ELECTRICIAN

NSQF LEVEL - 5

1st Semester

TRADE PRACTICAL

SECTOR: Electrical

Directorate General of Training

DIRECTORATE GENERAL OF TRAINING
MINISTRY OF SKILL DEVELOPMENT & ENTREPRENEURSHIP
GOVERNMENT OF INDIA

NATIONAL INSTRUCTIONAL MEDIA INSTITUTE, CHENNAI

Post Box No. 3142, CTI Campus, Guindy, Chennai - 600 032

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FOREWORD

The Government of India has set an ambitious target of imparting skills to 30 crores people, one out of every four Indians, by 2020 to help them secure jobs as part of the National Skills Development Policy. Industrial Training Institutes (ITIs) play a vital role in this process especially in terms of providing skilled manpower. Keeping this in mind, and for providing the current industry relevant skill training to Trainees, ITI syllabus has been recently updated with the help of Mentor Councils comprising of various stakeholder's viz. Industries, Entrepreneurs, Academicians and representatives from ITIs.

National Instructional Media Institute (NIMI), Chennai has come up with instructional material to suit the revised curriculum for **Electrician 2nd Semester Trade Practical NSQF Level - 5** in **Electrical** sector under Semester Pattern required for ITIs and related institutions imparting skill development. The NSQF Level 5 will help the trainees to get an international equivalency standard where their skill proficiency and competency will be duly recognized across the globe and this will also increase the scope of recognition of prior learning. NSQF level 5 trainees will also get the opportunities to promote life long learning and skill development. I have no doubt that with NSQF level 5 the trainers and trainees of ITIs, and all stakeholders will derive maximum benefits from these IMPs and that NIMI's effort will go a long way in improving the quality of Vocational training in the country.

The Executive Director & Staff of NIMI and members of Media Development Committee deserve appreciation for their contribution in bringing out this publication.

Jai Hind

RAJESH AGGARWAL
Director General / Addl. Secretary,
Ministry of Skill Development & Entrepreneurship,
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New Delhi - 110 001

PREFACE

The National Instructional Media Institute (NIMI) was established in 1986 at Chennai by then Directorate General of Employment and Training (D.G.E & T), Ministry of Labour and Employment, (now under Ministry of Skill Development and Entrepreneurship) Government of India, with technical assistance from the Govt. of the Federal Republic of Germany. The prime objective of this institute is to develop and provide instructional materials for various trades as per the prescribed syllabi (NSQF) under the Craftsman and Apprenticeship Training Schemes.

The instructional materials are created keeping in mind, the main objective of Vocational Training under NCVT/NAC in India, which is to help an individual to master skills to do a job. The instructional materials are generated in the form of Instructional Media Packages (IMPs). An IMP consists of Theory book, Practical book, Test and Assignment book, Instructor Guide, Audio Visual Aid (Wall charts and Transparencies) and other support materials.

The trade practical book consists of series of exercises to be completed by the trainees in the workshop. These exercises are designed to ensure that all the skills in the prescribed syllabus are covered. The trade theory book provides related theoretical knowledge required to enable the trainee to do a job. The test and assignments will enable the instructor to give assignments for the evaluation of the performance of a trainee. The wall charts and transparencies are unique, as they not only help the instructor to effectively present a topic but also help him to assess the trainee's understanding. The instructor guide enables the instructor to plan his schedule of instruction, plan the raw material requirements, day to day lessons and demonstrations.

In order to perform the skills in a productive manner instructional videos are embedded in QR code of the exercise in this instructional material so as to integrate the skill learning with the procedural practical steps given in the exercise. The instructional videos will improve the quality of standard on practical training and will motivate the trainees to focus and perform the skill seamlessly.

IMPs also deals with the complex skills required to be developed for effective team work. Necessary care has also been taken to include important skill areas of allied trades as prescribed in the syllabus.

The availability of a complete Instructional Media Package in an institute helps both the trainer and management to impart effective training.

The IMPs are the outcome of collective efforts of the staff members of NIMI and the members of the Media Development Committees specially drawn from Public and Private sector industries, various training institutes under the Directorate General of Training (DGT), Government and Private ITIs.

NIMI would like to take this opportunity to convey sincere thanks to the Directors of Employment & Training of various State Governments, Training Departments of Industries both in the Public and Private sectors, Officers of DGT and DGT field institutes, proof readers, individual media developers and coordinators, but for whose active support NIMI would not have been able to bring out this materials.

R. P. DHINGRA
EXECUTIVE DIRECTOR

Chennai - 600 032

ACKNOWLEDGEMENT

National Instructional Media Institute (NIMI) sincerely acknowledges with thanks for the co-operation and contribution extended by the following Media Developers and their sponsoring organisations to bring out this Instructional Material **(Trade Practical)** for the trade of **Electrician NSQF LEVEL - 5** under **Electrical** Sector for ITIs.

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NIMI records its appreciation for the Data Entry, CAD, DTP operators for their excellent and devoted services in the process of development of this Instructional Material.

NIMI also acknowledges with thanks the invaluable efforts rendered by all other NIMI staff who have contributed towards the development of this Instructional Material.

NIMI is also grateful to everyone who has directly or indirectly helped in developing this Instructional Material.

INTRODUCTION

This manual for trade practical is intended for use in the ITI workshop. It consists of a series of practical exercises that are to be completed by the trainees during the first semester of course is the **Electrician trade under Electrical Sector. It is National Skills Qualifications Framework (NSQF) - Level 5,** supplemented and supported by instructions/information to assist the trainees in performing the exercise. The exercises are designed to ensure that all the skills prescribed in the syllabus are covered including the allied trades.The syllabus for the1st Semester **Electrician** Trade under **Electrical Sector** Trade Practical is divided into six modules.The allocation of time for the various modules is given below:

Module 1 - Safety Practice and Hand Tools	14 Exercises	75 Hrs
Module 2 - Basic Workshop Practice (Allied Trade)	09 Exercises	100 Hrs
Module 3 - Wires, Joints - Soldering - U.G. Cables	10 Exercises	125 Hrs
Module 4 - Basic Electrical Practice	11 Exercises	75 Hrs
Module 5 - Magnetism and Capacitors	08 Exercises	50 Hrs
Module 6 - AC Circuits	12 Exercises	100 Hrs
Total	64 Exercises	525 Hrs

The syllabus and the content in the modules are interlinked. As the number of workstations available in the electrical section is limited by the machinery and equipment, it is necessary to interpolate the exercises in the modules to form a proper teaching and learning sequence. The sequence of instruction is given in the schedule of instruction which is incorporated in the Instructor's Guide. With 25 practical hours a week of 5 working days 100 hours of practical per month is available.

Contents of Trade Practical

The procedure for working through the 64 exercises for the 1st semester with the specific objectives as the learning out comes at the end of each exercise is given is this book.

The skill objectives and tools/instruments, equipment/machines and materials required to perform the exercise are given in the beginning of each exercise.Skill training in the shop floor is planned through a series of practical exercises/experiments to support the related theory to make the trainees get hands on trainning in the Electrician trade along with the relevant cognitive skills appropriate for the level. A minimum number of projects have been included to make the training more effective and develop attitude to work in a team. Pictorial, schematic, wiring and circuit diagrams have been included in the exercises, wherever necessary, to assist the trainees broaden their views. The symbols used in the diagrams comply with the Bureau of Indian Standards (BIS) specifications.

Illustrations in this manual, help trainess visual perspective of the ideas and concepts.The procedures to be followed for completing the exercises is also given. Different forms of intermediate test questions have been included in the exercises, to enhance the trainee to trainee and trainee to instructor interactions.

Skill Information

Skill areas which are repetitive in nature are given as separate skill information sheets. Skills which are to be developed in specific areas are included in the exercises itself. Some subexercises are developed to fulfill the sequence of exercises in keeping with the syllabus.

This manual on trade practical forms part of the Written Instructional Material (WIM). Which includes manual on trade theory and assignment/test.

CONTENTS

*** Steps to download and scan the Quick Response (QR) code**

- Download QR Code app on your phone
- Run app and scan the QR code
- Your smartphone will read the code and navigate to the destination

ASSESSABLE / LEARNING OUTCOME

On completion of this book you shall be able to

- **Apply safe working practices**
- **Prepare profile with an appropriate accuracy as per drawing**
- **Prepare electrical wire joints, carry out soldering, crimping and measure insulation resistance of underground cable**
- **Verify characteristics of electrical and magnetic circuits.**

Visit various sections of the institutes and location of electrical installations

Objectives: At the end of this exercise you shall be able to
- **visit the various sections/trade in your ITI and draw the layout of your ITI**
- **record the telephone numbers of the ITI office, hospitals, police station and fire station**
- **draw the layout of your section**
- **identify the locations that have electrical installations.**

PROCEDURE

TASK 1: **Visit various sections of the ITI and draw the layout of your ITI**

Instructor will lead the new trainees to various sections of the ITI.

1 Visit the various sections in your ITI and identify the sections of the ITI. List the trades and record it in your note book.

2 Collect the information about the staff members in each trade.

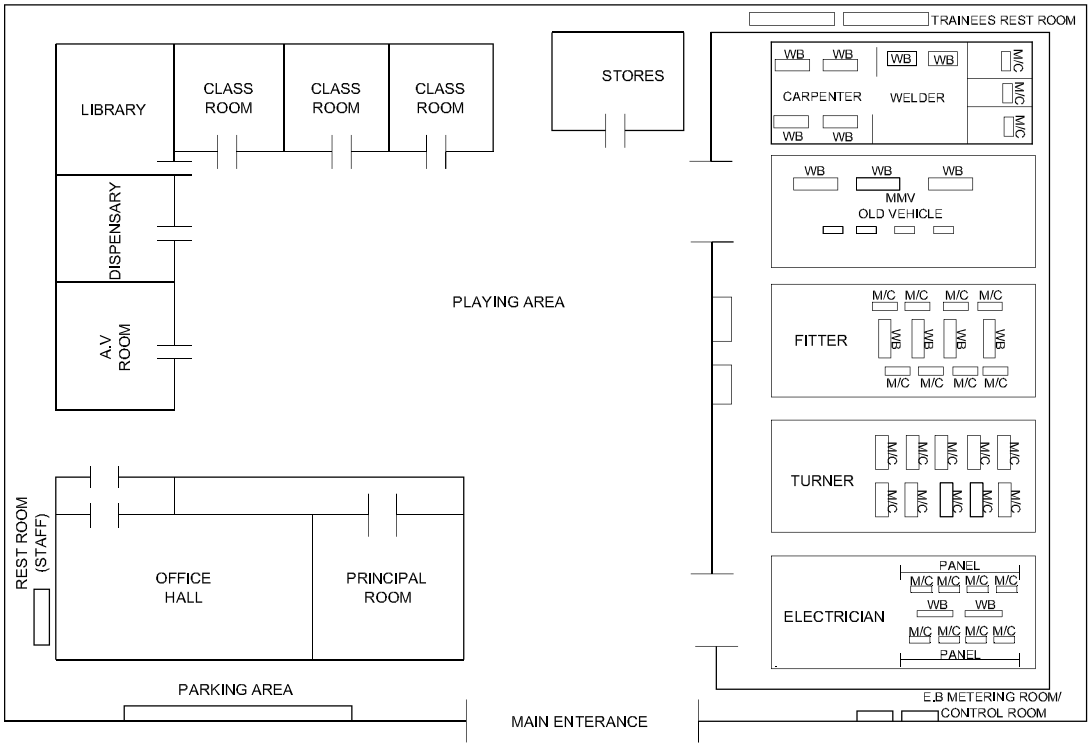
3 Identify the location of the ITI with details abouit the railway and bus stations in the locality and note down the list of bus route numbers which ply near the ITI.

4 Collect the telephone numbers of the ITI office, nearest hospitals, nearest police station and the nearest fire station and record.

5 Draw the layout of your ITI showing various trades.

Note :A Sample layout of the ITI (Fig 1) is given for your reference. Now draw the new layout of your ITI, with the trades/sections.

Fig 1



TASK 2: **Draw the layout of your section in the ITI**

1 Draw the plan of your section to a suitable scale in a separate sheet of paper (A4 size).

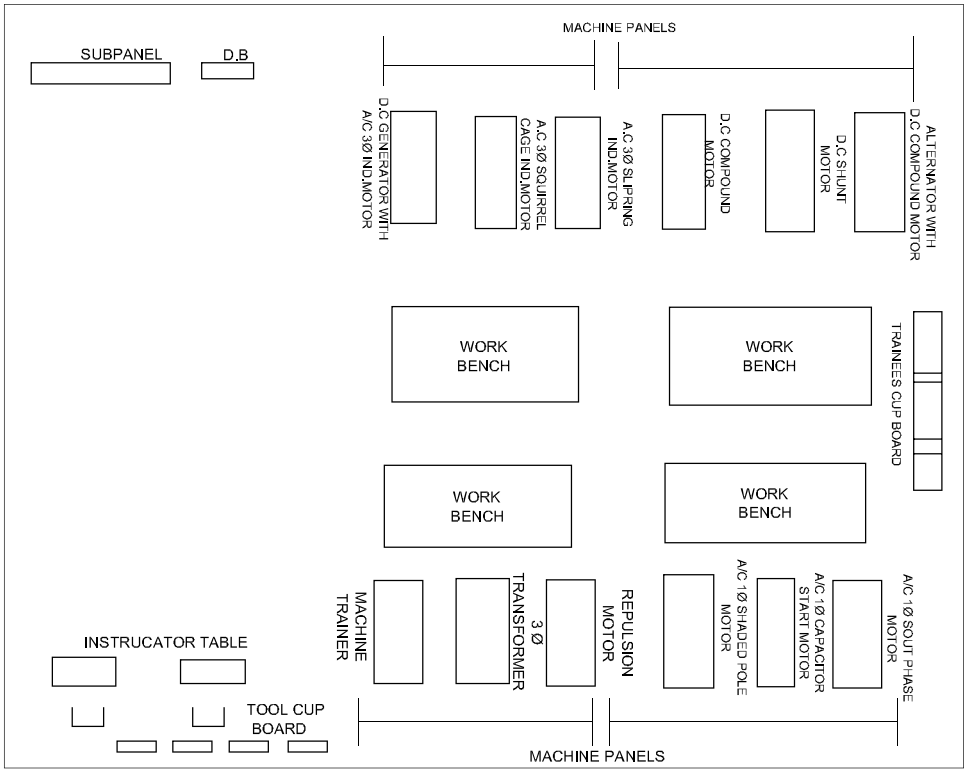
2 Take the length and the breadth measurements of machine foundations, work benches, panels, wiring cubicles, doors, windows, furniture, etc.

3 Draw the layout of the machines, work benches, panels and furniture.

The section plan should be in the same scale as in step 1 as per the actual placement of the machine foundations, panels, furniture, work benches etc.

Note : The sample layout of a typical electrician trade section is given for your reference (Fig 2). You have to draw your section's is layout using the sample as reference.

Fig 2



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TASK 3: **Identify the locations of electrical installations**

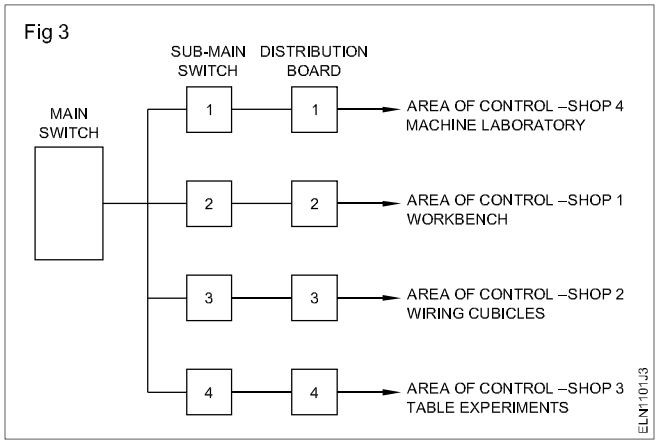
1 Identify the main switch and mark its position in the layout. (Fig 3)

2 Identify each of the sub-main switches, the area of control in the section and mark them on the layout.

3 Identify 3 or 4 spots in various locations of the electrician sections layout and identify the respective sub-main switches.

4 Practice switching 'off' the control switches, depending upon the area of control,imagining that victim are etectrocuted in a specific location/spot.

Fig 3



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Identify safety symbols and hazards

Objectives: At the end of this exercise you shall be able to
- **identify the safety symbols from the chart and their basic categories**
- **write their meaning and description mentioning where they are used**
- **identify road safety signs in traffic signals from the chart**
- **read and interpret different types of occupational hazards from the chart.**

Requirements

Materials

- Basic safety signs chart - 1 No.
- Road safety signs and traffic signal chart - 1 No.
- Occupational hazards chart - 1 No.

PROCEDURE

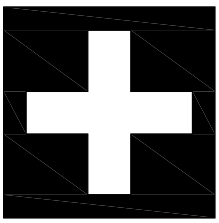
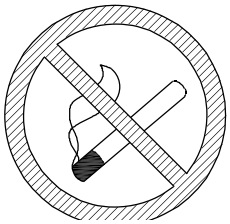
TASK 1: **Identify safety symbols and interpret what thay mean with the help of their colour and shape**

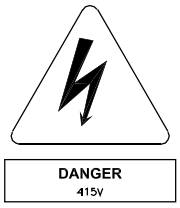
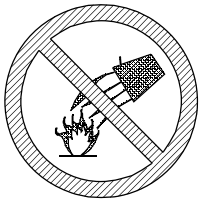
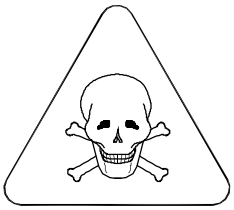
Instructor may provide charts with various safety signs for the road safety signs in traffic signals. Then, explain the categories meaning and colour. Ask the trainees to identify the signs and record it in Table 1.

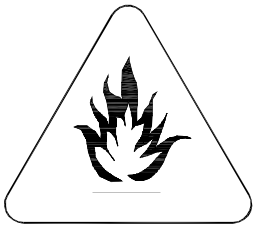
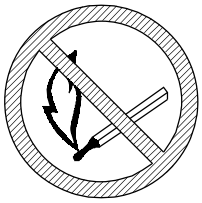
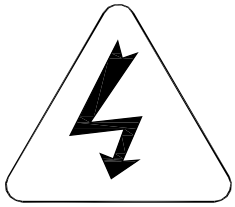
1 Identify the sings and their categories from the chart.

2 Write the name, categories, meaning and description of each sign and its place of use in Table 1.

Table 1

No.	Safety signs	Name of the sign and category	Place of use
1			
2			
3			

No.	Safety signs	Name of the sign and category	Place of use
4			
5	 DO NOT EXTINGUISH WITH WATER		
6	 WEAR HEAD PROTECTION		
7	 TOXIC HAZARD		
8	 WEAR EYE PROTECTION		

No.	Safety signs	Name of the sign and category	Place of use
9	 RISK OF FIRE		
10	 PEDESTRIANS PROHIBITED		
11	 WEAR HEARING PROTECTION		
12	 SMOKING AND NAKED FLAMES PROHIBITED		
13	 RISK OF ELECTRIC SHOCK		

TASK 2 : **Identify the road safety signs and traffic signal signs.**

Instructor will explain all the road safety signs and traffic signal signs

1 Identify the sign and give details of its kind and meaning in Table 2.

2 Get it checked by the instructor

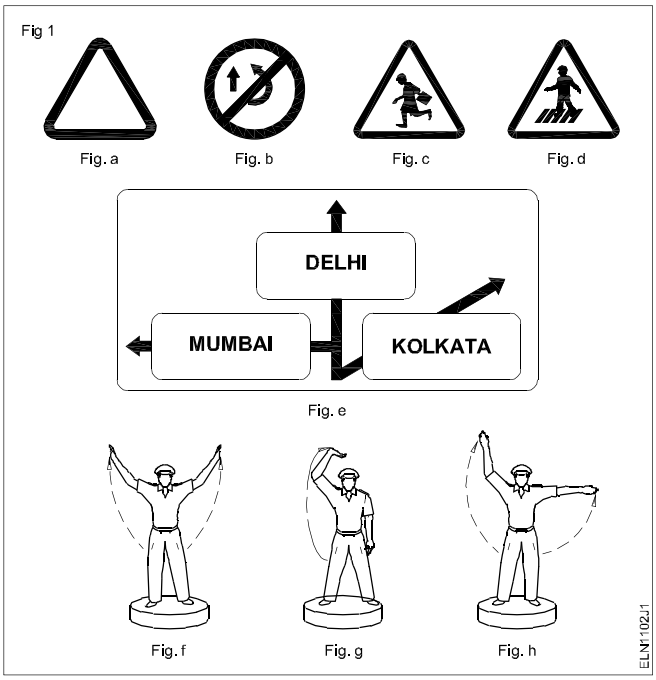


Table 2

Figure Number	Kind of road sign	Name of the signal	Meaning of the sign
1			
2			
3			
4			
5			
6			
7			
8			

TASK 3: **Read and interpret the different types of personal protective equipment (PPE) from the chart**

Instructor may brief the various types of occupational hazards and their causes.

1 Identify the occupational hazard matching it to the corresponding situation with the given potential in Table 3.

2 Complete the details and get it checked by your instructor.

Table 3

Sl.No.	Source or potential harm	Type of occupational hazard
1	Noise	
2	Explosive	
3	Virus	
4	Sickness	
5	Smoking	
6	Non-control device	
7	No earthing	
8	Poor housekeeping	

Preventive measures for electrical accidents and practice steps to be taken in such accidents

Objectives: At the end of this exercise, you shall be able to
- **practice and follow preventive safety rules to avoid electrical accidents**
- **rescue the electric shock victim.**

Requirements

Materials

- Heavy insulated screwdriver 200 mm - 1 No.
- Electrical safety chart (or) display - 1 No.
- Gloves - 1 No.
- Rubber mat - 1 No.
- Wooden stool - 1 No.
- Ladder - 1 No.
- Safety belt - 1 No.

PROCEDURE

TASK 1: **Practice and follow preventive safety rules to avoid electrical accidents**

1 Do not work on live circuits. If unavoidable use rubber gloves or rubber mats.

2 Do not touch bare conductors.

3 Stand on a wooden stool or an insulated ladder while repairing live electrical circuits/appliances or replacing fused bulbs.

4 Stand on rubber mats while working, operating switch panels, control gears, etc.

5 Always use safety belts while working on poles or high-rise points.

6 Use screwdrivers with wooden or PVC insulated handle when working on electrical circuits.

7 Replace (or) remove fuses only after switching off the circuit switches.

8 Open the main switch and make the circuit dead.

9 Do not stretch your hands towards any moving part of the rotating machine and around moving shafts.

10 Always use always earth connection for all electrical appliances along with 3-pin sockets and plugs.

11 Do not connect earthing to the water supply electrical lines.

12 Do not use water on electrical equipment.

13 Discharge static voltage in HV lines/equipment and capacitors before working on them.

14 Keep the workshop floor clean and tools in good condition.

TASK 2 : **Rescue the electic shock victim**

1 Proceed with treatment as early as possible without panic or becoming emotional.

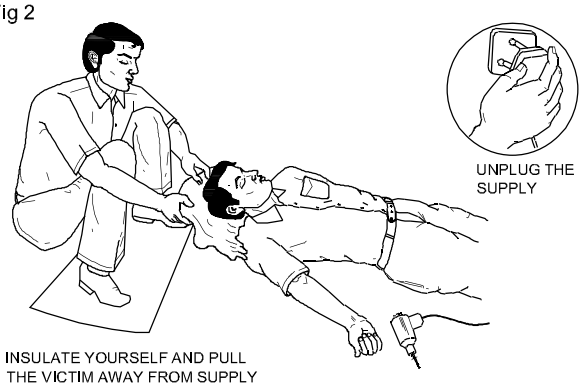
2 Switch off the power or remove the plug or wrench the cable free.

3 Move the victim from contact with the live conductor by using dry non-conducting materials like wooden bars. (Fig 1 & 2)

Avoid direct contact with the victim. Wrap your hands with dry material if rubber gloves are not available. If you are uninsulated, do not touch the victim with your bare hands.

Fig 1

Fig 2



4 Keep the patient warm and at mental rest.

Ensure that there is good air circulation. Seek help to shift the patient to a safer place. If the victim is aloft, take steps to prevent him from falling.

5 Loosen the clothing near the neck, chest and waist and place the victin in a relaxed position, if the victim is unconscious.

6 Keep the victim warm and comfortable. (Fig 3)

Fig 3

7 Send someone to call the doctor, in case of electric burns.

If the victim has electrical burns due to shock, it may be very painful and is dangerous. If a large area of the body is burnt do not give treatment. Give first-aid as given in step 8

8 Cover the burnt area with pure running water.

9 Clean the burnt area using a clean cloth/cotton.

10 Send someone to call the doctor immediately.

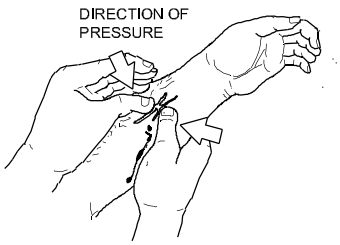
In case of severe bleeding

11 Lay the patient flat.

12 Raise the injured part above the body level. (If possible)

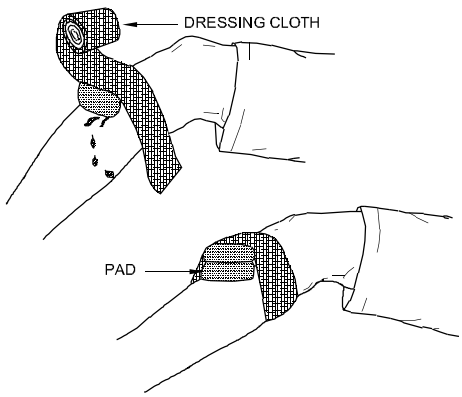
13 Apply pressure on the wound ,as long as necessary, to stop the bleeding. (Fig 4)

Fig 4



14 cover the injured area with a clean pad and bandage firmly, if it is a large wound. (Fig 5)

Fig 5



If bleeding is severe, use more than one dressing.

15 initiate right methods of artificial respiration, if the person in unconscious

Practice safe methods of fire fighting in case of electrical fire

Objectives: At the end of this exercise you shall be able to
- **demonstrate the ability of fire-fighting during electrical fire**
- **as a member of the fire-fighting team**
- **as a leader of the group.**

Requirements

Equipment/Machines

- Fire extinguishers- CO_2 - 1 No.

PROCEDURE

General procedure to be adopted during electrical fire

1 Raise an alarm. Follow the methods giving below to raise an alarm signals when the fire breakes out.
   - – Raise your voice and shout Fire! Fire! to draw attention.
   - – run towards fire alarm/bell to activate
   - – switch off the mains (if possible)

2 when you hear the alarm signal:
   - – stop working
   - – turn off all machinery and power
   - – switch off fans/air circulators/exhaust fans. (it's good to switch off the sub-main)

3 If you are not involved in the fire fighting:
   - – leave the place using the emergency exit.
   - – evacuate the premises
   - – assemble at a safe place along with others
   - – check, if anyone has called the fire services
   - – close the doors and windows, but do not lock or bolt

As a member of the fire-fighting team

4 If you are involved in fire fighting:
   - – take instructions to extinguish fire in an organised way.

   If taking instructions:
   - – follow the instructions, and obey. Be safe and do not get trapped.
   - – do not use your own ideas.

As a leader of the group

If you are giving instructions:

–locate and use co_2 fire extinguisher

- – seek for sufficient assistance and inform the fire brigade
- – locate locally available suitable means to put out the fire
- – judge the magnitude of the fire, Ensure that emergency exit paths are clear with no obstructions and then attempt to evacuate the place. (Remove explosive materials, substances that would easly catch fire.
- – Put off the fire with assistance identifying people with assigned responsibility for each activity.

5 Report the measures taken to put out the fire, to the authorities concerned.

Detailed reports on the fire accidents, even if they are small accidents, shall help in identification of the causes of the fire. The identified causes shall help in taking preventive measures to avoid similar occurences in the future

Use of fire extinguishers

Objectives: At the end of this exercise you shall be able to
- **select fire extinguishers according to the type of the fire**
- **operate the fire extinguisher**
- **extinguish the fire.**

Requirements

Equipment/Machines

- Fire extinguishers-CO_2 - 1 No.
- Scissors 100mm - 1 No.
- Cell phone - 1 No.

PROCEDURE

1 Alert people in the surrounding area by shouting fire, fire, fire when you see fire (Fig 1a & b).

2 Inform fire service or arrange to inform them immediately (Fig 1c).

3 Open the emergency exit and ask the people inside the area to go away (Fig 1d).

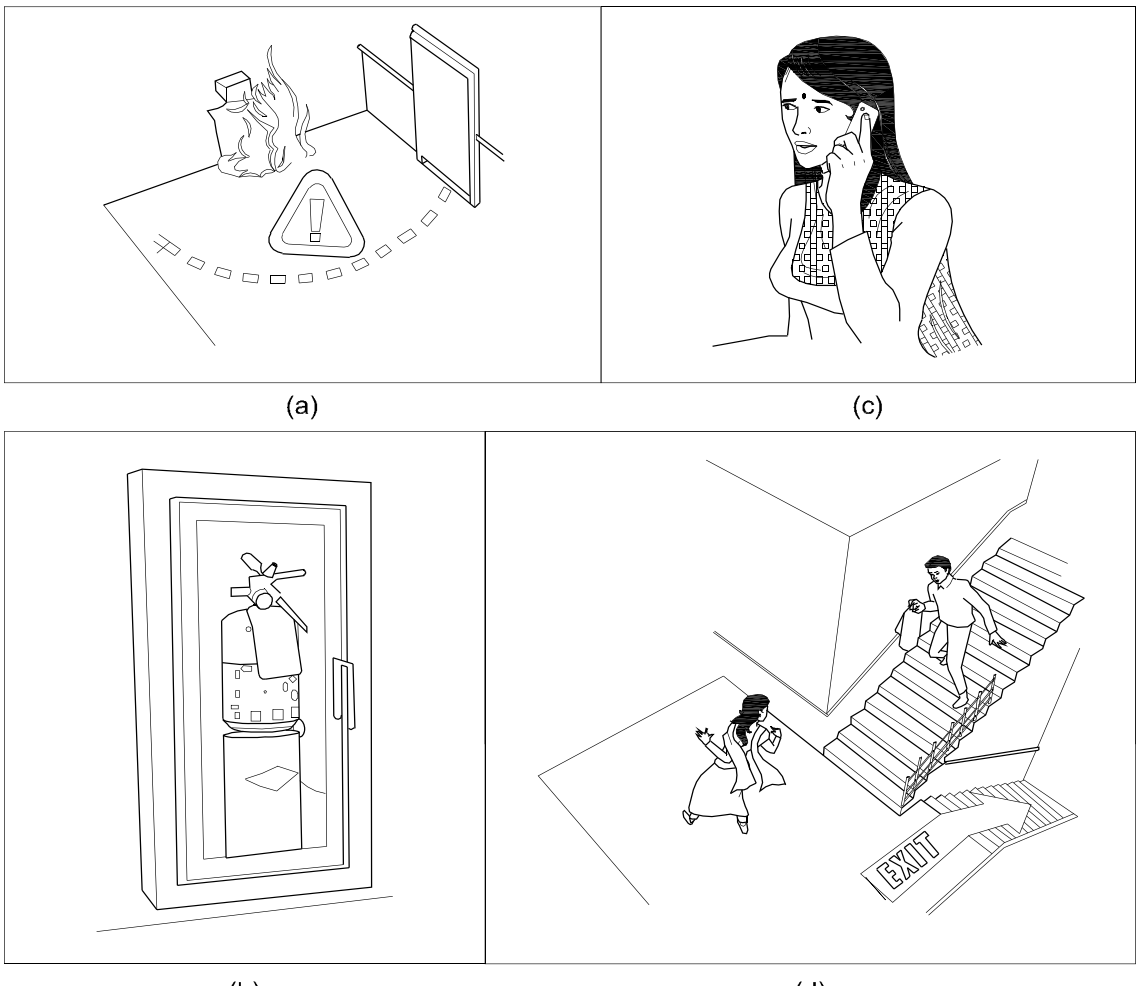
4 Switch "OFF" all electrical power supply.

