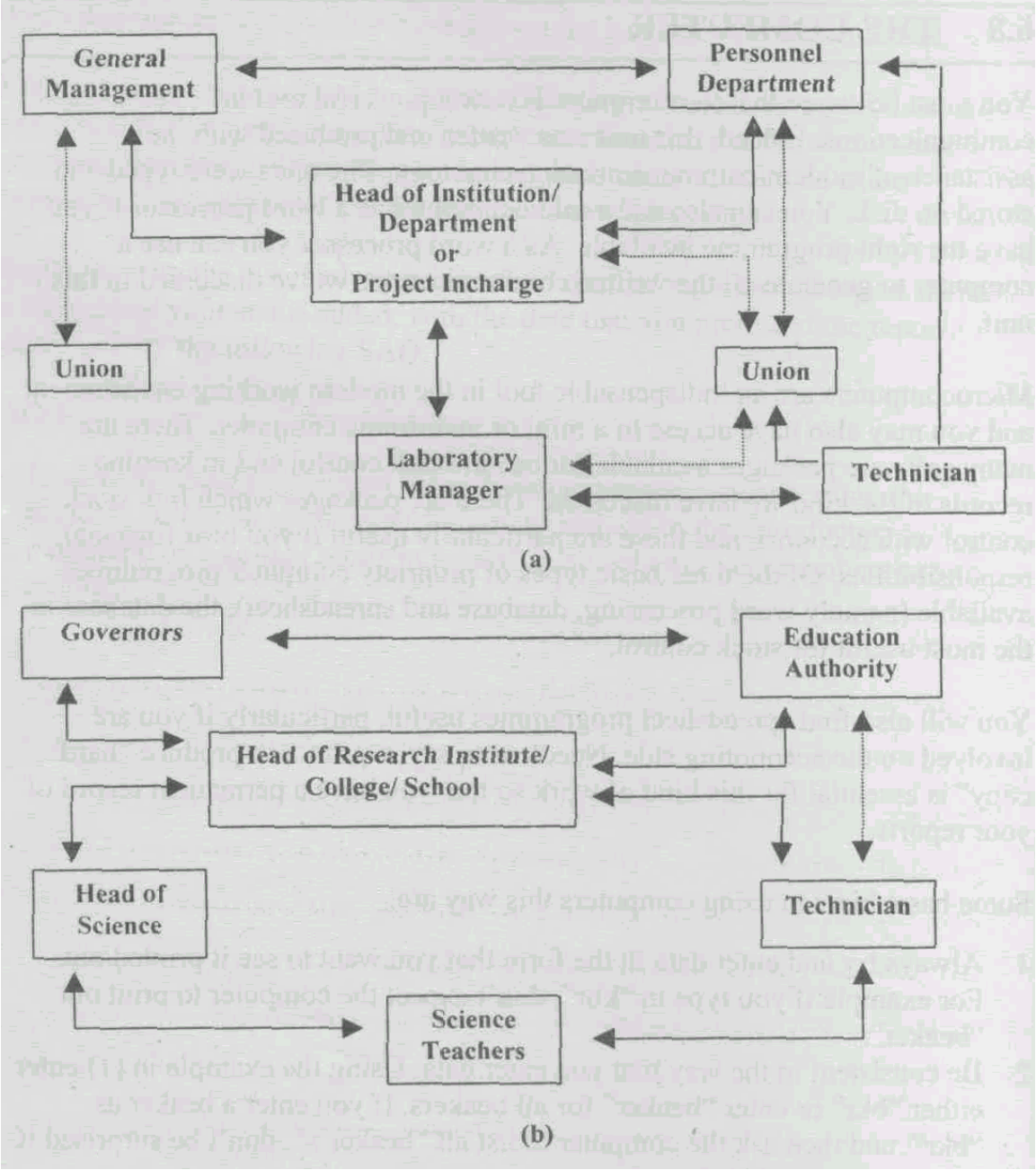

Fig. 6.2: (a) A general example, (b) Example in an education lab.

Note: _____ unrestricted path of communication.
…….... restricted path of communication.

Having discussed how to communicate with people, let us now consider the people with whom we need to communicate and the ways of communication that are most appropriate. After all, you might be an extremely effective communicator, but if you don't use the correct channels of

communication your efforts will be wasted. Worse still you could easily provoke an adverse reaction from some "links" in the chain! Fig. 6.2 illustrates two typical chains of communication. You will appreciate that there are variations possible, e.g. a lab might have trainee technicians working under supervision. In this case, there would be slightly different channels of communication.

First, consider Fig. 6.2. The main channel of communication for a lab technician is to the lab manager or, in a school for example, the head of the science department. It is likely that the responsibility for the employment of lab technician is part of this person's (Head's) duties. This means that, in theory anyway, he or she is the person who directs the technician's activities. Here, the line of communication is an unrestricted two-way channel and the formality inherent in it depends on the relationships at work. Both parts of Fig. 6.2 could be represented in general as shown in Fig. 6.3.

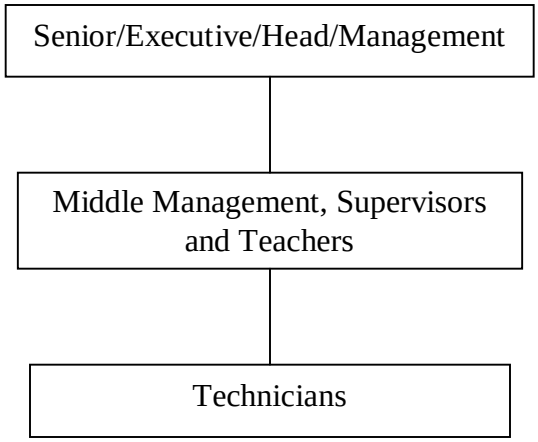

Fig. 6.3: General lines of communications

This figure shows fairly limited view of organizational structure and communications, and there are of course many other possibilities. Now try the following SAQ to test what you have learned in this section.

SAQ 8

Consider Fig. 6.2 and Fig. 6.3 together. We said that Fig. 6.3 is a general summary of the two situations illustrated in Fig. 6.2. In fact there are also two important links in the chains of communication that are missing. One link is that of the personnel/advisory office. What is the other?

_____

_____

6.10 SUMMARY

Let us now summarise what we have studied in this unit.

- Communication is a two-way process whereby transmission of messages or exchange of ideas, facts or opinions occur between the persons as well as between the systems.
- Oral, written and use of computers are the three ways by which
- communication can be carried out effectively. It is important to choose the most suitable means of communication at an appropriate occasion.

- Written communications can be personal or official. Official
- communication can be in the form of letters, memoranda etc. Reports are made to write about any event.
- In the present day computer is a powerful tool in the communications. Infact it is increasingly becoming an essential tool for communications and other purposes such as for filing and keeping records.
- Along with what to communicate and how to communicate it is also important to know whom to communicate. In any organisational set-up there is a channel through which the communication should travel.

6.11 TERMINAL QUESTIONS

1. On which of the following occasions do you think the telephone would be the most suitable sole means of communication?
   (v) Checking train times at the nearby railway station
   (vi) Ordering food for livestock
   (vii) Asking for details of a training course
   (viii) Booking a place on a training course

   _____

2. List three examples from your working life when written communications are essential.

   _____

   _____

   _____

3. Recall the three situations outlined in SAQ 5. For each, how would you contact the person/organization concerned? Include all the means that you would use, in chronological order, and mention any other person/people who might be involved with the communication process.

   _____

   _____

   _____

4. Which of the following words could be used to describe a well-presented memo? (Select as many as you wish)
   (viii) Polite
   (ix) Concise
   (x) Signed
   (xi) Brief
   (xii) In note form
   (vi) Detailed

5. Below is a letter that a technician drafted to a supplier to complain about an item of defective equipment. What, if anything, is wrong with this letter? Correct the letter by rewriting it in the space given below (using your imagination to insert any missing information).

Dear Sirs

We have received a delivery from you containing 10 porcelain crucibles, 3 of which wer broken. I demand that you replace the broken ones immediately.

Yours sincerely

_____

_____

_____

6.12 ANSWERS

Self Assessment Questions

1. (i) Appropriate means of communications
   (ii) Language
2. (i) (1) You can always retain a copy.
   (2) You have the time to identify the precise words needed for any situation. In other words you have time to write exactly what you mean,
   (ii) You might be able to obtain an immediate reply or response. For example, if you request "urgent action" in a letter, you would expect some sort of action within a working day of receipt of your letter – this could mean a delay of days. However, if you requested "urgent action" in an oral communication, you could reasonably expect within minutes.
3. (a) It is verbose, and while it is correct, it is badly written and difficult to understand easily.
   (b) It is too abbreviated to be either courteous or concise.
   (c) This would be appropriate for (1) - a supplier. There is sufficient information for the supplier to identify the product; the use of the word "please" incorporates some courtesy; and the abbreviations are acceptable.
   (d) This would be appropriate for (2) as it is polite and contains sufficient information.
4. (1) Addresses - Sender's address block should be located top right not left, unless the letter is on printed note paper. It is better if the addressee's address is set below the last line of the sender's address, but set left as shown.
   (2) Date and references - These are better grouped below the sender's address.
   (3) Style - While this letter conveys its meaning, it could be structured better and expressed in a more business - like fashion. For example, the first sentence would be better put as "I apologize for the delay in fulfilling the above mentioned order. This is because this item is out of stock". Note the use of "I" and not "we" - if you sign a letter personally then you should be direct in what you say. The other sentences could be tidied up in a similar way. This letter is an example of the use of clinches i.e. shortened form of the expression, e.g. "nil stock", "unable to invoice you".
   (4) There is no indication of the title of the writer - Mr. Miss, Mrs., or Ms. Also the signature block would normally be ranged left.

Science Equipment Ltd.
50, Onikoko,
Abeokuta Road
Lagos.
4th April 2000
Our ref: DRS
Your ref:

The Chief Technician
Chemical Industries Ltd
Okpala Industrial Estate
Ilupeju
Lagos.

Dear Sir,

Re. Your order no. E023904

I apologise for the delay in fulfilling the above mentioned order. This is because this item is out of stock, but new stocks are expected within twenty-one days. Do you wish to cancel this order and re-order for April invoicing, or do you require the order to stand?

Yours faithfully,

D.R. Abubakar
Sales Office

5. (1) The supplier and, possibly, the carrier.
   (2) Caretakers, or perhaps the lab manager or Head of the Science Department. This depends on your channel of communication for reporting faults of the buildings, fittings and services at your workplace. Usually there will be a set procedure which may eventually lead to the works manager or works department.
   (3) If you are employed by an education authority you would need clearance from your head of science, (science adviser, inspector and personnel officer). If you are employed by, say, a company, you would contact your lab manager and personnel and training officers.
6. (1) 1. Date.
   2. Approximate time
   3. Place
4. Name(s) of person/people directly involved.
5. Whether there were other people in the area (as possible witnesses).
6. Brief description (one sentence) of nature of incident. The next part of the report would contain a detailed description of the incident as you saw it and what action was taken by you and other people.
   (2) (i),(ii),(iii),(v),(vi)and(vii)
7. (1) For simulations of experiments and educational use.
   (2) For keeping records of stock, etc.

(3) For keeping and printing copies of worksheets, etc.

8. The trade unions are the missing link. Just as you will be in direct communication with the personnel office, in relation to your pay and conditions of employment, so you may be in direct contact with a trade union in the form of a safety representative, local representative, or even local secretary. Both trade unions and personnel offices are available for the discussion of employment-related matters and advise managers through appropriate committees and groups, independent of the usual channels of communication.

Terminal Questions

1. (i) (iii).
2. Your list could include
   (1) Your employer[1] s statement of safety policy.
   (2) Your pay slip.
   (3) Orders for goods.
   (4) Requests for building repairs and maintenance, etc.
   (5) Requests for leave.
   (6) Accident/incident reports.
3. (1) To the supplier: telephone followed by letter. To the carrier: letter (sent immediately as there is a time limit for complaints). (These letters would be signed by the head of department or other person with sufficient authority).
   (3) To the caretaker: oral. To the head of science or lab manager: oral, and then a memo.
   (3) To the head of science or your personnel/training officer: oral and, perhaps a letter. To the Area Education Office (if applicable): a letter. (If your head of school is supportive, he/she might write on your behalf).
5. (i), (ii)
   (v) is wrong.
   (iii), (iv) and (vi) could apply, depending on the nature and amount of information that is being given.
5. The letter lacks:
   (1) date of delivery
   (2) delivery note number
   (3) order number
   (4) catalogue number

   In addition, the second sentence is much too abrupt and "Yours sincerely" is incorrect. It would be better written as follows.

Dear Sir

On 10 January 2000, we received some goods from you (with delivery note No. Z1234) in response to our order no. A5678. Unfortunately three porcelain crucibles (cat. No. L1112) were broken.

Please would you replace these at your earliest convenience?

Yours faithfully,

V. Olowonla
Lab Manager

UNIT 7 FILES AND RECORDS

Structure

7.1 INTRODUCTION

In modern days an office acts as information centre. It is a place where information is collected, processed, stored and made available for the conduct of various activities of an organisation. In these modern times there is lot of written communication which generates large amount of papers. Thus the filing, its system and methods become highly important. Filing constitutes the core of record keeping. It serves as important aid to office persons because we cannot rely on memory alone. In order to run the laboratory work we all need to refer some person or to a variety

of publications and papers. The problem is where to go and find the proper papers. The correct and efficient filing is answer to the above raised questions. In this unit you will study about various filing systems, their function, types of records, filing procedure, way of cataloguing and record maintenance.

These records become handy in case of emergency. If you are keeping the records of instruments, chemicals, glassware, instructions given from time to time, etc. you will be able to do work and monitor it in a better way. These records can be kept in files, record books and computer files. In this unit you are going to study various filing system, types of records and how the records are kept.

Objectives

After studying this unit you will be able to:

understand the importance of filing and filing systems,
describe suitable system for filing science stock and paperwork using some examples,
describe ways of cataloguing,
state what records should be kept and what information should be recorded (including abnormal incidents), and
maintain a record of breakages and report them periodically to the persons concerned.

7.2 SOURCE OF INFORMATION

In the last few years there has been a vast growth in the development of information system and the generation of information. Along with this development comes the real problem of finding out relevant information quickly and easily. This problem can be solved by proper filing system and record keeping.

In general there are three principal sources of scientific information:

1. Original papers published in learned journals (primary sources).
2. Compilation of data on specific subjects (secondary sources)
3. Text books (tertiary sources)

7.2.1 Classifying Secondary and Tertiary Information Sources

Secondary and tertiary sources are usually in the form of books or recorded material which are commonly stored in libraries. In an attempt to overcome the problem of locating information, libraries have adopted a standard method of arranging publications so that information can be readily found. An example of a standard system is the Dewey Decimal Classification System. This consists of assigning an arbitrary number to broad areas of human knowledge. These large areas are then subdivided again and again so that the more subdivisions there are, the more precise is the definition of the subject.

In the Dewey Decimal System, the number 5 is ascribed to scientific subjects. The system is then progressively sub-divided as shown in Fig. 7.1.

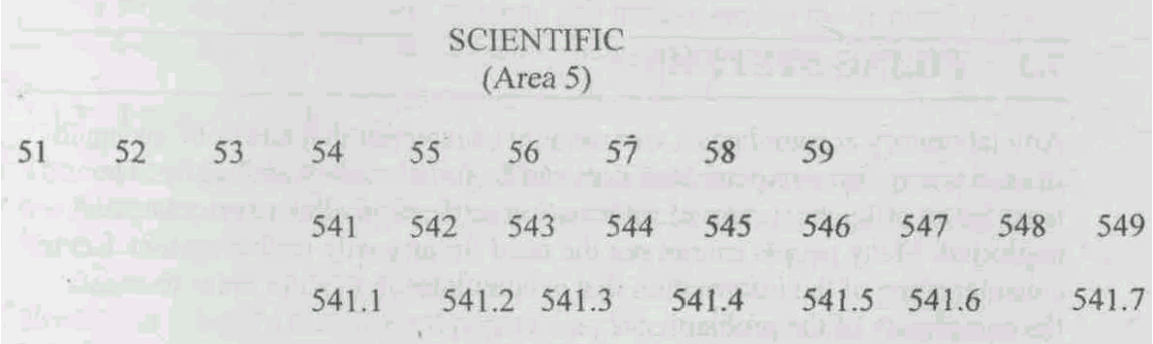

Fig. 7.1: Dewey Decimal System for Science

Books in libraries, therefore, are arranged in a numerical order. However, the great disadvantage is that the Dewey Classification number is assigned by a librarian who may be guided by the title rather than the content and thus assign an inappropriate number. If this happens it can be very difficult to find a particular book.

The Dewey Decimal System could be applied to some types of equipment classification. For example, a large collection of microscopes could be effectively indexed using the Dewey Decimal System.

7.2.2 Sources of Information in the Lab or Prep. Room

Every lab ought to contain two or three reference books of information for everyday use, such as:

- Essentials of plant techniques, scientific publishing, Enugu, Nigeria.

There are other sources of information which are valuable and might not be found in the library such as trade catalogues, e.g., the Catalogue from various manufacturer and exporters, technical specifications, articles from periodicals of interest to technicians such as *Laboratory News* or *Laboratory Digest*, and so on. Again some method of cataloguing and accessing these must be devised.

The following is atypical list of sources of information:

(1) Reference books
(2) Catalogues
(3) Card indexes
(4) Computer databases
(5) Personal experience

As you can see, information sources are widespread and various, and to locate precisely the material you require can be a formidable task without expert advice. To simplify matters, most sources of information have a reference/index system, which enable large quantities of information to be examined quite quickly. The aim of constructing such an indexing system is to enable relevant information to be stored and accessed quickly.

