EXPERIMENT 7

FABRICATION OF AN EXTENSION BOARD

Structure

7.1 INTRODUCTION

You must have seen electrical sockets fixed on the walls of your home. If you wish to use an electrical appliance such as a table lamp or an iron at some distance from the wall, you need an (electrical) extension board. Similarly, in a physics laboratory, you may be required to use an extension board particularly when many students are working on a table or when many electrical instruments are to be used. An extension board provides for more than one electrical socket. These sockets are connected to a plug through a long three-core electrical wire. When this plug is inserted in the socket on a wall of the laboratory, electricity becomes available at the sockets of the extension board. And that is why an extension board is such a useful laboratory tool. In this experiment, you will learn how to fabricate an extension board.

7.2 AIM

The main purpose of this experiment is to enable you to learn how to fabricate an electrical extension board. Moreover, as you do this experiment, you will also learn to identify the live, neutral and earth wires and corresponding terminals of electrical sockets and plugs.

After doing this experiment, you should be able to:

- identify the live, neutral and earth terminals of a socket and corresponding wires in a three-core electrical wire;
- select appropriate wires, plugs, switches and sockets for fabricating an extension board; and
- fabricate an extension board.

The apparatus required for this experiment is listed below.

Apparatus

Wooden or plastic box (30cm × 15cm × 4cm), good quality 5m three-core electric wire of 20 gauge, 2 two-in-one (5A and 15A) sockets, 1 three-pin plug (15A); 2 switches (15 A), half meter single core electric wire of gauge 22.

7.3 LABORATORY WIRING

In Unit 5, you have learnt that household electricity connection is provided through a heavy cable which has two wires. These two wires are insulated from each other. One of these wires is called the **live** (L) wire and another is called the **neutral** (N) wire. The electric supply is AC (alternating current) and the live wire is alternately at positive and negative potential of 220V with respect to the neutral wire. The potential of the neutral wire is zero because it is earthed at the local electric sub-station. Therefore, when an electrical appliance is plugged to AC mains, charge flows from the live wire, through the appliance to the neutral wire when the live wire is at positive potential and vice-versa when the live wire is at negative potential.

The electrical connection to the mains of the physics laboratory is also provided through a two-core heavy cable. The electricity supplied is used for lighting, running electrical and electronic equipment etc. You will note that the laboratory electrical wiring has many sockets (in addition to light and fan points) at various points on the walls.

From Unit 5, you will recall that household electrical wiring comprises a number of parallel circuits. It means that all live wires should be connected at one point. Separate electrical circuits are used for lighting and power.

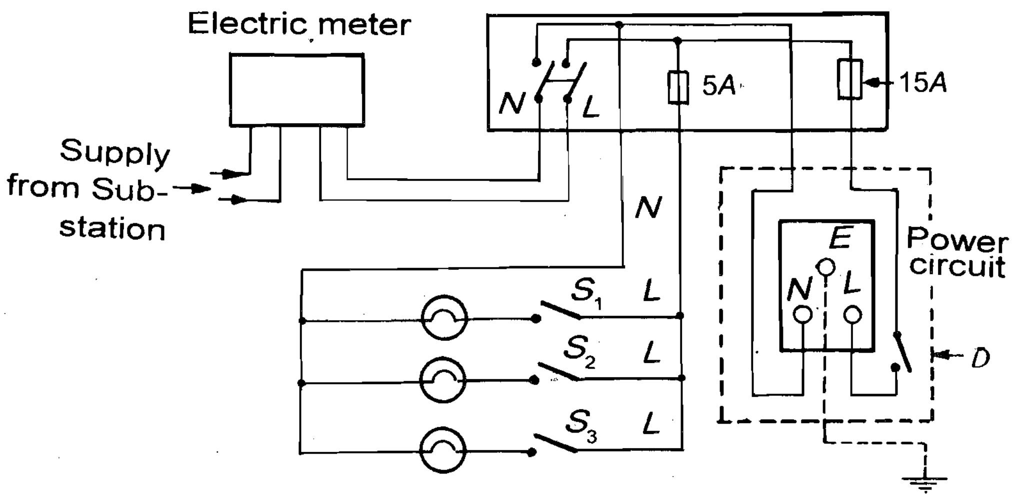

Fig.7.1: A typical laboratory wiring system

Fig.7.1 shows a typical laboratory wiring. Some of its salient features are:

a) The switch such as S_1 is always connected in the **live** (L) wire of the circuit so that when it is **off**, the socket (or the bulb holder) is not live. However, if the switch is connected in the neutral wire, the socket is live even when the switch is in off position (see margin remark on page 57). In such a condition, anyone touching the socket or the bulb holder would get a shock. For this reason, you should fix switches in the extension board along the live wire.

b) The fuse is connected along the live side of the circuit so that when it (fuse) blows, the appliances are also dead. The fuse will indeed blow even if it is on the neutral side. But, in this case, the appliance may be damaged.

c) Although neutral wire of the circuit is earthed at the electric substation, for extra safety, the power circuit (Fig.7.1) contains an additional earth wire E.

You will learn the rationale for the additional earth wire in power circuit of the laboratory wiring in the next sub-section.

The above features of laboratory wiring pertaining to the placement of switches, earth wire etc. are of vital importance for assembling an extension board. Further, earthing is the most important aspect of any wiring from safety point of view. Therefore, we now briefly discuss earthing.

To understand the rationale for putting switches along the live wire, refer to Fig.7.2 which shows a portion of the laboratory wiring.

7.3.1 Earthing

The neutral wire of the electric cable supplying electricity is grounded at the electric power station. Therefore, you may like to know: Why do we need a separate earth wire for power circuits in the laboratory? To appreciate the need of an additional earth wire, refer to Fig.7.3a which shows an electric supply cable connected to a socket. You will note that a person standing on the floor is at the same potential as the neutral wire. If s/he happens to touch the live wire by mistake, her/his body provides a low resistance path for electric current. Thus, the individual is at a risk of receiving electric shock, particularly, if the floor is wet and the person is bare-foot. The possibility of getting in contact with the live wire increases while handling electrical appliances or equipment with metal casing. It is because the live wire may become loose and touch the metal casing.

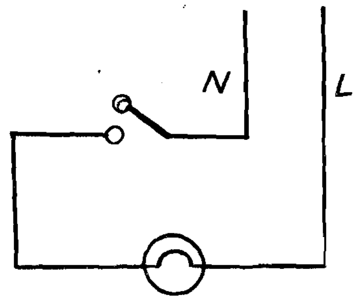

Fig.7.2: Portion of laboratory wiring

The switch for the light point has been placed along the neutral (*N*) wire. Let the switch be in **off** position. In this condition, if you touch the holder of the bulb, your body provides the earth (the conducting path) and hence completes the circuit for the current to flow. As a result, you would feel an electric shock. Thus, even if the switch along the *N* wire is off, the electrical point (such as bulb holder, socket etc.) is live and may cause harm to anyone touching it accidentally.