Do not allow people to go near the fire.

5 Analyze to identify the type of fire. Refer Table1.

6 Assume that is it type D fire (Electrical fire).

Fig 1

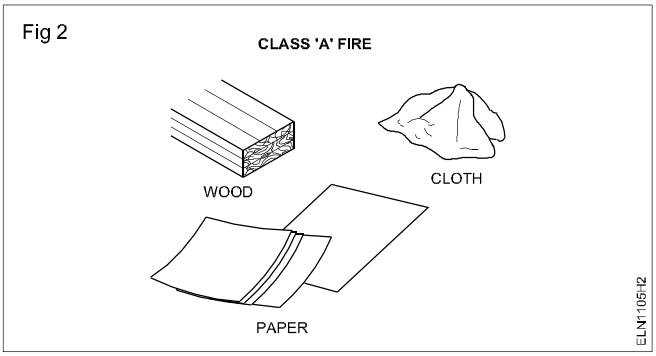
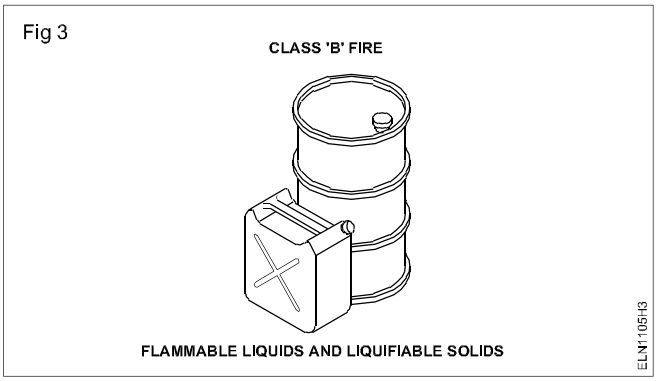
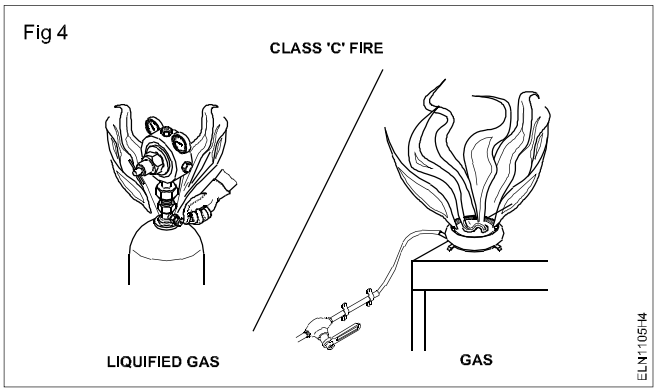
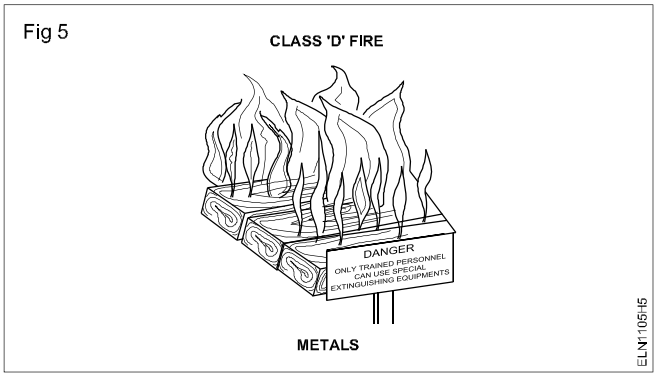


(a) (c)

(b) (d)

ELN-105-11

TABLE1

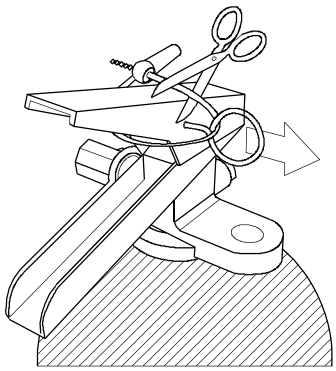
Class 'A': Wood, paper, cloth, solid material	Fig 2 
Class 'B': Oil-based fire (grease, gasoline,oil) and liquefiable solids	Fig 3 
Class 'C': Gas and liquefied gases	Fig 4 
Class 'D': Metals and electrical equipment	Fig 5 

6 Select CO_2 (carbon dioxide) fire extinguisher.

7 Locate and take the CO_2 fire extinguisher. Check for its expiry date.

8 Break the seal. (Fig 6)

Fig 6

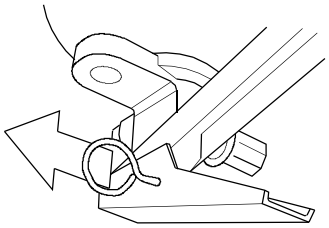


BREACKING OF SEAL

EL1105-H6

9 Pull the safety pin from the handle. (Fig 7) (the Pin is located at the top of the fire extinguisher.) (Fig 7)

Fig 7



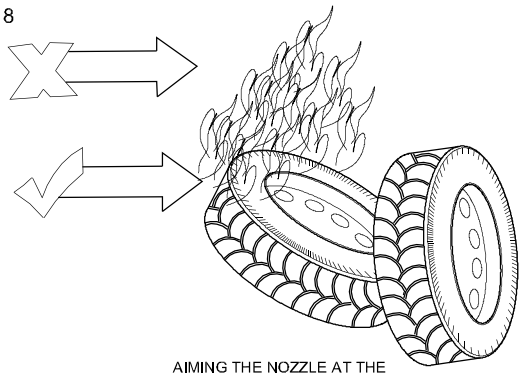
PULLING THE SAFETY PIN

ELN1105-H7

10 Aim the extinguisher nozzle or hose at the base of the fire. (This will remove the source of the fuel fire.) (Fig 8)

Keep your self low.

Fig 8



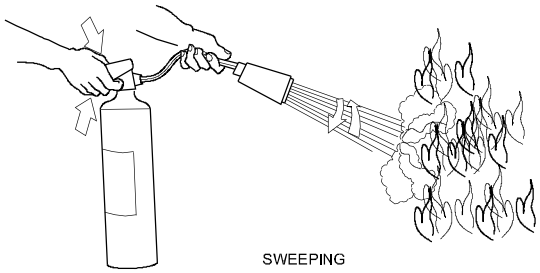
AIMING THE NOZZLE AT THE BASE OF THE FIRE

ELN1105-H8

11 Slowly squeeze the handle lever to discharge the agent. (Fig 8)

12 Sweep from side to side approximately 15 cm over the fuel fire until the fire is put off. (Fig 9)

Fig 9



SWEEPING

ELN1105-H9

Fire extinguishers are manufactured for use from a distance.

Caution

- While putting off fire, the fire may flare up.
- Do not panic so long as it is being put off promptly
- If the fire does not respond well even after you have used the fire extinguisher, move away from the fire point.
- Do not attempt to put out a fire when it emits toxic smoke. Leave it to the professionals.
- Remember that your life is more important than the property. So do not take risks.

In order to remember the simple operation of fire extinguisher, remember P.A.S.S.

This will help to use the fire extinguisher.

P for pull

A for aim

S for squeeze

S for sweep

Practice elementary first aid

Objective : At the end of this exercise you shall be able to
- **prepare the victim for elementary first aid.**

Requirements

Equipment/Materials

- Number of Persons (Instructor can divide the trainees into suitable Number of groups.) - 20 Nos.

PROCEDURE

Assumption: For easy manageability, Instructor may divide the trainees into groups and ask each group to perform one method of resuscitation.

TASK 1: **Prepare the victim before giving first-aid treatment**

1 Loosen the tight clothing as it may interfere with the victim's breathing. (Fig 1)

Fig 1

LOOSENING TIGHT CLOTHING

ELN1106J1

2 Remove any foreign material or false teeth from the victim's mouth and keep the victim's mouth open. (Fig 2)

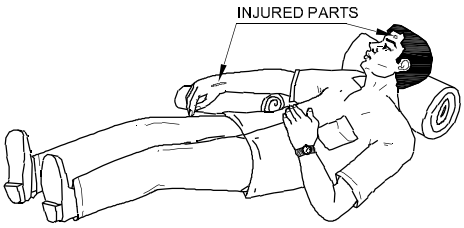
Fig 2

KEEP THE MOUTH OPEN

ELN1106J2

3 safely bring the victim to the level ground, taking the necessary safety measures. (Fig 3)

Fig 3



SAFETY ON THE LEVEL GROUND

ELN1106J3

Do not waste too much time in loosening the clothes or trying to open the tightly closed mouth.

4 Avoid violent operations to prevent injury victim's to the victim's internal parts.

Task 2: **Prepare the victim for artifical respiration**

Observe the condition of electric shock victim.

If breathing has stopped, try to provide artifical respiration

1 Send word for professional assistance. (If no other person is available, you stay with the victim and help as best as you can.)

2 Look for visible injury in the body and decide on the suitable method of artificial respiration.

- In the case of injury/burns on the chest and/or belly follow the mouth to mouth method.
- In case the mouth is closed tightly, use Schafer's or Holgen–Nelson method.
- In the case of burn and injury in the back, follow Nelson's method.

3 Place the victim in the correct position before giving artificial respiration.

All actions should be taken immediately.

Delay by even a few seconds may be dangerous.

Take extreme care to prevent injury to the victim's internal organs.

4 Cover the victim with coat, sacks or improvise with your own method. Help to keep the victim's body warm.

5 Proceed to perform the suitable artifical respiration method.

Rescue a person and practice artificial respiration

Objective : At the end of this exercise you shall be able to
- **rescue a victim from electric shock**
- **apply respiratory methods**
  - **Nelson's arm - Lift back method**
  - **Schafer's method**
  - **mouth to mouth method**
  - **mouth to nose method**
  - **revive breathing during cardiac arrest.**

Requirements

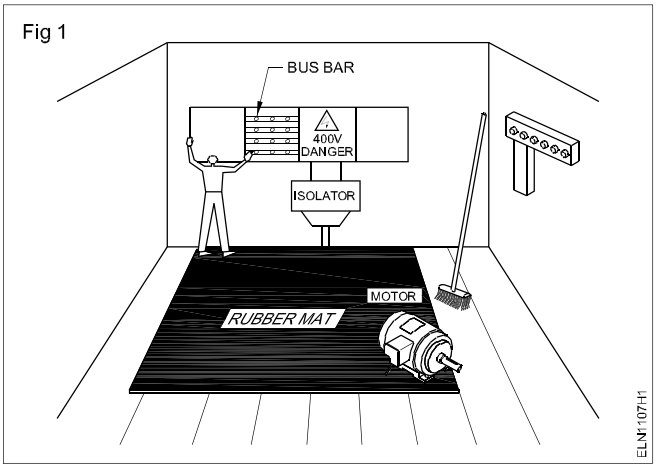
Equipment/Materials

- Control panel arrangement - 1 No.
- Motor - 1 No.
- Rubber mat - 1 No.
- Wooden stick - 1 No.
- 2 persons for demonstration purpose

PROCEDURE

TASK 1**: Rescue a person (mock victim) from live supply (simulated).**

Fig 1



1 Observe the person (mock victim) receiving an electric shock. Interpret the situation quickly.

2 Safety move the victim away from the `live` equipment by disconnecting the supply or using any insulating material.

Do not run to switch off the supply that is far away.

Do not touch the victim with bare hands until the circuit is made dead or the victim is moved away from the equipment.

Push or pull the victim away from the point of contact of the live equipment, without causing serious injury to the victim.

3 Physically move the victim to a nearby place.

4 Check for the victim's natural breathing and consciousness.

5 Take steps to revive breathing if the victim is unconscious and not breathing.

TASK 2 : **Revive breathing in the victim by Nelson's arm-Lift back pressure method**

Nelson's arm-lift back pressure method must not be used when there are injuries to the chest and belly.

1 Place the victim with his arms folded with the palms one over the other and the head resting facing the ground with his cheek over the palms.

2 Kneel on one or both knees near the victim's hand.

3 Place your hands on the victim's back beyond the line of the armpits, with your fingers spread outwards and downwards, thumbs just touching as in Fig 2.

4 Gently rock forward keeping your arms straight until they are nearly vertical, and steadily keep pressing the victim's back as shown in Fig 3 to force the air out of the victim's lungs.

Fig 2

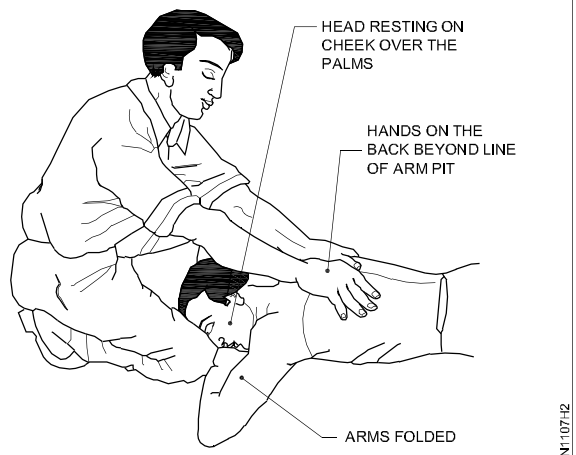
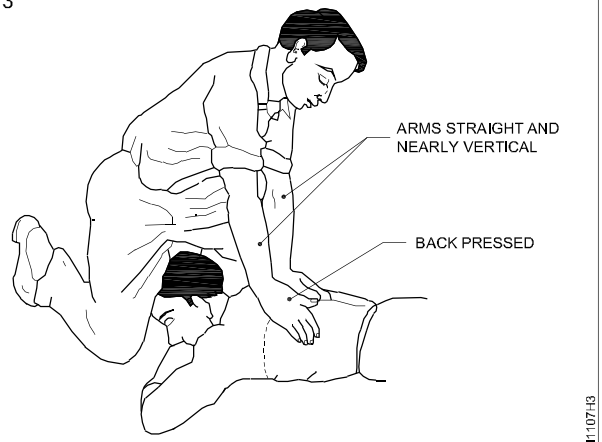


Fig 3



5 Synchronise the above movement of rocking back wards with your hands sliding downwards along the victim's arms, and grasp his upper arm just above the elbows as shown in Fig 4. Continue to rock backwards.

6 As you rock back, gently raise and pull the victim's arms towards you as shown in Fig 5 until you feel the tension in his shoulders. To complete the cycle, lower the victim's arms and move your hands up to the initial position.

7 Continue artificial respiration till the victim starts to breathe naturally. Please note, in some cases, it may take hours.

Fig 4

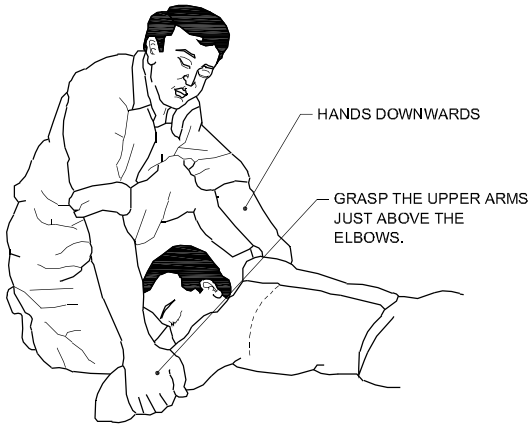
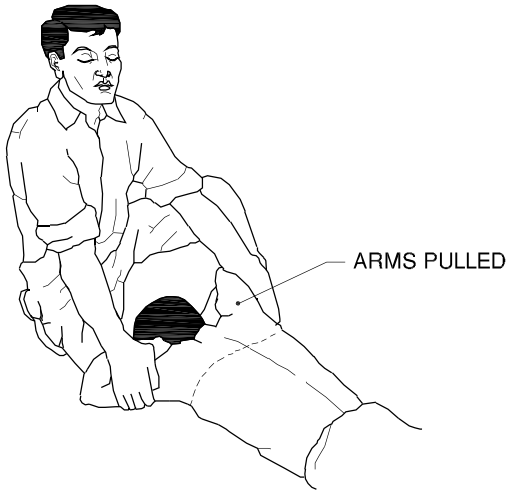


Fig 5



8 When the victim revives, keep the victim warm with a blanket, wrapped around him or with hot water bottles or warm bricks. Stimulate blood circulation towards the heart by stroking the insides of the arms and legs.

9 Keep him in the lying position and do not let him exert himself.

Do not give him any stimulant, until he is fully conscious.

TASK 3 : **Revive breathing in the victim by Schafer's method**

Do not use this method when the victim has injuries on the chest and belly.

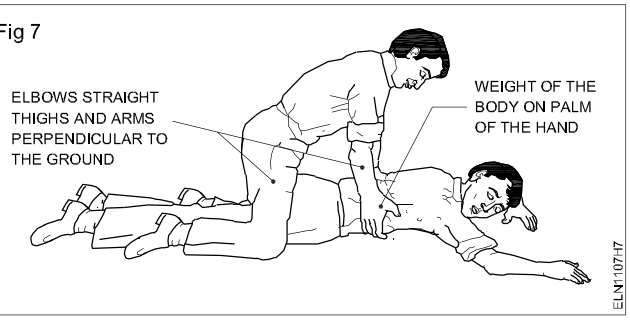
1 Lay the victim on his belly, one arm extended direct forward, the other arm bent at the elbow and with the face turned sideward and resting on the hand or forearm as shown in Fig 6.

2 Kneel when the victim is astride, so that his thighs are between your knees with your fingers and thumbs positioned as in Fig 6.

Fig 6

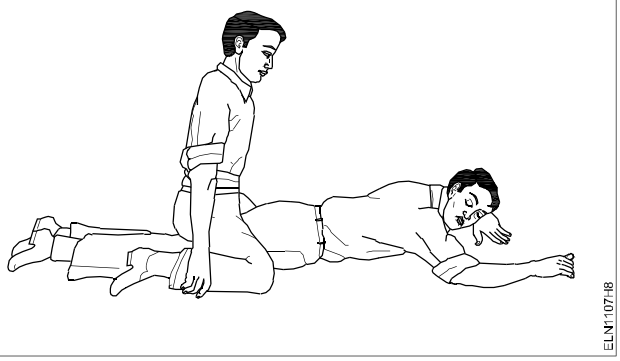
3 With the arms held straight, slowly swing forward so that the weight of your body is gradually brought to bear upon the lower ribs of the victim to force the air out of the victim's lungs as shown in Fig 7.

Fig 7



4 Now immediately swing backwards removing all the pressure from the victim's body as shown in Fig 8, to allow the lungs to fill with air.

Fig 8



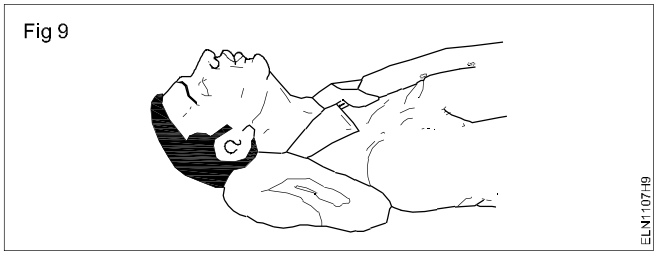
5 After two seconds, swing again forward and repeat the cycle twelve to fifteen times per minute.

6 Continue it till the victim begins to breathe naturally.

TASK 4: **Revive breathing in the victim by mouth-to-mouth method**

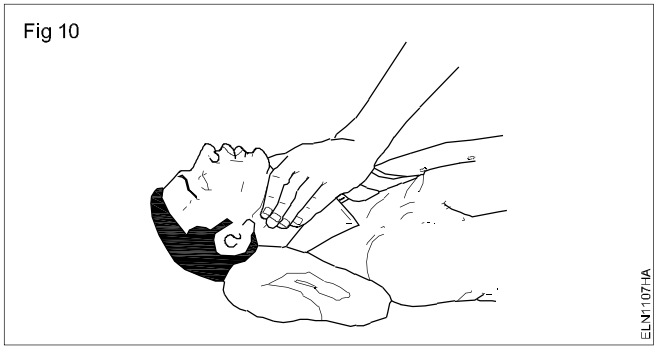
1 Lay the victim flat on his back and place a cloth roll under his shoulders to ensure that his head is thrown well back. (Fig 9)

Fig 9



2 Tilt the victim's head back so that the chin points straight upwards. (Fig 10)

Fig 10



3 Grasp the victim's jaw as shown in Fig 11, and raise it upwards until the lower teeth are higher than the upper teeth you may also place your fingers on both sides of the jaw near the victim's ear lobes and pull upward. Maintain this jaw position throughout the duration to revivel respiration to prevent the tongue from blocking the air passage.

4 Take a deep breath and place your mouth over the victim's mouth as shown in Fig 12 making airtight contact. Pinch the victim's nose shut with the thumb and forefinger. If you dislike direct contact, place a porous cloth between your mouth and that of the victim's. For an infant, place your mouth over the infant's mouth and nose. (Fig 12)

Fig 11

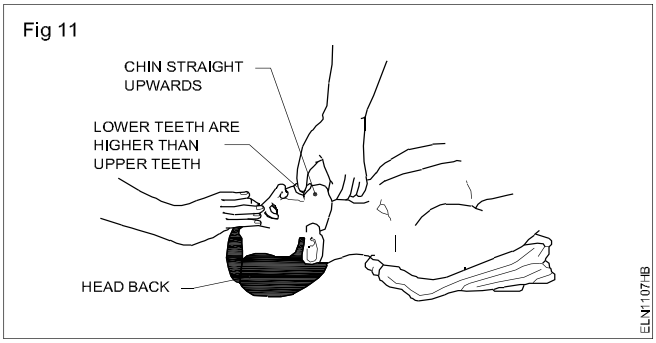
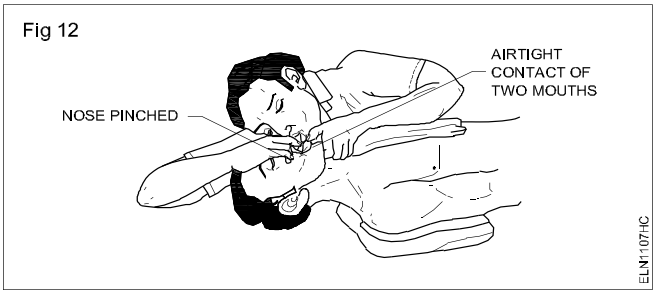


Fig 12



5 Blow into the victim's mouth (gently in the case of an infant) until his chest rises. Remove your mouth and release the hold on the nose, to let him exhale, turning your head to hear gushing the out of air. The first 8 to 10 breathings should be as rapid as the victim responds. Thereafter the rate should be slowed down to about 12 times per victim's minute (20 times for an infant).

If air cannot be blown in, check the position of the victim's head and jaw and recheck the mouth for obstructions. Then, try again more forcefully. If the chest still does not rise, turn the victim's face down and strike his back sharply to dislodge obstructions.

Sometimes air enters the victim's stomach as evidenced is the swelling of the stomach. Expel the air by gently pressing the stomach during the exhalation period.

TASK 5: **Revive breathing in the victim by Mouth-to-Nose method**

Use this method when the victim's mouth will not open, or has a blockage you cannot clear.

1 With the fingers of one of your hand that keep the victim's lips firmly shut. Seal your lips around the victim's nostrils and breath the air into him. Check to see if the victim's chest is rising and falling. (Fig 13)

2 Repeat this exercise at the rate of 10-15 times per minute till the victim responds.

3 Continue this exercise till the arrival of the doctor.

Fig 13

ELN1107HD

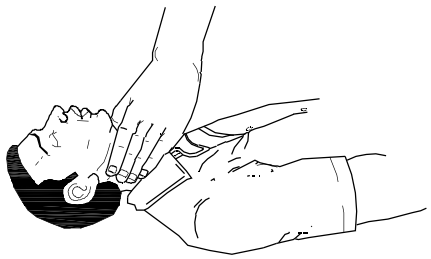
TASK 6 : **Revive breathing in a victim who is under cardiac arrest**

In cases where the heart has stopped beating, you must act immediately.

1 Check quickly whether the victim is under cardiac arrest.

Cardiac arrest could be ascertained by the absence of the cardiac pulse in the neck (Fig 14), blue colour around lips and dilated pupil of the eyes.

Fig 14

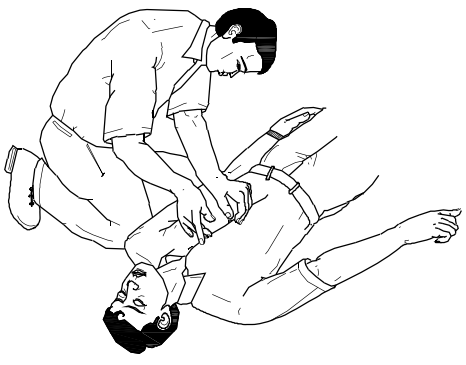


ELN1107HE

2 Lay the victim on his back on a firm surface.

3 Kneel alongside facing the chest and locate the lower part of the breastbone. (Fig 15)

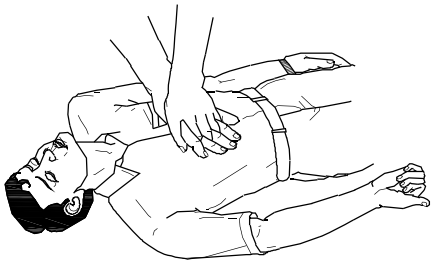
Fig 15



ELN1107HF

4 Place the palm of one of your hands on the centre of the lower part of the breastbone, keeping your fingers off the ribs. Cover the palm with your other hand and lock your fingers together as shown in Fig 16.

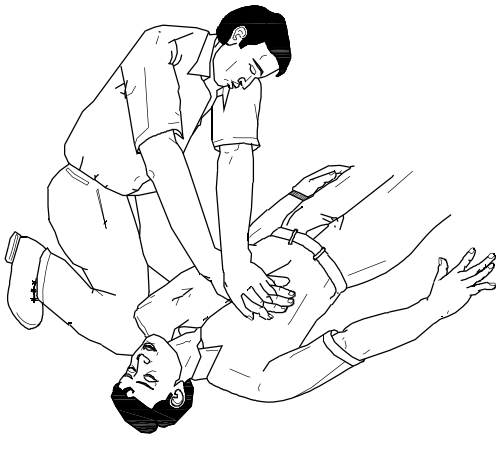
Fig 16



ELN1107HG

5 Keeping your arms straight, press sharply down on the lower part of the breastbone. Then release the pressure. (Fig 17)

Fig 17



ELN1107HH

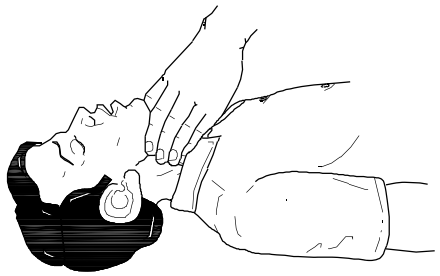
6 Repeat step 5, fifteen times at the rate of at least one time per second.

7 Check the cardiac pulse (Fig 18).

8 Move back to the victim's mouth to give two breaths (mouth-to-mouth revival of breathing) (Fig 19).

9 Continue with another 15 compressions of the heart followed by two breaths of mouth-to-mouth revival of breathing. Check the pulse at frequent intervals.

Fig 18



ELN-1107-II

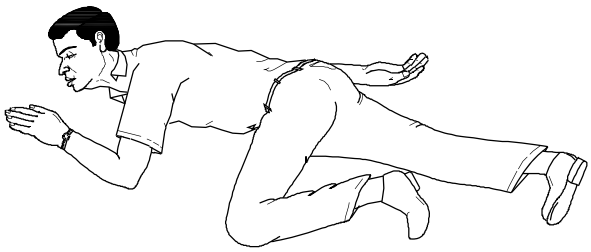
Fig 19

ELN-1107-IJ

10 As soon as the heartbeat is revived, stop the compressions immediately. Continue mouth-to-mouth revival of breathing until natural breathing is fully restored.

11 Place the victim in the recovery position as shown in Fig 20. Keep him warm and quickly get medical help.

Fig 20



ELN-1107-IK

Other steps

1 Send for a doctor immediately.

2 Keep the victim warm with a blanket around him or wrapped up with hot water bottles or warm bricks. Stimulate blood circulation towards the heart by stroking the insides of the arms and legs.

Scan the QR Code to view the video for this exercise

Disposal of procedure of waste materials

Objectives: At the end of this exercise you shall be able to
- **identify the different type of waste material**
- **segregate the waste materials in the respecive bins**
- **sort non-saleable and saleable materials separately and maintain record.**

Requirements

Materials

• Shawel	- 1 No.	• Trolly with wheels	- 3 Nos.
• Plastic/Metal bins	- 4 Nos.	• Brush and gloves	- 1 Pair

PROCEDURE

1 Collect all the waste materials in the workshop.

2 Identify and segregate them like cotton waste, metal chips, chemical waste and electrical waste (Fig 1) separately and label them.