Essentially, the manager of each lab must decide on the sources of information that are required and then stock and store these, if these are appropriate. (Some reference books are expensive and it may make economic sense to use local library for these).

7.3 FILING SYSTEMS

Any laboratory accumulates a vast amount of material that has to be arranged in such a way that any particular item can be found readily and easily. The need for an efficient system of information retrieval is often overlooked and neglected. Many people cannot see the need for an easily usable system. Let us consider some of the information that accumulates in a lab in order to assess the complexity of the problem.

> File: Information located forever. Not more than 200 pages should be accommodated in one file. Always use tag for filing papers. Always number your file papers.

(1) Correspondence and related materials
(2) Literature references
(3) Indexes for slide and film libraries, samples, general stock, etc.
(4) Manufacturers' catalogues and specifications

None of this information can be ignored if it is required in a lab's work. At some stage someone will need to gain access to the material quickly and easily. The test is 'is it relevant to the lab's work?' If it is, it is worth keeping. If not it can be thrown away. Filing is often a job to be delegated to the most junior member of staff because it is considered to be too boring a work.

7.3.1 Aims of Filing System

A filing system aims to keep information in its proper place so that it can be easily retrieved when needed. Bearing this in mind, it might be useful to outline what makes for a good filing system:

(a) It should be clear and easily understood.
(b) It should be accessible.
(c) It should be adaptable and easily updated.

All of these are made easier by some kind of indexing of each group of items by some kind of "key" e.g. alphabetical or numerical ordering, or colour coding.

7.3.2 Classification of Files

You can classify the files in different ways. Some important ways are given below:

(i) **Alphabetical classification:** This is the simplest method of classification in which files are arranged strictly in alphabetical orders.
(ii) **Numerical classification:** Under this method you can give supplier or subject a number and all the papers are placed in one folder bearing distinctive number as allotted. The folders are arranged in cabinet in the numerical sequence and guide cards are used to divide them into suitable groups of 10 or 20. The numerical filing may be combined with alphabetical system e.g. A-l, A-2, A-3 and so on and files are kept in this order. It is called 'Alpha-numerical filing' which is more flexible than the alphabetical or numerical filing.
(iii) **Chronological classification:** In this method the papers are filed date wise in a sequence as and when correspondence has taken place. It is suitable for filing correspondence.
(iv) **Subject wise classification:** Under this method, records are classified according to subject matters of papers. For example there may be one folder for the main subject Botany (general), Chemistry, Physics, Electronics, Zoology, and separate sub folders having lower plant, higher plants, physical chemistry, organic chemistry, inorganic chemistry etc.

7.3.3 Filing methods

The conventional methods of filing (like metal holders, bound or guard books, box filing) are not of much use. Nowadays there are: (1) Horizontal filing (2) Vertical filing.

Horizontal filing: In this method papers are placed in folders and folders are kept in horizontal position. Folders or files are kept one upon the other and the papers are inserted in the order of date on which received or despatched. Naturally, the latest papers are found at the top. An index prepared allotting number to the files.

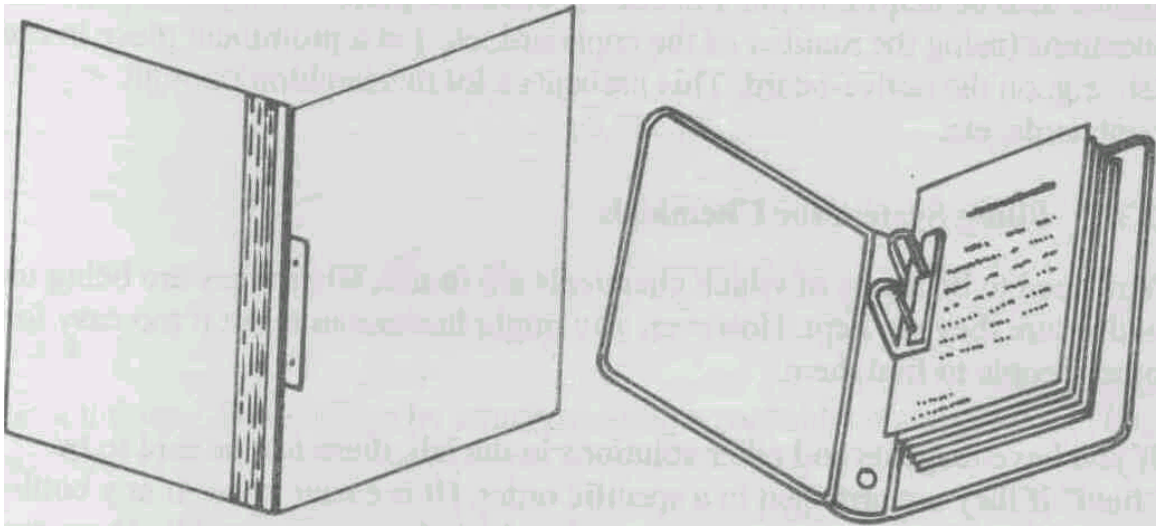

Fig. 7.2: (a) Flat tile, (b) Arch lever file

Vertical filing: Under this method all the papers, folders and files are kept in a vertical or standing upright positions. We will show you some equipment required in vertical filing by figure only.

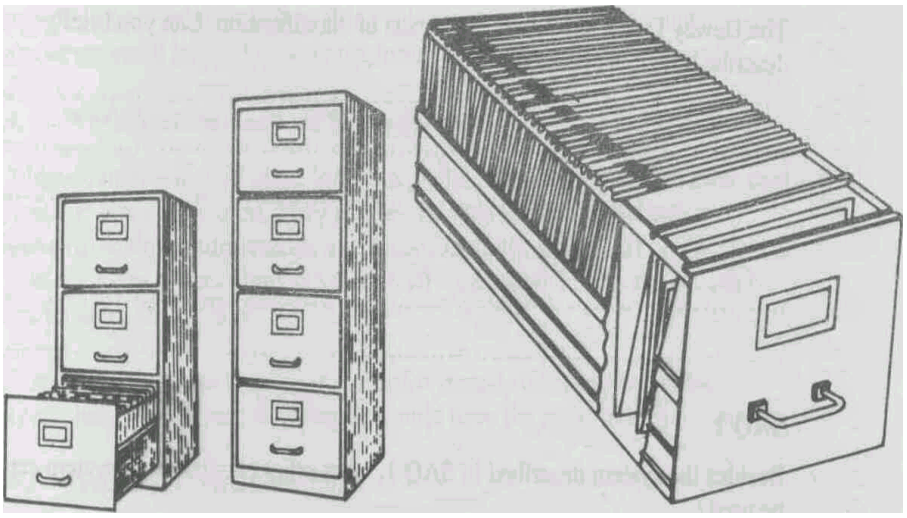

Fig. 7.3: (a) Vertical filing cabinets, (b) Cabinet with drawer and folders

7.3.4 Filing System for Equipment

You may have thought that our description of the storage of apparatus and equipment as a filing system was inappropriate. Yet this is not entirely farfetched. For example, retrieval of specific items is aided by the clear numbering and labelling of cupboards, drawers, shelves, etc. Plastic embossing tape can be used but if vandalism is a problem, white, plastic drafting or artists' tape (which can be written on with spirit-based felt-tip pen) is very useful. Using a stencil to paint the name of the contents of the cupboard, etc. on the door can create problems if you decide to move things round!

If you find that glassware and other small pieces of apparatus tend to "wander" from lab to lab, you can "colour-code" each lab's contents using a spot of paint of the appropriate colour on each item in a lab (selecting a site where the paint will not be burnt off during heating).

It may also be helpful to put a list of the common pieces of apparatus and their locations (using the number of the cupboard, etc.) in a prominent place in each lab, e.g. on the notice-board. This prevents a lot of searching through cupboards, etc.

7.3.5 Filing System for Chemicals

You need to be aware of which chemicals are in use, where they are being used and where they are kept. However, you might hesitate to make it too easy for other people to find them.

If you have reagents and other solutions in the lab, these can be said to be "filed" if they are arranged in a specific order. (It is easier to see if any bottles are missing if you have a set sequence in which they are arranged). There are several ways in which solutions can be arranged, e.g. alphabetical order, sets for particular experiments (such as staining slides or food tests), in order of oxidizing power (for bench acids), in order of strength (for bench alkalis), etc. If you use plastic embossing tape for "permanent" labels, you have the opportunity to incorporate a system of colour-coding.

SAQ 1

The Dewey Decimal System is a means of classification. Can you briefly describe how it is operated?

_____

_____

_____

_____

SAQ 2

Besides the system described in SAQ 1, what other classification system can be used?

_____

_____

_____

_____

SAQ 3

What sources of information do you think should be held in the lab/prep, room?

_____

_____

_____

_____

SAQ 4

Can you think of three ways by which locating a particular chemical could be made easier?

1.
2.
3.

7.4 FILING PRINTED AND WRITTEN MATERIAL

It is important not to let printed and written material accumulate, otherwise filing becomes a monumental task. There are a variety of headings under which paperwork can be filed and a variety of places in which it can be filed. Boxes, folders, varieties of files, filing cabinets, card index boxes and computers can all be used to store the information recorded.

7.4.1 Worksheet/Instructions for Experiments

A filing cabinet is a good place for these. Failing that, a cardboard storage case or suitable box can be used. They can be arranged in a variety of ways depending on the circumstances, e.g. according to the group/s of people that would use them or according to topic. In all cases, an indexing system can be used, together with a "key".

Incidentally, if you are keeping ink or spirit stencils that have been used to prepare these worksheets, the stencils should have the same indexing systems.

7.4.2 Technical Communications

These are notes, diagrams, etc. that are produced to provide theoretical scientific information. A filing cabinet is the best place to keep them, but of course, the originator concerned may wish to keep them. Once again, if an indexing system is used for these hand-outs, the same system should be applied to any stencils prepared.

7.4.3 Instructions for use of Apparatus

One or more box-files or lever-arch files are suitable for these [see Fig. 7.2 (b)]. If you have more than one set of instructions for a particular piece of apparatus you must decide whether to file them all in the same file, create a back-up file with the spares or throw them away.

Alphabetical order is as good a way to file them as any other. You could file them according to manufacturer/supplier wise and then in alphabetical order. It is a good idea to keep guarantees and service or maintenance agreements with the instructions, although you could create special files for these. There is also a case to be made out for keeping guarantees with the instructions. The alternative is to create a special file for guarantees. The same can be said for service/maintenance agreements. Either file them with the instructions for use of the apparatus to which they refer or create a file specially for service/maintenance agreements.

7.4.4 Correspondence

The widespread use of the telephone seems to have reduced the volume of correspondence that is generated. But for now, there will still be some level correspondence. If the volume of this is small, a lever-arch file is suitable: file incoming letters in the front, and copies of outgoing letters in the back. Incoming letters can be numbered whilst outgoing letters can be filed by alphabetical order of the addressee and put in date order. It might be useful to keep a brief summary of each letter at the front of the file; an example is shown in Fig. 7.4.

No.	*Date*	*Sender*	*Subject*
1	11.11.99	Ashaye John	Quotation for electronic balance
2	14.11.99	Job & Company	Will send replacement prism
3	21.11.99	Haruna-Chigbo	4 mm spade adapters discontinued

Fig. 7.4: Index for File of Incoming Correspondence.

These letters are also kept in date wise order and with the most recant one having the highest number.

7.4.5 Orders

If you are involved in ordering materials or equipment for your lab, you will require a file to house copies of orders that have been sent and possibly delivery notes on which you have written the date of the goods arrived. You may also keep accounts.

Even if, you don't keep copies of the actual orders, you might choose to keep copies of the requests for apparatus, materials, etc. that you have made.

7.4.6 Requests for Equipment

Your main function is to provide equipment for experiment and investigations. The first stage in this process is for someone to ask you for certain items. It is not enough to have an oral request; to avoid confusion, a written requisition is vital, and it should be made available to you some time in advance. It is also possible that the same requests will be made year after year or by different people. It can save your effort, therefore, if you keep the written requests together with the list of equipment and materials that you supplied. You should also have a file containing requests that you have not yet fulfilled.

SAQ 5

Imagine that you are working in a school laboratory, and a biology teacher hands you a scrap of paper with the following written on it. "A dissection tray and animal for demonstration". You assume that this is a request for practical work but what further information would you need before you could provide the necessary apparatus and materials? (List the items of information below).

1.
2.
3.
4.
5.
6.
7.

7.5 SPECIAL FILES

As a lab technician some very important files are kept in labs under your direct supervision. We are going to describe such files in this section.

7.5.1 Safety File

Now we will describe what a safety file should contain.

Every now and again hazard warnings are issued. They originate from manufacturers/ suppliers, from your employer, from the scientific press and from union safety offices in case of factories, these should be filed in the Safety File. You might choose to include copies of memos reporting hazards and your subsequent actions, as well as any communications from safety representatives and management concerning safety. You can also keep the statement of health and safety policy of your employer if available in a safety file.

Any regulations concerning the use of a Lab's Safety instructions for the treatment of spillage, basic first aid and other information that is "safety" related should also be included in the safety file. If you have a Safety Check List, this, together with the records of such checks made from time to time, should also be kept in the Safety File.

With all this information, this file constitutes a useful package for new members of staff to read. In some establishments, new staff are required to sign a document confirming that they have read the Safety File.

7.5.2 Technician's File

Technician file is for you to keep any information that might be of use to you or your successor in the future. The form that it takes is a matter of personal preference. You could use any of the systems we have mentioned.

The file may include the following information:

1. *Names and addresses:* suppliers, sources of information, useful contacts, etc.
2. *Recipes:* for all the solutions, stains etc. that you have to prepare.
3. *Sources of specific items and materials,* e.g. fertile hens' eggs, hearts, insects, mouse, various chemicals, various instruments, glassware etc.

Technician's file must include asset's register, which include all the received chemicals, equipment, glassware etc. from time to time. In case of audit, you will be able to locate any particular item and place it for audit. This register or stock book should be passed to your successor in future.

No doubt you can think of many more things as file entries - especially if you are new to the job! In this case, there must be several things that you wish you could ask someone about. The technician's file would solve this problem.

SAQ 6

You have decided that, as there are now 25 slide sets and filmstrips (some with a taped commentary) in the biology section, the time has come to catalogue them.

1. What sort of indexing system would you use?
2. What information would you record for the catalogue? (Write you answers below.)

1.

2.

SAQ 7
From the list given below which items do you think should be placed in the Safety File?

(1) The employer's Statement of Health and Safety Policy.
(2) Lab Safety Regulations.
(3) Instructions for use of apparatus.
(4) Procedure when the fire alarm sounds.
(5) Employer's advice about hazards.
(6) List of chemicals in stock.
(7) Names and addresses of suppliers.
(8) Accident report forms.

(1), (2), (3), (4), (5), (6), (7), (8) - delete as appropriate.

SAQ 8
Give two reasons why it can be helpful to keep the previous year's requests for equipment, materials, etc. from your colleagues. (Write your answers below.)
(1) _____

(2) _____

7.6 RECORDS

Records means "any written matter or document prepared for possible future uses". It may be in the form of a letter, notice, circular, invoice, voucher, picture, chart, report, registers, books of accounts etc.

A record provides a summary of information. For example, if you want to know how many beakers you have in stock, you have at least two ways of obtaining this information. You can count the beakers in each lab and store or you can consult the stock record, (the accuracy that is required and when you last took stock will be relevant here).

If your lab had the misfortune to catch fire or suffer a major disaster, how could an accurate claim be presented to the insurance company? How can the number of accidents/near misses and incidences of bad practice, etc. be assessed and monitored? How can Excise department monitor the use of alcohol? How can you make sure that you know where specific pieces of equipment, etc. are? The answer to all these questions is not by relying on your memory, but is that you need to keep records. These can be kept on record cards, in record books, or on computer files.

Principles of record keeping

(x) Safety
(xi) Period
(xii) Economy
(xiii) Flexibility
(xiv) Classification
(xv) Justification
(xvi) Verification
(xvii) Accessibility
(xviii) Simplicity

7.7 STOCK RECORDS

As far as record-keeping is concerned, recording stock levels is likely to be most time-consuming. There are three kinds of record that are required. First is acquisition register where all purchases are entered. The second is stock register which reflect purchase, issue and active stock and the third one is laboratory indent register. The stock registers are maintained in stores. **One of the most important things to remember when you make a stock register is to count the pages and sign it.** Here we have an example of stock level records of biology lab. If you are following numerical classification then you may have register no. 1 for chemicals, Register No. 2 for glassware, Register No. 3 for apparatus, Register No. 4 for biological material, Register No. 5 alcohol etc. Now each year you can have a fresh register but again in the next year you will have Register No. 1 for chemicals and so on.

Whichever system you use, you should keep a list detailing stock kept in each lab, preparation room etc; from this you can draw up a "master" stock list of overall stock levels. Stock arriving or departing should be noted on both lists.

A separate register may be maintained for stock of rectified spirit, alcohol, lab animal, radio active material, poisons etc.

The time of year when you take stock will vary with your workplace. However, it is likely that the official inventory will need to be made up at the end of each financial year, e.g. 31st March.

The departmental stock records are probably best made up during a holiday or slack period. It is easier if two persons can take stock - one to count and one to record. Either file cards or a stock-book can be used to record stock levels in each lab/prep room/ storage area. File cards have the advantage that they are easier to keep in alphabetical order.

STOCK BOOK

ARTICLE _____

Month and Date		Particulars	Receipt			Issued Quantity	Balance Stock	Remarks
			Quantity	Rate	Amount			

Fig. 7.5: Illustrate stock-book entries

7.8 LOCATION

This is essential piece of information for anyone trying to find a particular piece of apparatus, etc. We mentioned that cupboards, drawers, etc. should be numbered and labelled with their contents. The location specified for each piece of apparatus should be unique.