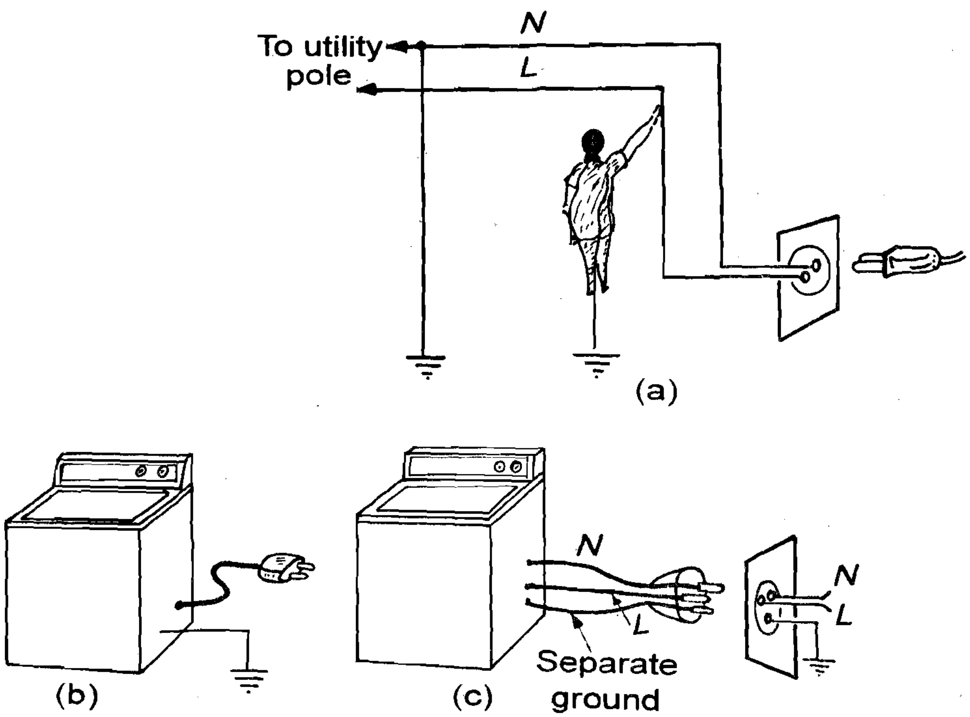

Fig.7.3: a) Human body provides low resistance path for electric current; b) and c) the two ways of earthing an electrical appliance.

We can avoid electric shock due to the absence of earthing in two ways (See Fig.7.3b and c): By grounding the metal casing of the electrical appliance or equipment and by using a **three-pin socket**.

When electrical equipment is provided with a separate earthing, the risk of electric shock is minimised. Generally, instead of separately earthing each equipment or appliance (Fig.7.3b), a common earth wire is provided in the power circuit of the laboratory. The earth terminal of the socket is connected to this common earth wire of the power circuit (Fig.7.3c).

So far you have studied about the laboratory wiring and its salient features. You now know why parallel circuits are used in wiring, how to obtain the value of current drawn by an electric equipment of given wattage (see margin remark), what is the importance of the earth wire in the power circuit etc. With this, you are ready to undertake the fabrication of an extension board. However, you need to understand the circuit diagram of the extension board before you wire its various components. Therefore, now we discuss various electrical components of an extension board and how they are connected.

For calculating the current required by an electrical appliance, you can use the formula

Power = Voltage × Current

Every electrical appliance or equipment is provided with its **rating**. Rating expresses the maximum power or current which is drawn by the equipment at a given voltage. Thus, the current drawn by a 40 W bulb is given as

$$\text{Current} = \frac{40\,\text{W}}{220\,\text{V}} = 0.18\,\text{A}$$

and by a 3 kW electric heater as

$$\text{Current} = \frac{3000\,\text{W}}{220\,\text{V}} = 13.6\,\text{A}$$

The power rating of an electrical appliance is marked on its body in one of the two ways:

i) **220 V, 2kW:** This power rating implies that when operated at 220 V, the appliance will consume 2kW power, that is, it will draw $\frac{2000\,\text{W}}{220\,\text{V}} = 8.7\,\text{A}$ current from the mains supply.
ii) **5 A, 220 V**: This power rating straight away gives the value of the maximum current (5A) the appliance/equipment will draw from the mains supply at 220 V.

7.4 ASSEMBLING AN EXTENSION BOARD

The basic activities involved in assembling the extension board are to wire switches, sockets and plugs in accordance with a circuit diagram. Therefore, let us first know about these components and the proper method of connecting them in a circuit.

A. Electrical wires

Electrical wires are made of copper because copper is a good conductor of electricity and relatively inexpensive. In recent years, there is an increasing trend towards the use of aluminium.