3 Sort waste materials as saleable, non saleable, organic and inorganic materials.

4 Record the sorted waste material and fill Table-1.

Fig 1

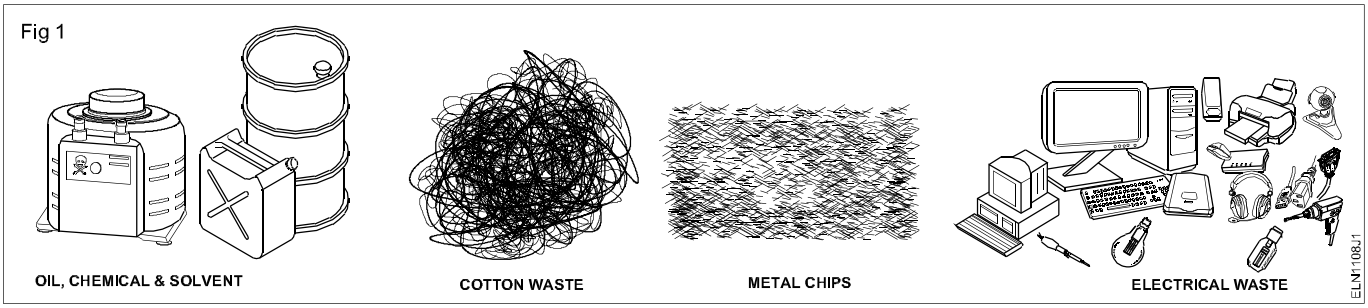


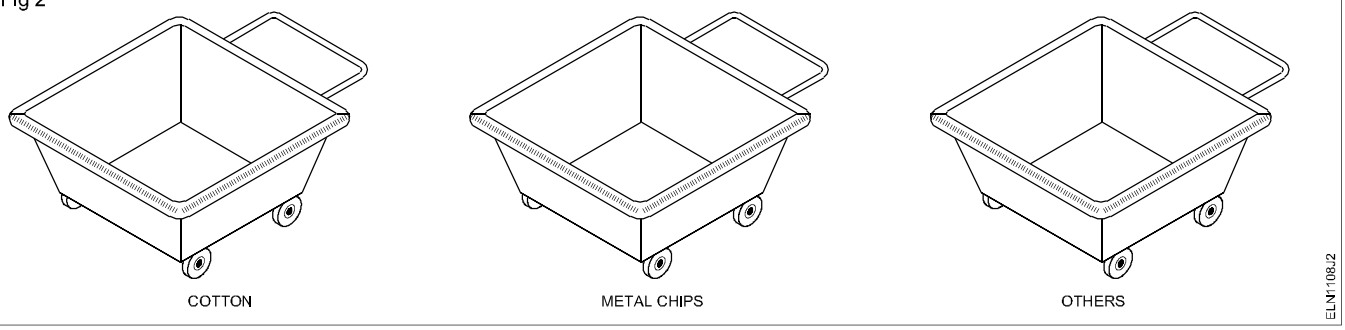
Table-1

Sl.No.	Name of the waste material	Quantity	Saleable or non Saleable
1			
2			
3			
4			
5			
6			

5 Arrange at least 3 trolleys with wheels for disposal. Stick label on each trolly as "Cotton Waste", "Metal Chips" and "others". (Fig 2)

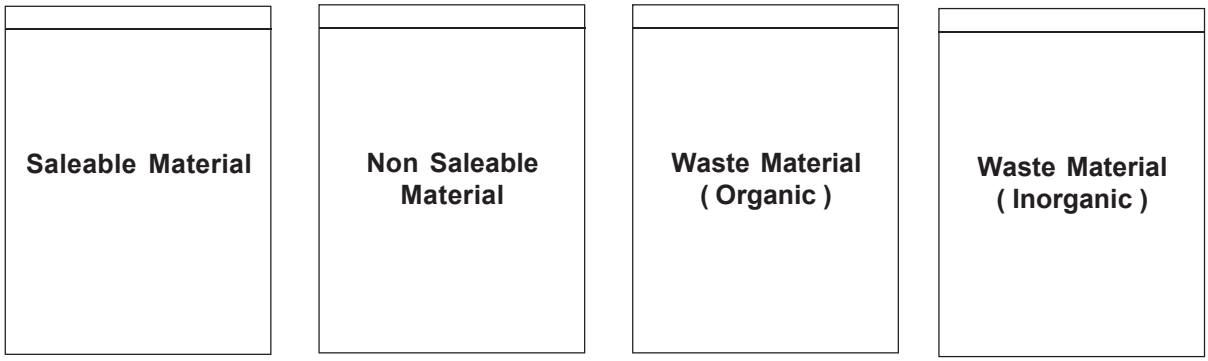
6 Put the cotton waste in the cotton trolly and similarly put the metal chips waste and others in the respective trolleys.

Fig 2



7 Keep 4 more bins to collect saleable scrap, non saleable scrap, organic waste and Inorganic waste and label them. (Fig 3)

Fig 3



Skill Sequence

Separate the cotton waste and dispose it

Objectives: This shall help you to
- **separate and dispose cotton waste.**

1 Collect the chips by hand shavel with the help of a brush.

2 Clean the floor if oil has been spilt.

Do not handle the chip with bear hand. Separate the chip according to the metal.

3 Separate the cotton waste and store it in the bin provided for the purpose.

4 Store the each category in the assigned bins.

Each bin have respective label.

5 Collect all the saleable material and non salable one seperately and put them in the respective bins.

6 Collect all the non-saleable materials like cotton waste, paper waste, wooden pieces, etc., and keep them in the respective bin as in Fig 3.

7 Check the non-saleable material (organic) and send it for disposal by burning after getting approval.

8 Check the saleable material and segregate like Aluminium, Copper, Iron, Screws, nuts and other items separately and send it to the stores for disposal by auction (or) as per recommended procedure.

Use of personal protective equipment

Objectives: At the end of this exercise you shall be able to
- **read and interpret different types of Personal Protective Equipment (PPE) from the chart (or) real PPE**
- **identify and name the PPEs corresponding to the type of protection and write their uses.**

Requirements

Tools / Equipment

- Chart showing different types of PPEs - 1 No.
- Real PPEs(available in section) - as required.

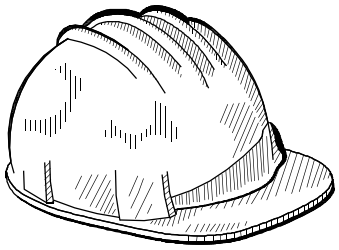
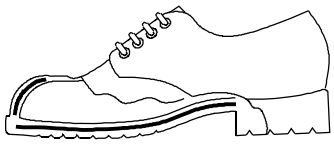
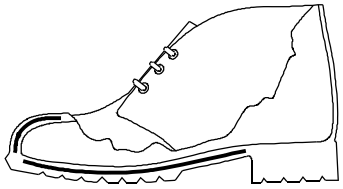
PROCEDURE

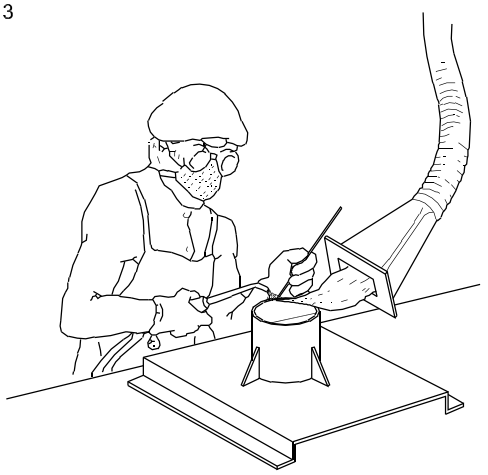
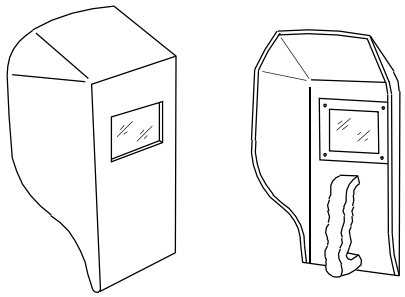
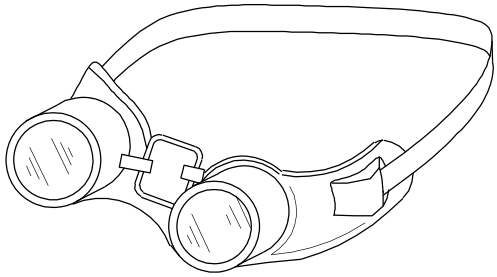
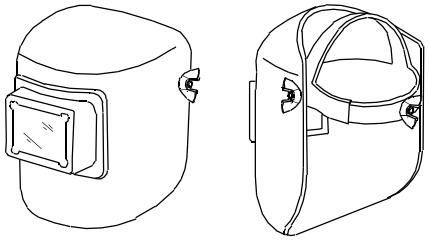
Instructor may arrange the available different types of PPEs in the table or provide the chart showing the PPEs. Instrcuter may also explain the types of PPEs and their uses, and the hazards for which each type is used.

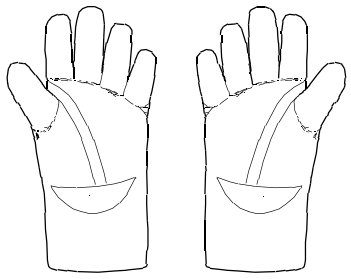
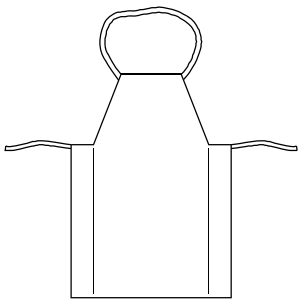
1 Identify the different types of PPEs and write their names with the help of the chart and write in Table 1.

2 Write the type of protection and uses in the space provided against each PPE in Table 1.

Table 1

Sl. No.	Sketches	Name of PPE	Type of protection	Uses
1	Fig 1 			
2	Fig 2  			

Sl. No.	Sketches	Name of PPE	Type of protection	Uses
3	Fig 3  ELN1109J3			
4	Fig 4  ELN1109J4			
5	Fig 5  ELN1109J5			
6	Fig 6  ELN1109J6			

Sl. No.	Sketches	Name of PPE	Type of protection	Uses
7	Fig 7  ELN1109J7			
8	Fig 8  ELN1109J8			
9	Fig 9  ELN1109J9			

3 Get it checked by your instructor.

Practice on cleanliness and procedure to maintain it

Objectives: At the end of this exercise you shall be able to
- **identify the places/machinery/equipment that are to be cleaned**
- **collect the cleaning materials/devices required for cleaning**
- **clean the machines/equipment and devices installed in your section.**

Requirements

Tools / Equipment

- Portable vacuum cleaner/blower - 1 No.

Materials

- Emery sheet-'O' grade - 1 No.
- Dusting cloth - as required.
- Dust bin - 3 Nos . (labelled)

PROCEDURE

Switch OFF all the machinery and equipment before starting the cleaning process. Use a mask or cover the mouth and nose.

Instructor has to brief the Japanese 5S concept to the trainees before starting the work.

Sort
Set in order
Shine
Standardise
Sustain

5s - concept

1 Identify the areas/equipment/machine that need to be cleaned.

2 Keep the movable items in one place and group them.

3 Clean the dust carefully, without damaging any part/ connection in the machine / equipment, using a cloth.

4 Use wet dusting cloth on areas that are wired.

5 Remove rust on parts of the equipment (or) devices using an emery sheet.

Do not remove lubricants in the machine while wiping/cleaning.

6 Use vacuum cleaners to suck dust from areas where a brush or cloth cannot help.

7 Collect the waste materials found in the lab and put it in the specified dustbin, as shown in Fig 1.

Dusting and cleaning can be arranged by dividing the trainees into groups under the supervision of the instructor.

8 Clean places where water or oil has been spilt on the floor

Note down abnormal things that you noticed while cleaning and report it to the instructor to take corrective action.

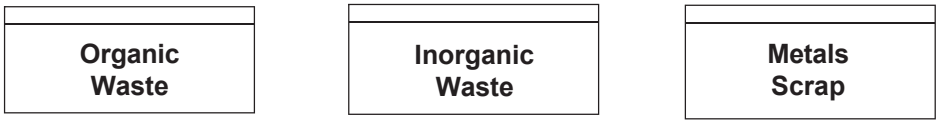
9 Put all the materials and equipment used for cleaning in their respective places.

10 Inspect and ensure that all machines are working after cleaning in the presence of the instructor.

11 Discuss abnormal things that you came across while cleaning with the instructor. Prepare a report if the instructor asks for it

Instructor may assign trainees the responsibilty of cleaning in batches. Disposal of waste may be organised as a routine actvity by coordinating with the stores.

Fig 1



Identify trade tools and machineries

Objectives : At the end of this exercise you shall be able to
- **identify tools and draw their sketches**
- **identify the machineries in the lab and note down their names.**

Requirements

Tools/Instruments

• Combination plier (150 mm)	- 1 No.
• Long round nose plier (200 mm)	- 1 No.
• Screwdriver (150 mm)	- 1 No.
• Firmer chisel (12 mm)	- 1 No.
• Wood rasp file (250 mm)	- 1 No.
• Flat file bastard (250 mm)	- 1 No.
• Bradawl (6 mm x 150 mm)	- 1 No.
• Gimlet (4 mm x 150 mm)	- 1 No.
• Ratchat brace (6 mm)	- 1 No.
• Rawl jumper holder with bit No. 8	- 1 No.
• Triangular file bastard (150 mm)	- 1 No.
• Saw-tooth setter	- 1 No.

Equipment/Machines

• Electric bench grinder	- 1 No.

Materials

• Lubricating oil	- 100 ml
• Cotton waste	- as required.
• Cotton cloth	- 0.50 m
• Grease	- as required.
• Emery sheet	- 1 sheet.

The instructor shall arrange for the necessary tool/equipment from other sections and also arrange for the required materials from scrap for practising the use of tools.

PROCEDURE

TASK 1 : **Identify tools with specification**

Assumption - A set of trainees tool kit and specified tools as given in this exercise are displayed on the workbench. Trainees are required to identify the tools from the specifications given and draw the sketch of the tools in the space allotted for the purpose.

1 Identify the tools from the specification given.

2 Draw a neat sketch against each item.

In case the specifications are different write the correct specification of the items given to you.

Table 1

Sl. No.	Name of tool with specification	Sketch of tools
i	Combination plier with pipe grip, side cutter and insulated handle - size 150 mm,	
ii	Long round nose pliers 200 mm,	
iii	Screwdriver 150 mm	
iv	Firmer chisel 12 mm	
v	Wood rasp file 250 mm	
vi	Flat file bastard 250 mm	
vii	Bradawl 6 mm x 150 mm square-pointed	
viii	Gimlet 4 mm x 150 mm	
ix	Ratchet brace 6 mm capacity	
x	Rawl jumper holder with bit No.8	
xi	Triangular file bastard 150 mm	

3 Get your sketches checked by your instructor.

— — — — — —

TASK 2: **Identify the machineries installed in the electrician section**

Instructor shall explain the names of the machineries installed in the electrician section and their locations. Then ask the trainees to write the name,and other details of each machine in the section.

1 Identify and locate the machines and their names in your section.

2 Read and recognise the name plate of each machine.

3 Write the name and other details of each machine against their names in Table 2.

Table-2

Sl. No.	Name of the machine	Name and other details
1	D.C. shunt generator	
2	Motor Generator set (A.C. motor with D.C generator)	
3	D.C. Compound generator	
4	D.C. Series motor	
5	D.C. Shunt motor	
6	D.C. Compound motor	
7	Motor generator set (D.C. motor with A.C generator)	
8	A.C.Squirrel cage induction motor	
9	A.C Slipping induction motor	
10	Universal motor	
11	Synchronous motor	
12	Diesel generator set	
13	Electrical machine trainer	

4 Get it checked by your instructor.

Practice safe methods of lifting and handling of tools and equipment

Objectives: At the end of this exercise you shall be able to
- **demonstrate how to lift and handle heavy equipment during working conditions while**
- **lifting from floor**
- **during lift**
- **carrying**
- **lowering to bench**
- **lifting from bench**
- **lowering to floor**

Requirements

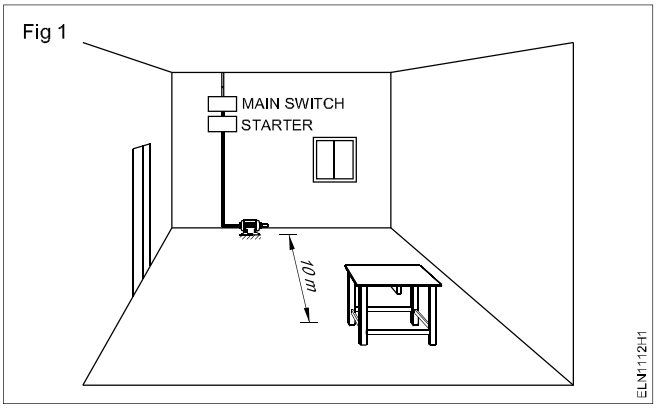
Tools and equipment

- Single phase one HP 240V/50Hz capacitor start induction motor - 1 No.
- D.E. Spanner set 5 mm to 20 mm - set of 8 - 1 No.
- Work bench or table - 1 No.

PROCEDURE

Instructor has to demonstrate, how to lift and handle heavy equipment and then ask the trainees to practice.

Fig 1



Assume one single phase motor has to be lifted and lowered to be placed on the floor.

1 Switch OFF the motor and remove the fuse carriers.

Ensure that the equipment is disconnected from power supply and that the base plate nuts of the motor have been removed.

2 Ensure that you know the position where the equipment is to be placed.

3 Assess whether you need any assistance to carry the equipment.

4 Check for clear route to the location where the motor is to be placed. Remove obstacles, if any.

5 Position yourself close to the equipment to be lifted.

6 Lift the equipment from the floor using the correct posture.

7 Carry the equipment to the work bench safely, keeping the equipment close to your body.

8 place the equipment carefully on the bench, and adjust it to the correct position.

Assume that the overhauling work is over and the motor is to be placed in its orginal place.

9 Lift the equipment correctly with a firm grip.

10 Carry the equipment to its original place.

11 Safely lower the equipment with your feet apart, knees bent, back straight and arms close to your body.

12 Safely place the equipment on the floor.

If you feel the equipment is too heavy, take help from others.

Scan the QR Code to view the video for this exercise

Select proper tools for operation and precautions in operation

Objectives : At the end of this exercise you shall be able to
- **select proper tools for specific uses.**
- **follow care and maintenance and procedures with precaution for each tool.**

Requirements

Tools

- Combination plier - 150 mm - 1 No.
- Flat nose plier 150 mm - 1 No.
- Diagonal cutting plier 150 mm - 1 No.
- Round nose plier 150 mm - 1 No.
- Screw driver 150 mm - 1 No.
- Star-headed screw driver 100 mm - 1 No.
- Neon tester - 1 No.
- Electrician's knife 100 mm - 1 No.
- Try square 150 mm - 1 No.
- Firmer chisel 12 mm - 1 No.
- Tenon saw 300 mm - 1 No.
- Plumb bob - 1 No.
- Centre punch 50 mm - 1 No.
- Cold chisel - 1 No.
- Hacksaw frame with blade - 1 No.
- Portable electric drilling machine - 1 No.

PROCEDURE

TASK 1: **Select the proper tools for specific uses**

1 Identify proper tools for specific uses from Fig 1 to 16 ,

2 Write the uses of each selected tool and the precautions to be followed while handling in Table 1.

Table 1

Tool	Uses/Operation used for	Care, Maintenance and Precautions in operation
1 Combination pliers (Fig 1)		

Fig 1(a)

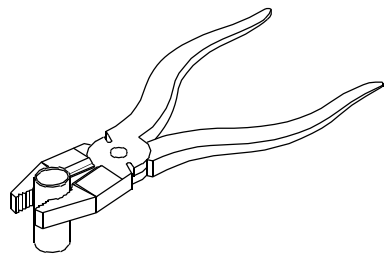
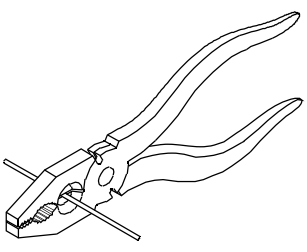
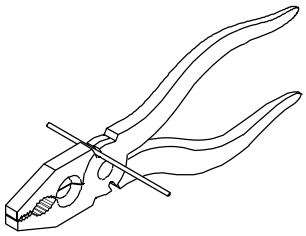
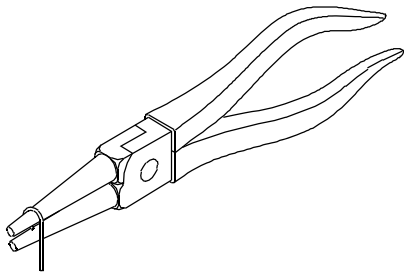
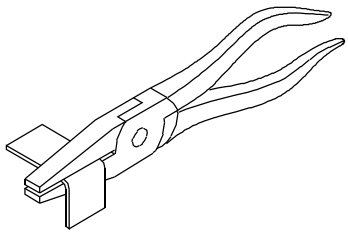
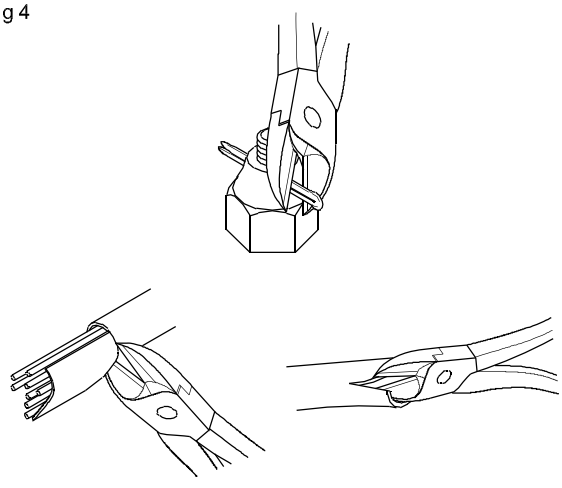
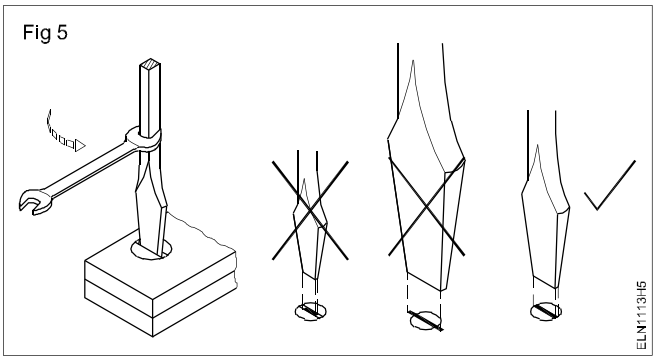
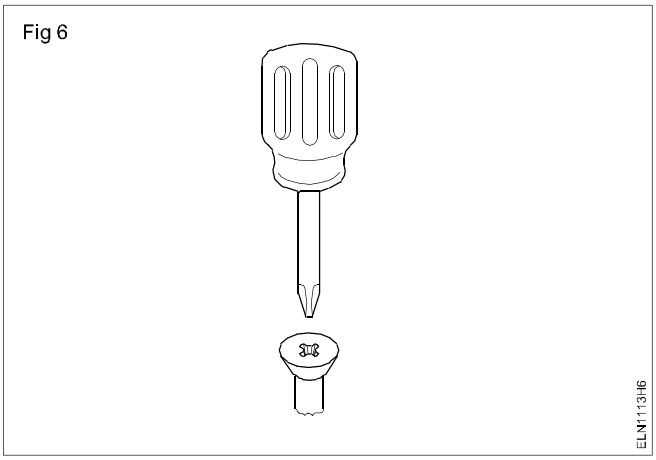
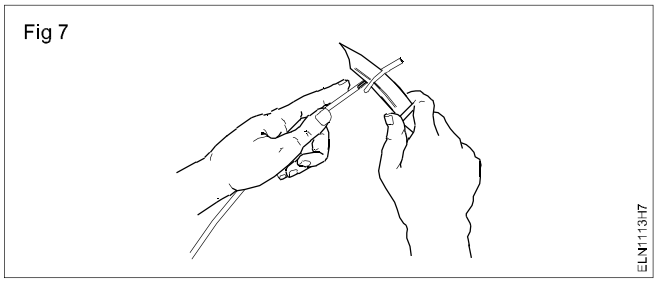
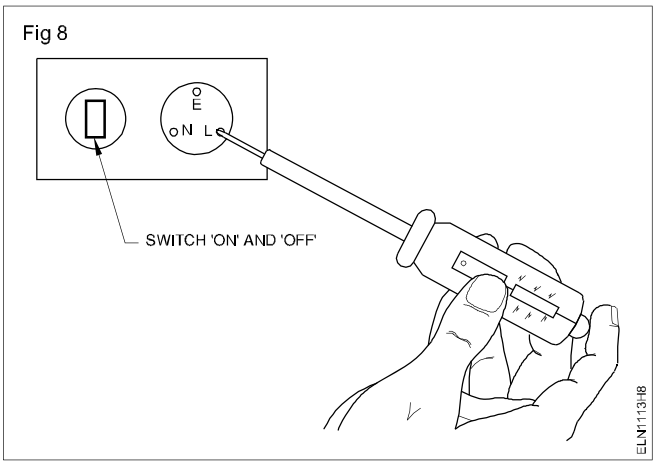
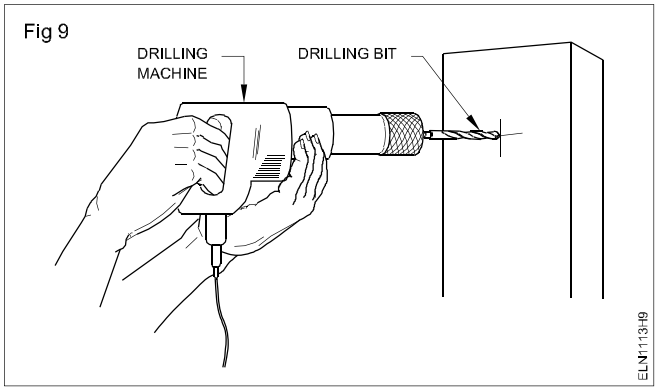
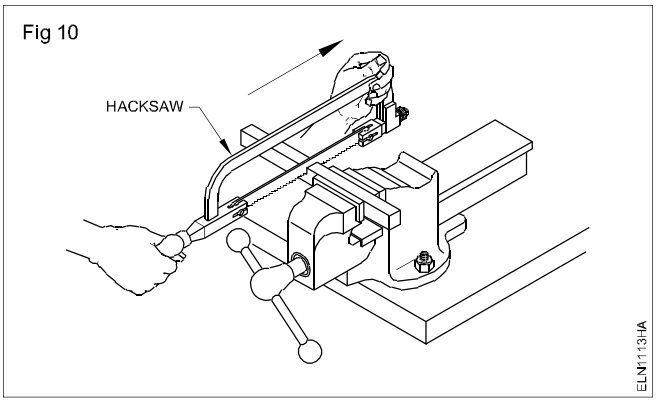
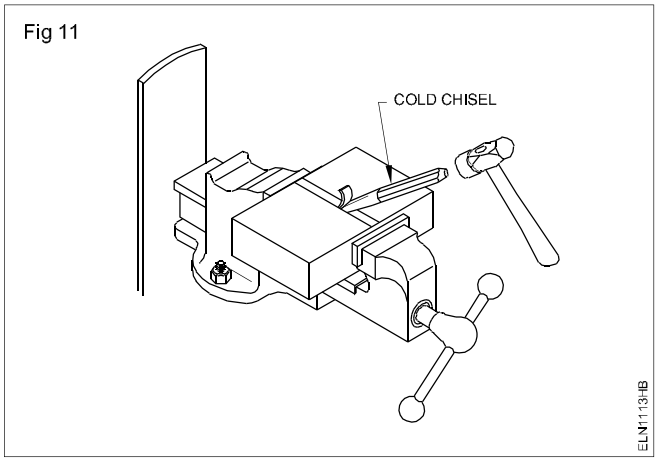


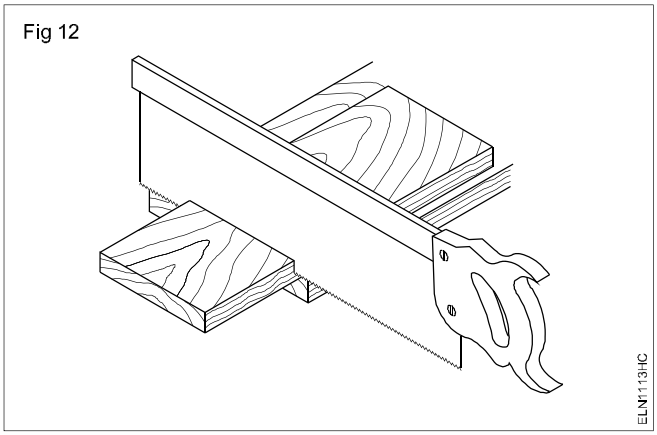
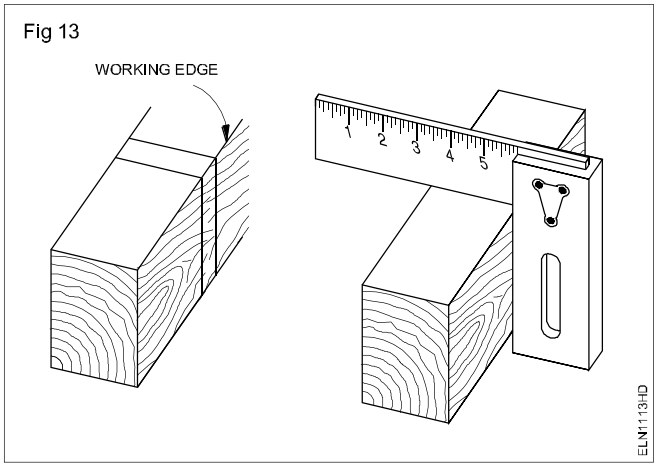
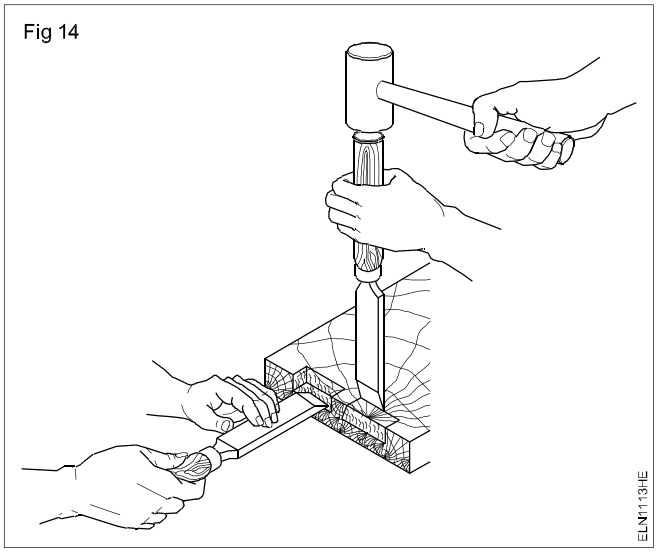
Fig 1(b)

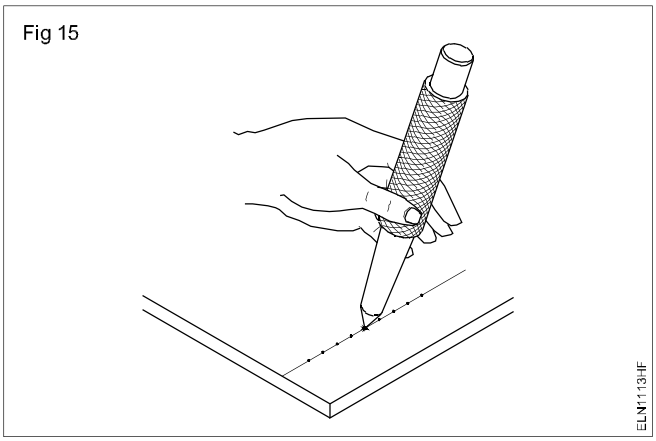
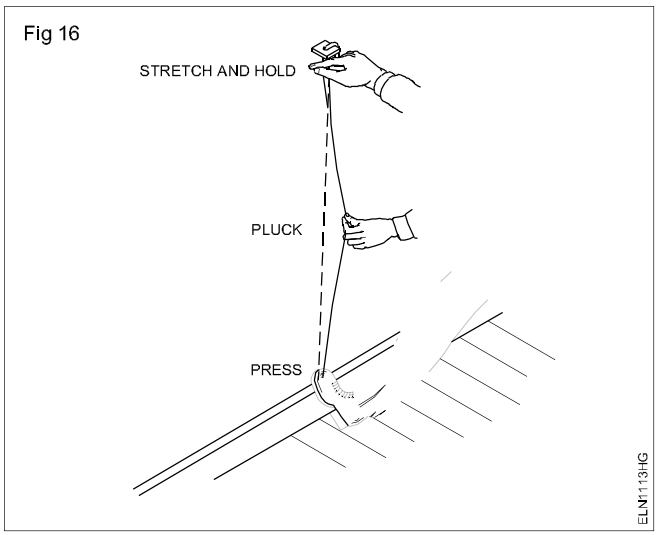


Tool	Uses/Operation used for	Care, Maintenance and Precautions in operation
Fig 1(c)  ELN1113-H3		
2 Pliers - round nose Fig 2  ELN1113-H2		
3 Pliers - flat nose Fig 3  ELN1113-H3		
4 Pliers - diagonal cutting Fig 4  ELN1113-H4		

Tool	Uses/Operation used for	Care, Maintenance and Precautions in operation
5 Screwdriver Fig 5  		
6 Screwdriver (Star) Fig 6  		
7 Electrician's knife Fig 7  		
8 Neon tester Fig 8  		

Tool	Uses/Operation used for	Care, Maintenance and Precautions in operation
9 Portable electric drilling machine 		
10 Hacksaw 		
11 Cold chisel 		

Tool	Uses/Operation used for	Care, Maintenance and Precautions in operation
12 Tenon saw Fig 12  		
13 Try square Fig 13  		
14 Firmer chisel Fig 14  		

Tool	Uses/Operation used for	Care, Maintenance and Precautions in operation
15 Centre punch Fig 15  		
16 Plumb bob Fig 16  		

4 Get it checked by your instructor.

Care and maintenance of trade tools

Objective : At the end of this exercise you shall be able to
- **perform care and maintenance of tools.**

Requirements

Tools/Instruments

- Combination plier (150 mm) - 1 Set.
- Long round nose plier (200 mm) - 1 No.
- Screwdriver (150 mm) - 1 No.
- Firmer chisel (12 mm) - 1 No.
- Wood rasp file (250 mm) - 1 No.
- Flat file bastard (250 mm) - 1 No.
- Bradawl (6mm x 150 mm) - 1 No.
- Gimlet (4 mm x 150 mm) - 1 No.
- Ratchat brace (6 mm) - 1 No.
- Rawl jumper holder with bit No. 8 - 1 No.
- Triangular file bastard (150mm) - 1 No.
- Saw tooth setter - 1 No.