A plan of the lab showing the siting of numbered cupboards together with a list of the contents of each numbered site pinned on the notice-board or stuck on a wall in the preparation room will provide a useful reference.

Location of people is also important. To this end, you need to know who is using and in which lab during the day and where each member of the department would normally expect to be working. You should know and, if necessary, have evidence to show where the people are working at any time in science department. To facilitate this, you need to know who has borrowed what and where he is using it.

7.9 RECORDING LOANS

All loans of stock, both apparatus and books, should be recorded in writing, no matter what time-scale is involved. In the case of apparatus and equipment, you need to know the name of the person concerned, what he/she is borrowing (and possibly why), where he/she is going to use it and when you can expect it to be returned. Items that feature in the official inventory should not be removed from the premises unless written permission has been given. In this situation, you could record this written permission with the loan details. "Borrowing" stock is not the same as using stock that you provide for experimental work.

In an educational establishment, it is necessary to record loans of textbooks to students. This is made easier if sets of books are numbered so that individual books can be identified. If an exercise book is ruled appropriately, it makes a useful loan record.

7.10 RECORDING STOCK USED AND MISUSED

On an hourly basis you should know what is being used, by whom and where it is being used. You will know this from the requests that have been made by other staff. There are three specific instances where you need to record the use of some materials in a little more detail:

1. Use of listed poisons;
2. Use of radioactive sources; and
3. Use of alcohol.

7.10.1 Record of Use of Listed Poisons

This should apply, to the substances that are locked in the poison cupboard, taking care that the same top and liner are in place. Your record should state the date, the substance withdrawn, the person responsible, for what it is required, the mass of substance used and your initials to denote that it was returned to the poisons cupboard. The mass of substance used is most easily determined by weighing the bottle when it is issued and again when it is returned. A book is most useful for recording these "before use" and "after use" masses and a specimen entry is shown in Table 7.1.

Table 7.1: Specimen entry in a Poisons Book

Date	*Name of User/ Supervisor*	*Group*	*Substance*	*Mass on Issue*	*Mass on Return*	*Used*
5.11.99	Mr. Jalingo	A1	Barium carbonate	541.8 g	536.1 g	5.7 g
8.11.99	Mr. Ram	(C22)	Barium nitrate	235.5 g	215.5 g	20.0 g

7.10.2 Record of use of Alcohol (Industrial methylated spirit absolute and ethanol)

As far as record-keeping is concerned, there are two aspects involved. First, you should keep a copy of the letter which is sent to the supplier of methylated spirits when you wish to buy alcohol. Secondly, it is considered to be good practice to keep a record of all the alcohol that is issued and new stocks that are received. A book is useful for this and specimen entries are shown in Table 7.2 which indicates stock positions of methylated spirit.

Table 7.2: Specimen entries in stock book for methylated spirit

Date	*Volume Issued*	*Area of Work*	*Cumulative Addition*	*Stock Remaining*	*New Stock*
4.11.99	100ml	R&D	100ml	2.4 litre	
5.11.99	250ml	Microbiology	350 ml	2. 15 litre	
8.11.99	50ml	Workshop	400ml	2. 10 litre	
8.11.99					2.5 litre
11.11.99	100ml	Quality Assurance	500ml	4.5 litre	

7.10.3 Record of Breakages

Misuse of stock is generally concerned with breakages and these usually involve glassware although all types of stock can be included. A book is useful for recording breakages and each lab should have its own "Breakage Book". The entry should include the date, name of person responsible, article broken and member of staff in charge. Whether or not you include a column for the cost of the article (for you to fill in afterwards) is a matter of policy.

There are one or two more details about equipment that we need to mention but which have not fitted in with our classification so far.

7.11 INFORMATION ABOUT EQUIPMENT

Equipment, in this context, is being taken to mean items that need a power supply of some kind and which are likely to be enclosed by a metal or hard plastic case.

7.11.1 Serial Numbers

Most of the expensive pieces of equipment have a serial number engraved on the name plate that tells you the operating voltage and current used/power consumption. It is important that the serial number should be recorded so that the equipment can be identified when stock is checked,

insured specifically and identified by the supplier/manufacturer in the event of a fault or complaint. If you keep a card index file of stock, the cards make an ideal place to record the relevant serial numbers. If you record stock location and serial number on a record card, you will have cards similar to the one illustrated in Fig. 7.6 or you can keep a separate record for this purpose.

Details of Item	*Inventory Kef.*
e.g. Make, Reg./Cat. No. Serial No. Location details	

Front

Date	No. in stock

Reverse

Fig. 7.6: Specimen Record Card

7.11.2 Maintenance Record

Your workplace may have a service contract covering such things as balances. This means that they should be checked (and repaired, if necessary) by a visiting engineer. If you don't have a service contract or if it is not possible to have one, you may choose to maintain some pieces of apparatus and equipment yourself, e.g. microscopes. It may also be necessary to send a piece of equipment back to the supplier for repair. In all these cases, you should keep a record.

7.11.3 Electrical Checks

Each piece of equipment that uses mains electricity should have its plug, cable, and fuse checked at least once a year, and you must keep a record of the checks that you make. Once again, a card index system can be useful. Each piece should have its own card. If you have several similar items with no serial numbers you must allocate each with a means of identification so that you can distinguish between them. A simple record card is shown in Fig. 7.7.

ITEM: Balance No: 2
MAKE: Torbal MODEL: PL400
SERIAL NO: 502186 POWER RATING: 400 W

Fuse		Plug	Earth	Date
Rating	Comment	Comment	Comment	
2A	OK	OK	Good	21.7.99

Fig. 7.7: Record Card Showing Details of Electrical Check.

7.12 MISCELLANEOUS

We are now left with three types of record that we cannot classify by any stretch of the imagination. The only way is to present them "as they come"!

7.12.1 Accident/Incident Record

All accidents, however minor, should be reported through appropriate channels. Most workplaces have an accident reporting procedure based on written reports which comply with statutory requirements and recommendations. However, it might also be appropriate to keep a record in your department. Certainly, a record of "incidents" should be kept. In both cases a book can be used. These provide a more permanent record than a loose-leaf file from which pages can easily be removed and mislaid.

7.12.2 Orders and Accounts

This is a topic that we mentioned in section 7.4.5. As far as a record is concerned, this will only apply if you handle orders. If you file orders, it can save time to have a list at the beginning of the file, showing date, order number, supplier and expected cost. In order to keep track of the expenditure, you will need to record the prices paid for goods, etc. If you handle petty cash, you will also, naturally, need to keep a record of income and expenditure.

7.12.3 Key to Unknown

In Chemistry, it is often the practice in educational establishments to give students unknown substances (unknown by them, that is!) to analyse. If you keep such a set of substances for use each year, it is important that you keep a record of the identity of each substance! It is also important that you keep this record in a safe place and that you remember where you put it.

Well, we have covered a number of records in this section and we acknowledge that it is quite possible that you might keep a record that we have not considered. Before we leave records, however, there are just a few general points to be made. Where to keep your records deserves some thought.

For records to be of any use in an emergency, they need to survive. Therefore, you should try to keep them in a relatively safe place.

For information useful for the day-to-day work in the labs, don't neglect the notice-board as a useful place to keep records. Records such as timetables, lists of batches of students, student number, etc. can well be displayed on a notice-board in the preparation room.

Finally, you should give some thought to the security of your records. If you handle any confidential information, this must be kept under lock and key, within the preparation room. This makes a lockable filing cabinet almost essential (although lockable desk drawers can be used).

SAQ 9

Would it be a good idea to keep your chemical stock records in the chemical store? (Explain your answer in one or two sentences.)

_____

_____

_____

SAQ10

Give three examples when up-to-date records could be useful. (Write your answer below.)

_____

_____

_____

_____

_____

_____

SAQ 11

List all the information that might need to be recorded about (Write your answer below).

(1) Top-pan balances,
(2) A video tape, and
(3) Chemicals.

(1) _____

_____

(2) _____

_____

(3) _____

_____

SAQ 12

Name three materials whose withdrawal from stock should be recorded. (Write your answer below)

(1) _____

_____

(2) _____

_____

(3) _____

_____

SAQ 13

Suggest how a record of breakages could be set out. (Write your answer below)

_____

_____

_____

_____

SAQ 14

Give two reasons why it can be useful to keep a record of "incidents" and/or "near-misses". (Write your answer below)

(1) _____

_____

(2) _____

_____

7.13 SUMMARY

A filing system is necessary for smooth running of any office, school and laboratory. All the information about experiment, chemical, stock books and correspondence should be clear, accessible, adaptable and easily understood in a good filing system. There are various systems of filing for science stock, paperwork and for practical. The catalogue filing can be done in different ways. The record of information about abnormal incidents is also to be kept for being reported to proper authority. Another important aspect is the recording of listed poisons and alcohol used. Record keeping is an important aspect of laboratory safety.

7.14 TERMINAL QUESTIONS

1. In the space below, write a list of items found in your lab that require filing. (Use only as many lines as you find necessary).

1)
2)
3)
4)
5)
6)
7)

2. Write a list of records that need to be kept in your lab. Describe each group of records from the point of view of the information that the record gives rather than listing specific details. An example of this would be "stock levels". (Use only as many lines as you find necessary).

1)
2)
3)
4)
5)
6)
7)
8)

3. Imagine that you have just taken a job as a sole technician in a science lab. You find that there is no technician's file. Write a list of headings that you would use in preparing such a file and give a few details about the contents under each heading.

4. Describe, in your own words (not exceeding 200), why you think that filing and record-keeping systems are necessary.

5. Write down in the space provided brief definitions for the following terms. Channels of Communication

Inventory

Requisitions

Stock Level

7.15 ANSWERS

Self Assessment Questions

1. The Dewey Decimal System involves assigning arbitrary numbers to broad areas of knowledge. These large areas are then subdivided again and again so that the more subdivisions there are, the more precise is the definition of the subject. See para 1.1.2.
2. Alphabetic. This system is used where only a simple system is required, e.g. filing of catalogues.

3. Every lab ought to contain two or three reference books of information for everyday use. Trade catalogues and articles of interest to technicians from periodicals should also be held in the lab.

4. You may have given any of the following three ways, all of which help in locating chemicals:
   (1) Labels on shelves;
   (2) A chart; and
   (3) A plan on the door of the store room.

5. (1) Date
   (2) Time and duration of class
   (3) Room/lab
   (4) Class set/demonstration
   (5) Which method of preparation
   (6) Which animals
   (7) Any other chemical, e.g. chloroform

6. (1) You have a choice. If they fall into definite categories, e.g. botany, histology, etc., you could give each category a prefix letter and then use numbers (this means that some would have the same numbers but different letters) or you could just use consecutive numbers. You should not use letters only since would run out of letters quite soon in future!
   (2) Title and whether or not there was a taped commentary. If you include the number of slides in the set or frames in the filmstrip, this could give some indication of the time they would take to be shown.

7. All could go in the Safety File except (3) and (7).

8. (1) So that you can get back to see what you provided when a similar request came in the previous year.
   (2) So that you can demonstrate the amount of work that you did in a given period of time!

10. No, for three reasons.

   (1) In order to refer to them, you would have to go to the store.
   (2) The atmosphere inside the store will not facilitate preservations of records.
   (3) In the event of a fire or explosion in the store, the records would be lost.

10. Choose from the following:
   (1) after a fire,
   (2) after a theft,
   (3) when reordering, or
   (4) when tracing down a specific item.

11. (1) Make and model
   Date of purchase
   Serial number
   Service/repair history
   (2) Title
   Running time
   Type of cassette, e.g. VHS.
   (3) Name Grade
   Catalogue number
   Date of receipt/transfer (from store to use)
   Hazard/s

Stock level

12. (1) Radioactive sources
    (2) Industrial Methylated spirits/Ethanol
    (3) Poisons

13. One possible way would be as shown in below – using an exercise book for each lab;

Date	*Name of the person responsible for breakage*	*Group*	*Article broken*	*Cost*	*Initials of Supervisor*

14. (1) To identify a commonly-occurring type of incident, e.g. a chemical reaction which often behaves unpredictably.
    (2) To identify a faulty technique, experiment or procedure.

Terminal Questions

1. The headings that we came up with are:
   (1) Equipment {including apparatus and glassware).
   (2) Chemicals (including radioactive sources).
   (3) Books.
   (4) Audio-visual aids.
   (5) Printed and written material.
   (6) Safety notes.
   (7) Technician's file

2. Your list could include:
   Stock levels of apparatus and chemicals Locations of apparatus and chemicals Book loans - text and reference
   Equipment on loan
   Service/maintenance information
   Accidents/incidents
   Electrical checks
   Apparatus and materials requested by colleagues
   Experiments performed
   Alcohol used
   Radioactive sources - stock and use
   Use of poisons
   Orders placed and expenditure

3. If you don't find the technician file then you should go through the previous correspondence file and would be able to make a list of following
   1. Supplier - names and their addresses.
   2. Useful contacts - name and their addresses
   3. Any useful information
   4. All the recipes of stains and solution that you have to make.
   5. Sources of specific items
   6. Sources of materials
   7. Record of files - you will like to see what is on file records.

4. See summary 7.13.

---

5. Channels of Communication
Formal lines or chains of communication throughout the organization.

Inventory Stock levels.
Requisitions

Written documentation of stock items in your charge, which is provided by the user, giving details of what is being used, by whom and where.

Stock Levels
A continuously updated record of all items for which you are responsible in your working environment.

UNIT 8 SCIENTIFIC REPORTING

Structure

8.l INTRODUCTION

Experimental investigation is one of the corner stones of scientific study – which is why many educational establishments have science labs. However, an experiment alone is quite useless without accompanying written reports for explanation, verification and hypothesis. For instance, what use would it be conducting an experiment in which you measured the time taken for a 100 g apple to fall 3.2 m from the top of a tree to the ground once? Even if you did write up this experiment in detail, it is unlikely that your conclusions would cause any excitement. But if your experiment was repeated many times for different masses of apples and different heights of trees; and your report included details of method, errors and observations; and the data was appropriately presented; your experiment would begin to have some scientific value. This unit will show that there are many concepts to be understood, apart from communication, when reporting experimental results. Accuracy, honesty and clarity of presentation are all important in

determining the validity of a scientific experiment. We will be considering the implications of all these aspects in this unit.

Objectives
After studying this unit you should be able to:

- state the importance of accurate, and consistent reporting of experimental results;
- record all your experimental observations and figures precisely in a permanent note book;
- comment on the importance of reporting the experimental results obtained, without any preconceived bias;
- explain the need for repeated results;
- describe the importance of the range of results and standard deviation;
- choose the appropriate forms for presentation of experimental results; and
- use an appropriate writing style for effective scientific reporting.

8.2 WRITING UP AN EXPERIMENT

Any scientific investigation remains incomplete and often inconclusive without experimental component. Experiments make scientific knowledge testable and repeatable by other scientists. It is therefore essential that all experiments be described fully, clearly and correctly, and their details be available in some form of record for use whenever required.

8.2.1 Keeping a Notebook

Firstly, we need to consider the accuracy of recording results. It is here that keeping an accurate practical notebook is of vital importance. It will prevent loss of valuable information if all your observations are recorded *immediately* into a practical notebook, and are not left until later or jotted down on bits and pieces of paper. You may also need to use your notebook at a later date say when you want to refer to an actual experiment, or for revision purposes. Here are some guidelines for keeping of such a notebook:

(i) A bound notebook is preferable to a loose leaved one.
(ii) We suggest labelling the front of the notebook very carefully so that if lost it returns to you!
(iii) You may also find it useful to leave the first few pages blank so that you can prepare a list of contents on these pages at a later date.
(iv) In this connection, we suggest that you number all your pages.
(v) Use ink rather than pencil, as pencil written material smudges fast and often becomes illegible after a few days.
(vi) It is a good idea to use a fresh page to begin each experiment, giving it a title and recording the date.
(vii) The experiment should be written up under standard headings such as Date, Title, Introduction, Apparatus and Materials, Methods, Results, Calculations, Conclusions, and References.

All the observations should be recorded *directly* into the notebook. You should also record all partial and intermediate results so that any calculations can be
double-checked.

The notes that you record should allow for the experiment to be repeated *exactly* by any other scientist - repeatability is an important test of scientific validity.

Final presentation of results is discussed in Section 8.3. Now you may try the following SAQ.

SAQ1
Why do you think it is important to record experimental results immediately into your notebook? (Write your answer below).

_____

_____

_____

The importance of honesty when recording your observations need not be Scientific stressed too highly. It is important to be honest even when the results do not seem to produce a clear pattern, or when an observation appears to contradict what you already know. We will touch on this point again in Section 8.3. Apart from inadvertent human error, there are many other sources of error which can creep in as you record your observations. Let's look at some of these.

8.2.2 Error

Some sources of error are connected with the use of instruments, and can be summarized as:

(i) *Instrumental error,* arising from the accuracy of the measuring instrument itself.

(ii) *Observational* or *reading error,* arising from the precision with which that instrument may be read.

(iii) *Setting* or *adjustment error,* arising from the accuracy to which it is possible to set the instrument. It is also partly dependent on the skill and experience of the operator.

When writing up an experiment one usually estimates the maximum expected error. Sometimes worst-case errors are known from specifications on a piece of measuring equipment; sometimes the errors have to estimated as they cannot be known absolutely, e.g., misreading a dial where the pointer lies between two marks on a scale. In this last case, percentage error cannot be known absolutely.