As you know from your school physics course, the current carrying capacity of a wire depends on its area of cross-section, and hence on its diameter. The thickness of the wire used for electrical wiring is expressed in terms of its **gauge**. The gauge of a wire is inversely related to its diameter. This means that a thick wire will have a smaller gauge. Electrical wires are categorised for different uses in terms of its gauge. A three-core electrical wire is shown in Fig.7.4a. For identifying the live, neutral and earth wires, a colour coding scheme is used. The live wire has red insulation, the neutral wire has black insulation and the earth wire has green insulation.

It is, therefore, obvious that the selection of the copper wire for the extension board would be determined by the maximum current that is likely to flow through it. Thus, you must have an idea about the maximum current which is likely to flow when an appliance or an equipment is plugged in the extension board. This can be easily calculated if you know the power rating of the equipment (see margin remark). **Generally, for equipment used in a typical physics laboratory, it is safe to assume that not more than 15A current would flow through the cable at any instant of time. Therefore, you should take copper wire gauge of 20 gauge for making an extension board.** In India, the terminology usually used for wires by electricians is 7/20, 3/20, 1/18, 3/22 where the first digit signifies the number of strands of wire and the second digit signifies the gauge. For power, 7/20 wire is used. For light, 3/20 and/or 3/22 may be used. For earthing 1/18 is used.

B. Socket and plug

Now refer to Figs.7.4b and 7.4c which show a 15A three-pin socket, and a 15A three-pin plug, respectively. Now-a-days, sockets are available in which both 5A and 15A loads can be plugged in one at a time. Such sockets are called two-in-one sockets (see Fig.7.4b). Both the three-pin socket and the three-pin plug have three terminals, namely, live (*L*), neutral (*N*) and earth (*E*). These terminals have to be connected to the corresponding wires of three-core electrical wire. It is, therefore, important to identify live, neutral and earth wires.

C. Switch

The electric switch (Fig.7.4d) has only two terminals. It is always connected along the live wire in a circuit.

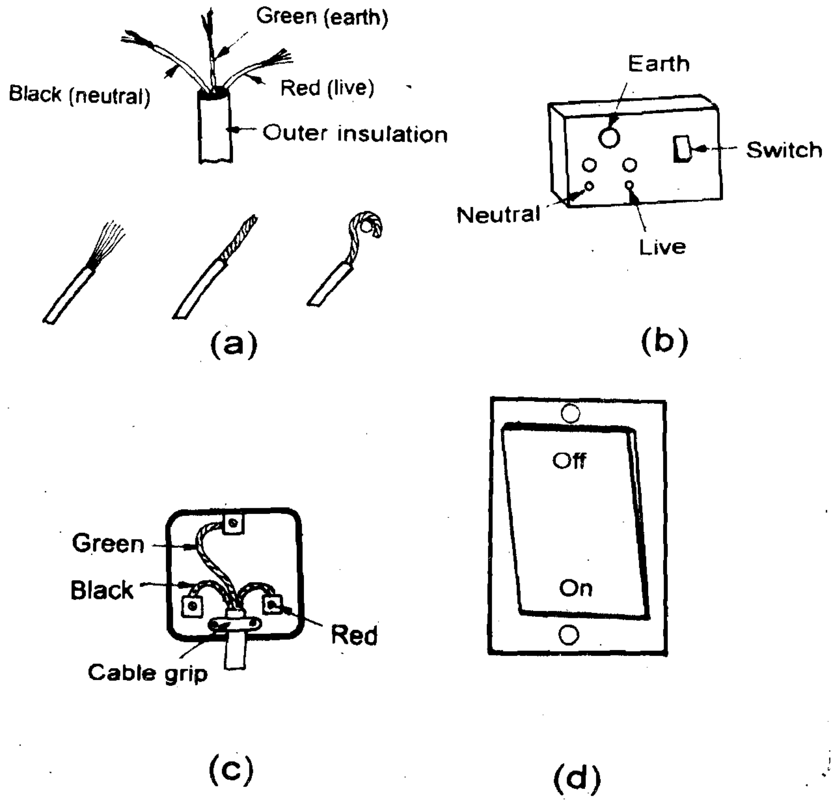

Fig.7.4: a) Three-core electric wire; b) two-in-one three-pin socket; c) three-pin plug; and d) 15A switch

For connecting the three-core wire in a plug, or a switch or a socket, you will be required to strip its outer insulation for about 3 cm length. Then, the insulation of the three inner wires should be stripped as per the requirement of the socket. Afterwards, you should tightly twist the strands so that the live and the neutral wire do not touch each other (if this happens, it will cause sparking and spoil the plug or the socket). You should **wrap each wire clockwise around the terminals of the socket so that the screws tighten in the same direction**. The same method should be used for connecting wires in a plug or a switch.