Equipment/Machines

- Electric bench grinder - 1 No.

Materials

- Lubricating oil - 100 ml
- Cotton waste - as reqd.
- Cotton cloth - 0.50 m
- Grease - as reqd.
- Emery sheet '00' - 1 sheet.

PROCEDURE

TASK 1: **Perform care and maintenance of tools**

Prevent rust formation

1 Inspect all the tools. If the tools are rusted, use fine emery paper to remove the rust.

While removing rust keep your hands safe from sharp edges. Do not use emery paper on steel rule or tape.

2 Apply a thin coat of oil over the surface of the rusted tool and clean with a cotton cloth.

A hammer should not have any trace of oil on its striking surface.

3 Check and lubricate tools for easy movement of the jaws of the pliers, blades of knives, jaws of wrench, pincers, gears of the hand drilling machine.

4 Apply a drop of oil on the hinged/geared surface, if the movement is hard.

5 Activate the jaws and gears till the muck/grim in the surfaces are cleaned

6 Apply a drop of oil again and clean the tools with a cotton cloth.

Remove the mushroom

7 Check the cold chisel and the hammer's striking face for mushrooms. If you find mushrooms report to your instructor to enable him to remove the mushroom through grinding.

Reshaping the screwdriver tip

8 Check the tips of the flat tipped screwdrivers. If the tip is blunt or disfigured report to the instructor.

Observe how the screwdriver tip is ground to form a perfect cornered tip for effective use.

Sharpen and set the saw-teeth

9 Check the teeth of the Tenon saw.

10 If the saw-teeth are blunt, report to your instructor.

Observe how the saw-teeth is filed to make the saw-teeth sharp.

11 Check the saw-teeth setting.

The teeth of the Tenon saw should be set to be able to alternately remove dust while sawing.

12 If the setting is not proper report to the instructor.

13 Check how the teeth are set by a saw-setter.

Operations of allied trade tools

Objectives : At the end of this exercise you shall be able to
- **identify fitting, carpenter and sheetmetal tools**
- **write the names, specifications and operations of each tool.**

Requirements

Tools

- Fitter, carpenter and sheetmetal tools - 1 set.

PROCEDURE

Instructor may display the fitter, carpenter and sheetmetal tools (allied trade) on the workbench in the section and demonstrate how to identify the tools, their operation with specifications. Then ask the trainees to record it in Table 1.

TASK 1: **Identify fitter, carpenter and sheetmetal tools and mention their operation/uses**

1 Identify fitter, carpenter and sheetmetal tools provided on the workbench and recagnise them with their names.

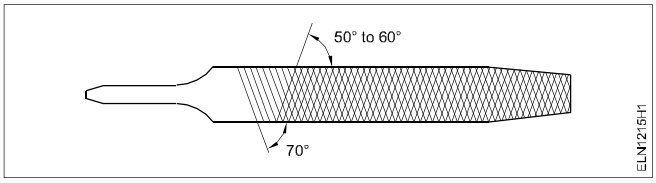
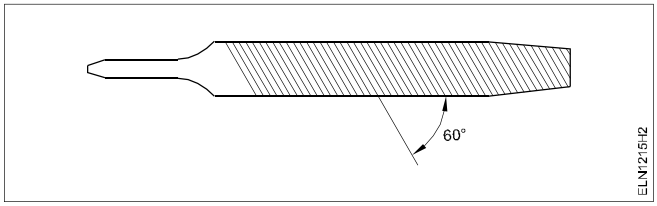
2 Write the name of the tool against the visual shown in Table 1 and mention the specifications.

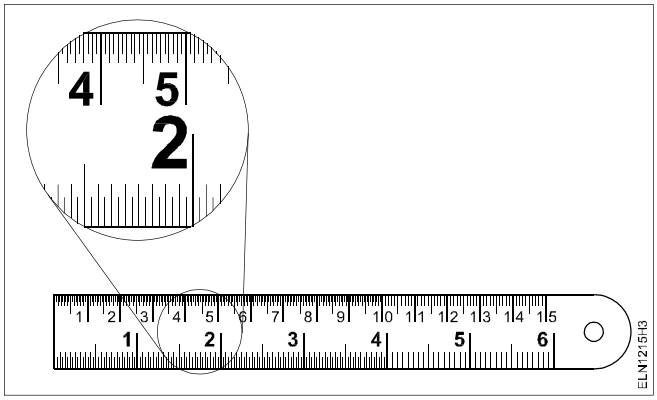
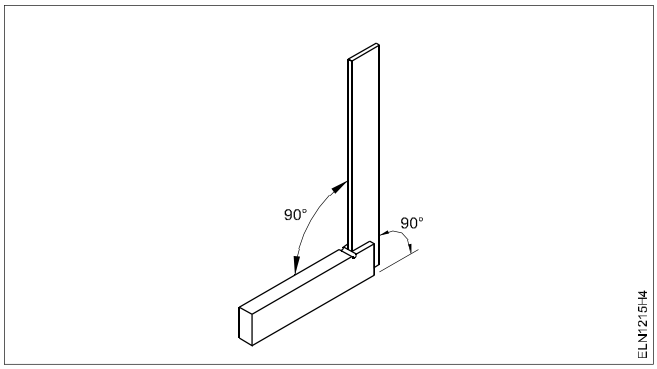
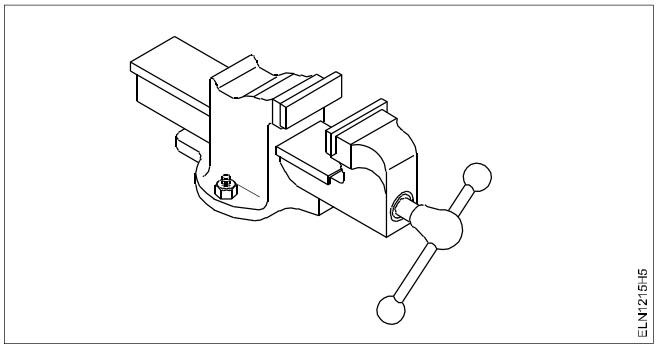
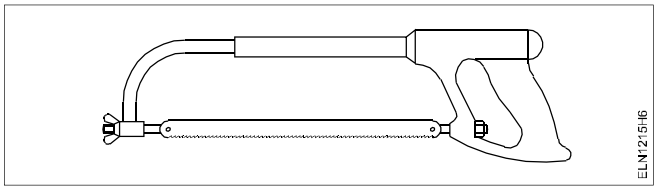
3 Write the operations / uses of each trade tool.

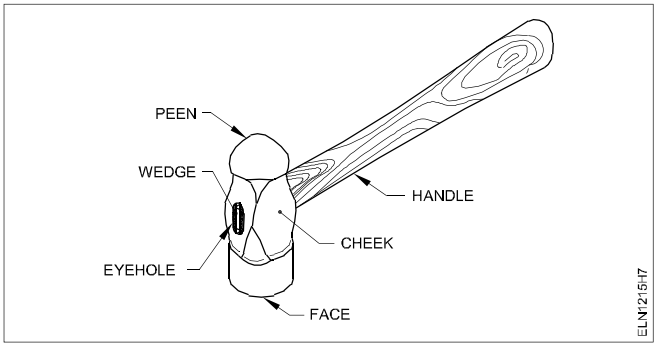
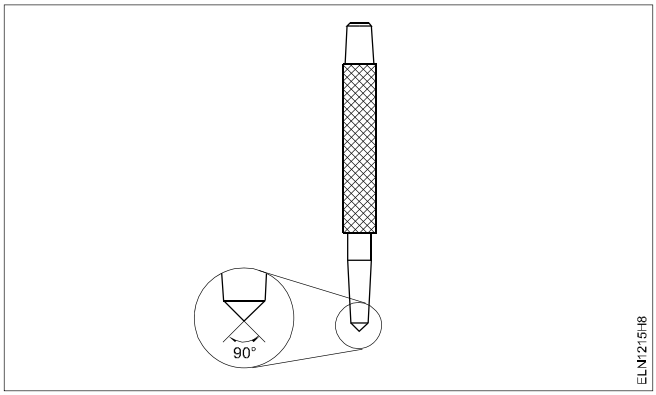
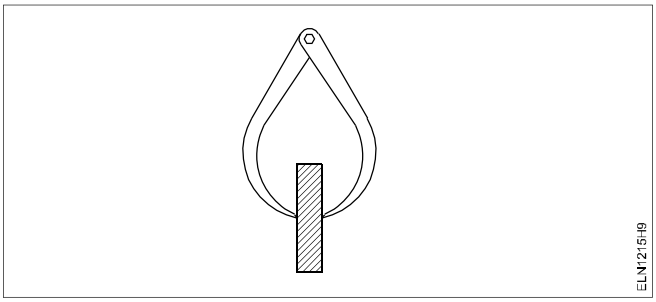
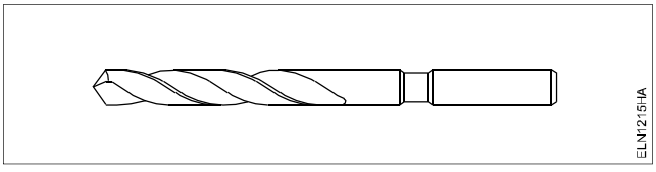
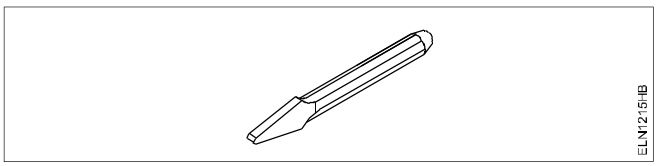
Fitter	-	Fig 1 to 12
Carpenter	-	Fig 1 to 11
Sheet metal Worker	-	Fig 1 to 5

Table 1

Fitter Tools

Sl. No.	Visual of tool	Name of the tool with specifications	Operation/ uses
1			
2			

Sl. No.	Visual of tool	Name of the tool with specifications	Operation/ uses
3			
4			
5			
6			

Sl. No.	Visual of tool	Name of the tool with specifications	Operation/ uses
7			
8			
9			
10			
11			

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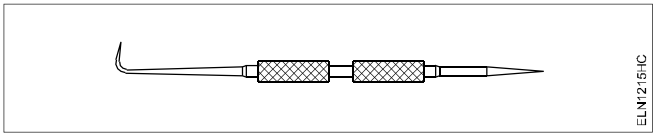
12			

Table 2

Carpentary tools

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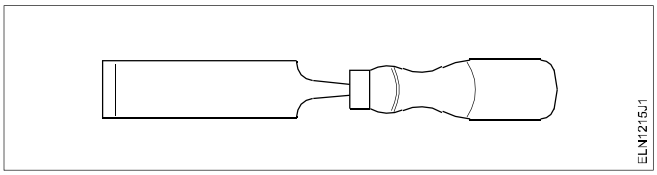
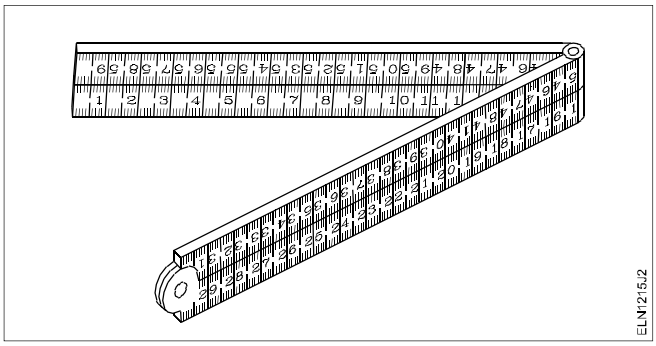
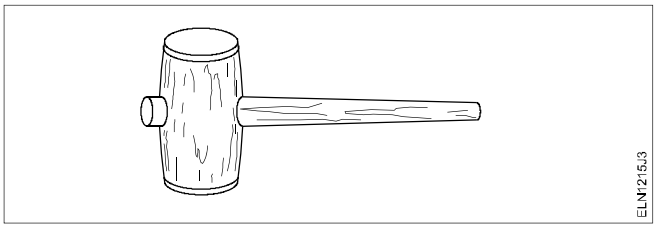
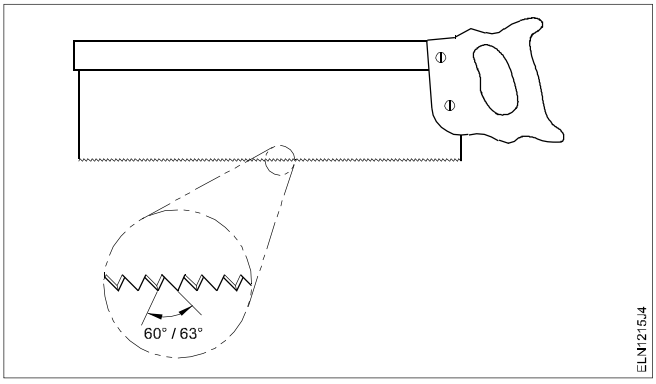
1			
2			
3			
4			

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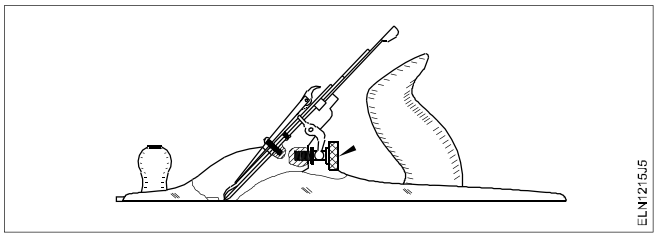
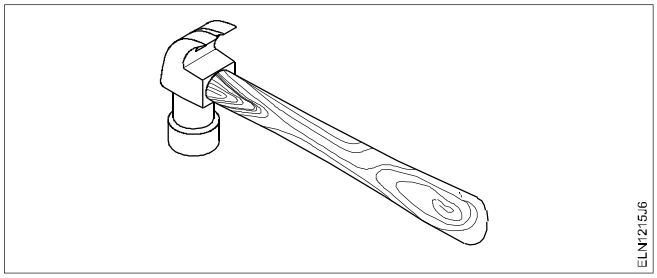
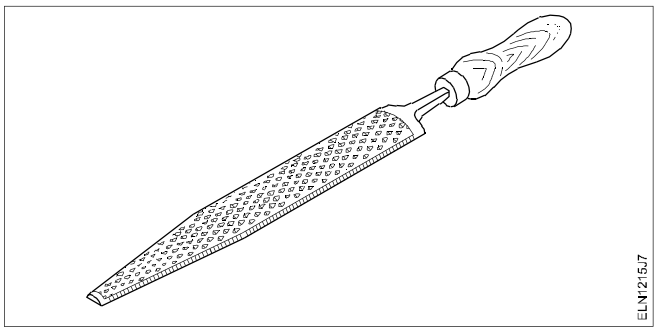
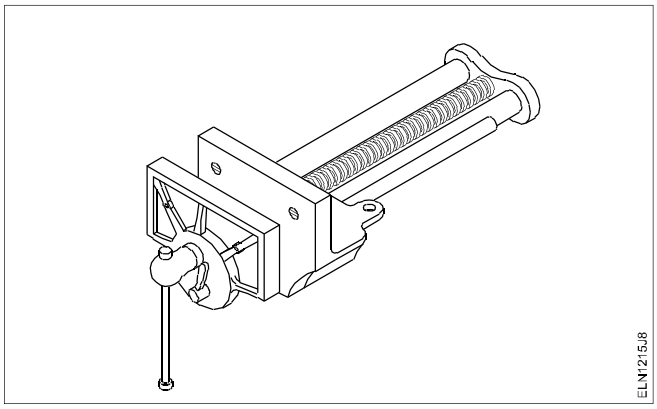
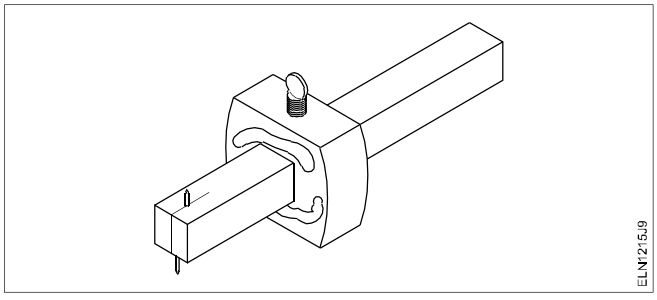
5	 ELN1215J5		
6	 ELN1215J6		
7	 ELN1215J7		
8	 ELN1215J8		
9	 ELN1215J9		

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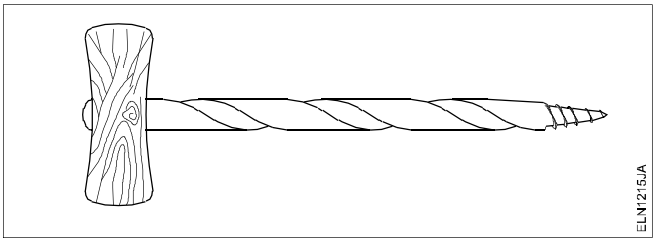
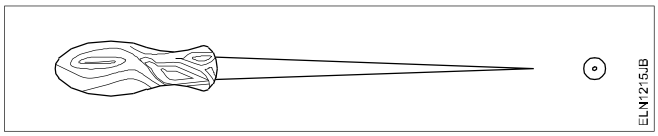
10			
11			

Table 3

Sheetmetal tools

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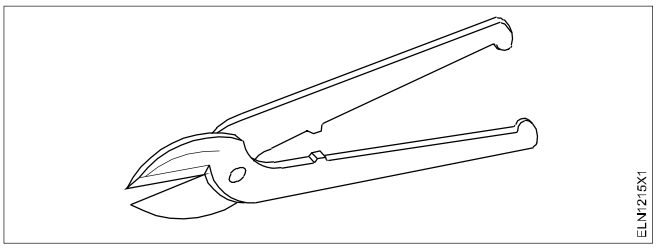
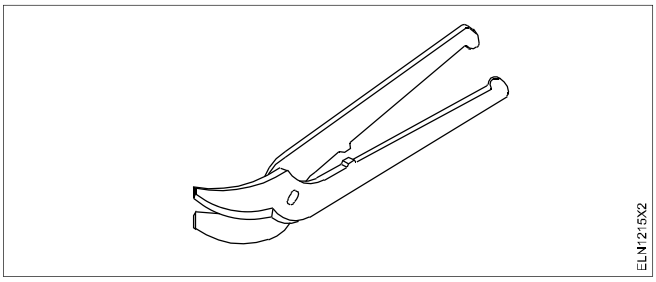
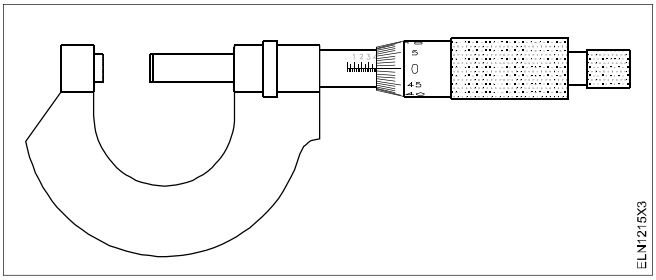
1			
2			
3			

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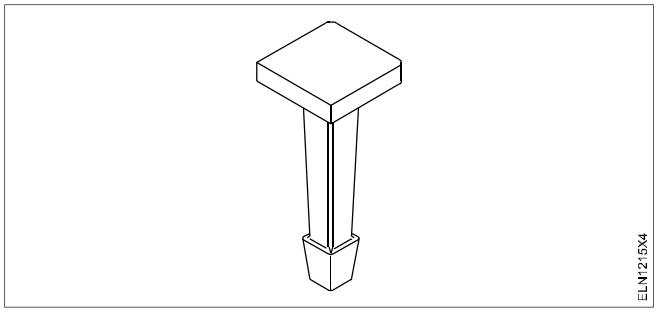
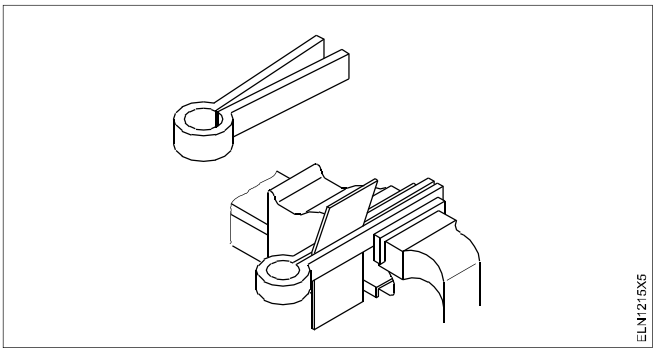
4			
5			

4 Get it checked by the instructor.

Workshop practice on filing and hacksawing

Objectives: At the end of this exercise you shall be able to
- **file a surface flat and check it with straight edge and light gap**
- **file two adjacent sides to 90° and check it with Try square**
- **perform operations of marking a straight line**
- **mark parallel lines to the given dimension using Jenny caliper**
- **file and finish surfaces to an accuracy of 0.5mm**
- **fix the hacksaw blade in the correct position and saw the metal.**

Requirements

Tools/Instruments

- File, flat bastred, double cut - 300 mm - 1 No.
- File, flat second cut, double cut 300 mm - 1 No.
- Try square - 150 mm - 1 No.
- Jenny caliper - 150 mm - 1 No.
- Ball peen hammer - 200 gm - 1 No.
- Hacksaw frame (200 mm) with blade (24 TPI) - 1 No.
- Mild steel square bar 25x25mx50mm - 1 No.

Equipment/Machines

- Bench vice - 50 mm Jaw size - 1 No.

Materials

- ISA 5555 Thickness - 8 mm
  Length -150 mm.

PROCEDURE

TASK 1: **Practice on filing**

1 Check the length and size of the given M.S.angle iron as per the sketch using a steel ruler.

2 Fix at right angle with one side (surface 'A') at least 15 mm above the jaws of the bench vice.

3 File the reference side (surface 'A' indicated in Fig 1) with the bastard file.

4 Test the flatness with the blade of the Try square.

Do not touch the surface of the job while filing.

Use a vice clamp for protecting the finished surfaces.

5 File the adjacent surface `B' with a bastard file.

6 Test the flatness and also check the right angle with the Try square.

7 File the side 'C' at right angle to surfaces 'A', 'B'.

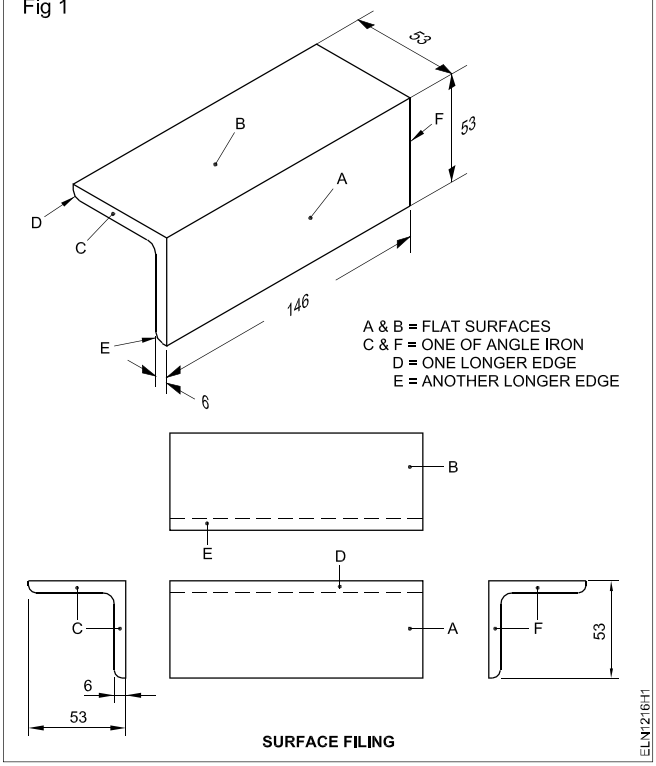
8 Evenly apply marking media (lump chalk) on the surfaces 'A' and 'B'.

9 Place surface 'B' on the levelling plate and scribe a line parallel to 'B' on surface A at a distance of 53 mm as shown in Fig 1. Similarly on surface 'A' mark a line parallel to 'B' at a distance of 53 mm.

10 Place surface 'C' on the levelling plate and scribe a line parallel to 'C' on surfaces 'A' & 'B' at a distance of 146mm from surface 'C'.

11 Punch all the scribed lines.

Fig 1



12 File the sides 'D', 'E' and 'F' with a bastard file.

13 Finish the job with a second cut file. File within ± 0.5mm and check the right angles with reference to surfaces 'A' and 'B'.

14 Use an outside caliper for checking the finished sizes.

15 Deburr all sharp edges.

Do not overtighten the vice.

Do not allow any pining of the file handle. Use a file card for removing pining of the file.

Skill sequence

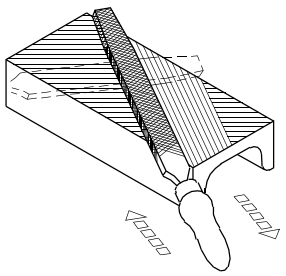
Types of filing

Objective: This shall help you to
- **file a flat surface.**

Filing methoda : The method of filing adopted depends on the type of surface profile to be filed, the type of surface texture required and the amount of materials to be removed.

Diagonal filing: This type of filing is done when heavy reduction of material is required. The strokes are at an angle of 45°. Because the stroke directions cross, the surface texture formed clearly indicates the high and low spots. Frequent checking of the level is not necessary, particularly, after one has developed a steady movement of the file. (Fig 1)

Fig 1

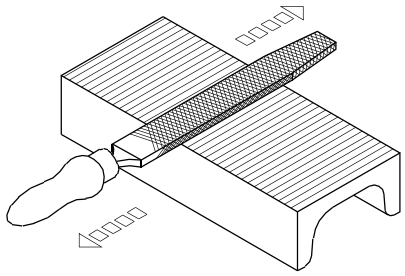


DIAGONAL FILING

ELN1216J1

Transverse filing: In this method the file strokes are at right angles to the longer side of the work. This is commonly used to reduce material from the edges. Using this method, the size of the workpiece is brought close to the finishing size, and then final finishing is done by longitudinal filing. (Fig 2)

Fig 2

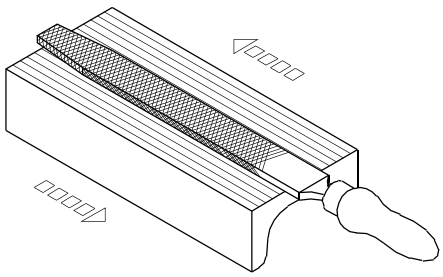


TRANSVERSE FILLING

ELN1216J2

Longitudinal filing: The file is moved parallel to the longer side of the work. Usually all surfaces are smooth–finished by this method. The filed surface texture will show uniform and parallel lines. (Fig 3)

Fig 3



LONGITUDINAL FILING

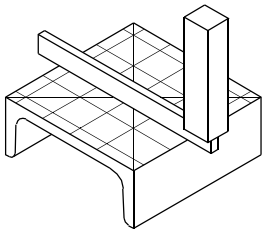
ELN1216J3

Checking flatness and squareness

Objectives: This shall help you to
- **check flatness**
- **check squareness.**

Checking flatness: During the initial stages of filing the evenness of the surface is visible to a reasonable degree of perfection from the surface texture of diagonal filing. To ensure perfection the surface should be checked with a straight edge. To do this, the blade of a Try square can serve as a straight edge. Flatness should be checked in all directions to cover the entire surface. Light gap will indicate high and low spots. (Fig 1)

Fig 1

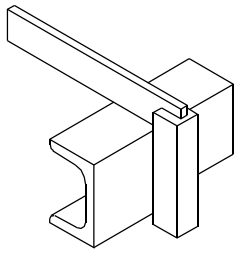


FLATNESS CHECKING

ELN1216X1

Checking squareness: While checking for squareness, the larger finished surface serves as reference surface. Ensure that the reference surface is perfectly finished before filing the other surfaces. (Fig 2)

Fig 2

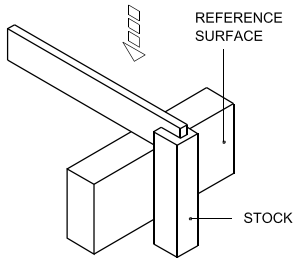


SQUARENESS CHECKING

ELN1216X2

Burrs, if any, should be removed before checking with the Try square. While checking with the Try square, press the stock against the reference face and then slowly bring the blade down. (Fig 3) Pressure is always applied to the stock against the reference surface.

Fig 3



CHECKING WITH TRYSQUARE

ELN1216X3

Marking parallel lines with Odd Leg Caliper

Objective: This shall help you to

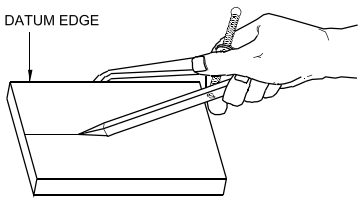
- **mark parallel lines with reference to a datum edge using an odd leg caliper or Jenny caliper.**

- Hold the job in the left hand if the job is small.
- Hold the odd leg caliper in the right hand.
- Transfer the required dimension from the steel rule to the odd leg caliper.

The tip of the bent leg should touch the datum edge of the job. The pointed leg should be on the surface of the job. (Fig 1)

The odd leg should be held at 45° from the surface of the job.

Fig 1



MARKING WITH ODD LEG CALIPER

ELN1216Y1

Scribing of lines should always towards the direction of marking person.