Percentage error can be obtained as:

$$\frac{\text{Estimated error}}{\text{Actual measurement}} \times 100$$

8.2.3 Recording of Figures

Accuracy can also be affected by the way you record figures. This should be done as precisely as possible. Figures recorded should show all the *certain* digits, and add also *the final estimated* or *uncertain* digit. For example, suppose a voltmeter has a guaranteed specification of ± 1%. A measurement is taken and the voltmeter reading is 125.11 V. From the known accuracy (+ 1%) it is therefore obvious that the actual voltage lies between 125.11 + 1% = 126.3611 and 125.11 - 1% = 123.87128 volts. It can be seen that the only *certain* digits are the 100 and the 20. We know it is one hundred and twenty something! The 5 is the final estimated or uncertain digit, and all the others are meaningless, given the accuracy of the instrumentation.

As a rule of thumb guide the following might be useful:

- If your estimated error is between 50% and 5%, record 2 significant digits.
- If your estimated error is between 4.09% and 0.5%, record 3 significant digits.

- If your estimated error is between 0.49% and 0.05%, record 4 significant digits.

Another point that you should keep in mind is, for scientific reporting large numbers should be shown by index notation.

e.g., 4,230,000 as 4.23×10^6.

Now try the following SAQ.

SAQ 2
Imagine that you are conducting an experiment in which ionising radiation is being measured from various sources with a Geiger counter. Would you:

(i) Record only the meter reading?
(ii) Record the meter reading and the background count?
(iii) Record only the net reading?

From (i) (ii) (iii) – delete as appropriate, and explain in the space provided below.

_____

_____

_____

_____

_____

_____

_____

_____

_____

8.3 RESULTS

Results – the total outcome of a scientific investigation, either validate a hypothesis as a testable knowledge, or reject it altogether, or bring out any deficiencies/shortcomings in a hypothesis. It is therefore a crucial component in the generation of knowledge.

8.3.1 Recording Results

We have already mentioned the importance *of honesty* in scientific reporting. It is a temptation to leave out or disregard unexpected results because they do not fit in with ideas which you already hold. Unexpected results may be the outcome of faults in instruments, procedure, etc. but it isn't safe to assume this. It could be that by ignoring such results an important new discovery is overlooked. Another point worth noting, of course, is that once someone is known to have falsified results, his or her professional standing is compromised.

Now try the following SAQ before you proceed further.

SAQ 3

Figure 8.1 is an illustration of the apparatus used in an experiment to establish the relationship between the frequency of a tuning fork and the length (L) of a resonance tube. The apparatus includes a water-filled resonance tube, a measuring scale, and three tuning forks of 256 Hz, 419 Hz and 512 Hz frequencies. When conducting this experiment in the usual way, you set a tuning fork vibrating and adjust the water level in the resonance tube until the tube makes a "booming" sound, indicating that the tube had attained a resonant length. The resonant lengths of the three tuning forks were recorded as follows:

Tuning Fork Frequency (Hz)	**Resonant Length (L) cm**
512	50.3
419	20.2
256	32.75

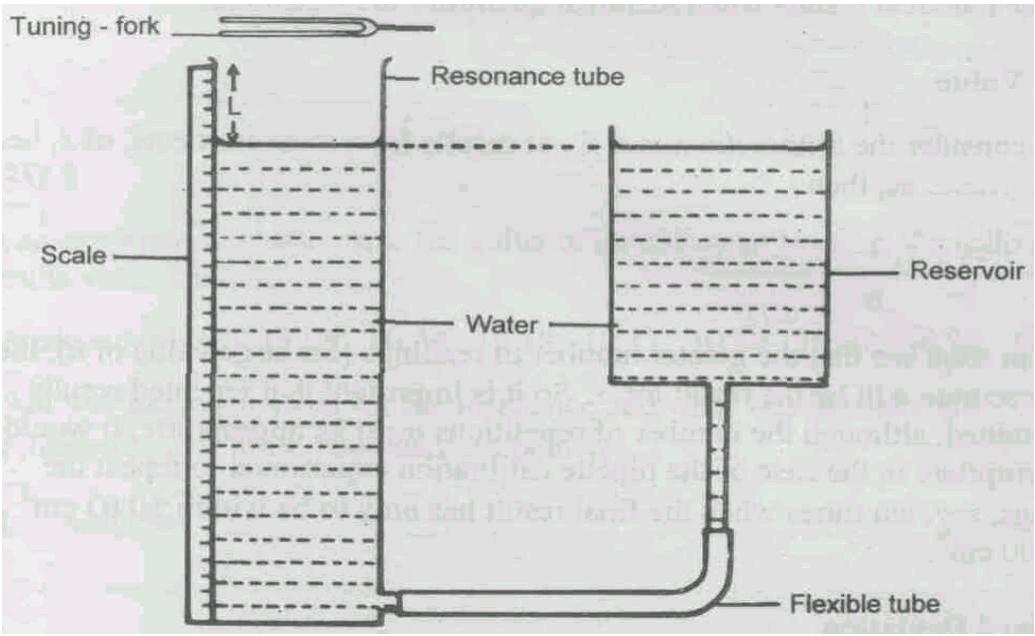

Fig.8.1: An experiment to establish the relationship between frequency of a tuning fork and the length of a resonance tube

Now you as the experimenter know that:

$$\text{Resonant length of tube } (L) = \frac{\lambda}{4}$$

(where λ, is the wavelength of the tuning fork's sound waves.) You also know that it is possible to achieve resonance when:

$$L = \frac{3\lambda}{4}$$

The inconsistency of your three readings shows you that your first resonant length was achieved at:

$\frac{3\lambda}{4}$, and not at $\frac{\lambda}{4}$ as you had intended.

The following three courses of action are open to you: which one will you take and why?

(i) Work out what X is from your measurements of $\frac{3\lambda}{4}$

(ii) Delete the result for 512 Hz from your records.

(iii) Note the suspected cause of the faulty result and obtain another result for 512 Hz.

From (i) (ii) (iii) select as appropriate. Check your answer with those given at the end of the unit.

8.3.2 Repeated Results

If investigations yield identical results in identical conditions, then the results may be accepted as valid. To put it in other words, the validity of results involves obtaining repeated readings of an experimental procedure. The number of readings taken also affects the accuracy of the results, as you will see a little later. Remember that the requirement for repeated results demands that your measuring technique is repeatable too, i.e., your technique would produce identical results when identical quantities are measured.

Mean Value

If you consider the arithmetic mean, $\bar{x}$, of results for *n* measurements, of *x*, i.e., x_1, x_2, …, x_n, then:

$$\bar{x} = \frac{x_1 + x_2 + ... + x_n}{n}$$

You can soon see that the greater number of readings (for large value of n), the more accurate will be the result for *x*. So it is important that repeated results are obtained, although the number of repetitions must be appropriate. It would be appropriate in the case of the pipette calibration experiment to repeat the readings, say, ten times when the final result has only to be within ±0.03 cm^3 of 25.00 cm^3.

Standard Deviation

Standard deviation *(SD)* is the average amount by which results deviate from the mean value. *SD* simply gives an indication of how much the data is spread.

Arithmetically, *SD*, σ_{n-1}, is found as follows:

$$SD = \sqrt{\frac{(x_1 - \bar{x})^2 + (x_2 - \bar{x}) + ... + (x_n - \bar{x})^2}{n-1}}$$

Where $\bar{x}$ = mean value

and n = total number of results of x.

Most scientific calculators now-a-days have an *SD* function built in. s_n is the symbol used for the *SD* of large number of results, i.e., hundreds or more. s_{n-1} is used for a few results – and this is the one you should use.

Now try the following SAQs.

SAQ 4
An experiment to determine Young's Modulus (coefficient of elasticity) for a steel spring involved hanging the spring from a fixed hook, adding weights in 50 g amounts to a carrier on the spring, and measuring the length of the spring for each weight to a maximum of 300 g. One technician took his zero reading, added 50 g weights to the spring and recorded the length of the spring at 50 g intervals. When he reached 300 g, he removed the weights and began to analyse his results. A second technician recorded the length of the spring as he increased the weight by 50 g increments to 300 g. Then he unloaded the weights 50 g at a time and again recorded the length of the spring at each interval.

Whose method was scientific and most rigorous? Why? (Write your answer below.)

SAQ 5
In an experiment to determine the value of an unknown resistor, the following results were obtained:

Resistance (ohms): 10.05, 10.24, 10.18, 10.11, 10.19, 10.07, 10.20, 10.19.

What was the mean value for the resistance and what was the standard deviation (σ_{n-1})? (Write your answers below.)

Mean value = _____

_____

_____

Standard deviation = _____

_____

_____

Check your answers from Section 8.7 before continuing.

8.3.3 Range of Results

In an experiment to determine the freezing point of octadecanoic (stearic) acid by cooling, some of the acid was melted in a small test-tube and a 100°C thermometer was placed in the test-tube. The thermometer was packed in the test-tube with cotton wool and the test-tube was mounted in a flask, thus preventing cooling. The experimental set up is illustrated in Fig. 8.2.

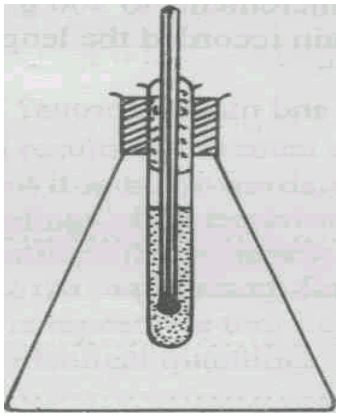

Fig.8.2: An experimental set up for determining the freezing point of octadeconic acid

The temperature was noted every 30 seconds and a graph plotted of temperature against time. The graph is illustrated in Fig. 8.3.

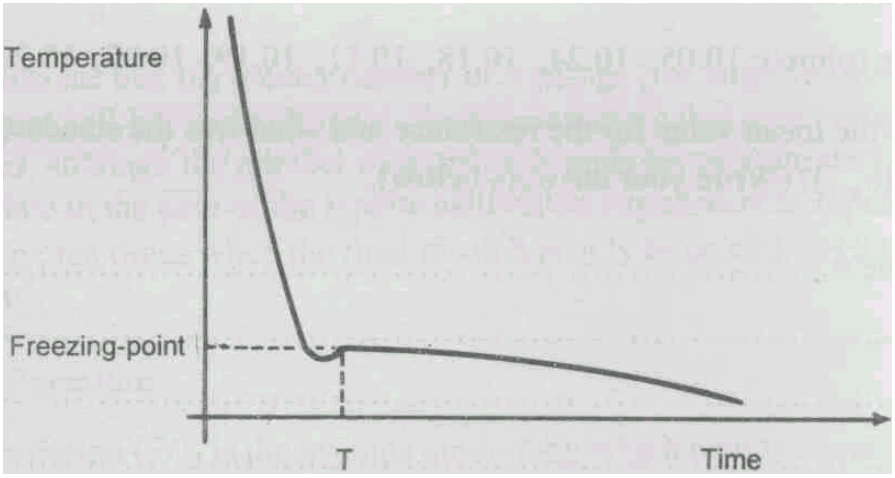

Fig.8.3: A temperature/time graph with a 30 seconds gap between readings

Looking at the graph, you can see that if the temperature was recorded every 30 seconds only up to time *T*, it would be impossible to establish where the freezing point of octadecanoic acid was. Similarly, if the temperature was only recorded after time *T*, you could not be certain exactly where the freezing point was. Thus time must be recorded for a wide range of values in order to be able to determine the freezing point accurately. However, appropriate time intervals must also be used. Consider what would happen if you recorded the temperature every 5 minutes instead of every 30 seconds. You would probably end up with a graph like the one shown in Fig. 8.4. Not only would you have trouble judging where the freezing point was from this graph, you would entirely miss the unexpected shape of the curve in Fig. 8.3 just before time *T*.

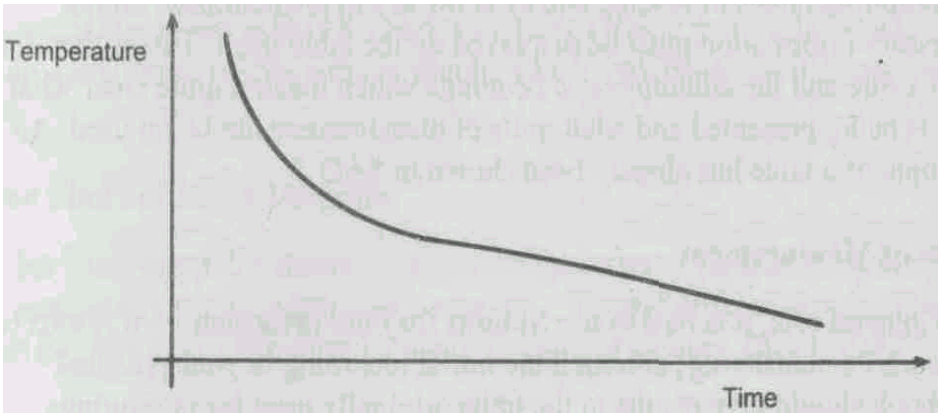

Fig. 8.4: A temperature/time graph using a 5-minute gap between successive readings

Conversely, it would be impracticable to record the temperature every 10 seconds, and it would certainly be pointless beyond time *T*. However, it might be beneficial to obtain more results before time *T* by more frequent measurement in order to obtain a more accurate plot of the cooling and supercooling curve.

You will see that a similar argument applies to the range of the temperature results. There would be little point heating the acid to, say 250°C, because this will not help you in your study of the freezing point of octadecanoic acid (70°C); and in any case the 100°C thermometer would not be of much use at this high temperature. Similarly there is also no point in making elaborate arrangements to cool the acid to –30°C.

It is important, then, that you ensure that the range of results recorded in an experiment ensures that results are:

1. *Accurate:* within the practical limits of experimentation and instrumentation.
2. *Useful:* covering the areas fundamental to the final analysis of the experiment.
3. *Complete:* not so inadequate in one part of an experiment as to prevent you making more than a partial analysis of results.

Consideration of these points is essential at the planning stage of an experiment. The range of results dictates, to a large extent, the apparatus you would use in an experiment. In our example, for instance, you would not use a thermocouple for measuring the temperature, and you would ensure that whatever timepiece was used indicated seconds and minutes.

8.3.4 Presentation of Results

Presentation of results of an experiment is an essential feature both for analysis and any conclusions drawn from that experiment. Results are mostly recorded in tabular form whenever some measurements are made and presentation of results into, say, reciprocals or logs is invariably presented in tabular form. A useful analysis of results can rarely be made from an unprocessed table of raw results. You have to consider what the aim of an experiment is. For instance, are you trying to establish a certain kind of relationship between two variables, or you want to show the relative magnitude of certain quantities?

You will generally find that most of your results will need to be summarized first of all in a table, although a diagram or graph may be more appropriate for your final presentation.

Use of Tables
In compiling tables of results, *clarity is the key to presentation;* alt the necessary information must be displayed on the table itself. Tables therefore need a title and the columns need headings which make it quite clear what data is being presented and what units of measurement are being used. An example of a table has already been shown in SAQ 3.

Units of Measurement
As a general rule, it is best to use SI units *for final* presentation of results {e.g. pressure/Pa, density/kg) although the initial recording in your practical notebook should give results in the units originally used for measuring. Conversions, etc. can thus be double checked later.

8.3.5 Use of Graphs

You may find it more appropriate to use graphs to present your results. You may refer to Box 8.1, that tells about the procedure for plotting a graph. Graphs are particularly useful in showing the *relationship between* quantities rather than the actual quantities themselves. As an example, refer back to Fig. 8.3 which shows the relationship between temperature and time in the experiment to determine the freezing point of octadecanoic acid. This is a *linear* or straight line graph.

Box 8.1: Procedure for Plotting a Simple Graph

In case you have any difficulty with elementary graphs and graph plotting, we have included some information to help you, although this material does not require learning for this unit.

When plotting graphs, use a sharp, fine pencil - grade HB or H. Do not use ink or felt-tipped pens on your graph, and ensure that you place your graph paper on a hard flat surface.

Imagine that you have a table of figures connecting two variables and you want to express them as a graph. Follow this procedure as an easy guide.

1. Count the squares on the graph paper along the two adjacent sides. Note the two ranges of values of the variables to be plotted. The range is obtained from the maximum minus the minimum values.
2. Fit two ranges to the numbers of squares by choosing a scale for each variable, i.e., work out how much of each variable there will be to each square. This should be as simple a value as possible, e.g., 0.1, 100 or some round number. Your scale should be such that you use up more than half the graph side.
3. Draw two lines (the axes) at right angles on the graph paper lines, near the sides. If possible, your lines should be ten small squares in from both sides and, for preassurance, include the values zero for each axis. The "co-ordinates" of this point are 0,0 - *the first* value is the *horizontal* value, preferably the measurement you alter.
4. Every point in the rectangle of the graph represents a possible pair of values (or set of co-ordinates). You have to mark the points representing each pair of values -horizontally from 0,0 for the measurement that was altered and then vertically up to the measurement that resulted. Use either dots, or crosses, or circles to mark the point.
5. Draw the best single line you can through the points. If you think or know it should be a straight line but can't see where to draw it, try this:
   (a) Using a transparent straight edge, *draw faintly* the most and least steep lines which seem satisfactory.
   (b) Then bisect the angle between the lines.
   (c) Draw this line in as your final line or curve.
6. The slope of the line can then be measured.
7. Label the axes of the graph and write your name and the date on the graph paper.