We would now like you to answer the following SAQ.

SAQ 1

a) How will you identify live, neutral and earth wires of the three-core electric wire?
b) State the precautions in wiring a three-pin socket.

You should proceed ahead only if you are confident about your answers. You may also discuss them with your counsellor.

D. Circuit diagram

For drawing a circuit diagram for an extension board, the following questions have to be considered:

a) How many electrical appliances/equipment are to be plugged in the extension board?
b) What are the **power ratings** of these appliances/equipment?

The number of electrical appliances to be used at one time will determine the number of sockets to be provided on the extension board. And, the answer to question (b) above determines the gauge of wire, and the type of sockets, switches and plug you would require.

Now suppose we wish to fabricate an extension board for plugging two instruments such as an oscilloscope and a signal generator. For such an extension board, the circuit diagram is shown in Fig.7.5. You will note that such an extension board has 2 two-in-one sockets with independent switches.

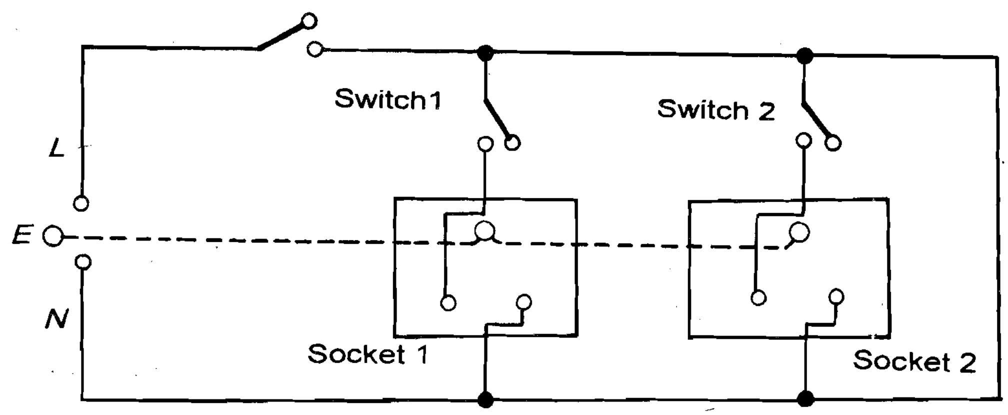

Fig.7.5: Circuit diagram of an extension board

We hope that now you understand the basic principle that determines the choice of various components of an extension board. Now you will learn to assemble an extension board.

E. Procedure

1. Take out the top of the wooden/plastic box for drilling holes in it to fix the sockets and switches (Fig.7.6). With a pencil, mark the points shown in Fig.7.6 for holes. Use a hand drill to drill holes of appropriate size at these points. Fix the sockets and switches in their appropriate positions on the top of the box with screws. Take help of your counsellor for this activity, if need be.

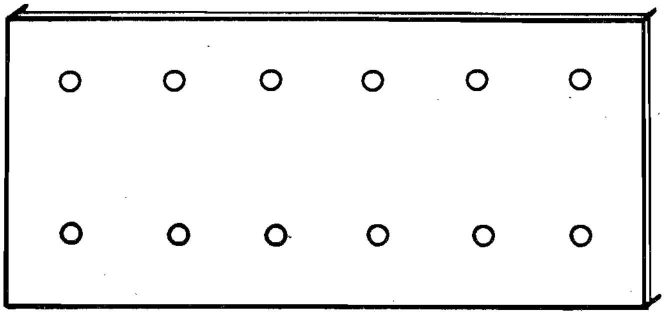

Fig.7.6: Fixing of sockets and switches on the extension board

2. Keep the labelled circuit diagram (Fig.7.7) of the extension board before you. This diagram is the labelled version of the circuit diagram of the extension board (Fig.7.5).