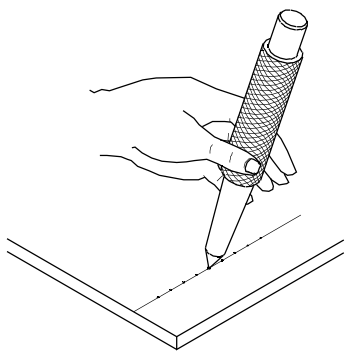
Method of using Centre Punch

Objectives: This shall help you to

- **hold a centre punch over a scribed line**
- **punch by dot/centre punch.**

Hold the punch in a relaxed manner between your thumb and your fingers. For centre/dot punching, place the workpiece on a steel support plate. Place the punch in position. Rest your hand on the workpiece while doing so. (Fig 1)

Fig 1

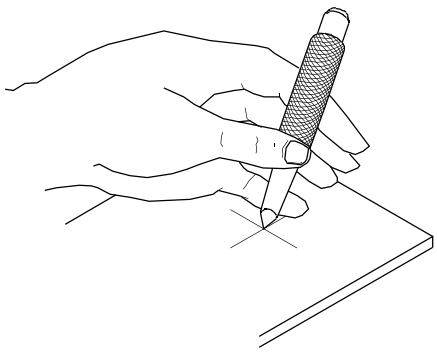


CENTRE PUNCH OVER SCRIBED LINES

ELN1216Z1

Place the point of the centre punch on the line of intersection. (Fig 2)

Fig 2

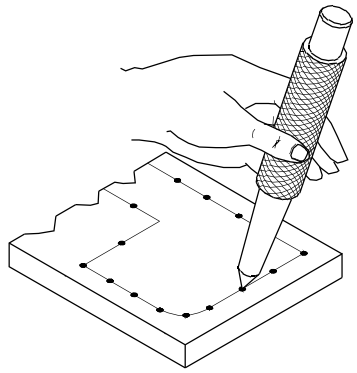


CENTRE PUNCH ON INTERSECTION

ELN1216Z2

Bring the punch in perpendicular position to the surface of the workpiece. (Fig 3)

Fig 3

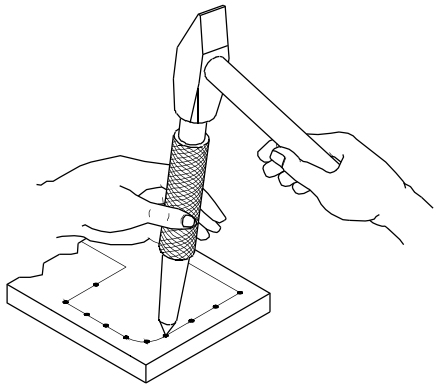


CENTRE PUNCH IN PERPENDICULAR

ELN1216Z3

Tap the head of the punch with a light blow by a hammer. A heavier blow is required for marking the position of drilling a hole. (Fig 4)

Fig 4



LIGHT BLOW BY HAMMER

ELN1216Z4

Practice in hacksawing

Objectives: At the end of this exercise you shall be able to

- **file one face flat and check by straight edge and light gap**
- **file angle to 90° within Try square accuracy**
- **mark straight lines**
- **mark parallel lines using a surface gauge**
- **mark parallel lines using a Try square**
- **file and finish surfaces flat and parallel within ± 0.5mm**
- **file and finish radius**
- **saw M.S.flat along a straight line.**

Requirements

Tools/Instrumentss

- File, flat bastard, double cut 300 mm - 1 No.
- File, flat, second cut, double cut 300 mm - 1 No.
- Try square - engineer's rule 150 mm - 1 No.
- Jenny caliper 150 mm - 1 No.
- Engineer ball peen hammer 200 gm - 1 No.
- Centre punch 100 mm - 1 No.
- Dot punch - 1 No.
- Steel rule 300 mm - 1 No.
- Hacksaw blade 300 mm - 1 No.
- Surface gauge - 1 No.
- Radius gauge - 1 set.
- File card - 1 No.
- Vice clamp - 1 pair.
- Divider - 1 No.
- Straight edge - 1 No.

Equipment/Machines

- Bench vice 50 mm jaw - 1 No.
- Surface plate - 1 No.
- Angle plate - 1 No.

Materials

- 60 ISF 8 (Length - 350 mm.) - 2 Nos.

PROCEDURE

1 Check the raw material size with the sketch using the steel ruler.

2 Securely fix the job in the bench vice.

3 File the reference face A (Fig 1) with a bastard file.

4 Check the flatness with the straight edge.

5 File adjacent edge or datum edge B (Fig 1) with a bastard file.

6 Check the right angle with a Try square.

7 File adjacent edge or datum edge C (Fig 1) with a bastard file.

8 Check the right angles to the datum edge B and reference surface A.

9 Evenly apply chalk on the surface A.

10 Place the job on the levelling plate and scribe the lines by the surface gauge, parallel to the datum edge B (size 58 mm) and on datum edge C (size 350 mm).

11 Scribe the saw, cut parallel lines a, b, c & d as per the sketch. (Fig 1)

12 Scribe two arcs of radius 10 mm with the divider at the datum edge C as in the Fig 1.

13 Punch all the scribed lines and also the arcs by a dot punch.

14 File the edges D and E with a file.

15 Check for the right angle between edges D and E and also with the surface A.

16 Check the finished piece for length 350 mm and breadth 58 mm with an outside caliper.

17 Saw the depth a, b, c, and finally saw part at 'd' in Fig 1.

18 File and finish the saw - Cut surface of part 1 for a length of 300 mm.

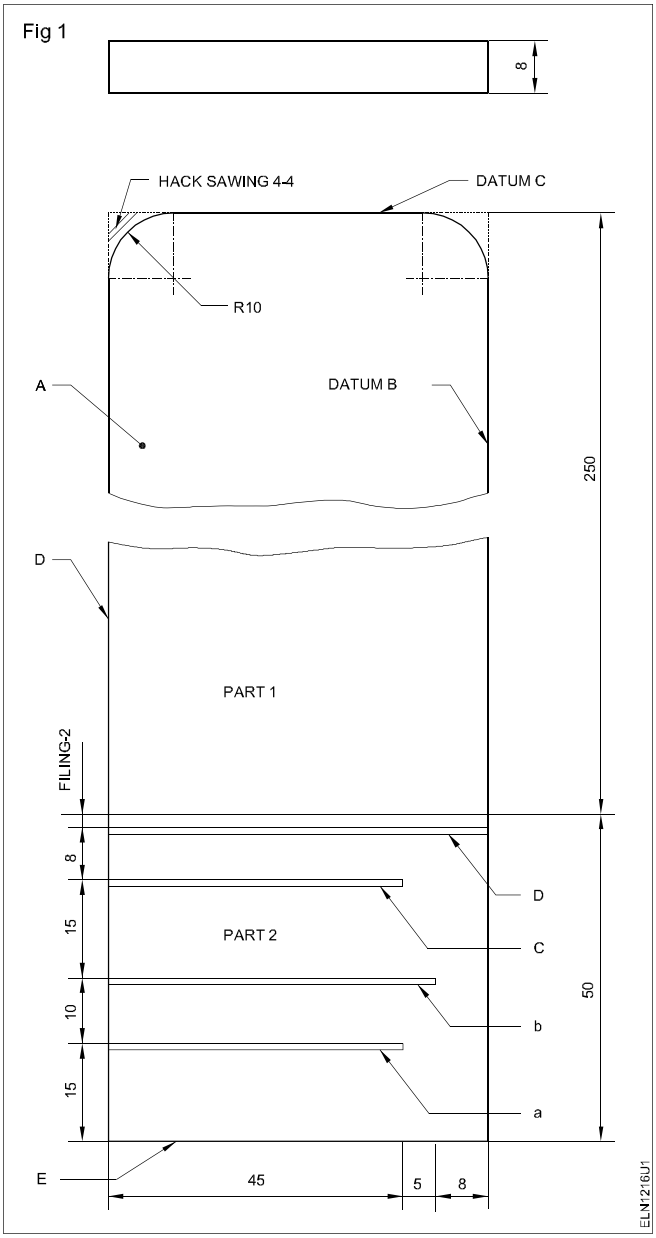
19 Saw the corners for removing the unwanted metal for filing the radius.

20 File and finish two corners by radius filing on part 1.

21 Check the radius with a radius gauge.

22 File and finish the job with a second cut file within a tolerance of ± 0.5 mm (use outside calipers for checking).

Fig 1



Skill sequence

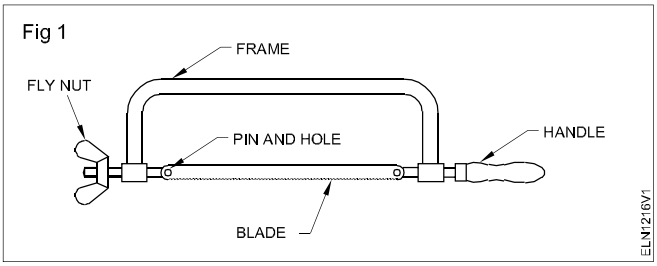
Fixing of hacksaw blade on the frame and sawing

Objectives: This shall help you to
- **fix the hacksaw blade on the frame**
- **practice sawing with dimensions.**

The teeth of the blade should point from the handle.

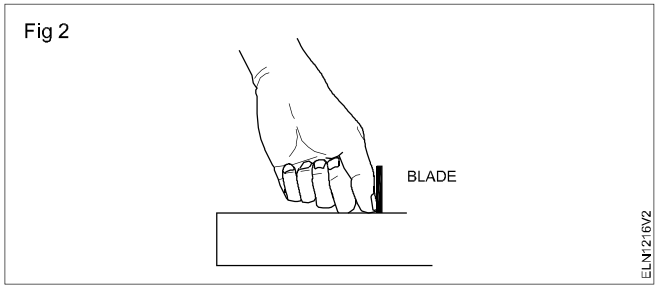
1 Fix the blade to the frame in good tension. (Fig 1)

Fig 1



2 Set your thumb nail vertically to the location of the cut, and this location should be at least 10 mm from the vice. (Fig 2)

Fig 2

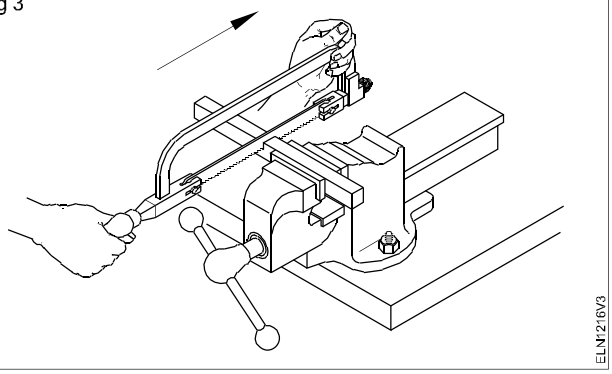


3 Hold and press the hacksaw straight. (Fig 3)

Do not use force when pulling back. Occationally apply cutting compound while cutting .

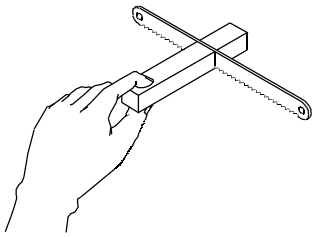
Use the full length of the hacksaw blade.

Fig 3



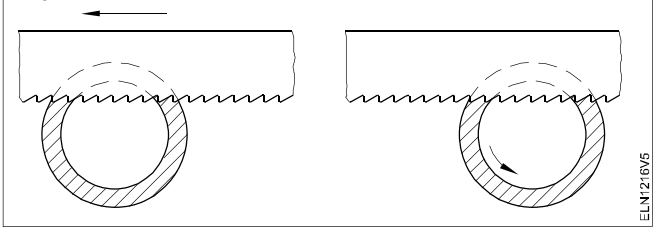
4 Make the last few cuts holding the piece to be cut in your left hand. (Fig 4)

Fig 4



For this section use a fine grade blade. A minimum of two to three teeth should be in contact with the work. (Fig 5)

Fig 5



Prepare hand coil winding assembly

Objectives: At the end of this exercise you shall be able to
- **identify the component /part that matches with the given drawings**
- **prepare the parts required for assembly with the help of sub exercises**
- **assemble the components (with the specified method) to the appropriate fitness and complete the assembly**
- **test the working of the assembly to the required standard.**

Requirements

Tool/Instruments

- Four folded wooden scale 600 mm - 1 No.
- Screwdriver 3 mm blade 150 mm - 1 No.
- Screwdriver 10 mm blade 200 mm - 1 No.
- DE spanner set of 8 pieces (Metric) - 1 No.
- Combination plier 150mm - 1 No.
- Smooth jack plane - 1 No.

Equipment/Machines

- Portable electric drilling machine ø 6 mm capacity - 1 No.

Materials

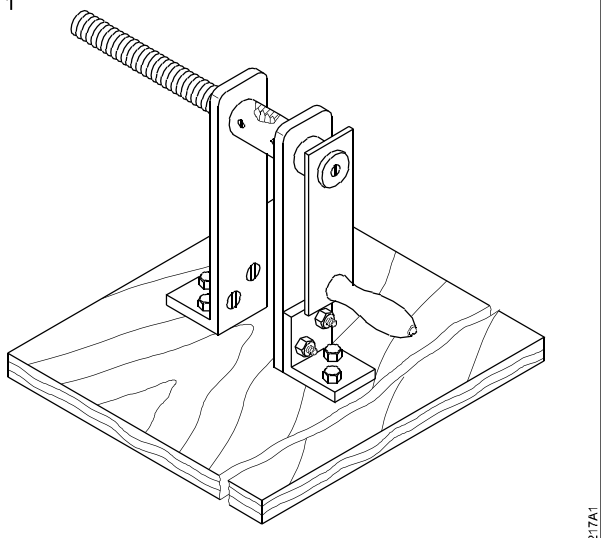
- Completed exercise jobs from Ex. 1.2.16
- Completed exercise jobs from sub exercises from (S. Ex. from 1.2.17 - 1 to 1.2.17 - 5)
- Slotted cheese head screw M 6 20 mm - 1 No.
- Slotted cheese head screw M 6 x 125 mm - 1 No.
- T.W. plank 30 x 350 x 500 - 1 No.
- M 10 slotted cheese head screw x 25 mm - 4 Nos.
- M 10 Hexagonal bolt and nut 50 mm - 4 Nos.
- Set screw M 3 x 8 mm - 2 Nos.
- Washer outer diamrter ø 20 bore 7 mm, thickness 1.5 mm - 1 No.
- Hexagonal nut for M 6 - 2 Nos.

PROCEDURE

TASK 1: **Preparation of the wooden base**

Fig 1 shows the completed sketch of a hand coil winding machine assembly.

Fig 1



HAND COIL WINDING MACHINE

ELN1217A1

1 Check the size of the wooden base with the dimensions. (Fig 2)

2 Plane the top surface A (Fig 2) using a planer.

3 Plane the longer edge B (Fig 2). Check the straightness using a straight edge.

4 Plane the shorter edge C (Fig 2) and check the right angle with reference edge B.

5 Mark the length and breadth as per sketch. (Fig 2)

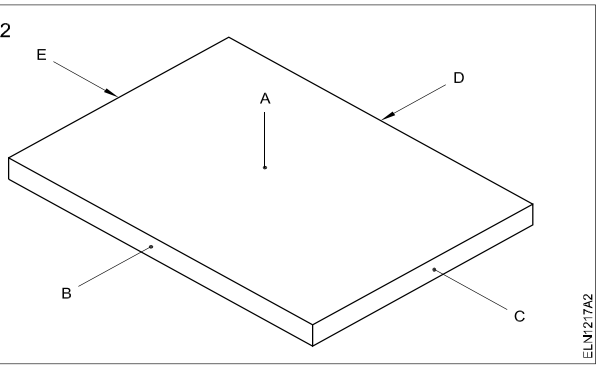
6 Plane the longer edge D as per the marked line, and check 90° with reference to edge C.

7 Plane the shorter edge E as per the marked line, and check right angle (90°) with reference to edge D. (Fig 2)

8 Check the length and breadth using a wooden scale (folded).

9 Polish the sharp edges and surface with sandpaper.

Fig 2



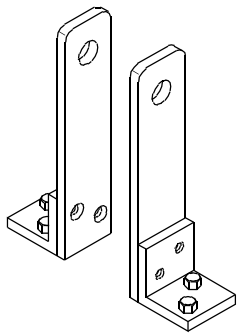
ELN1217A2

TASK 2: **Assemble the hand coil machine**

Note: The instructor shall give as sub exercises of Ex. 1.2.17 (S. Ex. 1 to 5) and keep the finished jobs done from these sub exercises securely. They must be required to assemble the hand coil winding machine. So, before commencing the assembling TASK 2, the trainees can be instructed to complete the 5 sub exercises given in this exercises 1.2.17.

1 Fix the angle iron (done in sub exercise so S.Ex. 1.2.17 - 2 - internal threading) on the base of the vertical stand (done in S. Ex. 1.2.17- 1 drilling and chipping) by bolt and nut (Fig 1).

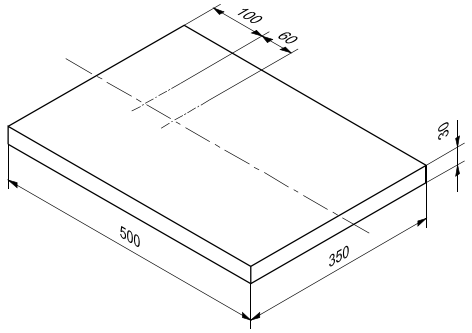
Fig 1



ELN1217B1

2 Mark on the wooden base for fixing of vertical stand (Fig 2).

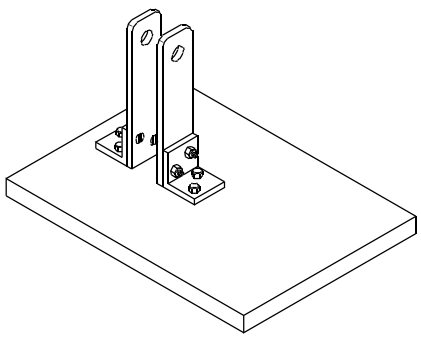
Fig 2



ELN1217B2

3 Fix the vertical stand on the wooden base using wood screws (Fig 3).

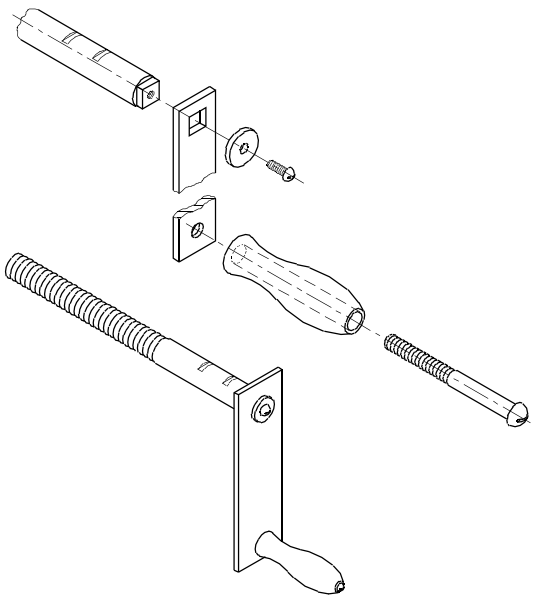
Fig 3



ELN1203B3

4 Insert the square end of the threaded rod (done in exercise S. Ex. 1.2.17 - 3 external threading and square slot filing) into the square slot (done in sub exercise S Ex.1.2.17 - 4 making square hole in crank handle) and fix using machine screw and washer (Fig 4).

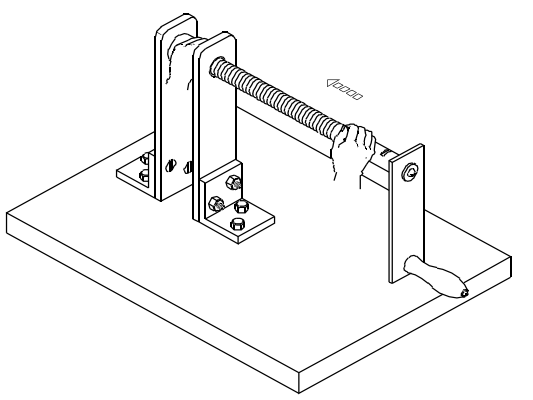
Fig 4



ELN1217B4

5 Hold the steel tube (done in sub exercise S Ex - 1.2.17 - 5 pipe hacksawing, drilling and internal threading) in one hand and the threaded rod in the other hand. Insert the rod through the spacer and the stand (Fig 5).

Fig 5

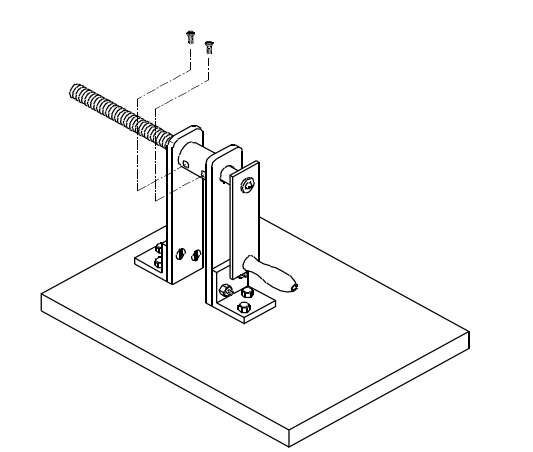


ELN1217B5

6 Fasten the spacer tube on the rod using screws.

7 Assemble all the components on the base (Fig 6) and finish the machine assembly.

Fig 6



ELN1217B6

Note: Before commencing TASK 2 of this exercise, complete the following sub exercises S. Ex. 1.2.17 - 1 to 5 and reserve the jobs for assembling in Task - 2.

Sub Exercise (S. Ex.) 1.2.17 - 1

Drilling and chipping practice

Objectives: At the end of this exercise you shall be able to

- **file two adjacent sides to 90° and mark parallel lines for filing**
- **file and finish surfaces within ± 0.5mm**
- **mark by surface gauge for saw cut**
- **mark locations for drill hole centre using the surface gauge**
- **transfer measurements from steel rule to the divider**
- **scribe circles for holes by the divider**
- **make centre punch for centering drill bit**
- **make dot punch for saw line and circumference of the drill hole mark**
- **saw M.S. flat along a straight line**
- **chip flat surface using cold flat chisel**
- **drill through holes within ± 0.5 mm countersunk holes**
- **grind the cutting edge of the flat cold chisel.**

Requirements

Tools/Instruments

- Flat cold chisel 20 mm - 1 No.
- Engineer's ball peen hammer 400 gm. - 1 No.
- Surface gauge - 1 No.
- Hacksaw frame 250 to 300 mm - 1 No.
- Twist drill - ø 6, ø10, ø 11.5, ø18 - 1 each
- Engineer's parallel blocks - 1 pair
- C.S.K. bit ø 15 - 1 No.

Equipment/Machines

- Bench vice - 1 No.
- Angle plate - 1 No.
- Pillar drilling machine - 1 No.
- Pedestal grinding machine - 1 No.
- Drilling accessories, chuck, sleeve, drift - 1 each

Materials

- 58 ISF 10, length 300 mm - 2 Nos.
  Finished part of Exercise No.1.2.16
- Hacksaw blade 300 mm - 2 Nos.

PROCEDURE

1 Check the dimensions of the finished job (EX. 1.2.16 - hack sawing practice).

2 Evenly apply lump chalk on the job.

3 Mark all lines parallel to the finished datum edge C (Fig 1) for saw cut and centre of drill holes as per the drawing by placing the job on the levelling plate. (Refer skill information - 1.2.16)

4 Scribe all the lines parallel to the finished datum edge B for saw cut and centre of drill holes as per the drawing by placing the job on the levelling plate.

5 Mark the intersection points of the centre lines of the drill holes with the dot punch.

6 Scribe the circle of the drill hole using the divider. (Refer skill information - 1.2.16)

7 Punch mark the circle at four intersecting points with centre lines.

8 Fix the job in the machine vice of the drilling machine to drill holes marked in part A. (Fig 1)

9 Drill holes of diameter. 6 mm, 10 mm and 15 mm.

10 Drill without altering the setting of the job, change the drill bit to 18 mm and drill the hole.

No holes should be drilled in the portion of the job marked part D.

11 Repeat the steps 1 to 10 in the second portion of the finished job in Exercise No 1.2.16

12 Make the saw cut at a b, 252 mm from datum C.

13 Chip off the L shape to the dimensions using a flat cold chisel and holding part A in the bench vice. (Refer skill information - 1.2.17)

Use goggles to protect your eyes.

Dip the tip of the chisel in oil at frequent intervals to keep the cutting edge cool.

14 Repeat steps 12 and 13 on the second piece.

15 File and finish the edge G opposite to the datum edge C in both the pieces.

16 Clamp both the job pieces together and fix them in the drill machine vice. (Refer skill information-1.2.17)

17 Drill 11.5 mm diameter. holes through both the pieces.

18 Drill a pilot hole for 18 mm diameter through both the pieces.

Do not disturb the setting in the drill machine.

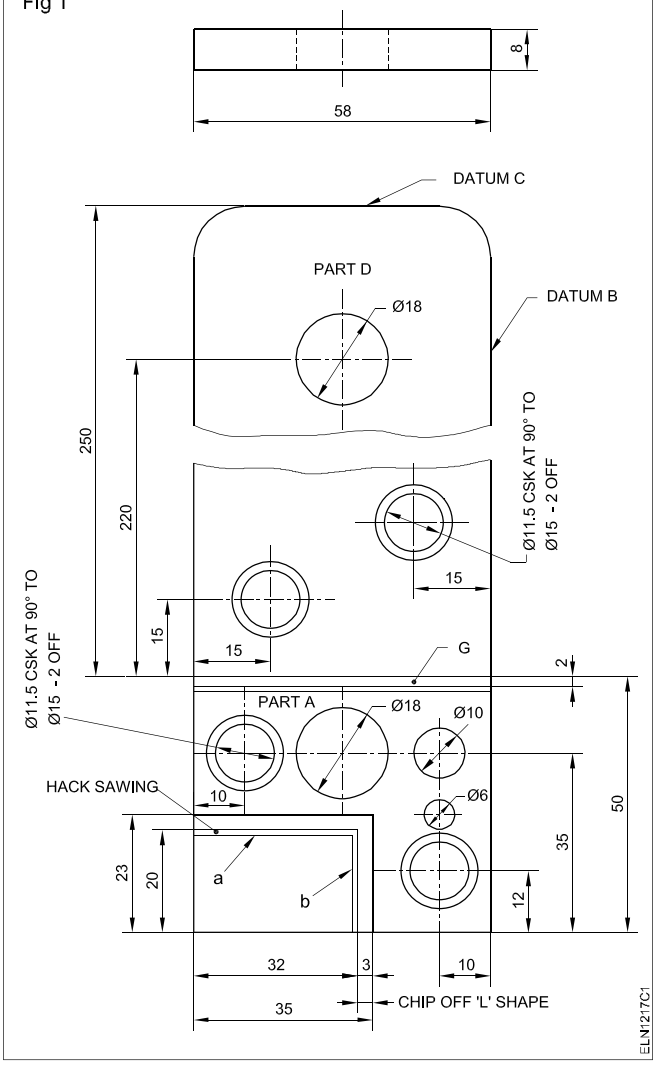
19 Drill 18 mm hole through the pilot hole already drilled.

20 Separate both the job pieces.

21 Countersink the 11.5 mm holes (4 OFF) as per the dimensions given in (Fig 1) in the two pieces of part A.

22 Countersink the 11.5 holes in part D of both the job pieces as per the drawing in Fig 1.

Fig 1



Skill Information

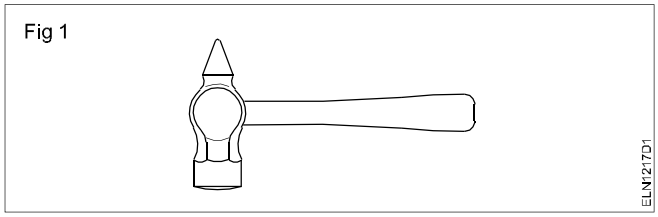
Hints on chipping

Objective: This shall help you to
- **chip metals adopting safe practices.**

Before commencing the chipping we must ensure the following factors.

The hammer head is properly secured. (Fig 1)

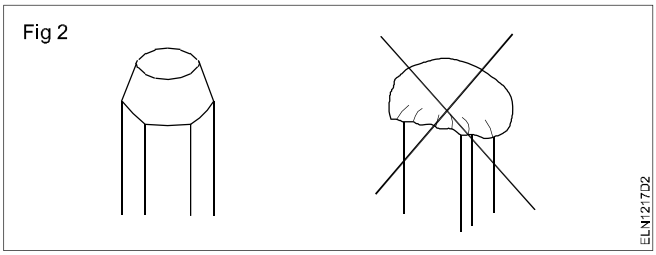
Fig 1



Oily substance, if any, is wiped off from the face of the hammer.

The chisel head is free from mushrooms. (Fig 2)

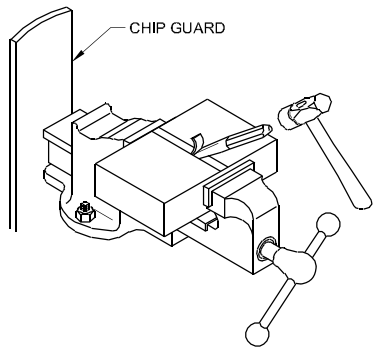
Fig 2



Safety goggles are used.

A chip guard is installed to prevent chips flying off. (Fig 3)

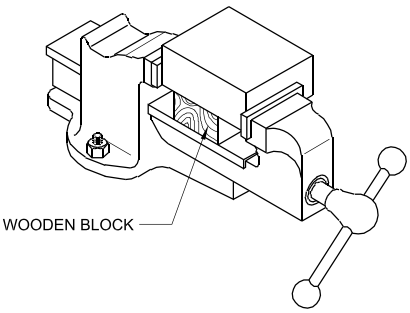
Fig 3



Bangles and wrist watches are removed.