Other Types of Graph

The information given in Box 8.1 above relates to *linear* graphs: however, there are other types of diagrams or graphs which may be useful in presenting results:

1. Bar Chart or Block Diagram

A bar chart generally shows the relationship between various *quantities*, and is particularly useful when *comparing* data. Several different kinds of data can be shown on a bar chart by using shading or colours. (See Fig. 8.5)

Balance of payment of a firm over a ten-month period

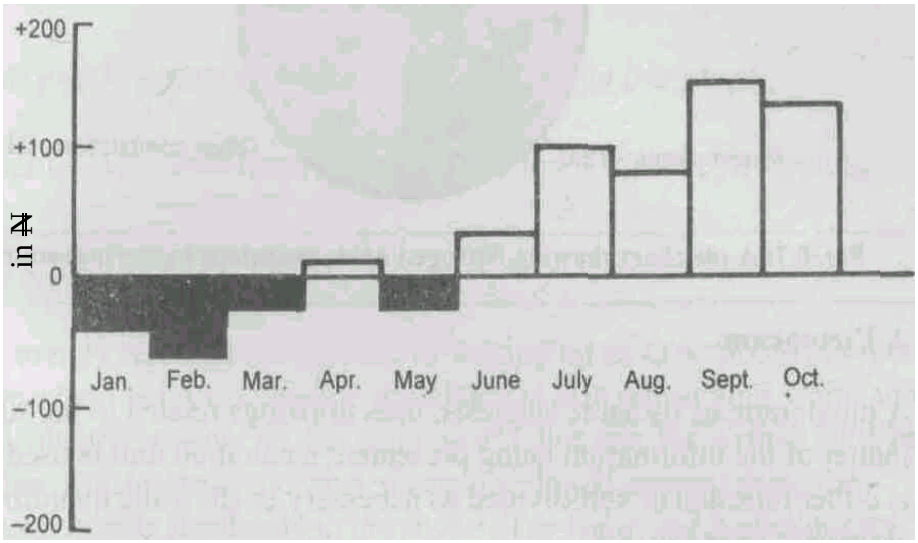

Fig. 8.5: A bar chart

2. A Histogram

A histogram looks rather like a bar chart, but shows the frequency distribution of a single variable rather than comparing different kinds of information (see Fig. 8.6).

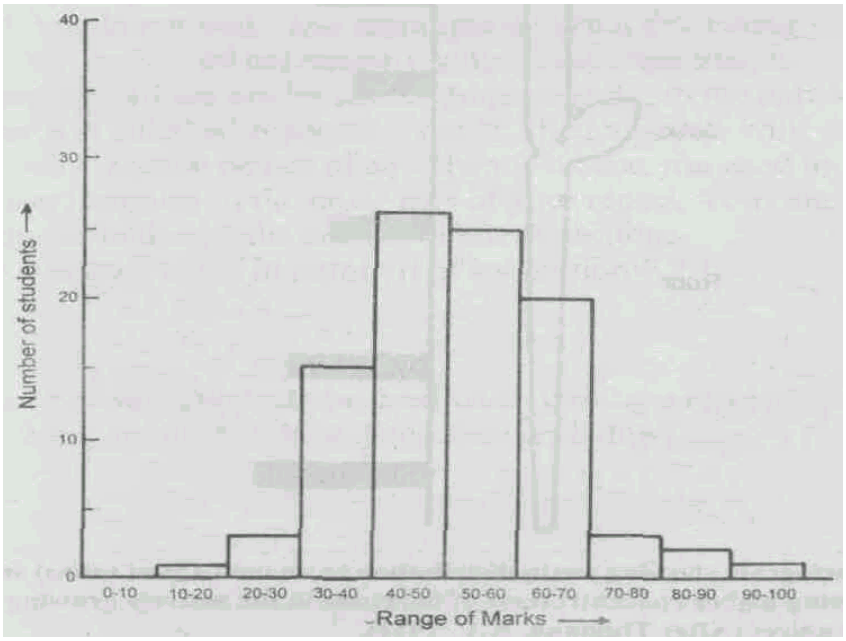

Fig. 8.6: A Histogram

3. A Pie Chart

A pie chart shows how a total is broken down into sub-units; for example, percentages may be shown as "slices of cake". Each "slice" represents a proportion of the total (100%). As a guide to compiling such a chart, each 1% is represented by 3.6° of the circle (see Fig. 8.7).

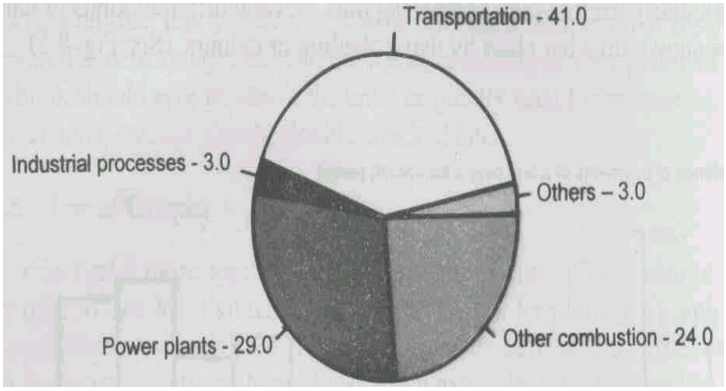

Fig. 8.7: A pie chart showing Nitrogen oxide emissions by various sources

4. A Pictogram

A pictogram, as its name suggests, uses drawings related to the subject matter of the information being presented; a common unit is used and this is either repeated or sub-divided as necessary to show the quantities being compared (See Fig. 8.8).

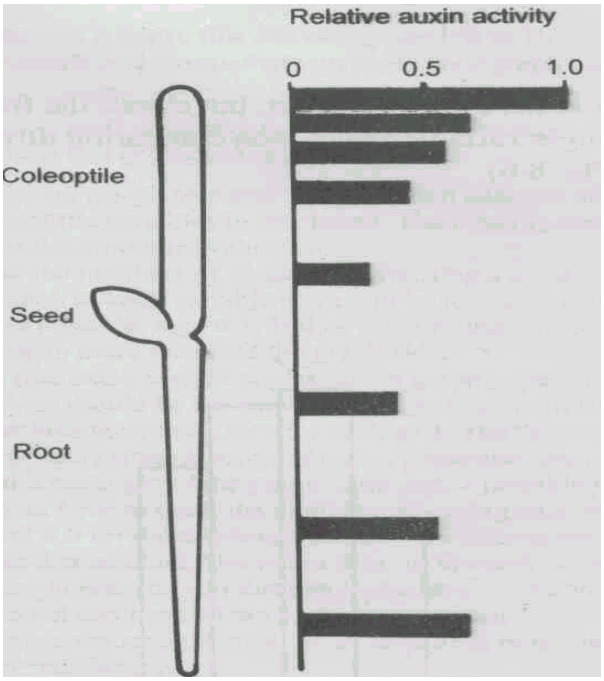

Fig. 8.8: A pictogram showing auxin distribution in an oat *(Avena sativa)* seedling, showing higher concentrations of hormone in the actively growing coleoptile and root apices (After Thimann, K.V. 1934).

SAQ 6

Complete the following sentences using the appropriate words from the list provided below.

(i) A ..... is used when results are recorded in an experiment.

(ii) A ..... is used when examining the relationship between quantities.

(iii) To show that two variables are directly proportional to one another (linear relationship), experimental results are used to draw a .....

(iv) A ..... is used to illustrate increases or decreases in the magnitude of results.

(v) A ..... is used to show how a total is broken down into sub-units.

histogram; graph, piechart; bar chart; table; straight line graph.

Check your answers with those written in Section 8.7 before continuing.

8.4 WRITTEN STYLE

We have already said that the purpose of writing up an experiment or other piece of practical work is to enable somebody else to repeat your work, and hopefully, obtain the same results that you did. For this, the written style has an important role to play. The written account should communicate the experimental details flawlessly to the reader. The following guidelines on written style should help you to communicate clearly, your practical work to others:

(i) You can assume, unless you have any reason or instructions to do otherwise, that the person reading your report is familiar with basic techniques used in practical work.

(ii) You should describe, in detail, any unusual or more advanced procedures. You can assume that your reader has the same scientific knowledge as yourself, but do not make any assumptions when describing your actions -after all, the reader did not actually witness the experiment.

(iii) The report should always be written impersonally, in the past tense, e.g., "a beaker was filled with water" – not "I filled a beaker with water".
(iv) Always write out the names of any chemicals that you used in full.
(v) Do not use formulae in the prose part of your report. You can, however, use formulae in the results and calculations sections.
(vi) Use the headings listed in point vii of subsection 8.2.1.

SAQ 7

There are nine headings that can be used when writing a report of an experiment. What are they? (Write your answers below).

(i) _____

(ii) _____

(iii) _____

(iv) _____

(v) _____

(vi) _____

(vii) _____

(viii) _____

(ix) _____

SAQ 8

Which of the following would you use to draw a diagram or a graph?

(i) A felt pen
(ii) An HB pencil
(iii) A fountain pen and black ink

From (i) (ii) (iii) - choose the appropriate one.

8.5 SUMMARY

In this unit the essentials of scientific reporting with particular reference to writing up experimental work have been dealt with. In this context the following aspects have been elaborated in the unit:

- importance of keeping a note book;
- necessity of accurate documentation of observations;
- meaning and significance of scientific validity of results;
- basic statistical techniques;
- different ways of presenting results; and
- the appropriate writing style.

We hope that after studying this unit you will now be of the opinion that a clear, accurate and honest scientific reporting is vital to the study of science and scientific experiment. For this it is

essential that first the experiment be planned well before selecting or assembling the apparatus. It is also important that prior thought be given to the kind of results desired and their intended use.

8.6 TERMINAL QUESTIONS

1. A manufacturer of a new continuous flow liquid analyser published a glossy advertising leaflet about the instrument's performance. One of the statements in the leaflet said:

   "_____ and the measurement system has excellent repeatability".

   Given that you understand repeatability in scientific terms means "capacity for measurements to be repeated in the same way", state briefly why the manufacturer thinks that excellent repeatability would be a good selling point for an analytical instrument? Your answer should be based on the material contained in this unit and your knowledge of scientific methodology.

   _____

   _____

   _____

   _____

   _____

   _____

2. Write down in the space provided, brief definitions for the following terms.

   (vii) Estimated Error

   _____

   _____

   (viii) Mean Value

   _____

   _____

   (iii) Repeatability

   _____

   _____

   (iv) Significant Figures

   _____

   _____

   (xiii) Standard Deviation

   _____

(xiv) Validity

3. Perform an experiment and write a brief report of this experiment. In your write-up, you should:
   (vi) Explain the aim of the experiment;
   (vii) Describe your method;
   (viii) Record all experimental observations;
   (ix) Choose the most appropriate form to present experimental results. For instance, tabular, graphical, pictorial or in some other form;
   (x) Discuss your results with your peers or the counsellor and write your conclusions.
4. Comment on the utility of making a notebook for jotting down the details of an experiment.
5. What aspects should be ensured while recording a range of results of an experiment?

8.7 ANSWERS

Self Assessment Questions

1. Your answer should make it clear that you are aware that important information may get lost unless your observations are carefully recorded at the time the experiment is conducted.
2. i, iii; Hint: You must consider all significant raw data, such as background count, distances, type of instrument used, units, etc. There are no short cuts to this.
3. To say it in a lighter way - 'Results cook' would choose (i) as the answer. If you opted for (ii) you have ignored the paramount importance of recording ALL the results of the experiment. Remember, one mustn't just record the results one expects.
4. The second technician's. His/her final results will be the mean of the two readings and will be more accurate than the first technician's result. In this particular experiment, it would be important to check that the initial and final zero readings were the same.
5. Mean value $= \frac{1}{8}(10.05+10.24+10.18+10.11+10.19+10.07+10.20+10.19)$

$= \frac{1}{8}\times 81.23$

$= 10.15\,\Omega$

$$SD = \sqrt{\frac{1}{8-1}}[(10.05-10.15)^2+(10.24-10.15)^2+(10.18-10.15)^2+(10.11-10.15)^2 + (10.19-10.15)^2+(10.07-10.15)^2+(10.20-10.15)^2+(10.19-10.15)^2]$$

$= 0.068$

6. (i) table
   (ii) graph
   (iii) straight-line graph
   (iv) bar chart
   (v) pie chart

7. (i) Date
   (ii) Title
   (iii) Introduction
   (iv) Apparatus and materials required
   (v) Method
   (vi) Results
   (vii) Calculations
   (viii) Conclusions
   (ix) References
8. (ii) An HB pencil

Terminal Questions

1. You may refer to Section 8.3, and particularly subsection 8.3.2.
2. (i) The maximum degree of error expected in an experiment estimated as a%.
   (ii) The mean (a kind of average) taken from repeated readings.
   (ix) Refers to the degree to which an experiment can be repeated exactly to give the same results by different researchers, i.e., it is a test of scientific validity.
   (x) Only significant or meaningful figures are meant to be recorded. This depends on the accuracy of the instruments used for measuring. One should record all the *certain digits* plus the final *uncertain* digit.
   (xi) Also abbreviated as SD. It is the average amount by which results differ from the mean value.
   (xii) If an experiment is to be scientifically valid, all relevant details must be documented so that other researchers may be able to repeat the experiment exactly.
3. Write an experiment of your choice. In case you need some clarification you should discuss with your counsellor.
4. See Subsection 8.2.1.
5. Refer to Subsection 8.3.3.
   Hint: Ensure the following three aspects: (i) accuracy, (ii) usefulness, and (iii) the complete range.

UNIT 9 THE USE OF COMPUTERS IN LABORATORY ORGANISATION AND MANAGEMENT

Structure

9.1 INTRODUCTION

In the earlier units of this block you learnt the importance of proper filing and record keeping. You are also aware that in laboratory organisation and management, work related to filing, records and stocks is generally maintained manually/typed on paper. In this unit, you will become familiar with the use of computers as a tool for laboratory organisation and management.

Most of you must have seen a personal computer, PC as it is popularly called. Some of you may already be familiar with its use. Often schools and colleges that have science education have computers for the student's use and in the office for administrative use. You would realise that computers are becoming a necessity in all spheres of life and there will hardly be any laboratory, office or institution of the future that will not use the computer at some level for manipulating and organising information. Therefore, it would be in your interest to learn its use in laboratory organisation and management

In this unit you will become familiar with the basic components of a personal computer, the terminology used in computerised systems and the various possibilities of their uses in laboratory organisation and management. For instance, computing systems can handle large amounts of information with far greater facility than humans can. Time consuming activities like filing, record keeping, stock controls and their link with accounts can be adapted and managed better with computerised systems.

Objectives

When you have completed all the work in this unit you should be able to:

- List the basic components of a personal computer system,
- describe the use of computers in laboratory organisation and management,
- state the advantages of using a computer system in laboratory organisation and management.

COMPONENTS OF A COMPUTER

We use a computing system basically to feed in some data that is processed by the computer and some information is generated as a result.. For this we need **input devices,** to feed in some data into a **central processing unit (CPU)** and the results of the processing are displayed through **output devices..** Let us first describe the parts of a personal computer very briefly for those of you who have not had a chance to work with a computer before. The input devices, the CPU, and the output devices that you see in Figure 9.1 form the **hardware.** These are the physical parts that you can see and feel. The instructions given to the computer to perform a task are known as a programme, A set of programmes is known as the software of the computing system. Software is usually prepared in advance and stored on magnetic disc and compact disc. These are then loaded into the computer when somebody is ready to use it.

Computers can be large enough to fill up a whole room. These are known as the mainframe computers, forming powerful systems used by large businesses and government departments etc. You will mostly have to deal with smaller computers the micro computers or personal computers (PCs) that can fit on a table or desk and accomplish all the tasks that a mainframe does.

Let us first talk about the hardware of computing systems.

9.2.1 The Central Processing Unit

Central Processing Unit (CPU) is the brain of the computer. The intricate electronic circuitry of the CPU performs the computer's tasks of handling data. It is composed of:

(i) The Arithmetic Logic Unit or ALU, which computes mathematical functions, like addition, subtraction, multiplication and division
(ii) The control unit which carries out the computations and coordinates the movement of data and executes the instruction given to the computer.

The CPU receives programs and data through input devices, processes it and gives out the result through output devices.

9.2.2 Memory

Computers store information internally as well as externally.

Linked to CPU is an internal memory unit where all the instructions and data are stored. It contains the computer operating instructions or **programme.** The memory of the computer is of two kinds; **RAM** and **ROM.** Random Access Memory (RAM) is the computer's short term working space. During it's working life, a computer's RAM may be overwritten with new information millions of times. RAM is more like a blank cassette which can be recorded, wiped clean and recorded again. The computer can get to or access any part of the RAM memory 'at random'.

ROM is the Read Only Memory that is, one can read from it but cannot written on it. It is used to store software which will always be needed. ROM software is a permanent part of the machine, unlike the RAM which is forgotten each time the machine is switched off.

The external memory of the computer are the 'floppy discs', the compact discs (CDs) and the more recent flash (USB) discs. They need special **disc drives** to read and write the information on them. CDs and USB discs can hold an enormous amount of information. Infact, entire encyclopaedias can be stored on one CD or a USB disc.

9.2.3 Input and Output Devices

The most common input devices that you will see in your PC are the **keyboard** and the **mouse.**
The keyboard of the computer looks like the keyboard of a typewriter with a few additional keys. One of the most common uses of the computer is as a word processor – basically a sophisticated typewriter that is capable of storing and manipulating text. With a few key strokes the writer can add or delete words and move entire similar sequences or paragraphs from one place to another in the text. Entire books can be written, edited, and printed with the use of computer discs without the manuscript even being committed to paper.

The mouse is a pointing device which is used while working with a display based computer system. It points or selects some area of display on the screen of the monitor and can be moved to another area of the screen. There are several other input devices like scanners, optical pens, joy-sticks that you may see associated with computing systems depending on the kind of requirements.