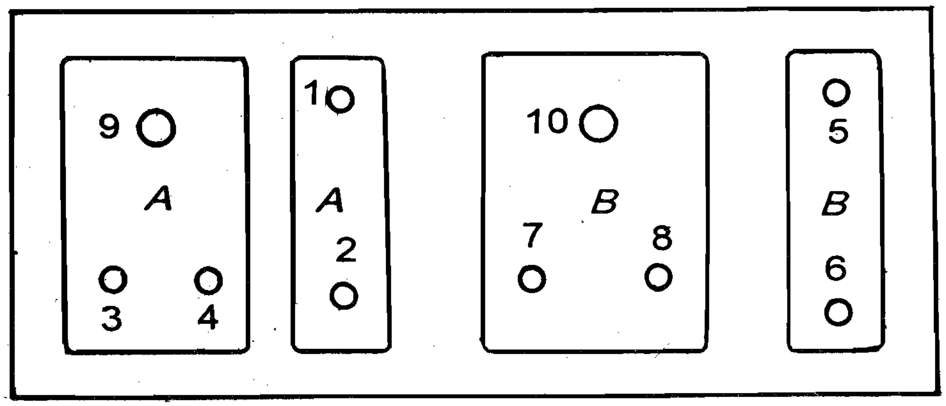

Fig.7.7: Labelled circuit diagram of the extension board

Note that all the terminals of sockets and switches in Fig.7.7 are numbered. You just have to join these numbered terminals as per the instructions given below using the single core wire of gauge 22. You will have to cut this wire into pieces of appropriate length:

a) Connect points 2 (the lower end of the switch *A*) and 3 (the live terminal of socket *A*).
b) Connect points 1 and 5 (the upper ends of switches *A* and *B*).
c) Connect point 6 (the lower end of switch *B*) with point 7 (the live terminal of socket *B*).
d) Connect points 4 and 8 (the neutral terminals of sockets *A* and *B*).
e) Connect points 9 and 10 (the earth terminals of sockets *A* and *B*).

Now all the internal electrical connections of the extension board are complete. Let us now join the 5m long three-core wire with the extension board so that it can be plugged into the wall socket.

3. Remove the outer insulation at both ends of the 5m long three-core wire. You will obtain three wires of different colours. Remove the insulation from about 1 cm length of each of these wires.
4. Connect the live wire (red in colour) to point 1 (the upper end of switch *A*) of the extension board.
5. Connect the neutral wire (black in colour) of the three-core wire with point 4 (the neutral terminal of socket *A*).
6. Connect the earth wire (green in colour) of the three-core wire with point 9 (the earth terminal of the socket *A*).

7. Connect the other end of the three-core wire with a three-pin 15A plug connecting earth, live and neutral wires at the appropriate terminals.

After these electrical connections are made, you must get it checked by your consellor. Now place the top on the box in such a way that all electrical connections are concealed in the box.

8. Fix the top on the box with the help of screws.
9. Your extension board is ready for use. Insert the plug fixed at one end of the three-core wire into a wall socket and switch it on. To check that electricity is available at your extension board, you should use an **electrical tester**.

7.5 SAFETY MEASURES

1. While fixing stranded copper wires at the terminals of the sockets, switches and plug, you must twist the strands properly so that no strand remains loose. This is necessary to avoid any short circuit.
2. In electrical connections, nothing can be as irritating and risky as loose connection. Therefore, properly tighten the screws on the terminals of the sockets and switches.
3. Give utmost importance to the proper connection of the earth wire. Otherwise you know how dangerous it may prove to be.
4. Since water conducts electricity, you should always dry your hands before switching-on or off any electrical appliance or equipment.
5. Do ensure that the switches on the extension board have been put along the live wire.