Work is properly gripped in the vice. If necessary, it is supported on a wooden block. (Fig 4)

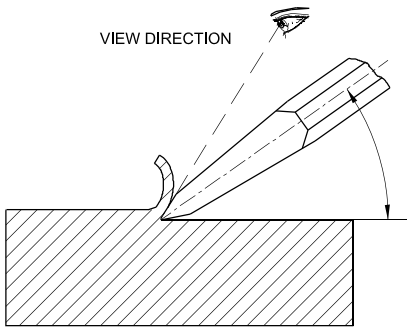
Fig 4



The cutting edge of the chisel is looked at and not the head of the chisel. (Fig 5)

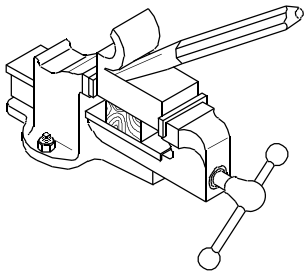
The chisel is positioned to cut the metal in uniform thickness. (Fig 5)

Fig 5



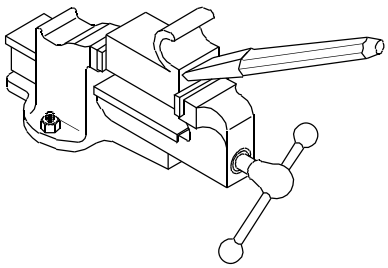
Chipping is stopped before the end of the surface to prevent the edge of the job from breaking off. (Fig 6)

Fig 6



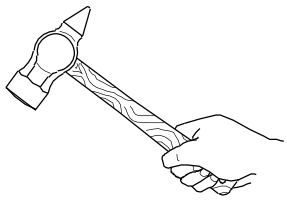
Chip from the end of the job from the opposite direction. (Fig 7)

Fig 7



Hold the hammer at the end of the handle for maximum leverage. (Fig 8)

Fig 8

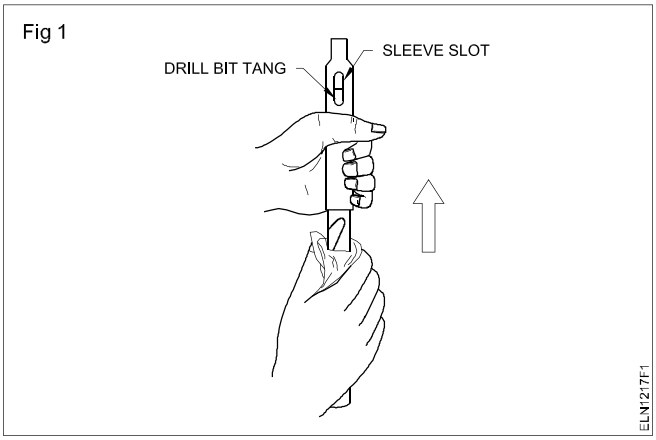


Inserting and removing taper shank drill bit

Objectives: This shall help you to
- **insert a drill bit (taper shank) in the spindle of the drilling machine**
- **remove the inserted drill bit from the spindle.**

Wipe the drill taper and the sleeve hole clean with a rag. Align the slot in the sleeve with the drill bit tang and insert it. (Fig 1)

Fig 1

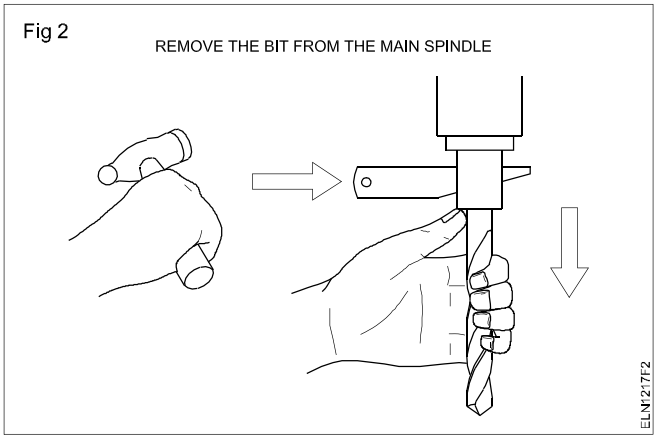


Lower the main spindle far enough to see the wedge insertion hole. Throw the main spindle vertical handle to the right and stop the vertical movement of the main spindle .

Wipe the sleeve taper and the main spindle taper hole with a rag. Align the sleeve tang with the main spindle slot, and insert it. Start the main spindle, and make sure there is no wobble. Turn the inclined edge of the wedge down, and insert it into the main spindle slot.

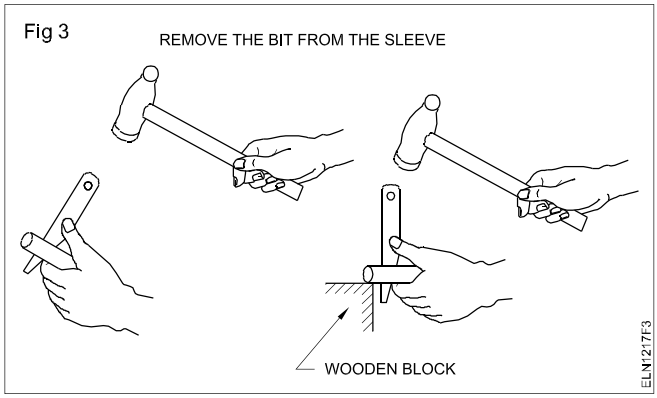
Support the bit with your left hand to prevent it from falling. Lightly tap the top of the wedge with a hammer. (Fig 2)

Fig 2



Insert the wedge into the sleeve slot. Lightly tap the top of the wedge with a hammer. If you cannot support it with one hand, place a wooden block at the bottom with the sleeve, and then tap. (Fig 3)

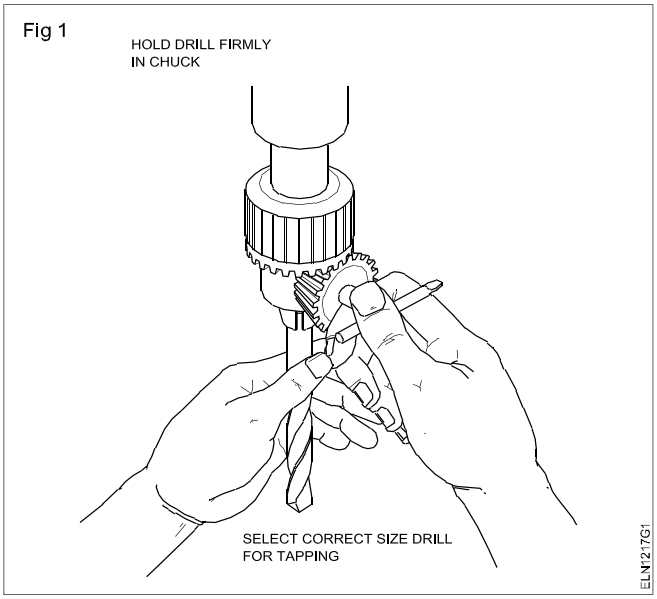
Fig 3



Drilling through holes

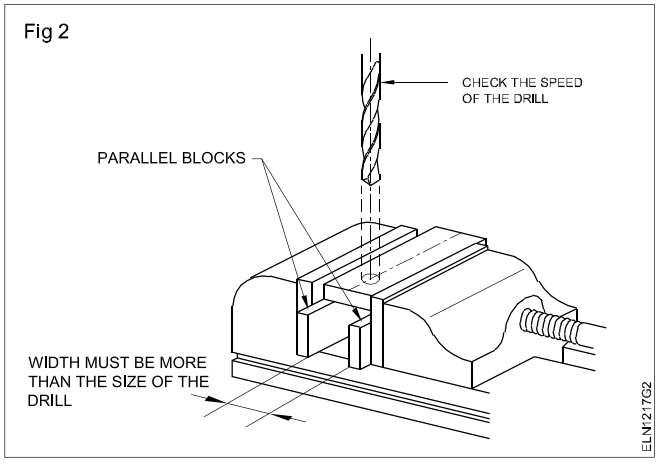
Objectives: This shall help you to
- **fix drill bit in the chuck**
- **drill a hole.**

Fig 1



Hold the straight shank drill firmly in the chuck. Adjust and check the speed of drill as per size. Hold the job deep in the vice jaws.

Fig 2



Support the job with suitable parallel blocks.

Remember that the drill must clear the parallel blocks when a hole is drilled.

Bring the drill point drawn for the correct centre punch position marked on the work. Use coolant at the time of drilling the hole. At the end of the drilling, apply less pressure on the drill.

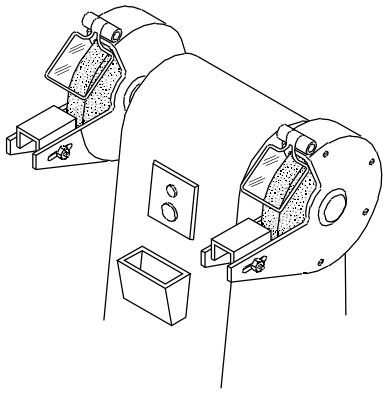
Sharpening of chisels

Objectives: This shall help you to
- **Safely operate a grinder.**

Sharpening of chisels: Chisels become blunt by use. For efficiency in chipping, chisels need to be regularly sharpened.

Chisels are sharpened on grinding machines. (Fig 1)

Fig 1



ELN12171I

After grinding many times, the cutting edges of chisels become very thick and are unsuitable for re-sharpening. They need to be forged and brought to shape before grinding (Fig 2).

Fig 2

ELN12172

Before commencing grinding, the following procedure should be observed.

Ensure the wheel guards are in place and are securely fastened.

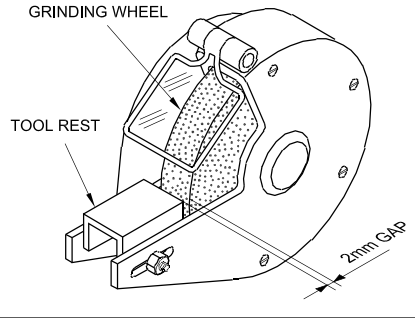
Inspect the condition of the grinding wheel for breakage and cracks.

Wear safety goggles.

When switching on the grinding machine, stand aside until the wheel reaches the operating speed.

Inspect the tool rest. If there is more gap between the tool rest and the wheel, adjust it and position it as close to the wheel as possible. (Fig 3)

Fig 3



ELN12173

Ensure that there is sufficient coolant in the container.

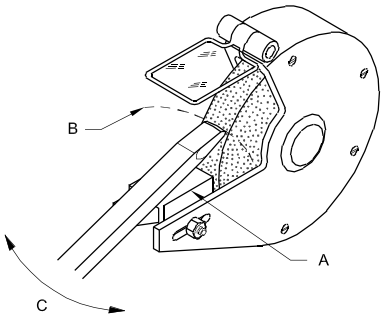
While grinding, rest the body of the chisel on the tool rest (A) and allow the point to touch the wheel. (Fig 4)

Rock the point slightly on both sides in an arc (B) to provide slight convexity at the cutting edge. This will save digging in of the sides while chipping. (Fig 4)

Dip the chisel frequently in the coolant to avoid overheating.

Overheating will reduce the temper of the chisel.

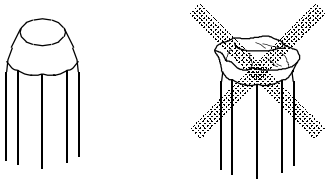
Fig 4



ELN12174

If the chisel head is mushroomed, it should be removed by grinding. (Fig 5)

Fig 5



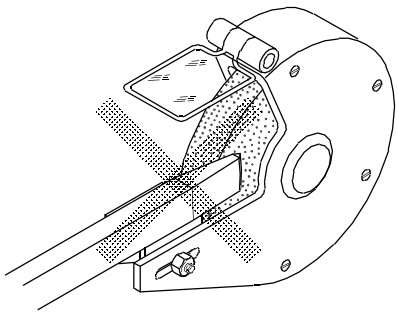
ELN12175

Use only the front face of the grinding wheel. (Fig 4) Do not grind on the sides. (Fig 6)

Any damage to the grinding wheel, if observed, should be reported to the instructor.

Do not use cotton waste or other material for holding the chisel while grinding.

Fig 6



WRONG METHOD

ELN1217I6

Off hand grinding with bench and pedestal grinders

Objectives: This shall help you to
- **state the purposes of off-hand grinding**
- **name the machines with which off-hand grinding is done**
- **state the features of bench and pedestal grinders.**

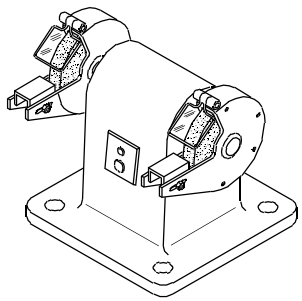
Off-hand grinding is the operation of removing material by pressing the workpiece against a grinding wheel. Work that does not require great accuracy in size or shape is ground in this manner. Work is held in the hands and manipulated to the desired shape.

Off-hand grinding is performed for

- rough grinding of a job
- re-sharpening of scriber, punch, chisel, twist drill and single point cutting tools.

Offhand grinding is performed with a bench grinder or pedestal grinder. (Fig 1 & Fig 2)

Fig 1



BENCH GRINDER

ELN1217J1

Bench grinders are fitted to a bench or table, and are useful for light duty work. (Fig 1)

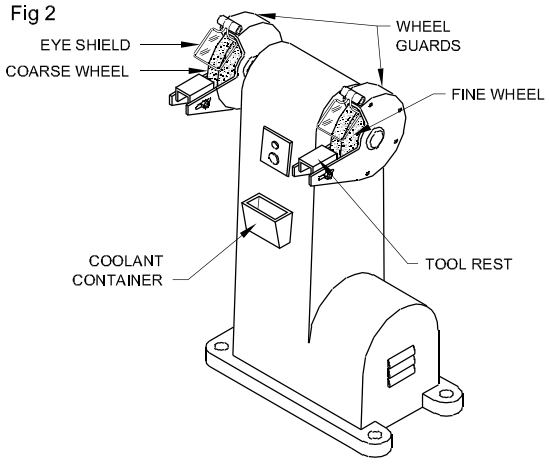
Pedestal grinders are mounted on a base (pedestal) and are fastened to the floor. These are used for heavy duty work. (Fig 2)

These grinders consist of an electric motor and two spindles for mounting the grinding wheels. On one spindle, a coarse grained wheel and on the other fine grained wheel are fitted. Wheel guards are provided for safety while working (Fig 2).

A coolant container is provided for frequently cooling the work. (Fig 2)

Adjustable work-rests are provided for both wheels to

Fig 2

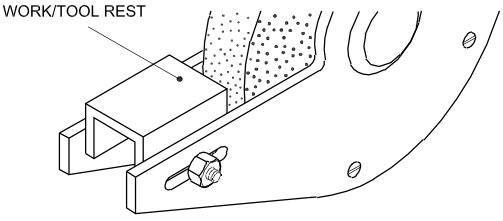


PEDESTAL GRINDER

ELN1217J2

support the work while grinding. These work-rests must be set very close to the wheels. (Fig 3)

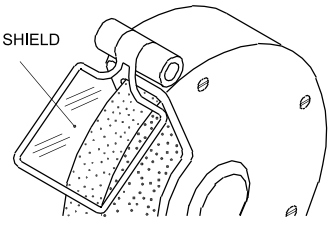
Fig 3



ELN1217J3

Extra eye shields are also provided for the protection of the eyes. (Fig 4)

Fig 4



ELN1217J4

Sub Exercise (S. Ex.) 1.2.17 - 2

Internal threading practice

Objectives: At the end of this exercise you shall be able to
- **mark off parallel lines by surface gauge (R)**
- **saw as per marking(R)**
- **file and finish to 90° ± 1° and to the required length to ± 0.5mm (R)**
- **mark for drilling holes (R)**
- **drill holes using the pillar drilling machine (R)**
- **form internal thread using hand tap and wrench.**

Requirements

Tools/Instruments

- Surface gauge - 1 No.
- Hacksaw frame 250 to 300 mm - 1 No.
- Engineer's ball peen hammer 200 gm - 1 No.
- M 10 tap and wrench - 1 set.
- Steel rule 300 mm - 1 No.
- Twist drill, ø 8.5 and ø11.5 - 1each.
- Try square 150 mm - 1 No.

Equipment/Machines

- Bench vice 50 mm jaw - 1 No.
- Drilling machine–pillar type - 1 No.
- Angle plate - 1 No.
- Surface plate - 1 No.
- Drilling accessories, chuck, sleeve and drift - as requried.

Materials

- Finished part of Exercise 1.2.02 (filed full surface)

PROCEDURE

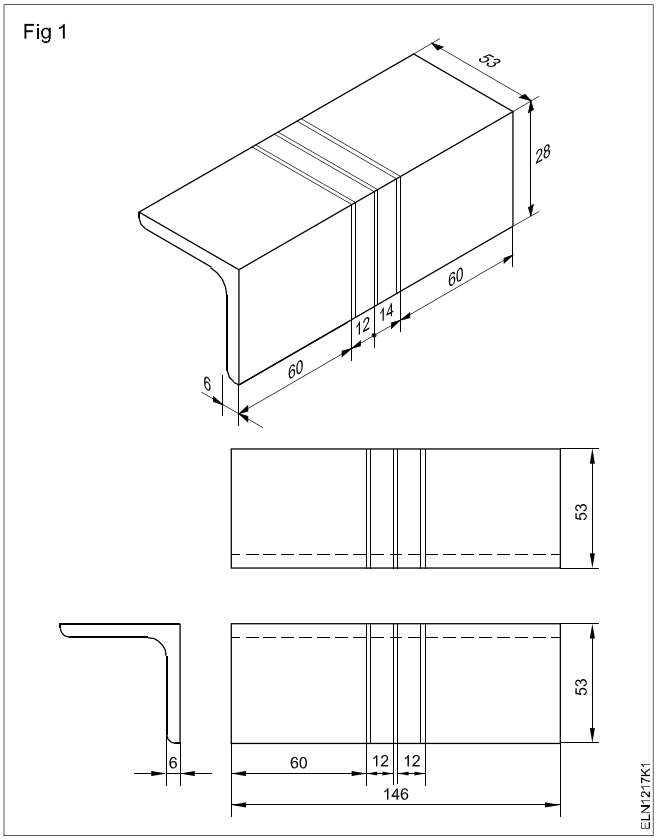
TASK 1: **Prepare the angle iron and drill through holes in it**

1 Check the dimension of the finished filed part of Exercise 1.2.16.

2 Apply lump chalk on the two flanges of the angle.

3 Mark off the length of the angle iron - 74 mm, using surface gauge. (Fig 1)

Fig 1



4 Punch scribed lines using dot punch.

5 Saw centrally, and part into two pieces.

6 Mark off again for 60mm length. (Fig 2)

7 Saw, file and remove unwanted metals.

8 File and finish one piece to 60 mm length.

9 Mark off in one flange for the tapping hole. Mark off the other flange for the clearance hole. (Fig 2)

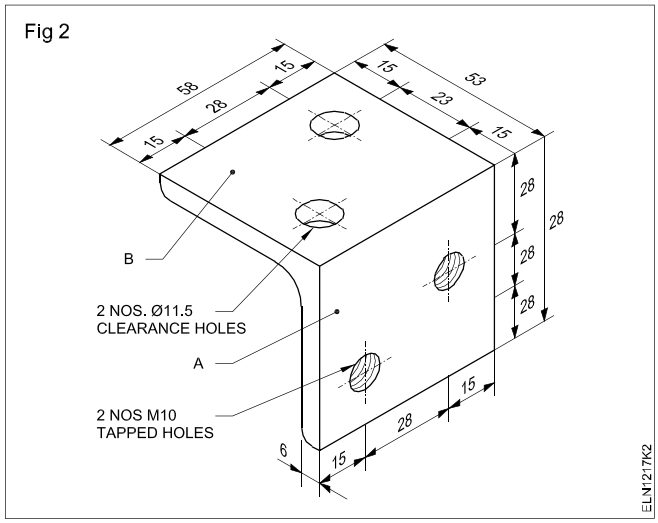
10 Drill ø 8.5 mm for two tapping holes.

11 Drill ø 11.5 mm for two clearance holes.

After performing the above operations get it approved your instructor.

12 Repeat steps 6 to 11 for finishing another piece.

Fig 2



Skill Information

Internal threading of through holes using hand taps

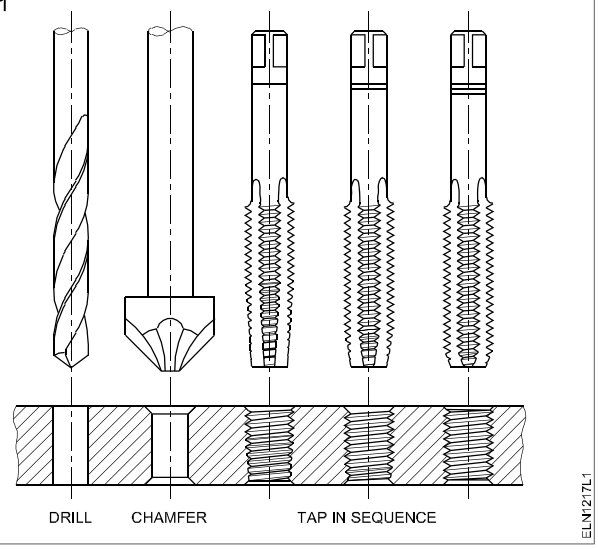
Objectives: This shall help you to
- **determine tap drill sizes for internal threading**
- **cut internal threads using hand taps.**

For cutting internal thread, it is necessary to determine the size of hole (tap drill size). This can be chosen from the table of tap drill sizes.

1 Drill the hole to the required tap drill size.

Remember give the chamfer required for aligning and starting the tap. (Fig 1)

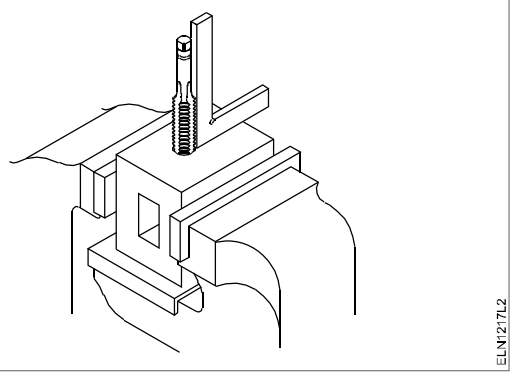
Fig 1



2 Hold the work firmly and horizontally in the vice.

The top surface should be slightly above the level of the jaws of the vice. This will help to use the Try square without any obstruction while aligning the tap. (Fig 2)

Fig 2

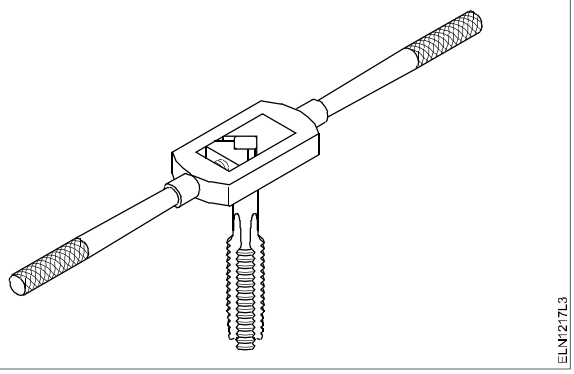


Use soft jaws while holding the finished surface on the vice.

3 Fix the first tap (taper tap) in the wrench.

Very small wrenches need more force to turn the tap. very large and too heavy tap wrenches will not give the required feel to turn the tap slowly as it cuts. (Fig 3)

Fig 3

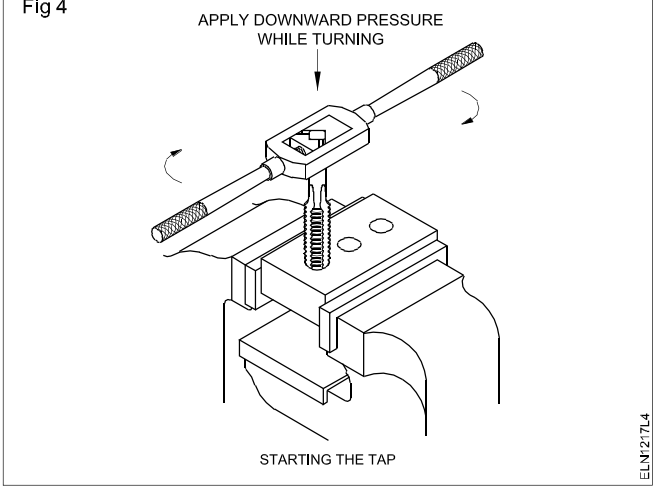


4 Position the tap vertically in the chamfered hole that ensuring the wrench is in the horizontal plane.

5 Exert steady downward pressure and turn the tap wrench slowly in the clockwise direction to start the thread.

6 Hold the tap wrench close to the centre. (Fig 4)

Fig 4



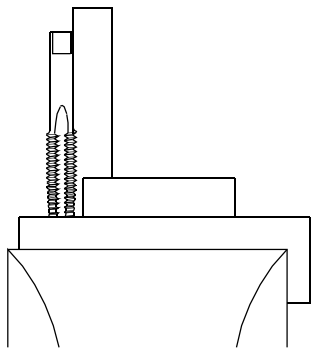
When you are sure of starting to thread, remove the tap wrench without disturbing the tap alignment.

7 Check that the tap is vertical, with the help of a small Try square. (Fig 5) Place the Try square in two positions, 90° to each other. (Fig 6)

8 Make corrections, if necessary.

This is done by exerting slightly more pressure on the opposite side of the tap inclination. (Fig 7)

Fig 5



ELN1217L5

Fig 6

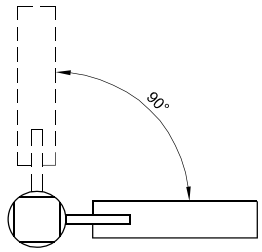


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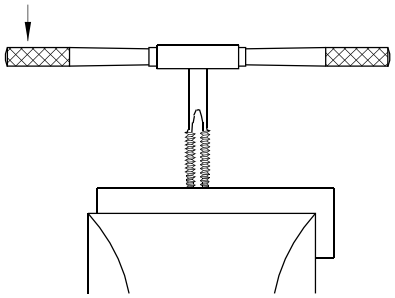
Fig 7



SQUARING UP THE TAP

ELN1217L7

Apply side pressure after giving a turning motion to the tap.

9 Check the tap alignment again with a Try square.

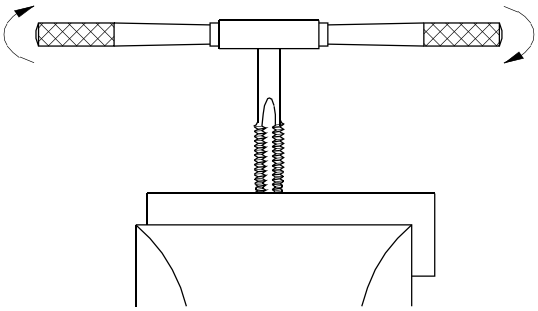
10 Fit the wrench and tighten without disturbing the tap alignment.

11 Make one or two turns and check the alignment.

The tap alignment should be achieved within the first few turns. This cannot be done afterwards as the threads may break.

Fig 8

APPLY CONSTANT TURNING PRESSURE



ELN1217L8

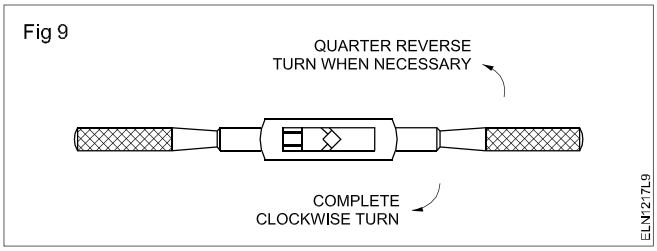
12 After the tap is positioned vertically, turn the wrench lightly by holding the ends of the wrench handles without exerting any downward pressure. (Fig 8)

While turning the wrench the movement should be well balanced. Any extra pressure on one side will spoil the tap alignment, and can also cause the tap to break.

13 Continue cutting the thread.

14 Turn backwards frequently about quarter reverse turn to remove the chips. (Fig 9)

Fig 9



ELN1217L9

15 Stop and turn backwards when some obstruction to the movement is felt.

Use a cutting fluid while cutting the thread.

16 Cut the thread until the tap is fully inside the hole that is being threaded.

17 Finish and clean using the intermediate and plug tap.

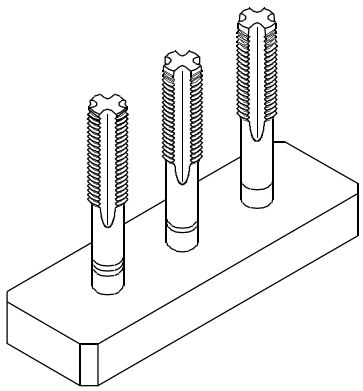
The intermediate and plug tap will not cut any thread if the taper tap has fully entered the hole.

18 Remove the chips from the work with a brush.

19 Check the threaded hole with a machining screw.

20 Clean the tap with a brush and place it back on the stand. (Fig 10)

Fig 10



ELN1217LA

Sub Exercise (S. Ex.) 1.2.17 - 3

External threading and square slot filing

Objectives: At the end of this exercise you shall be able to
- **make internal thread in blind holes**
- **make external thread on M.S. rod**
- **make square slot on M.S. rod**
- **make square on one end of the rod.**

Requirements

Tools/Instruments

- Square, second cut file 200 mm - 1 No.
- Try square (Engineer's) 150 mm - 1 No.
- Surface gauge - 1 No.
- Dot punch - 1 No.
- Engineer's ball peen hammer 200 gm. - 1 No.
- Outside caliper 150 mm - 1 No.
- Steel rule 300 mm - 1 No.
- Twist drill ø 5 - 1 set.
- M 6 tap - 1 No.
- Round split die ø/18 - 1 No.
- Die stock - 1 No.
- Odd leg caliper - 1 No.

Equipment/Machines

- Bench drill machine - 1 No.
- Bench vice 50 mm jaw - 1 No.
- 'V' block - 1 No.
- Clamp (G) - 1 No.

Materials

- ISRO 20 turned and finished to ø 18 length 270 mm. - 1 No.

PROCEDURE

1 Check the size of the raw material as per the sketch (Fig 1) using an outside caliper and a steel rule.

2 Fix the job vertically in the bench vice at least 50 mm from the jaw of the vice.

3 File one end of the rod and check 90° with the Try square.

4 Evenly apply the lump chalk on one end.

5 Set the job vertically on the surface plate supported by the `V' block and clamp.

6 Mark off the centre of the round rod with the odd leg caliper.

7 Punch for centering the tap drill hole.

8 Set the job horizontally on the `V' block.

9 Mark off square with the surface gauge and Try square.

10 Punch the square scribed lines.

11 Mark off open right angle slots (G) on the rod.

12 File the square on the end of the rod and check 90° with a Try square.

13 Check from side to side of the square with an outside caliper.

14 File the right angle slots (G).

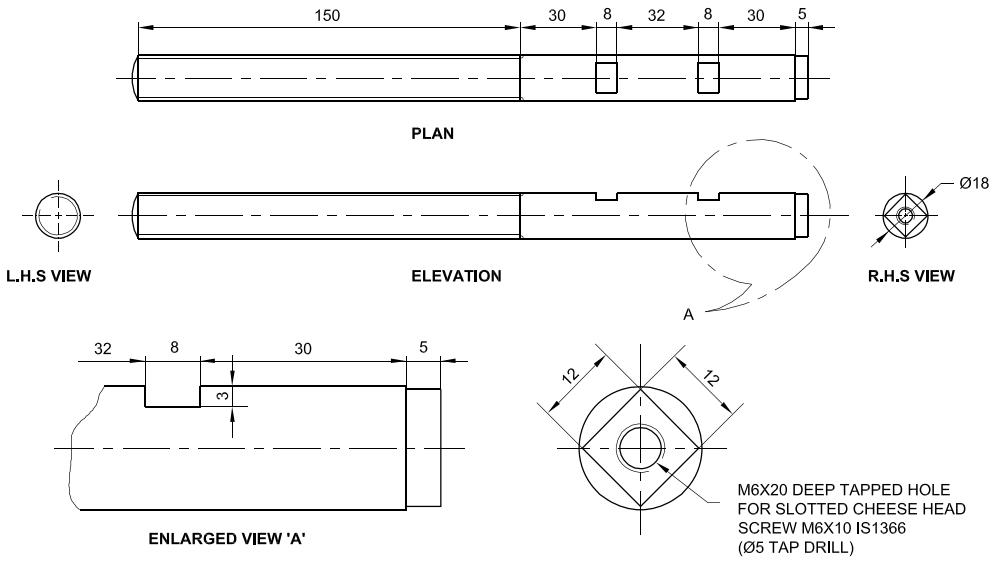
15 Check the depth and width of the slot with the steel rule.