The output devices of the computer present the results of its work to users. The most common output device is the **monitor** which looks like a TV screen and the **printer.**

The input and output devices are so closely related that they are referred to as **input/output or I/O.** The most common I/O devices are floppy discs, compact discs, USB discs, modem (MOdulator-DEModulator) that connect to telephone lines. There are several other devices that can be connected to the computer. These are called **peripherals.** I/O peripherals are XY plotters to print graphs, devices that recognise and produce sounds, optical scanners to see text.

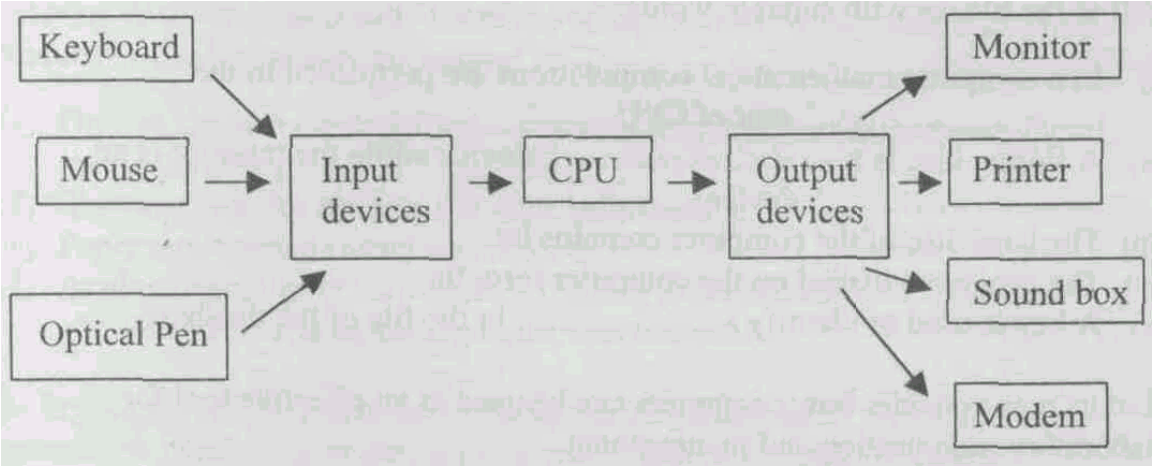

Fig. 9.1: Components of a Computing System.

9.2.4 Computerised Systems

You would have realized by now that computing systems are most useful for manipulating information. Any organisation and management of information basically involves 3 steps:

1. Information input
2. Information processing
3. Information output.

Information is usually in the form of data. Can you think of items which could form the data in a laboratory setup?

Data could be any of the following: information about stocks, equipment, finances, personnel, technical data, student records etc. You could add more to this list according to your own situation. This data is normally stored, processed or analysed and then we get final results based on it. Sorting information fed into the computer is one of the most important operations it performs. The computer is able to arrange similar data items in a particular order, be it, numerical, alphabetical or some other sequence. On command the computer can compare any two data items and determine which is the next one in that sequence.

A collection of similar data is known as a **file** and each item is a **record**. In a file on students for example, each record contains data about one student such as the registration number, name, date of birth etc. of a student and sorting can be done according to the type of required information.

Once data has been sorted it is stored internally on the hard disc of the computer or on a floppy or a CD and can be printed out on paper. This information in a computer can be logically organised

into files with separate records within files and individual items within records. When files are arranged in a database, each record contains identification labels known as keys. A key could be a code number, a name or perhaps data. When looking for particular data, the computer calls up each item from memory and checks to see if it contains the suitable key. Therefore, when a key is entered into a record, the computer scans its memory and displays that record.

SAQ 1

Fill in the blanks with suitable words:

(i) In a computer mathematical computations are performed in the ..... unit of CPU.

(ii) A floppy disc is a ..... device while the monitor is an ..... device.

(iii) The hard disc of the computer contains its .....

(iv) The programs loaded on the computer form the .....

(v) A key is used to identify a ..... in the file of the database.

Let us now consider how computers can be used as an effective tool for laboratory organisation and management.

9.3 OVERALL FUNCTIONS

There are three points that must be borne firmly in mind when considering the use of computers in laboratory management.

1. Overall Function

This includes the three steps we highlighted earlier, namely:

(a) Data input
(b) Data processing
(c) Data output

2. The G1GO Principle

This is a simple principle with a clear message and universal application – Garbage In – Garbage out!

Always try and enter any data in the form you want to see it printed out. For example, if you type in 'bkr' don't expect the computer to print out 'beaker'! Secondly be consistent in the way you enter your data. Using the same example, enter either 'bkr' or enter 'beaker'. Don't enter both because if you ask the computer to list all beakers, don't be surprised if it misses out the 'bkr'.

3. Paper System

When setting up a computer system you need to ask yourself 'Does the system you plan to operate work manually, i.e., on paper?' It is a popular misconception that to computerize a system that does not work will remedy the system's faults. Nothing could be further from the truth. If a system does not work, no amount of computing equipment will make it work. On the contrary, the system is likely to fall apart! It is always better to set up a system manually before attempting computerization.

Let us discuss overall functions in detail.

9.3.1 Data Input

There are several aspects of data input that need careful consideration. We shall assume that in a laboratory environment you are mainly concerned with entering data via a keyboard. There are other methods which, although not frequently used, you may encounter:

(1) Optical character recognition – scanners that read text from paper directly into a computer;
(2) Scanners, e.g. for reading bar code information;
(3) Paper tape systems – old equipment;
(4) Analogue-to-digital converters – reading experimental data from photoelectric cells in, for example, spectrometers.

At first sight, entering data into a computer might not seem problematical. Indeed, the mechanics of data entry are well tried and straightforward. However, from a management point of view there are several considerations.

First of all, there is the problem of access. This is often an acute problem in educational establishments where there might be an abundant supply of computers for teaching but a desperate shortage for management and administration. Sharing a computer terminal does not really work satisfactorily, and if a computer is to be a really useful management tool, it must be on hand at all times.

Another point to consider is that of training. Whoever enters data into your system, must know what they are up to. Otherwise it will not be long before the GIGO principle is brought into play. Adequate training is the cornerstone of good computer systems.

Coupled to both access and training is the problem of the time taken to 'key in' data. Consider the case of card index system being transferred to a computer system. At some stage, every character in the card index needs to be keyed into the computer. The computer system will not be any use until the transfer is complete and it may take months of time for keying- in the data. Even then there will be a need to update the data regularly which will require more time at the keyboard. **Never understimate 'keying-in' time**.

Working conditions are especially important in computer work, particularly if it is for protracted periods. You cannot, for example, put a computer on someone's desk one day and expect everything to run smoothly. Operating computers can be particularly tiring and stressful and hence it is worthwhile investing in proper furniture, ensuring that lighting conditions are suitable, and that noise and heat levels are kept under review.

9.3.2 Data Processing

Processing data is the most complex function of a computer system. It is where the computer itself (as opposed to a peripheral, e.g. a visual display unit or a printer) is brought into play together with suitable programs. We will discuss programs, or software, later; so here let us consider what kind of management decisions need to be taken in relation to the hardware - the computer itself. In practice, when you choose a computer system, you decide:

(1) What your aims are;
(2) What programs (software) will meet those aims; and
(3) What machines (hardware) will support the programs.

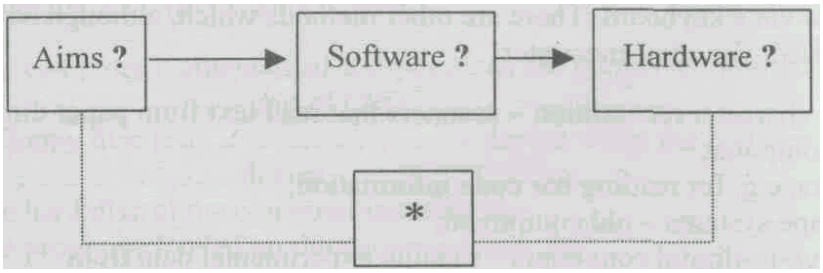

Fig. 9.2: Choosing a Computer System

Sometimes your aims affect the choice of hardware directly. For example, you require more than one person to gain access to the system at a time, you will need a multi-user system.

In defining your aims, you will define what data processing needs to take place and this will lead to a number of options - choices of programs. Once you have chosen a program for your task you will usually have a range of options, and a set of parameters for choosing hardware you may ask:

- Will you require a stand-alone workstation, a network, or a full multi-user system?
- What size RAM (the computer's own working memory) is required to support the program?
- What size hard disk (data store) is required?
- What data storage method will you use for backing up information?
- What is the cost of the computer and its subsequent maintenance?

9.3.3 Data Output

Processed data is no use to you if you cannot use it. Once data has been processed, you will either:

(1) Send it as a data file to another system, e.g. write a file to disk, transmit a file over a phone link via a modem, etc. For example as e-mail.

(2) Send it to a peripheral where it is decoded into information that can be readily understood. The most common peripherals are visual display units (VDUs) or printers.

SAQ 2

Can you remember from the previous paragraph what were the THREE steps to be decided when choosing a computer system? Write them down in order here.

(1)
(2)
(3)

Check your answer with ours at the end of the unit before continuing.

9.4 APPLICATION PACKAGES

In relation to item (2) in SAQ 2, there are two options. You can either write your own program or buy an applications package, i.e. a proprietary program, 'off-the-shelf. ' The former option is time-consuming and is a science in its own right and you have to be a computer programmer to do so.

There are applications package to suit almost any requirement, including:

- Database Management Software(data storage/retrieval)

- Spreadsheet Software (arithmetical calculations)
- Word processing Software
- Computer Aided Design (CAD)
- Accounts
- Stock control

We will look at some common types of applications software in more detail.

9.4.1 Database Management Software

For storage of large amounts of varied data, and rapid retrieval and interpretations of data, the database is the ideal tool. It is most useful for stock control.

Generally it tells a computer to behave just like a card index system. In computing terms the entire card index is called a file, each card is called a record, and each line of information on the card is called a file. Good database software will allow you to store information in exactly the same way as your index card.

A relational database is a type of computer program that allows you to store different information on a similar format for many different items. It also enables you to retrieve that information rapidly in a variety of ways. It can be used for applications like maintaining personnel records or student records, preparation of mailing lists and many other operations of a similar nature.

Figure 9.3 is an example of how a stock control data file might look for a database program. The concept is similar to a conventional card index system. The master file (your stock control file) contains many 'records'. Each 'record' relates in this case to a different stock item uniquely identified by its stock number. For each record there are several 'fields' or sections of information. In this case, the field descriptions are shown - stock number, description, etc.

The advantage that the computer has over a card index system is space. It can store thousands of records on many master files. That is the equivalent of many large card index systems. Also in a matter of a few seconds, the program could, in the case of the example in Fig. 9.3, list, say, all records for which a re-order was due.

It would do this by comparing the data in the 'requirement' field with the data in the "current holding' field and list all stock items where the 'current holding' is less than 'requirement'. This program would print the address labels of the supplier for you.

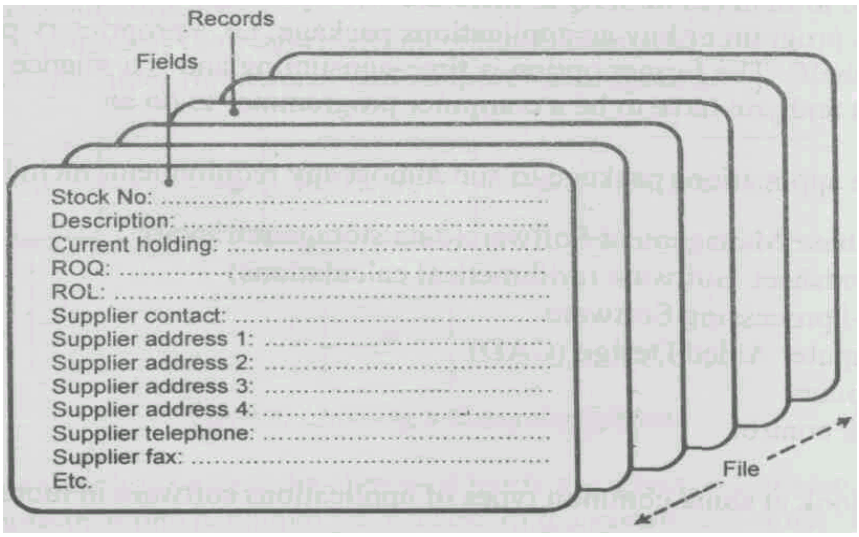

Fig. 9.3: Pictorial Representation of a Data File

When purchasing a database program, you must have a clear idea of what you need it for. Ask yourself the following questions.

(1) *Will it perform all the operations necessary for my system ?*

Many programs will manage 90% of what you want, but only a few will manage 100%. Your computer system will be a waste of time and money if it is a "ninety percenter", because you will have to operate a paper system in parallel. For example, can the program:

(a) Carry out batch processing, e.g. updating an entire file?
(b) Manipulate alpha, numeric and data information?
(c) Select records on matching or mismatching the contents of more than one field?
(d) Sort the data file into ascending or descending order on the contents of one or more fields?
(e) Produce useful reports to both a visual display unit and a printer?
(f) Link to another program, e.g. store a file of address data which can be used with a word-processing program for a mail merger?

(2) *Is it large enough?*

In this context beware of a common mistake, i.e., do not buy an educational program and expect it to carry out a business function. Check the possible:

(a) Number of files
(b) Number of records per file
(c) Number of fields per record
(d) Number of characters per field.

These features are interdependent to a certain extent but it is important to ascertain upper limits.

(3) *Is its cost justified?*

'You do not get what you do not pay for' in the computing world. However, it always pays to shop around. Some suppliers will adhere to a heavily marked-up tariff while

others will offer massive discounts, particularly in the education sector. Make sure that if you accept a large discount, you do not lose out on training.

Activity 1
List in the space below any activities at your workplace that you think could be usefully managed with a relational database?

We've listed some at the end of the unit for comparison.

9.4.2 Spreadsheet Software

Consider the grid in Fig. 9.4. It is split into rows and columns and is a pictorial representation of a typical spreadsheet program.

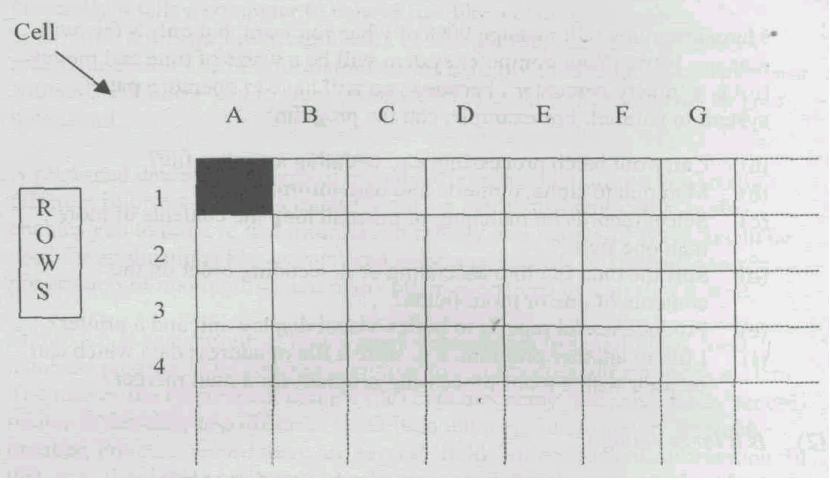

Fig. 9.4: Spreadsheet Cells

You can enter data in any 'cell', e.g. Al, Z53, etc. and, for example, perform arithmetic operations on that data and then 'post' the result to another cell. Take the following example. If you wanted to maintain a record of lab expenditure, you could set up a spreadsheet in the following way:

Column A Date	*Column B* Order No.	*Column C* Item	*Column D* Net Cost
Column E VAT/Sales Tax (Value added tax)	*Column F* Total Cost		

If all items in column D had VAT or sales tax chargeable at 17.5%, then

$$E = D \times 0.175$$

Column G TOTAL of net expenditure	*Column H* Total sales tax paid

In a separate cell you could show the balance outstanding on your annual budget.

You should be able to see the possibilities of such a program. Figure 9.5 shows an example of a printout from a spreadsheet.

	A	B	C	D	E	F	G
1	CASH FLOW ANALYSIS						
2							
3		TOTALS	MAY	JUN	JUL	AUG	SEPT
4							
5	INCOME						
6	Lab budget	3750	750	750	750	750	750
7	Grants	1500	1500				
8	Capital grants	500					500
9	Miscellaneous	150	50		50		50
10							
11	TOTAL	5900	2300	750	1000	1000	1600
12							
13							
14	EXPENDITURE						
15	Insurance & maintenance	175	35	35	35	35	35
16	Books, etc.	200				100	100
17	Phone	500	250			250	
18	Postage	150	30	30	30	30	30
19	Stationery	215		95	95		25
20	Replacements	635	45	45	500		45
21	Chemicals, etc.	700	100	200	200		200
22	Print & copying	350			250		100
23	Miscellaneous	250	50	50	50	50	50
24	Contingency (10%)	352	57	51	129	52	65
25							
26	TOTAL COSTS	3527	567	506	1289	571	650
27	CAPITAL EXPENDITURE	1250			1250		
28							
29	INCOME-COSTS-CAP.EXP.		1733	244	-1539	483	950
30							
31	CASH FLOW		1733	1978	439	922	1872

Fig. 9.5: Example Printout from Spreadsheet

You still need to ask yourself the same general questions as we listed for database as follows:

(1) *Performance*

For example, can the program:

(a) Carry out all arithmetic functions?
(b) Accept full character data and editing?
(c) Allow title lock and windowing?
(d) Allow easy cursor movement?
(e) Allow copying of blocks of cells?
(f) Allow alternative screen displays of formulae/data?