16 Form blind hole tapping with hand tap and wrench.

17 Form external thread with die and stock.

18 Check the thread using the screw pitch gauge.

Fig 1



Sub Exercise (S. Ex.) 1.2.17 - 4

Practice of making square holes in crank handle

Objectives : At the end of this exercise you shall be able to
- **file on face to flatness using straight edge and light gap (R)**
- **file angle to 90° within Try square accuracy (R)**
- **perform operations of marking straight lines (R)**
- **file and finish surfaces within ± 0.5 mm (R)**
- **mark off for drill and square holes with surface gauges**
- **drill holes**
- **form internal thread using a hand tap**
- **file the surfaces of the inner square hole with a safe edge square file**
- **measure the inner square hole with an inside caliper.**

Requirements

Tools/Instruments

- File flat, bastard, double cut 300 mm - 1 No.
- File flat, second cut double cut 300 mm - 1 No.
- Try square (Engineer's) 150 mm - 1 No.
- Surface gauge - 1 No.
- Engineer's ball peen hammer 200 gm - 1 No.
- Inside caliper 150 mm - 1 No.
- M 6 tap and wrench - 1 set.
- Square safe edge file 200 mm - 1 No.
- Straight edge - 1 No.
- Twist drill ø 5 - 1 No.

Equipment/Machines

- Bench drill machine - 1 No.
- Angle plate - 1 No.
- Bench vice - 1 No.

Materials

- 30 ISF 6 (Length - 184 mm) - 1 No.

PROCEDURE

1 Check the size of the raw material as per the sketch using a steel rule.

2 Fix the job horizontally in the bench vice.

3 File the reference face No.1 to flatness and check the flatness by straight edge and light gap.

4 File two datum edges 2 and 3 with reference to face No.1 at right angles and check with a Try square. (Fig 1)

5 Evenly apply lump chalk on the job.

6 Mark off length and width using a surface gauge on datum edges 2 and 3.

7 File and finish length and breadth as per dimensions.

8 Mark off in one end for tap drill hole and another end for square hole as per dimensions.

9 Punch scribed lines.

10 Drill ϕ5mm for tap drill and square hole for ϕ10.5 mm.

11 Form internal thread with M6 tap.

12 Finish square hole using square safe edge file and warding file.

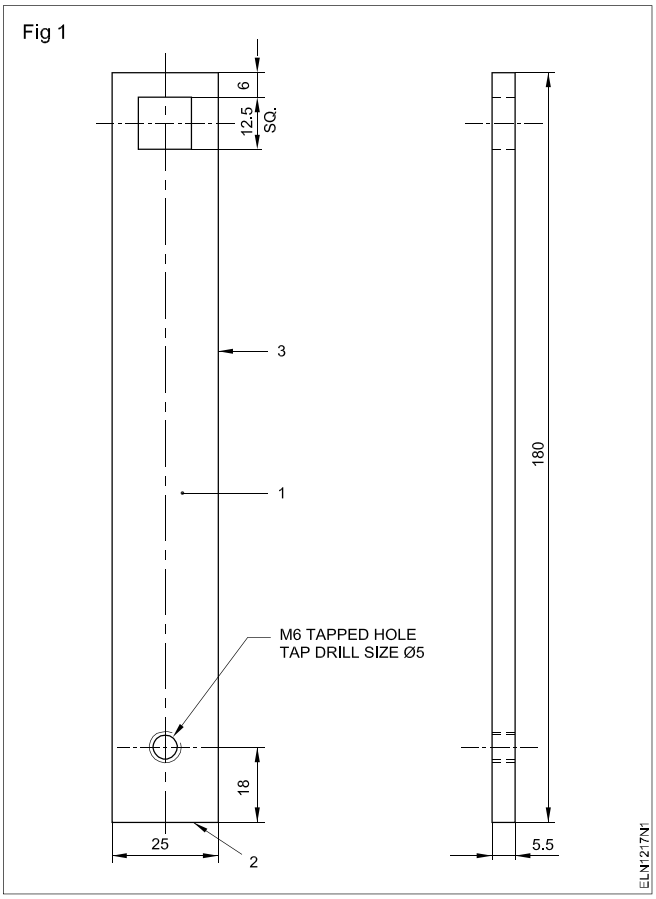
13 Check the inner square hole with an inside caliper.

14 Round the firm corners.

15 Deburr all the edges.

16 Finish the job with a second cut file within an accuracy of ± 0.5mm.

Fig 1



Sub Exercise (S. Ex.) 1.2.17 - 5

Hacksawing, drilling and internal threading on the pipe

Objectives: At the end of this exercise you shall be able to
- **file one end of M.S. tube and check 90° at the end of the pipe**
- **perform marking on M.S. tube to different dimensions as per the sketch with the help of a surface gauge**
- **perform marking for different depths using the box square**
- **saw M.S. tube along straight lines and slant lines**
- **drill a hole on M.S.pipe.**
- **form internal thread (small size on the M.S. tube).**

Requirements

Tools/Instruments

- File flat, second cut, double cut 300 mm - 1 No.
- Steel rule 300 mm - 1 No.
- Try square (Engineer's) 150 mm - 1 No.
- Surface gauge - 1 No.
- Engineer's ball peen hammer 200 gm. - 1 No.
- Dot punch - 1 No.
- Hacksaw frame, adjustable 250 to 300 mm - 1 No.
- Box square - 1 No.
- Outside caliper - 1 No.

Equipment/Machines

- Bench vice 50 mm jaw - 1 No.
- Sensitive drilling machine - 1 No.
- `V' blocks - 1 pair.
- Surface plate - 1 No.

Materials

- Steel tube H.F.W ø 20, length 174 mm. - 1 No.
- Hacksaw blade 300 mm, 18 TPI - 1 No.

PROCEDURE

1 Check the size of the steel tube as per sketch (Fig 1) with an outside caliper and steel rule.

2 File one end of the tube and check 90° with the Try square.

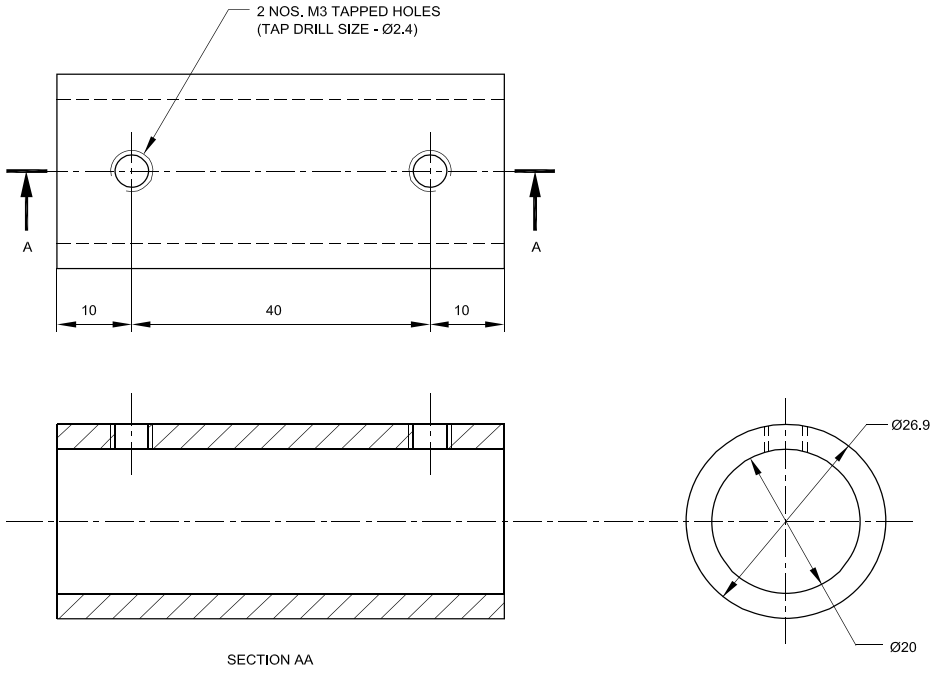
3 Apply lump chalk on the outside of the tube.

4 Place it vertically on the surface plate.

5 Mark off the required length for part A - 60 mm length, with a surface gauge.

6 Saw part A. (Fig 1)

Fig 1



7 Mark off the other end as part B. (Fig 2)

8 File and finish the required length of part B.

9 Set part B vertically on the surface plate supported by a `V' block.

10 Mark off the different heights as per the sketches with the surface gauge by rotating the job for a saw cut.

11 Place the tube horizontally on the `V' block.

12 Mark off different depths of saw cut using box square or key seat rule.

13 Punch the scribed lines.

14 Saw all cuts as per the marking.

15 Finish the job, part B by removing the burrs.

16 Mark off part A as per the required length 60 mm.

17 File and finish part A and check with the Try square.

18 Mark off for two tap drill holes on part A.

19 Fix the job on a `V' block and clamp it.

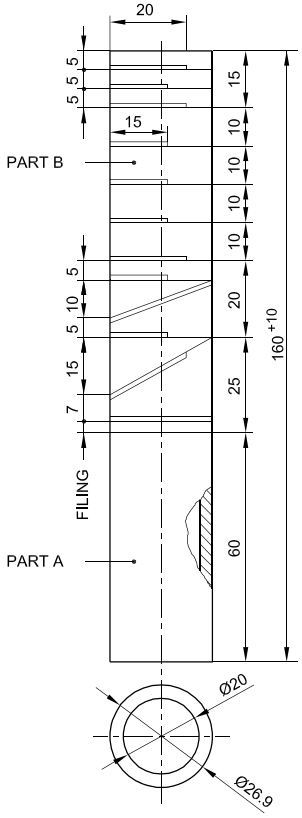
20 Drill ø 2.4 mm on the punch mark on one side of the steel tube.

21 Form internal thread on the drilled hole.

22 Remove burrs and finish parts A and B.

Part A will be kept for assembly fitting as a spacer.

Fig 2



Skill Information

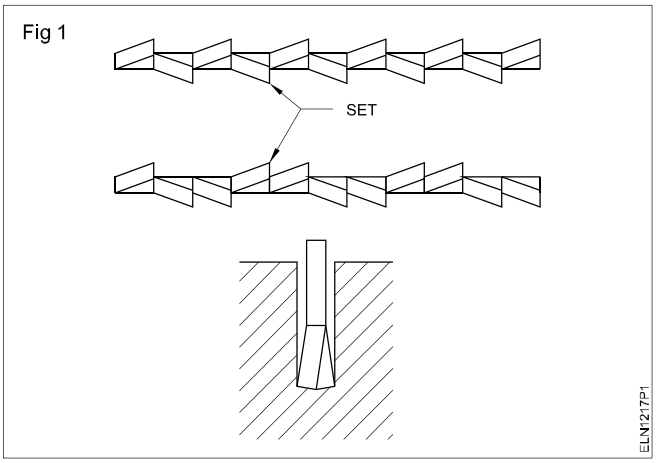
Hacksaw blade

Objectives: This shall help you to
- **identify the set of hacksaw blades**
- **state the number of teeth in the sawing tubes.**

There are two sets of blades

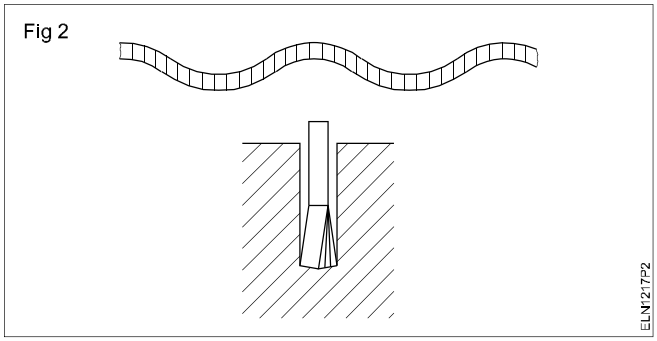
- Staggered set (Fig 1)

Fig 1



- Wavy set (Fig 2)

Fig 2



Hacksaw blade section

Teeth per inch (25.4 mm)	Material and shape of workpiece
14 teeth	Mild steel, brass,
18 teeth	Cast iron, gas pipe,
24 teeth	Hard steel, angle irons,
32 teeth	Thin iron sheet, thin steel pipe,

Select and use blades in such a way that the number of teeth cutting the wall of the tube is at least two at a time. (Fig 3 & 4)

Fig 3

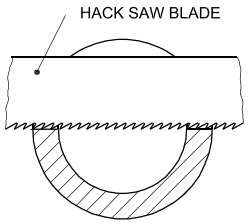
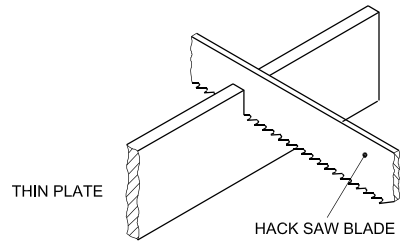


Fig 4



Less than two teeth will resuli in tearing of the thin plate, or damage the blade's teeth.

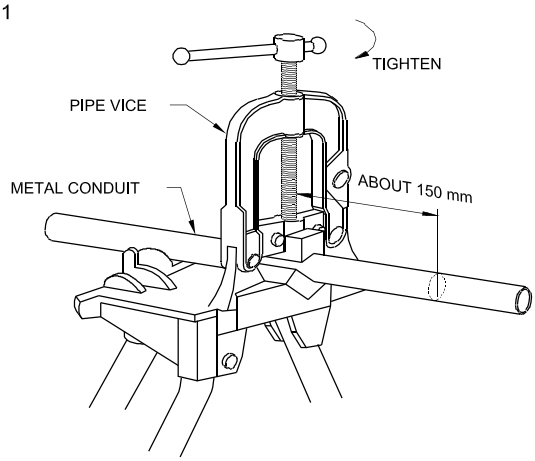
Saw thin plates at an angle such that a minimum of two or three teeth are in cutting action.

Cutting pipes

Objective: This shall help you to
- **cut a metal pipe.**

Metal pipes can be held firmly by a pipe vice for cutting at the desired, marked position. (Fig 1)

Fig 1

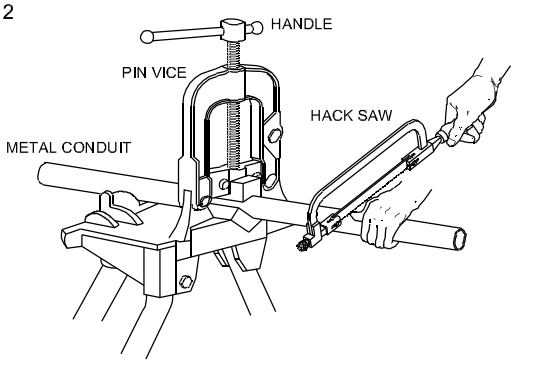


Locate the spot to be cut, about 150mm outside the vice.

Tighten the handle securely.

Slide the handle forward so that it does not interfere with the work area. (Fig 2)

Fig 2

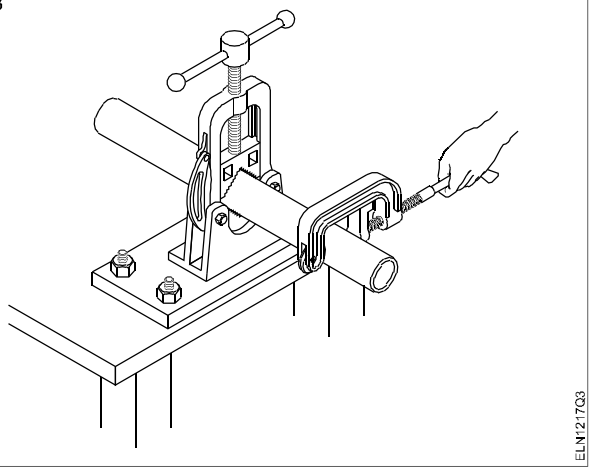


Set the hacksaw blade at right angles to the conduit on the spot to be cut.

Set your left thumb on the conduit as a guide and make the initial cut into the conduit by moving the hacksaw back and forth across a small distance. (Fig 2)

Pipe cutters are used to cut thin walled non-ferrous pipes.

Fig 3

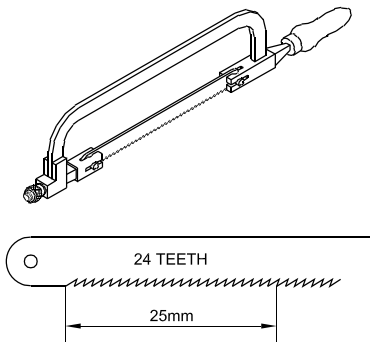


Hacksawing steel pipe/tube

Objectives: This shall help you to
- **fix a steel pipe in a pipe vice**
- **saw steel pipes.**

For cutting steel pipes, a blade with a pitch of 24 teeth per 25mm should be selected. (Fig 1)

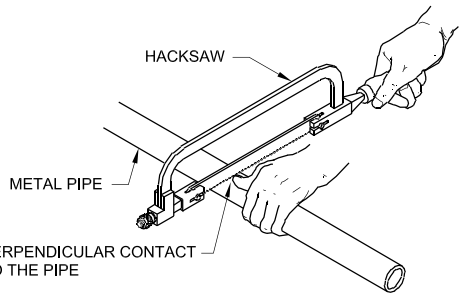
Fig 1



The steel pipe should be fixed in a pipe vice.

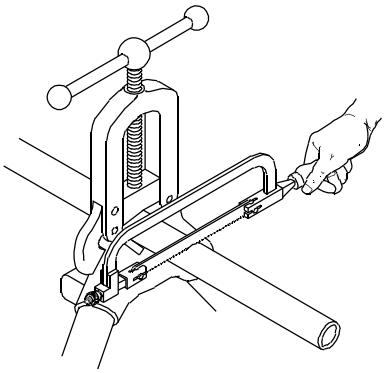
Set your left thumb on the pipe as a guide. (Fig 2)

Fig 2



Grip the hacksaw handle in the right hand. The blade should be on the top of the cutting line. (Fig 3)

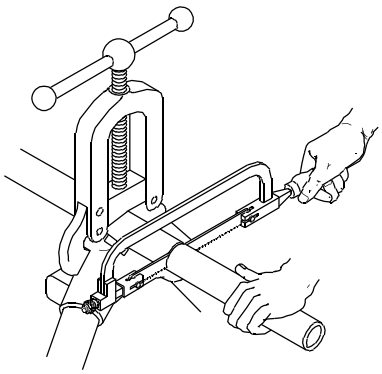
Fig 3



Hold the handle of the hacksaw in your right hand and the front of the frame in your left hand. Gradually increase the pressure on the forward stroke.

To finish cutting, use your left hand to support the pipe end and make the final cuts very tightly. (Fig 4)

Fig 4



After cutting the pipe you have to do the following things:

- Square the end of the pipe.
- Remove the outside burrs. (Fig 5)
- Remove the inside burrs with a half round file. (Fig 6)

Fig 5

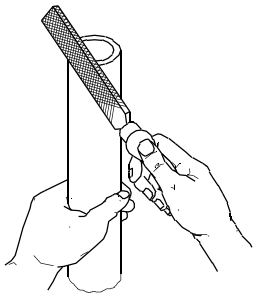
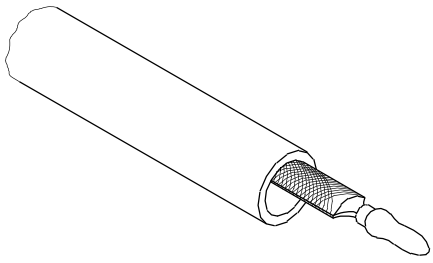


Fig 6



Practice on preparing 'T' joint, straight joint and dovetail joint on wooden blocks

Objectives: At the end of this exercise you shall be able to
- **mark lines on wooden planks**
- **cut the given planks with hand saw and Tenon saw to the required sizes**
- **set the jack plane blade for rough and fine cut**
- **plane the surfaces and edges of the board using jack and smoothing plane**
- **make the pin and socket on the wood**
- **make half lap 'T' joint with pin and socket on the wood**
- **make a straight joint (half lap)**
- **make dovetail angle**
- **make a half lap dovetail joint.**

Requirements

Tools/Instruments/Equipment

- Pencil - 1 No.
- Scriber 75 mm - 1 No.
- Hand saw 450 mm - 1 No.
- Try square 200 mm - 1 No.
- Tenon saw 300 mm - 1 No.
- Four fold wooden rule (600mm) - 1 No.
- Marking gauge - 1 No.
- Firmer chisel 25 mm, 35 mm & 50 mm 300mm - 1 No each
- Hammer (0.57 g & 200 gm) - 1 No. each.
- 'T' Bevel square - 1 No.
- Dovetail saw - 1 No.
- Mallet - 1 No.
- 'G' clamp - 1 No.
- Straight edge 600 mm - 1 No.
- Steel rule 300 mm - 1 No.
- Jack plane - 1 No.
- Smoothing plane - 1 No.
- Work bench with vice (10cm jaw) - 1 No.
- Paring chisel - 1 No.
- Bench hook - 1 No.
- Oil stone - 1 No.

Materials

- Hard wood 340 x 200 x 30 mm (for sawing machine) - 1 Piece.
- Teak wood or any other hard wood (360 x 60 x 25 mm) for planning practice and 'T' joint - 3 Piece.

PROCEDURE

Instructor shall demonstrate, marking, cutting (sawing) and planing operations on the given wooden planks before making joints.

TASK 1: **Marking lines and cutting (sawing) on the marked lines on the wooden planks**

Practice on marking lines on the wooden plank and cutting (sawing) on the marked lines

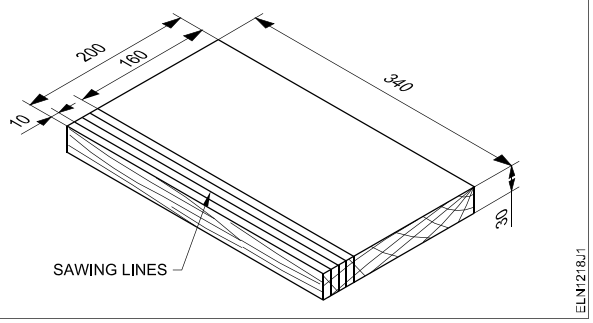
1 Check the raw material size.

2 Draw 4 lines parallel to the edge along the grain with 10 mm spacing between the lines and straight edge on one face of the given wooden piece using pencil.

3 Extend these lines to both ends using a Try square and connect them on the other face, using a straight edge. (Fig 1)

4 Draw 4 lines across the grains on one face from one end with 20 mm spacing between the lines using a pencil and try square and extend these lines on both edges and the other face using a Try square. (Fig 2)

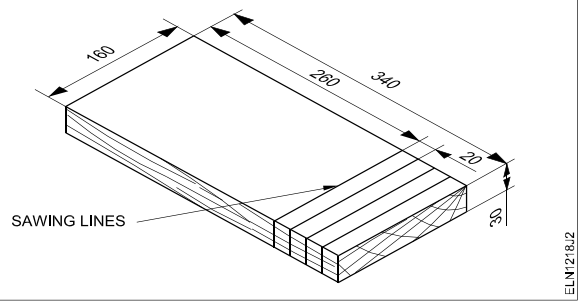
Fig 1



5 Fix the piece on the workbench top with a `G' clamp. See that the cut along the grain-marked portion is clear on the workbench top.

Do not overtighten the `G' clamp.

Fig 2



6 Start cutting along the grain on the first line from the edge with a hand saw.

Use a well sharpened saw for good results.

Saw with even strokes using the full length of the saw blade.

Keep your eye on the line being cut.

Keep your left hand away from the cutting edge of the saw while sawing.

7 Repeat sawing on the remaining 3 lines, one after the other.

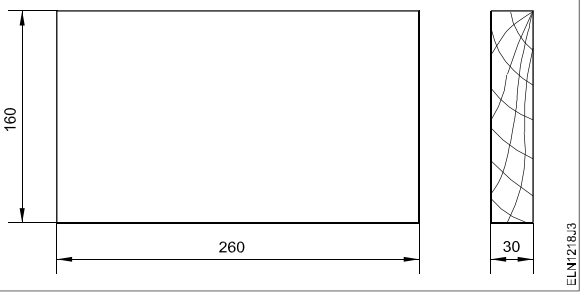
8 Remove the `G' clamp and fix the wooden piece such that the marked portion across the grain is clear of the workbench top.

9 Start cutting across the grain on the first line from the end with a Tenon saw.

10 Repeat sawing on the remaining 3 lines, one after the other. Check whether the board size is 260 x 160 mm (Fig 3).

11 Repeat sawing practice on the wood everyday to produce at least 6 mm thick and 300 mm long plank from 25 mm thickn plank.

Fig 3



TASK 2: **Practice on sawing along the grains to the marked lines using hand and Tenon saw**

1 Identify the grain direction of the piece prepared under Task 1.

2 Draw a line parallel to the edge along the grain using a steel rule/straight edge and a pencil keeping the width of the board as 155 mm.

3 Draw a line across the grains from one end measuring 245 mm length of the board.

4 Saw along the grains to the marked line with a hand saw.

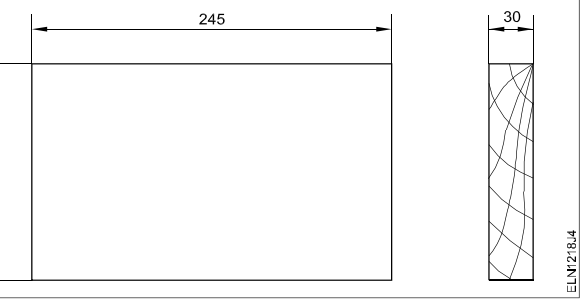
5 Saw across the grain to the marked line with a Tenon-saw.

Saw with even strokes using the full length of the saw blades.

Keep this finished wooden plank for Ex. 1.2.19

6 Check the piece with a straight edge/steel rule and Try square for squareness and size of 155 x 245 x 30 mm. (Fig 4)

Fig 4



Skill Information

Use of try square

Objectives: This shall help you to
- **mark lines on wooden boards/battens**
- **test flatness and squareness using a Try square.**

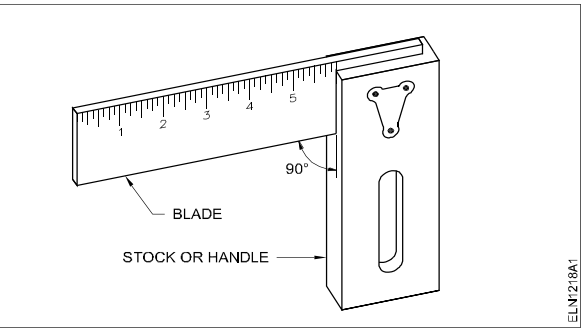
A Try square is used for testing squareness and to mark lines at right angles to the given surface and edges.

The Try square has two parts. (Fig 1)

– Stock or handle

– Blade

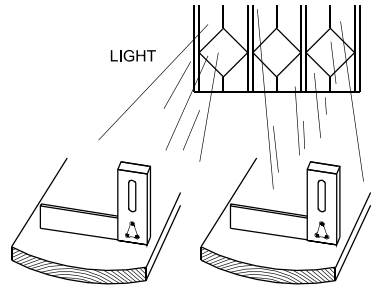
Fig 1



Common uses

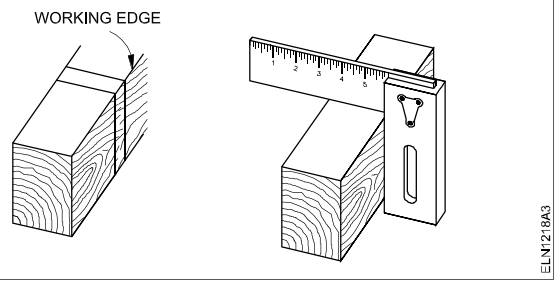
To test surfaces: Hold the Try square in the reverse position and keep one edge of the blade vertical on the surface to be tested. Look through between the edge of the Try square and the surface being tested (facing source of light). This will show the high and low spots. (Fig 2)

Fig 2



To test the squareness of edges: Place the stock firmly against the face. Then lower the inner edge of the blade on the edge to be tested and look through between the surface of the edge and the edge of the blade of the Try square. (Fig 3)

Fig 3



To test the squareness of ends: Test from the face and the edge. Hold the Try square as shown in Figs 4 and 5.

While testing the squareness hold the handle firmly against the surface.

Fig 4

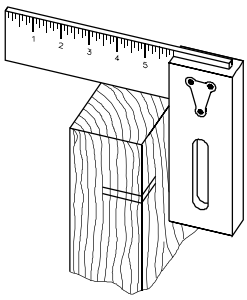
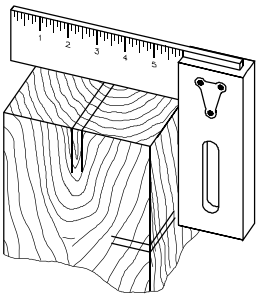


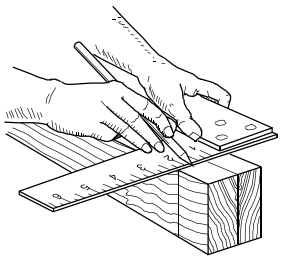
Fig 5



To mark lines: To mark lines on the edge or face at right angles, hold the Try square as shown in Fig 6.

Use a marking knife or pencil and draw the lines.

Fig 6



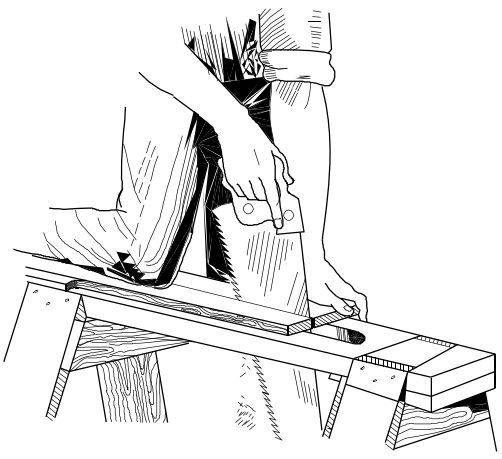
How to handle a hand saw

Objective: This shall help you to
- **cut the given battens, boards etc, with a hand, saw.**

Saws are used to cut wood pieces to the required sizes. Proper holding of the saw gives ring better control during use.

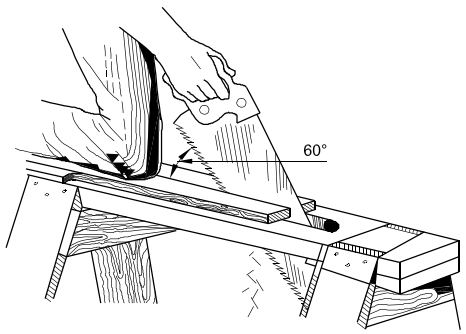
How to hold?: Hold the handle by inserting 3 fingers (little,ring and middle fingers) of the right hand in the opening of the handle unit supporting the opposite side with the thumb. Keep the index finger along the face of the handle pointing towards the length of the blade. (Fig 1)

Fig 1



For sawing along the grain, keep the cutting edge of the saw at an angle of approximately 60° to the face of the board being cut. (Fig 2)

Fig 2



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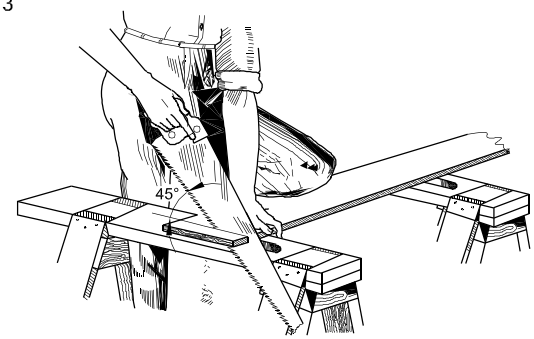
For sawing across the grain, keep the cutting edge of the saw at an angle of 45° to the face of the board being cut. (Fig 3) Hold the piece with the left hand at the finishing cut.