(2) *Size*

The size of the spreadsheet may be limited by the program itself or the size of the computer's RAM (Random access memory). A useful working size is 50 columns × 250 rows.

(3) *Cost*

The same criteria apply as for databases.

Activity 2
List in the space below any activities at your workplace that you think could be usefully managed with a spreadsheet.

Compare your answer with some activities listed at the end of the unit.

9.4.3 Communications Programs

By communications programs, we mean those programs which allow a computer to communicate via a transmission cable to another electronic device. Here we do not include multi-user system or small networks. We are mainly interested in communications for rapid data input and retrieval, and so we consider the telephone network as the transmission medium. Computer communications are most easily explained in Fig.9.6.

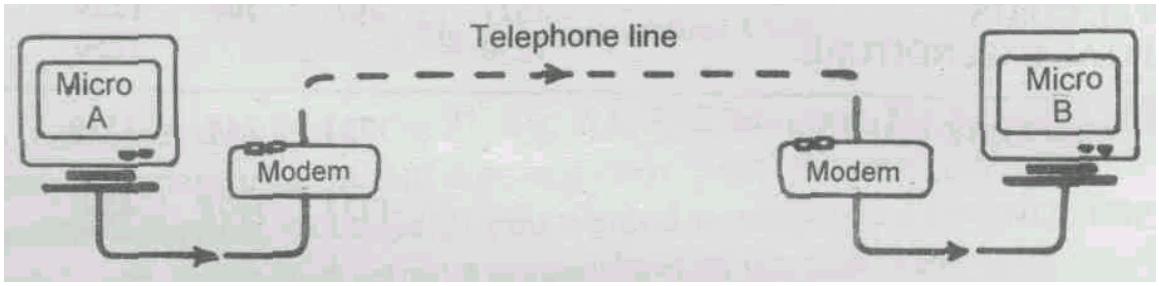

Fig. 9.6: Computer Communications

This shows one personal computer 'talking' to another. PC A reads a data file, say, from its floppy disk and sends it to a modem (Modulator -DEModulator). Here, PC A's electronic signal (the data file) is converted into a signal that can be transmitted over a telephone line. B can only read PC A's signal by receiving the signal via its own modem which translates the signal back into a computer signal. In fact, this example is typical for most computer communications over telephone lines:

(1) Between mainframe computers, or
(2) Between PCs and mainframes.

This situation is illustrated in Fig. 9.7 and is the basis on which PC users can communicate with the outside world.

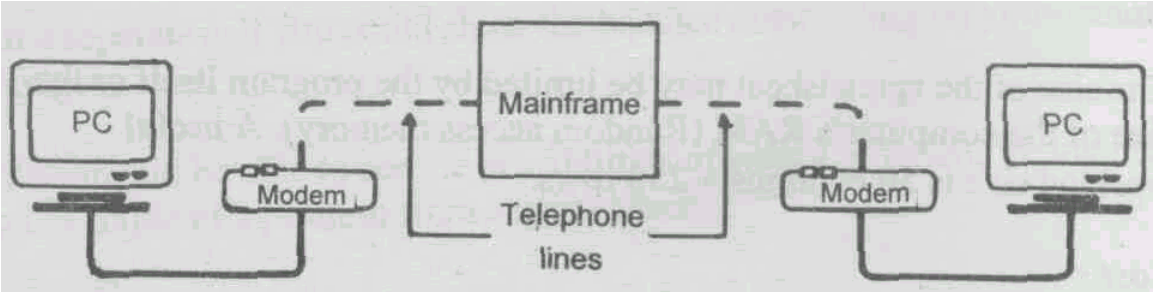

Fig. 9.7: PC/Mainframe Communicates

There are two main uses of PC to mainframe communications which may assist you in the management of your work. The first is accessing national databases and the second is electronic mail.

There are many databases for which you can become a subscriber and which your computer can access more or less at the touch of a button to obtain specialist information. **The Internet or the World Wide Web** is the most familiar and popular example. These databases hold vast amounts of information, for example, on companies. By obtaining details in this way, you do not need to hold large stocks of reference books, or spend time journeying to your local library and thumbing through weighty volumes. You obtain only the information you want, when you want it. In the education world, there are databases whose users not only draw data out, but put their own data in thus providing a dynamic data exchange, for example, web sites of companies which have information about their products and how to obtain them.

Electronic mail is another PC to PC and PC to mainframe data exchange. If .you subscribe to an electronic mail service, it will enable your PC to gain access to a 'mailbox' on a mainframe somewhere. You can either post data to the mailbox for someone else's PC to read later; or your PC can interrogate the mail box to see if anyone has left any data for you.

This system is now widely used for stock ordering, and many of your suppliers will have an electronic mailbox. The most competitive companies equip their salesmen with computers. Once a sale is made, the salesman sends exact ordering details to his distribution manager's mailbox. The distributor interrogates his mailbox every few hours, and should be able to despatch and invoice the sale within hours.

If you have to consider the installation of communications packages, the same questions have to be asked.

(1) *Performance*
   (a) Does the software and the modem support the necessary transmission rates?
   (b) Is the software secure? Telephone lines are often 'noisy' and unless there are sufficient data checks and error messages, you may end up with garbage instead of useful data.
   (c) Is the software 'user friendly'? Some packages do not allow much operator control.
   (d) Is the modem reliable? They can be susceptible to 'noise' and cause trouble. Generally, the more you pay for a modem, the more control you have over its operation and the more reliable it is. Internal modems are usually reliable.

(2) *Capacity*
   This is not really a feature of communications packages. Just make sure that you are not locked in to slow transmission rates which can produce high telephone charges.

(3) *Cost*
   You need to work this out carefully as costs mount up and may be difficult to justify. The elements are:
   (a) Software for your PC.
   (b) A modem for your PC.
   (c) Subscription charges for database/mail service.
   (d) Access charges to a database or mail box.
   (e) Telephone call charges.

Activity 3
Are there any national databases that you think could be of assistance to you in your work? If so write down their names here.

Do any of your suppliers have an electronic mail facility? Write down their names here.
Can you see a use for data communications in the management of your work?

Yes No

Be prepared to discuss your answers with your tutor or mentor.

9.4.4 Word Processing Software

The main use for word processing is found in secretarial offices and small publishing companies. However, if you are involved in generating your own correspondence, or you are lucky enough to have your own secretarial support, you might find word processing programs useful. They are useful if you need to generate a large number of standard items of correspondence with small adaptations. Since we are mainly concerned here with information and management we will not dwell on word processing programs further except for one point and that is the use of word processing files to hold data in records.

You may recall that in the paragraph on databases, we spoke of the need to link details out of a database to a word processing program to enable mail merger to be carried out by a computer 'merging' two text files. One will be a letter, or address label layout; and the other will contain the variable details, e.g. the salutation, name and address and so on. If you are involved in carrying

out mail mergers or circulars, it might well be worth your while maintaining a 'details' file of all the names and addresses of your correspondents. This file can be edited like any other text file. Nowadays you can find integrated software which combine several of the capabilities of packages listed in earlier subsections. Microsoft Windows is the most popular such software.

9.5 DATA OUTPUT

Whatever, data or information that you feed into a computer will be the data output from a computer system and will be a data file sent from the computer to a peripheral unit. It may take the form of:

(1) A file written on to a floppy disk,
(2) A file sent to a VDU and displayed on a screen, or
(3) A file sent to a printer and printed onto paper (hard copy).

A file may even be sent first to a VDU and then to a printer.

The consequences from an organisational point of view can be summarised as follows:

(1) *Disk output*
You will already have decided whether to use a hard disk or floppies for storing data. An important point of disk management is to ensure a secure method of keeping copies of your (valuable) data. The method shown in Fig. 9.8 is suggested

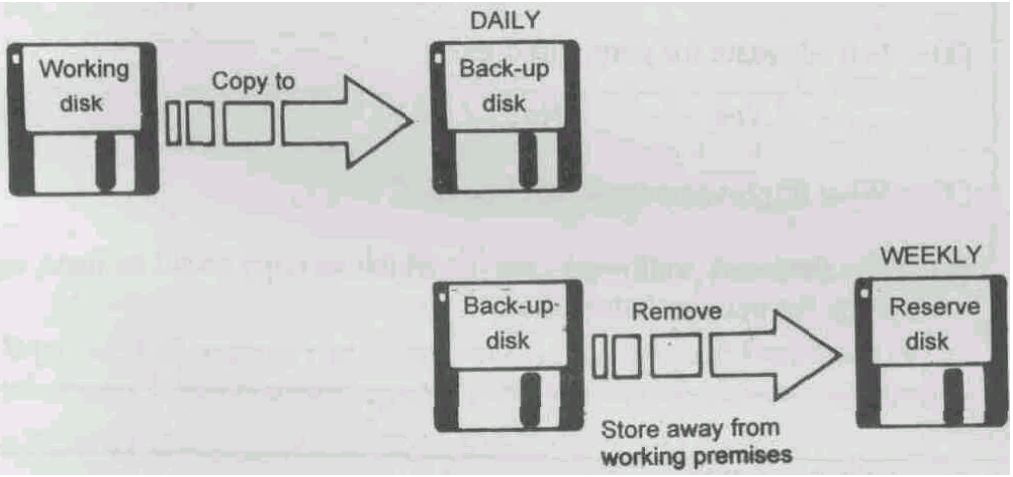

Fig. 9.8: Backing Up Data

This can be expensive in terms of time and disks. Those who economize usually learn the hard way!

(2) *VDU (Visual Display Unit) output*
Make sure that VDUs are of an appropriate type. They can cause severe eyestrain and tension if you do not check:
(a) Colour
(b) Resolution and screen size
(c) Flicker rate
(d) Viewing angle adjustment.

(3) *Printer output*

Consider what is required here. Do you just require management information on the one hand or camera copy for reprographic purposes?

InkJet — Very quiet. Cheaper than laser printer. Quality can be very good, and colour printing is a real option with inkjets. They are slower than laser printers, but their technology is changing rapidly.

Laser — Have graphics capability. Printouts give camera copy. Best choice for quality work. Speed varies from 4 pages per minute to 20 pages per minute. Some print double sided.

Resolution of printers is measured in d.p.i. (dots per inch) with 600 d.p.i. being relatively high resolution. A good laser printer may be capable of 600 + d.p.i.

Activity 4
If you have a computer printer at your workplace:

(1) What general type is it:
- Laser?
- InkJet?

(2) Is it adequate for your purposes? Yes No

(3) What improvements would you like?

9.6 SUMMARY

You have learnt in this unit that:

- Computers can be used for better and more efficient management and organisation of laboratories. A computer like the human brain receives information, stores and processes it and then displays the results. It receives information through input devices and stores it in its memory, processes that information in the central processing unit and displays it on an out put device like a monitor or through a printer. The physical parts of the computer form its hardware and the instructions given to the computer to process the information form the software.
- Software can be of two kinds, system software that controls the actual working of the computer and applications software that are the programs written to achieve the desired results for the user. The most important categories of applications software useful for laboratory organisation and management are: database, spreadsheet^ communications programs and word processing.
- Any organisation and management of information basically involves three steps. Data input, Data processing and Data output.
- Before using computerised systems it is important to understand and decide what the aims are what software/programs will meet those aims and what hardware will support the programs. It is also important to work out the costs of using a computerised system.

9.7 TERMINAL QUESTIONS

(1) What sources of information are there that you can think of that you could access with a computer to help you in your work in a lab?

(2) List the following sources of information in order of speed, of retrieval. Start with the slowest.

(i) Subscription database
(ii) Catalogue
(iii) Card index
(iv) Own database

(3) What kind of computer program would you choose to keep track of laboratory budgets over the year? (Tick the correct answer.)

(i) Word processor
(ii) Spreadsheet
(iii) Database
(iv) Stock control software

(4) What advantages do computers offer when used for information retrieval or for stock control?

A Cautionary Word

A final cautionary word on computing systems. It is imperative that any computer-based information system is backed up by a sound paper-based system. For example, can you imagine a petty cash ledger on a spreadsheet where invoices and orders were not numbered and filed properly? The spreadsheet would soon become meaningless and an auditor would have a fit!

9.8 ANSWERS

Self-assessment Questions

1. (i) ALU
   (vi) I/O, output
   (vii) Permanent memory
   (viii) System software
   (ix) Record

2. (i) Decide on the aims of the system.
   (ii) Decide what programs will achieve the aims.
   (iii) Decide what hardware will support the progress. Computer salesman would like you to believe that these items are in reverse order! You will probably not have to look far to find a system running at fifty per cent efficiency as a result of this simple discipline being ignored!

Activity 1

Typical examples are:

(1) Stock control
(2) Inventory
(3) Library records
(4) Personnel records. You may need to register under the Data Protection Act if you hold personnel details on a computer system.

Activity 2

(1) Inventory. Although you cannot find particular details quickly in the same way as with a database, you can more readily ascertain asset values, written down values, etc.
(2) Ledgers. More or less any accounting ledgers are suitable for putting on spreadsheets, although there are dedicated accounts packages designed for the purpose.
(3) Budgeting and forecasting. A spreadsheet could help in monitoring a budget. However, in setting up a forecast of, say, cash requirement for a year, a spreadsheet is invaluable and will save much time with a calculator. It also enables you to see the effects of 'What if questions.

Terminal Questions

1. Subscription databases, your own database, bought-in disk-based data (e.g. dictionaries), electronic mail, other computers (via a communication network).
2. (ii) You might have to go to the library for this.
   (iii) Although this depends on its efficiency, it could be as quick as (4).
   (i) Access times vary.
   (iv) If you've set it up well, this should be quickest.
3. (ii) would be best, although you can also get more specialist software.
4. Computing systems can handle large amounts of information with far greater facility than people. They are speedier and more reliable.

UNIT 10 INFORMATION DISTRIBUTION

Structure

10.1 INTRODUCTION

Like any other office we need equipment to provide for information distribution in the laboratory office also. For information distribution we require multiple copies of various letters and document which can be handed over personally or mailed to the concerned persons. A variety of office machines and equipment's are now available for preparing documents and making multiple copies.

In this unit we will cover the following:
(i) various kinds of typewriters and their uses,
(ii) various reprographic processes for information distribution.

Objectives
After studying this unit you should be able to;

- list various types of reprographic methods,
- describe uses of various kinds of typewriters,
- explain duplicating and copying processes and describe materials and machines required for the purpose,
- compare the advantages and disadvantages of spirit, stencil and litho duplication, and
- describe the uses of microfiche and facsimile.

10.2 INFORMATION DISTRIBUTION

The organization and management of any institution, be it an isolated lab or a large site with many labs, requires that information is managed. Methods of managing information - selecting it and distributing it to the right people - are the subject of separate study, usually under the heading of 'Information Technology'. Here we will restrict ourselves to information distribution.

In unit 9 we discussed some of the most efficient ways of managing information with the use of computers. However, if a computer in a lab receives information, it is only available to those with immediate access to it. The information is not widely available. In order to disseminate information widely, machines and equipment are used in all types of offices. The common examples of such machines are typewriters, duplicators, photocopying and Xerox machines. These labour saving devices are an integral part of any office. Therefore, it is important that you get familiar with them.

Office mechanisation should be considered a must for all laboratory organisation and management. You may not have come across this term before. Office mechanisation is the process of introducing the use of machines and equipment in place of manual operation of office work with a view to increase efficiency and output, and reduce office cost. It is preferred mainly to improve quality and efficiency of work and ensure accuracy. Introduction of the latest devices in lab offices from time to time facilitates handling of information and its distribution effectively.

Reprography
In order to disseminate information widely some method of reprography is invariably used. Reprography is the science and practice of copying documents by photography or xerography.

You may have used a Xerox machine for making copies of your degree, grade card, application forms etc.

The scope of reprography is wide, covering areas such as duplicating, document reproduction and copying, including photographic copying.

The wide range of methods can be divided into two basic techniques.

(1) Duplicating, and
(2) Copying.

Though the terms appear to imply the same process, technically they are different. One of the fundamental differences is that *in duplicating a special master has to be prepared from which copies are made.* The duplicating process will often eventually expend the master. With copying however, *copies are made directly from the original which remains intact for further use.* The choice of method will depend on the facilities that are available in an office, the number and quality of the copies required, and cost.

Here we will consider some of the more usual processes from the point of view of convenience, copy quality and cost. The knowledge of those processes is essential because you will certainly require to use them sometime in the lab office.

Before we discuss duplicating processes and requirement of material and machine, we must consider various kinds of typewriters commonly available in labs and their uses. Besides routine work typewriters are also used for cutting stencils about which you will learn in section 10.4.

SAQ 1

(a) Indicate which of the following statements are true or false? Write T for true and F for false in the given boxes.

(iii) Reprography includes duplicating and copying processes ☐

(iv) Duplication and copying are the same process. ☐

(iii) In duplicating the multiple copies are obtained directly from the original. ☐

(iv) Reprography methods are used in order to disseminate information widely. ☐

(b) In the following statements fill in the blank spaces with the appropriate words.

(v) ..... are used for managing information in the most efficient way but they are costly.

(ii) The common machines used in the offices for making multiple copies of a document are ..... and

10.3 TYPEWRITERS

Typewritten letters are attractive in appearance as compared to handwritten ones. The same matter can be typed in lesser space on writing paper along with carbon copies. Thus, use of a typewriter helps to bring about speed and efficiency in written communication and lab management. Many other advantages such as quick tabulation, storage of data, typing of formulae, etc., may also be obtained by the use of special purpose typewriters.

There are a variety of typewriters available in the market. Each of them has some specific features and uses. The details of some commonly used typewriters are given below:

Standard typewriter
You must have seen this manually operated machine. Standard typewriters of various makes such as Remington, Facit, Godrej, etc., are available in the market. A standard typewriter can type ten characters to the inch horizontally and six lines to the inch vertically with single spacing. Moreover, a number of carbon copies can also be obtained depending upon the quality of typing and carbon papers used.

Electric typewriter
Electric typewriters are similar to standard typewriters but with-an electronic motor taking the place of human energy. It is much faster than the standard model. They can produce up to 20 copies of a document if paper of appropriate thickness is used. The slightest touch of fingers sets the keys in motion and the impressions produced are uniform and perfect. Electric typewriters are commonly preferred because of the speed of typing, fineness and uniform quality of the print. Besides they are good for cutting stencils, typing invoices and preparing material for printing.

Automatic typewriter
It is a power-driven machine, which automatically types a standard pro forma from a previously punched or stencilled master (Ref. to section 10.4). When the master is placed on the machine and the machine is switched on, the matter is automatically typed on the paper at a speed of about 150 words per minute. Non-standard information like names, addresses, etc., may be inserted at appropriate places by manual typing. Thus, it is suitable when letters or circulars bearing routine messages have to be reproduced in large numbers.

Electronic typewriter
An electronic typewriter has a 'memory' or 'electronic brain' which enables it to recall the whole document at a time and type it automatically at the press of a button. A small display panel reads out the memory and permits editing and modification of drafts on the typewriter itself prior to final print-out. An electronic typewriter is shown in Figure 10.1.

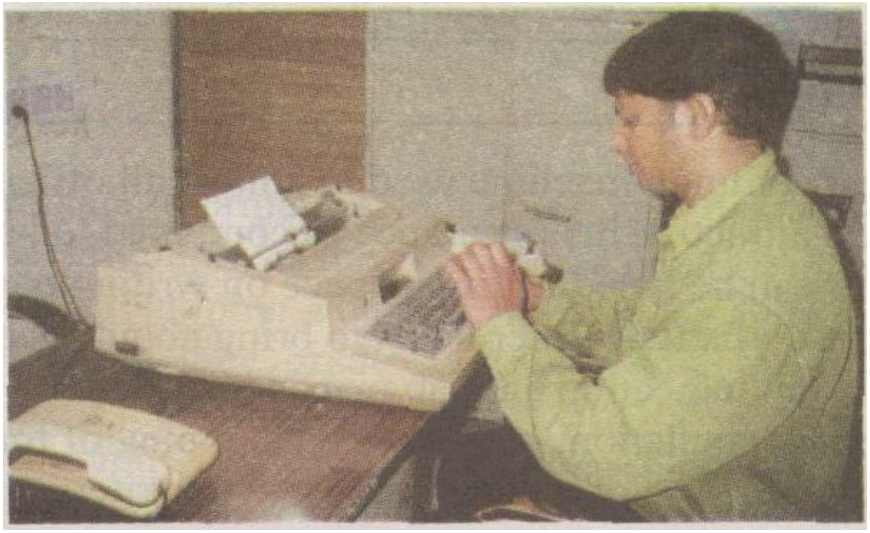

Fig. 10.1: Electronic Typewriter

Typewriters with special attachments
Certain special attachments can be used to the typewriter for typing work of a special nature. These are:

The continuous stationery device - It is used for typing continuous strips of office forms.
The front feed device - It enables insertion and typing of cheques and receipts.
Card-holding attachment - It enables small stiff cards or labels to be fed and curved round the roller.

Use of Typewriters for Multiple Copies
Offices frequently require copies of various letters and documents. The simplest method is to make the copies at the same time along with the original letter or document. Carbons, carbon-coated sheets or carbonless copy papers are often used to get a small number of legible copies. A standard typewriter can produce up to six carbon copies, whereas an electric typewriter can produce up to 20 copies as compared to four legible copies by handwriting. But where the number of copies required is more than 20, a duplicator may be used for the purpose.

In the following section we will discuss the duplicating process. But before moving further try the following SAQ.

SAQ 2
(a) List the various kinds of typewriters.
(b) In the following statements fill in the blank spaces with appropriate words.
   (vi) An..... typewriter automatically types a standard pro forma from a previously stencilled master.
   (vii) An..... typewriter has a memory and can automatically type a whole document on command.
   (viii) Approximately twenty copies can be produced by an..... typewriter.
   (iv) With ..... device the standard typewriter can type cheques, receipt etc.

Check your answers with ours before continuing.

10.4 DUPLICATING PROCESSES
As we mentioned earlier duplicating is a process whereby a master copy is prepared from which a large number of other copies are obtained with the help of a duplicating machine. It is a substitute for printing. It is used when the number of copies required is more than the capacity of a typewriter and yet not large enough to justify printing.
There are three main duplicating processes. These are listed in increasing order of cost and copy quality.

1. Spirit duplicating
2. Stencil duplicating
3. Offset litho duplicating

These three processes require duplicator and special material for making copies. Thus there are spirit duplicators, stencil duplicators and offset litho duplicators. Besides you may come across others such as electronic stencil duplicators and type set duplicators.

The duplicating machines available in the market can produce 200 to 500 legible copies of letters, circulars, notices, reports, forms, price lists, etc.

Let us now consider equipment, materials, master preparation and making of copies in each of the processes listed above.

10.4.1 Spirit Duplicating

Equipment Required

Spirit Duplicator (also known as hectograph) Thermal copier (optional)

Materials

Masters
Hectographic carbon Copy paper Duplicating spirit

Method

Master Preparation

By hand, typing or thermal.
Line drawings possible.

The master from which the copies will be taken is first prepared from a special non-absorbent glazed sheet of paper and special carbon paper which acts as the reproducing medium. This carbon paper is known as *hectographic carbon* and contains aniline based dye. These carbons are available in different colours, typically purple, red, green, black, blue, brown and yellow.

To construct a master the glazed surface of the master paper is placed in direct contact with tne coated surface of the hectocarbon. The required information is then drawn, typed or written onto the surface of the master paper, causing a mirror image to be developed on the glazed side.

If a thermal copier is available it can also be used to prepare a hectographic master. This is a quicker and cleaner method.

Duplication

Once the master is ready it is attached to the drum of the duplicator with the carbon image outward. The copy paper is then fed into the machine. The function of the machine is to impregnate the copy paper with spirit in its passage through the machine so that it is moistened immediately before it comes into contact with the master on the drum. Since the contact of paper with master is brought about by a pressure wheel, the reaction of the spirit with the carbon causes an image to be transferred to duplicating paper.

Use

Mainly in educational establishments, that is class handouts.

Individual duplicating copies are relatively cheap to produce, the duplicator itself is simple and easily maintained.

Copy Quality

Poor - satisfactory

Multiple colours available simultaneously

Economic Run 10-100

- Both carbon and master paper are cheaply available.
- Master copy can be prepared easily.
- The process is simple.
- Good quality paper is used for copies.
- Many colours can be duplicated simultaneously.

Disadvantages

- The copies are inferior in quality because the dye tends to spread and ink on the copies tends to fade with time.
- The clarity of the image becomes progressively weaker as the copies are rolled out.
- It is difficult to alter the master copy if there are mistakes in the master.

10.4.2 Stencil Duplicating

Equipment Required

Stencil Duplicator
Thermal copier (optional)
or
Electronic stencil cutter

Materials

Stencil Copy paper Ink Cleaning Fluid

Method

Master Preparation

By hand, typing, thermal or electronic cutter.
Line drawings possible.

The master in this case is a sheet of fibrous, porous material which has a plastic coating. Such stencils are often referred to as 'skins'. An image is cut into the coating either by:

A typewriter,
By hand using special styli,
By thermal copier
Electronically by use of electronic scanner.

Duplication
After preparation, the master is attached to the drum of the duplicator. Once in position, the paper backing sheet is removed from the stencil and the stencil 'inked'. As the machine is operated; the

semi-absorbent copy paper is fed in and bought into contact with the rotating copy via a pressure roller.

The stencil duplicator is commonly used in offices where a large number of notices, circulars, price lists etc., are to be reproduced quite often. Such duplicators can be manually-operated or power-driven. They are available in the market under different brand names.

Use

In offices and educational institutions for bulletins, circulars, notices, etc.
Again, it is relatively inexpensive to produce individual copies, and the equipment is basic and easily maintained.

Copy Quality

Satisfactory

Colour

Multiple colours possible so long as machine rollers, etc. changed.

Economic Run 10-100

Advantages

- This duplicating process is cheaper as compared to printing or other processes.
- Graphs, diagrams, etc., can be prepared easily on the stencil .by using a stylus pen.
- Stencil can be altered easily by using correcting fluid.
- A good number of copies can be obtained within a short period of time.
- Photographic reproduction is possible with electronic stencils.
- Stencils can be stored and used again for more copies when required.

Disadvantages

- The main disadvantage of stencil duplicating is that separate runs are required for two or more colours. However, complicated duplicators have been developed for impression in multiple colours simultaneously.
- Stencil duplicating proves quite costly if only a few copies (say up to 25) are required.

10.4.3 Offset Litho Duplicating

Equipment Required Duplicator

Plate-making equipment (not always, essential), e.g. printing box and processing unit

Materials
Plates
Paper
Ink
Plate making materials

Method

This process is far more complex than the previous two methods of duplicating. In fact, it is more like printing than a duplicating process, and ' gives a much better overall quality to the finished copy, including illustrations.

Master Preparation

By hand, typing, electrostatic copying, or photographic copying.

Line drawings and contrasting photographs possible.

Duplication

In lithographic process the plates can be either paper, plastic, or metal. Paper plates for short runs are cheaper and easier to prepare than metal plates (for longer runs). Cost increases with quality. Paper plates are usually used once, whereas metal plates have an almost indefinite life. Paper plates can be prepared directly by the use of special grease-based pencils, ink or ribbons. Alternatively, the image of an original can be produced by means of an electrostatic copier, or by photo-transfer.

The plate is attached to the drum of the duplicator and a supply of grease-based ink and a watery fluid are applied to it simultaneously. The inked image is not transferred directly to the copy paper, but is brought into contact with another drum which transfers the mirror image created on this drum to the copy paper.

Use

Offices, educational institutions and purpose-built reprograpahic facilities e.g. bulletins, promotional literature etc.

This is a more expensive option in terms of equipment and maintenance but may be economic where longer runs (see 'economic runs') are required.

Copy Quality

Good - excellent

Colour

Multiple colours possible so long as machine rollers, ink fountain, etc. changed. Accurate registration possible

Economic Run
50-10,000

Advantages

- The process is well-suited to the production of office forms, particularly those with complex rulings.
- A very large number of copies can be obtained.

- It is a cheap form of printing. Compared with normal printing, cost of printing is lower by 30% to 40% in offset litho printing.
- The quality of production is much better as compared to stencil duplicators.
- Master can be stored for an indefinite period. Copies can be obtained with the help of master whenever required.

Disadvantages

- Separate runs are required for printing in different colours.
- It can be run only by trained operators.
- It is costlier than other duplicating machines.
- It requires sufficient office space for storing chemicals, plates, and paper etc.

SAQ 3

In the following statements fill in the blank spaces with appropriate words.

(i) The carbon used for spirit duplication is called .....

(ii) In Lithography ..... and ..... plates are also used.

(iii) The quality of print of lithography is superior than ..... and ..... duplication.

(iv) The process of..... is more like printing.

10.5 COPYING

There are basically two methods of copying:

Photocopying

This is a modified development of photography. It is quite expensive and slow and is not often used for routine reprographic work these days.

Electrostatic copying

This method is often incorrectly called photocopying.

The electrostatic copying machine or xerography helps in getting exact copies of the original at a very fast speed. This eliminates the need for preparing a master copy.

Equipment Required

Copier

Usually copiers are available on lease. Outright purchase is possible, but may not be cost effective. For the lease the following should be inquired and checked.

(i) The period of lease

(ii) Conditions to which the lease can be terminated and a new copier used

(iii) The method of charging for copies

(iv) Charges for ancillary items, e.g. document handler, paper feed trays, sorter, standing cabinet, etc.

(v) Maintenance.

Materials

Toner: may be supplied under a lease agreement
Paper

Economic Run

This depends on leasing arrangements. Generally there is a flat rate cost for every copy made up of:
Machine cost + Paper cost + Toner + Maintenance

Master Preparation

There is no master to be prepared. The original may be in virtually any form, but certain colours, e.g. light blue, light yellow, etc. will not reproduce.

Copy Quality

Good - excellent

Colour

Usually one colour, multicoloured copiers are also available but they are very expensive.

Use

Almost any reprographic use.

Xerox machines are relatively expensive to run and to maintain (maintenance contracts allow serving from time to time). Because they are easy to use, normally everyone is allowed to use them. As a result they can suffer inexpert handling. You may find that some sort of control is required.

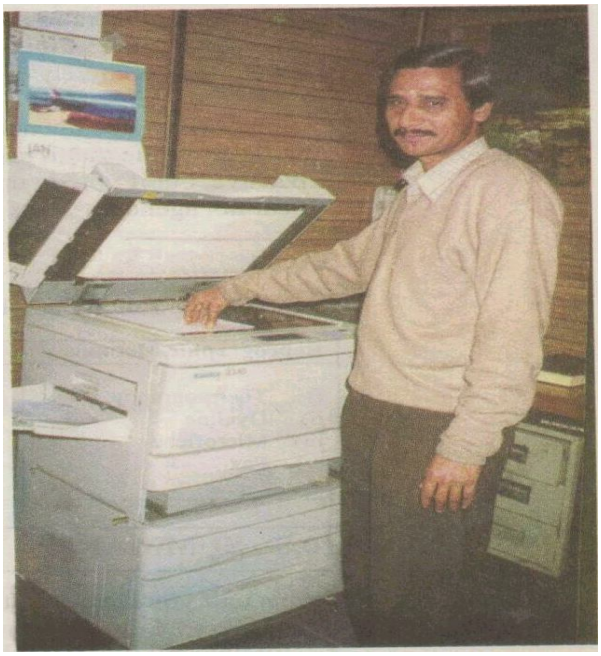

Fig. 10.2: Xerox machine

10.6 AUXILIARY METHODS

There are other reprographic methods which although commonly used earlier, are now mainly used for specific purposes. We think you should be aware of these methods also.

Thermography

Used mainly for preparation of reprographic masters, e.g. hecto, stencil, etc.

Dyeline

A cheap method ideal for large originals, e.g. circuit diagrams, engineering drawings, construction plans, etc. (Blue prints)

Microfiche

This is a standardized form of microfilm storage of information. Such a system allows the storage of approximately seventy-two pages of A4 per slide. The slide is viewed by placing it into a viewer, which projects enlarged sections of the slide onto a screen.

Microfiche systems allow high density storage of any material which can be photographed.

10.7 FACSIMILE

This is often known as 'fax' and it represents the interface between reprographic and computer technology. By using fax, the contents of a sheet of paper (text or illustration) can be transmitted over a telephone line. A typical example of the use of this method would be to send a schedule to the various speakers for a conference and to receive a reply and finalise accordingly.

Locally, urgent documents can be faxed from one end of the country to the other in less time that it takes to walk to the nearest post box! Fax terminals are expensive, but if you do not have immediate access to one, there is bound to be a local fax agency.

SAQ4

Complete the following table:

Reprographic Methods		Used for
(i)	Thermography	
(ii)	Dyeline	
(iii)	Microfiche	
(iv)	Fax	

10.8 SUMMARY

In this unit you have learnt that:

- Methods of reprography are used for the distribution of information.
- Typewriters are the most commonly used copying machines. They produce written matter on paper in type similar to the printer's type, along with 3 to 4 carbon copies. Standard typewriter, electric typewriter, electronic typewriter and typewriters with special attachments are commonly used.
- Duplicating is a process whereby a large number of copies can be obtained from a master copy with the help of a duplicating machine. A duplicating machine is used when the

number of copies required is more than the capacity of a typewriter and yet not large enough to justify printing.

- Various makes of duplicating machines are available which can produce 200 to 500 legible copies from the same master copy. Some of the important kinds of duplicating machines used are: spirit duplicator, stencil duplicator, offset litho machine.
- Thermography is also used for preparing reprographic masters.
- The choice of method of duplication is made according to the required quality, number of copies and the cost involved.
- In present times copying machines are widely popular because they are easy to use, several copies can be obtained within minutes and the original remains intact for further use.
- Microfiche can be used for storing large information.
- Facsimile or fax is revolutionary for information distribution. The content or illustration on a paper can be transmitted over a telephone line.

10.9 TERMINAL QUESTIONS

1. List the advantages of an electric typewriter.

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2. Is there a difference between duplicating and copying? If yes, what is it?

_____

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3. In duplicating and copying quality is of considerable importance. Of these systems described in the text, how does the quality vary?

_____

_____

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_____

10.10 ANSWERS

Self-assessment Questions

1. (a) (i) T, (ii) F, (iii) F, (iv) T
   b) (i) Computers
   (ii) duplicators, photocopier or Xerox machine
2. (a) See section 10.3.

(b) (i) automatic
(ii) electronic
(iii) electric
(iv) front feed

3. (i) hectographic carbon
(vi) metal, plastic, paper
(vii) spirit, stencil
(viii) lithography

4. (i) Preparation of masters for hecto and stencil.
(ii) Blue prints for engineering drawing.
(ix) Storage of large information.
(x) Quick transmission of information on paper via telephone lines.

Terminal Questions

1. (i) Much faster than standard typewriters.
(ii) Require much less energy in processing the keys
(iii) Provide uniform and perfect impressions
(iv) High speed
(v) Uniform quality and print

2. In duplicating a special master has to be prepared from which copies are made. While in copying copies are made directly from the original.

3. The offset litho duplicating process gives the best quality copies, as good if not better than those produced by photocopying. Although both stencil and spirit duplication give satisfactory copies on the whole, stencil duplication is preferable.