Fig 3



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How to handle a Tenon saw

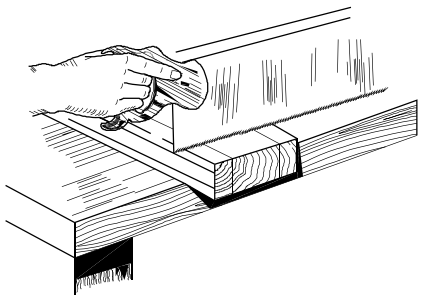
Objective: This shall help you to

- **cut the given board and batten to the required shape/size with a Tenon saw.**

A Tenon-saw is used for sawing both across and along the grain, and is particularly suitable for fine cutting for light jobs.

How to hold a Tenon saw? Hold the handle by inserting 3 fingers tittle, ling and middle fingers of the right hand in the opening of the handle, while holding the opposite side with the thumb. Keep the index finger along the handle pointing towards the length of the blade. (Fig 1)

Fig 1



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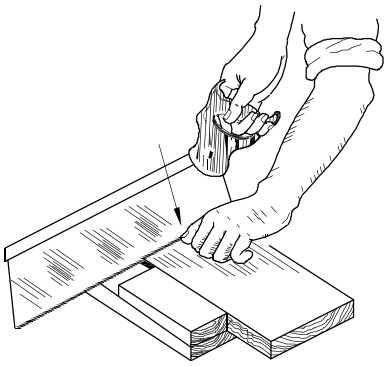
When starting a cut, guide the saw's cutting edge to the marked line with the thumb of the left hand as shown in Fig 2.

Fig 2



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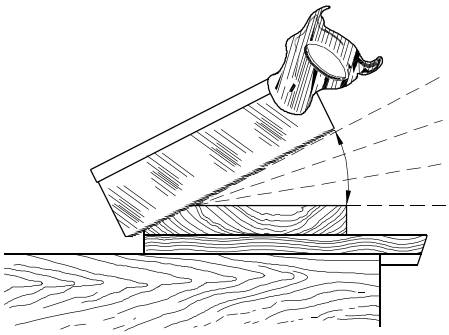
Initially, mark a `Kerf' at the starting point by taking one or two back strokes, and then start sawing using forward strokes. (Fig 3)

Fig 3



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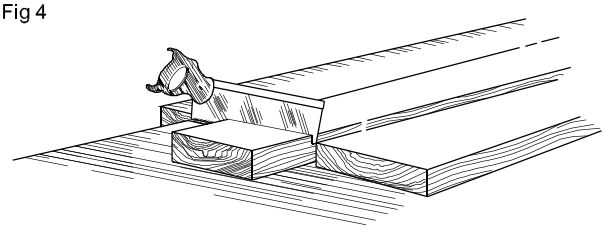
Gradually, bring the cutting edge of the saw parallel to the surface of the piece being cut. (Fig 4) Exert moderate pressure on the forward strokes, but reduce the pressure on the return strokes. Reduce the pressure and make short and light strokes, while finishing the cut.

Always use well sharpened saws. Hold the material firmly while sawing. Saw with even strokes.

Fig 4



ELN1218C4

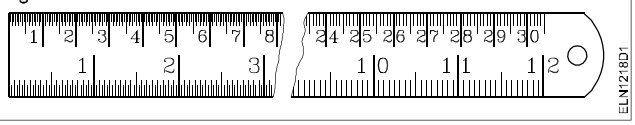
Method of using a steel rule

Objective: This shall help you to

- **mark perfect lines on wooden boards/battens using a steel rule.**

A steel rule is graduated both in inches and millimeter (Fig1).

Fig 1

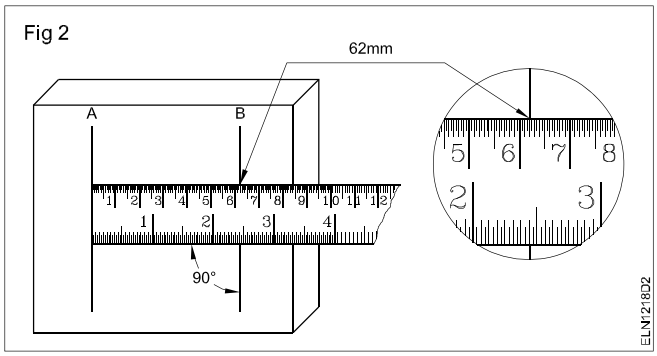


A steel rule with mm and cm graduations is used for checking distances, and for taking linear measurements.

How to use?

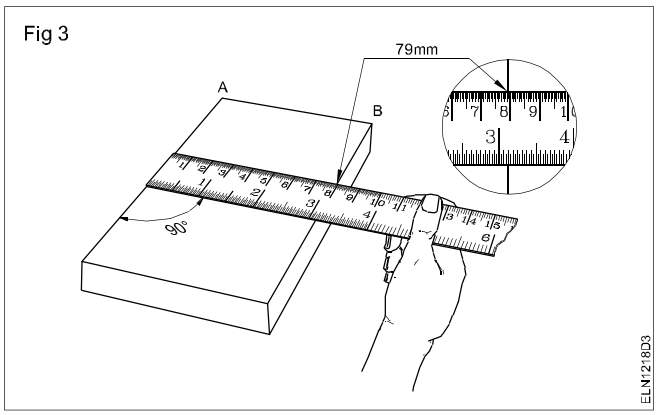
To measure between lines: Position the front end exactly on line `A' with the scale of the rule at 90° to line `B'. Read the distance where line `B' coincides with the graduation on the scale. (Fig 2)

Fig 2



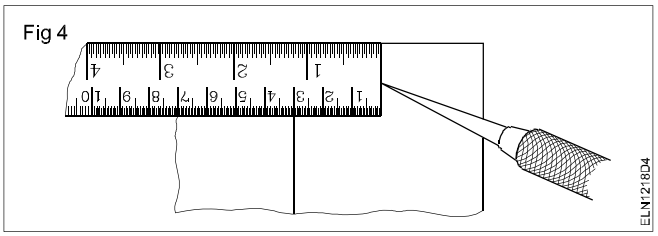
To measure between edges: Position the front end of the rule exactly in line with edge `A' of the workpiece and the scale at 90° to the edge. Read the distance between the edges `A' and `B'. (Fig 3)

Fig 3



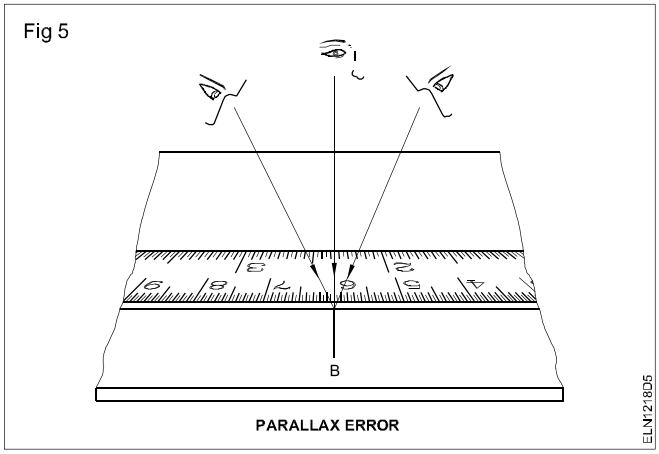
To mark the distance: Position the rule as shown in Fig 4. The required scale graduation is in line with the marked line. Use a sharp, pointed tool or scriber to mark.

Fig 4



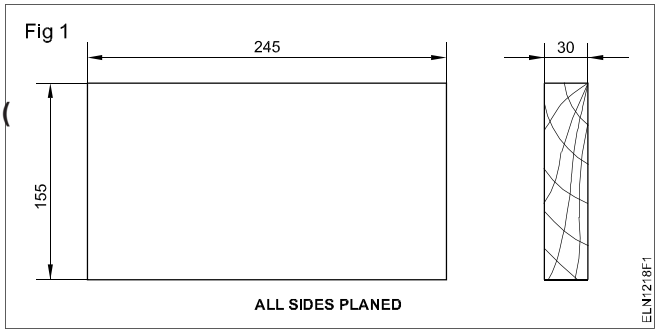
For accurate reading, you have to look straight and vertical at the point where line `B' and the graduation of the scale meet. Looking at this point, from an angle from either side, will result in a reading error. (Fig 5)

Fig 5



TASK 3: **Practice on planing the surfaces and edges of the board using jack and smoothing planes**

1 Fig 1 shows the size of the wooden piece after planing. Check the raw material size.



2 Set the jack plane for planing. Use a well sharpened plane blade.

3 Place the batten on the workbench against the bench stop. Plane one face of the batten flat and straight.

Maintain proper pressure on the plane, while planing.

4 Check the flatness with a Try square across the length, and check the straightness with a straight edge along the length.

5 Indicate the finished face as a reference surface by marking with a pencil.

6 Hold the batten in the bench vice, and plane the edge straight and square to the face.

Lay the plane side ways to protect the cutting edge of the blade, when not in use.

7 Check for squareness and straightness of the finished edge and make a mark with a pencil to indicate it as the reference edge.

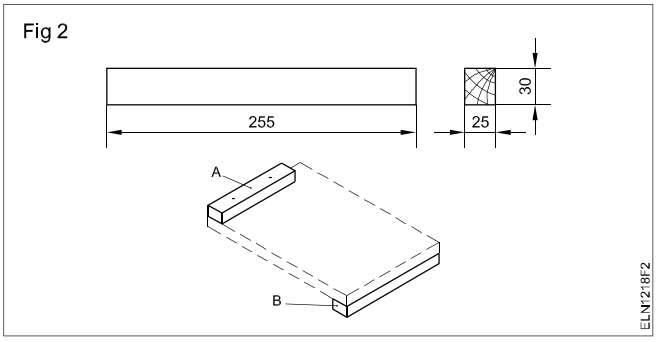
8 Set the marking gauge to 30 mm and mark a line for the width of the batten on both the faces.

9 Plane the batten edge holding on the bench vice and remove the excess material up to the marked line.

10 Set the marking gauge for 25 mm. and mark for the thickness of the batten on both edges.

11 Fix the batten in the vice and plane the other face to remove the excess material up to the marked lines.

12 Check the planed batten for its dimensions 255 x 30 x 25 mm. (Fig 2)



13 Plane one face of the board, used in the previous exercise, flat.

14 Check for its flatness (using a Try square) and also check lengthwise and diagonally with a straight edge.

15 Plane the edge of the board flat and square to the face.

16 Set the marking gauge for 150 mm and mark the line for the width of the board on both the faces.

17 Plane the other edge to the marked line.

18 Set the marking gauge for 25 mm and mark for thickness on both the edges.

19 Plane the other face to the marked line and check the face for flatness.

20 Check the planed board to the dimensions of 240 x 150 x 25 mm.

21 Firmly hold the board in a vertical position in a carpenter's vice, keeping the end of the board projecting 25 mm to 30 mm above the vice jaws.

22 Set the smoothing plane for a moderate cut.

23 Plane the end of the board half way from both the edges using the smoothing plane.

24 Test the squareness of the end from the face and edge using a Try square.

25 Mark the length of the board as per the drawing, using steel rule, Try square and scriber on both faces and both edges.

26 Cut the extra portion using a Tenon saw, keeping the saw thickness on the waste side.

27 Plane the other end (by repeating steps 21 to 24).

Skill Information

Setting a jack plane blade

Objective: This shall help you to
- **set the jack plane blade for rough and fine cuts.**

A jack plane is used to plane the wood to the required dimensions with smooth surface finish.

It is neccessary to set and adjust the plane blade for even and uniform cuts while planing.

Steps in setting

The two steps in setting the plane blade are:

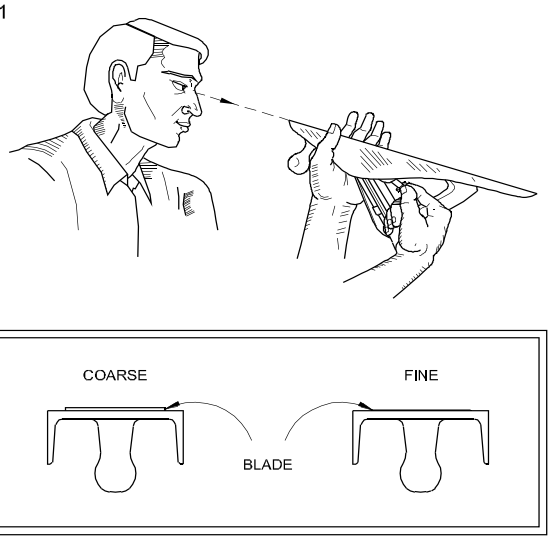
– setting the plane blade to the required depth of the cut

– adjusting the cutting edge of the plane blade parallel to the plane sole or bottom face.

Setting the plane blade to the required depth of cut: Hold the plane in the left hand keeping the sole of the plane in line with your view at a convenient distance.

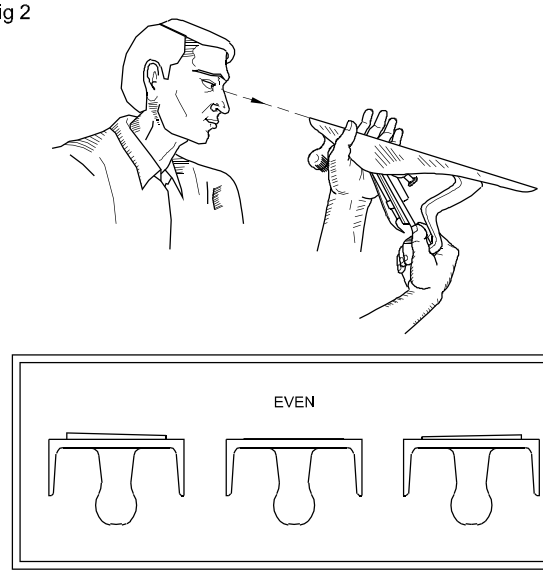
Turn the adjusting the nut in the anticlockwise direction to the required depth of cut until the cutting edge of the blade projects above the sole or bottom face of the plane. (Fig 1)

Fig 1



Adjust the plane blade parallel to the sole of the plane: Check whether the cutting edge of the blade is parallel to the bottom face of the plane. Gently, move the adjusting lever to the left or right until it is parallel if it is not parallel to the bottom face of the plane. (Fig 2)

Fig 2



While setting the plane blade, face the source of light.

To protect of the cutting edge of the blade, withdraw the plane blade into the plane before replacing the jack plane in the tool kit.

Jack plane - Care and use

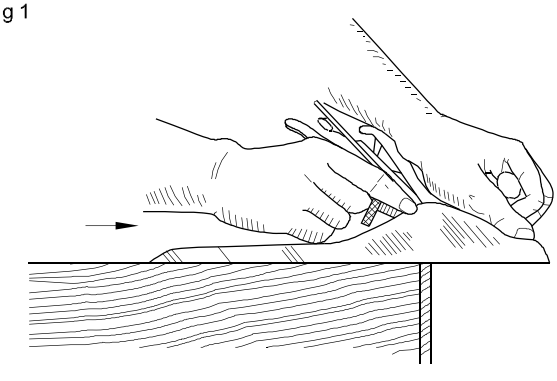
Objective: This shall help you to
- **plane the surfaces and the edges of boards and battens using a jack plane.**

How to hold a jack plane? It is necessary to hold the plane properly in both hands so as to maintain balance and have better control of the plane while planing. While planing hold the plane as shown in Fig 1.

How to operate? Start of stroke Apply downward pressure on the knob with the left hand and push the plane forward.

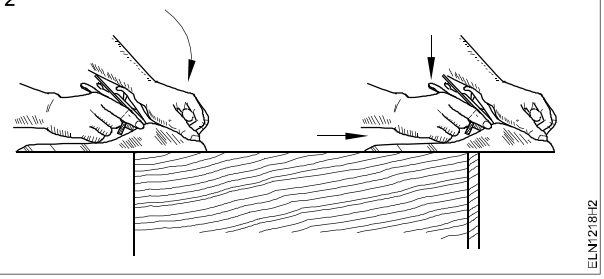
Length of stroke: Apply equal pressure with both hands on both the knob and the handle.

Fig 1



End of stroke: Reduce the pressure on the knob while applying pressure only on the handle (Fig 2) at the tail end of the planing until the stroke is completed.

Fig 2



When setting down a plane on the bench, for example between operations, ensure that the cutting edge is clear of the bench. This can be done by:

– resting the front of the plane's body on a piece of wood, or

– placing the plane on its side.

If the cutting edges are allowed to come in contact with the bench, it will be damaged or become blunt.

Any damage to the face of the plane will be transferred to the workpiece. Ensure that the face is smooth and free from burrs.

Use of marking gauge

Objective: This shall help you to

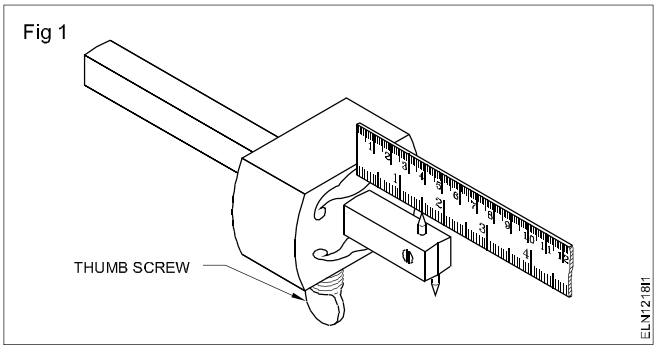
- **mark lines on wooden boards and battens according to the drawing, using a marking gauge.**

A marking gauge is used for marking lines parallel to the face or the edge at any given distance. Correct use of the marking gauge will help to produce perfect and clear lines.

How to set? Release the thumb screw.

Hold the scale in the right hand and the marking gauge in the left hand. (Fig 1)

Fig 1



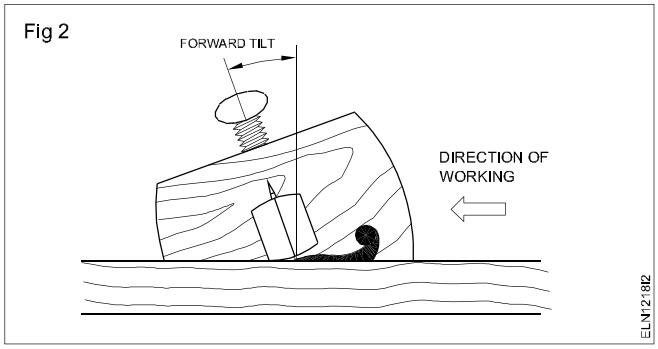
Move the stem or beam to the required measurement between the face of the stock and spur.

Keep the scale away and tighten the thumb screw.

Recheck the gauge setting for accuracy of measurements before use.

How to use? Hold the marking gauge in the right hand. Tilt it forward in the direction of the marking. (Fig 2) Exert minimum pressure for the spur to scribe a line.

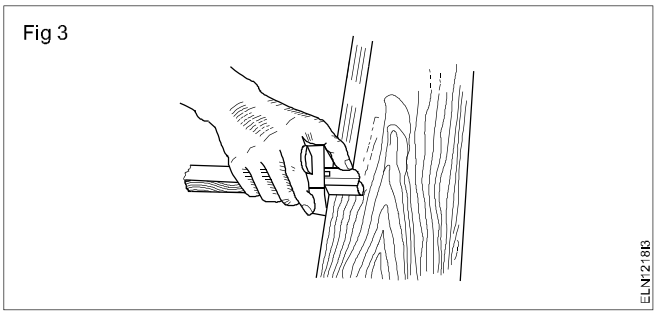
Fig 2



Ensure that the stock or head of the marking gauge is firmly touching with the reference edge or face.

Push it forward to mark a line, parallel to the reference or face, as required. (Fig 3)

Fig 3



While using a marking gauge, always give forward strokes.

Method of checking flatness

Objective: This shall help you to

- **check the faces and edges of boards for flatness.**

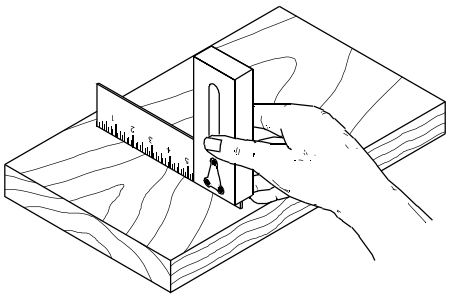
Wider surfaces of planed boards are checked for flatness. This is done at a number of places on the board while planing to ensure that the surfaces planed are perfectly flat.

How to check? Check the flatness by placing a Try square across over the board. (Fig 1)

Repeat the above step at a number of places on the boand along the length of the surface.

Check the flatness by placing a straight edge over the surface of the board and lengthwise and diagonally. (Fig 2)

Fig 1



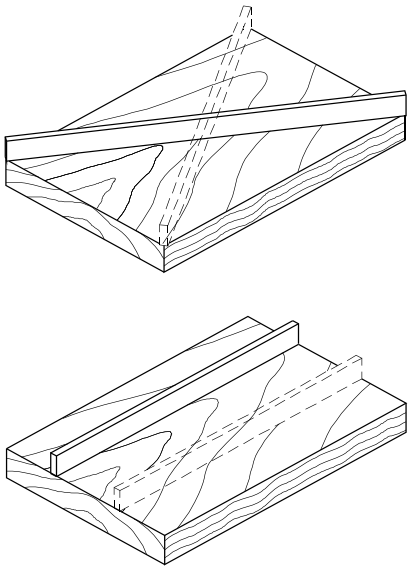
TESTING SURFACE

ELN1218K1

Never drag the Try square over the surface of the board.

While testing surfaces for flatness, face towards the light.

Fig 2



ELN1218K2

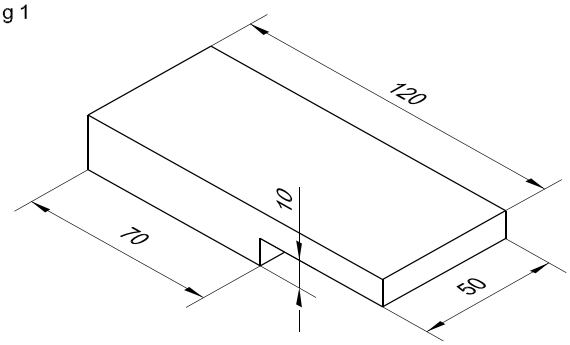
TASK 4: **Prepare a half lap 'T' joint on a wooden plank**

Check the size of the given plank. (300 x 60 x 25 mm)

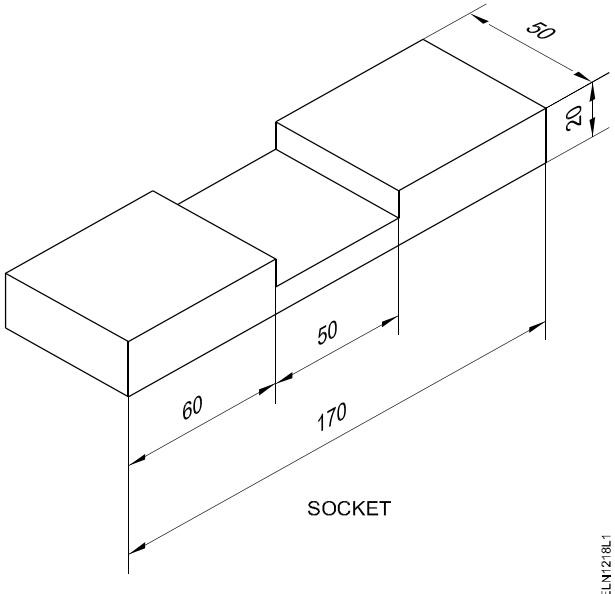
1 Plane the piece as per required size 50x20x300mm.

2 Saw it into two pieces of sizes 50x20x170 (socket) and 50x20x120mm (pin). (Fig 1)

Fig 1



PIN

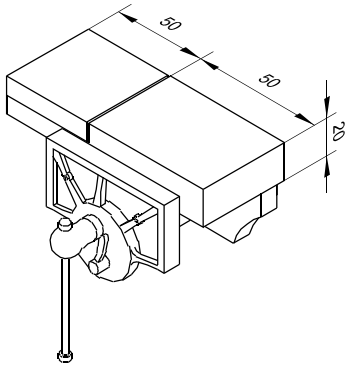


SOCKET

ELN1218L1

3 Mark both the pin and socket pieces as per the drawing. (Fig 2)

Fig 2



ELN1218L2

4 Check the markings as per drawing.

Pin piece

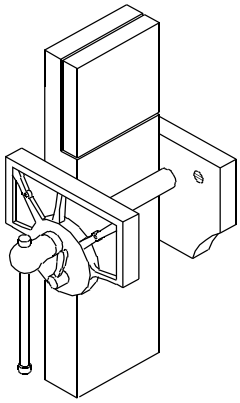
5 Hold the piece in the vice.

6 Cut the shoulder line down to the centre of the face edge using Tenon saw. (Fig 2)

7 Cut on the waste side on the line.

8 Hold the piece in the vertical position in the vice. (Fig 3)

Fig 3



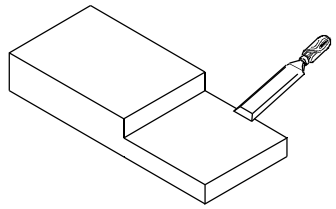
ELN1218L3

9 Cut the centre line down to the shoulder. (This cut should be on the waste side of the line).

10 Complete the cut.

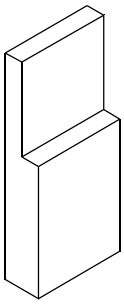
11 Smooth the surface with paring chisel as shown in Figs 4 and 5 and complete it.

Fig 4



ELN1218L4

Fig 5



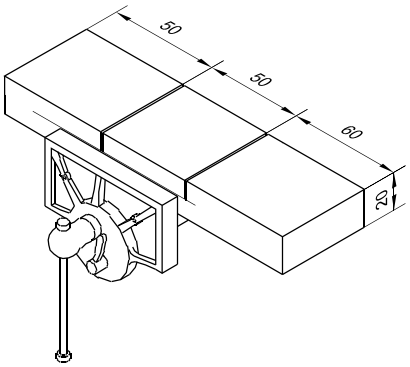
ELN1218L5

Socket piece

12 Hold the socket piece in the vice.

13 Saw close to the marked line (shoulder line) up to the depth of 10 mm using Tenon saw. (Fig 6)

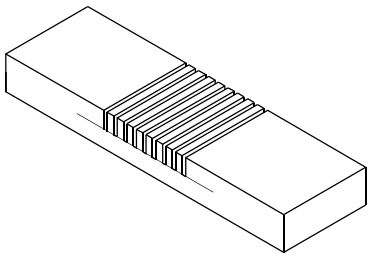
Fig 6



ELN1218L6

14 Make several saw cuts as shown in Fig 7.

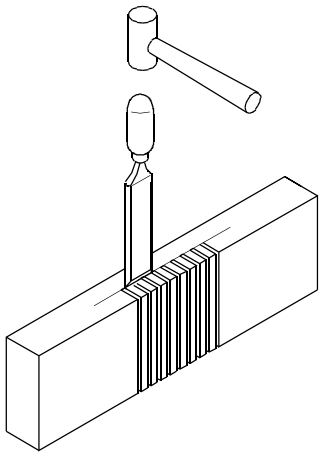
Fig 7



ELN1218L7

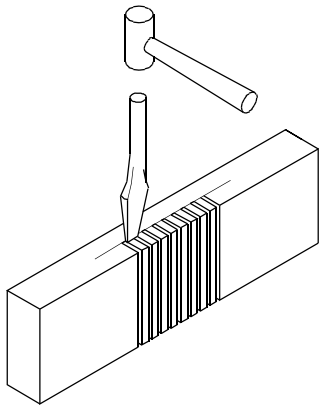
15 Chisel off the waste portions. (Fig 8 and 9)

Fig 8



ELN1218L8

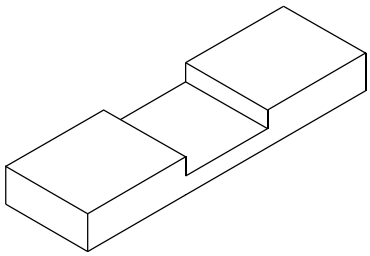
Fig 9



ELN1218L9

16 Smooth the trench surface side and the side walls with firmer or parting chisel. (Fig 10)

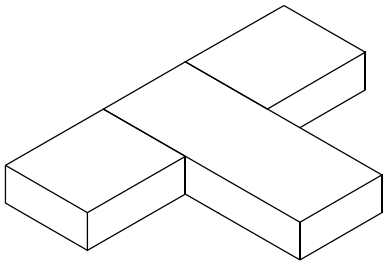
Fig 10



ELN1218LA

17 Assemble the pin and socket pieces together. (Fig 11)

Fig 11



ELN1218LB

18 Check the squareness of the job/joint.

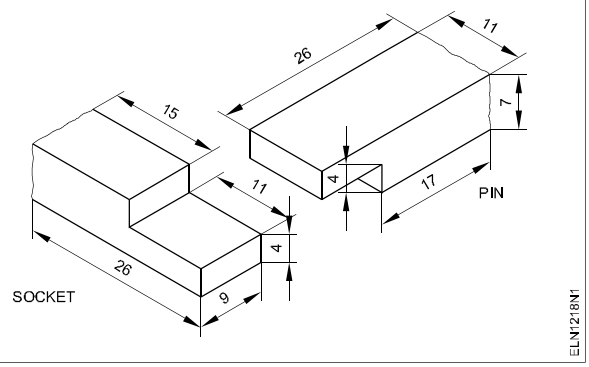
TASK 5: **Prepare a straight joint on wooden block**

1 Check the measurement of wood piece of 300 x 60 x 25 mm.

2 Plane into size 300 x 50 x 20 mm (socket and pin).

3 Saw into two pieces of size 140 x 50 x 20 mm as in Fig 1.

Fig 1



4 Mark both the pin and socket pieces as per the drawing.

5 Check the markings as per the drawing.

6 Hold the piece in the vice.

7 Repeat from step 6 to 10 as in TASK 4 for both the pieces (socket and pin).

8 Smooth the surface with paring chisel as shown in Figs 2 & 3.

Fig 2

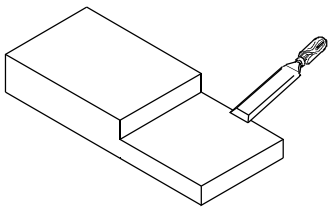
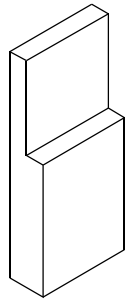


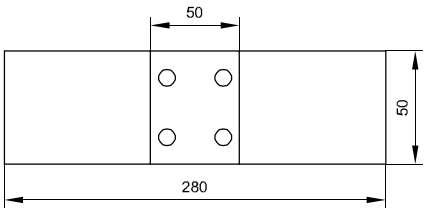
Fig 3



9 Assemble the pin and socket pieces together (Fig 4), in proper position without overlapping.

10 Fasten the assembly of straight joint by hammering with four wire nails at equal distance as in Fig 4.

Fig 4



While fixing the nail, the head of the nail should not project on the other side. Avoid fixing nails on the edges as it may cause cracks.

11 Finish the straight joint by planing the joining surfaces using smoothing plane.

TASK 6: **Prepare dovetail (half lapped) joint**

Preparation of material

Check the measurement of wooden piece 300 x 60 x 25mm.

Plane it to size 300 x 50 x 20mm.

Saw into two pieces of 170 x 50 x 20 and 110 x 50 x 20mm.

1 Mark dovetail pin and socket as per the drawing. (Fig 1)

2 Check the marking as per drawing.

3 Hold the pin piece in the vice vertically.

4 Cut near the marked lines up to half of the thickness using Tenon saw. (Fig 2)

5 Cut the shoulders with Tenon saw. (Fig 3)

Fig 1

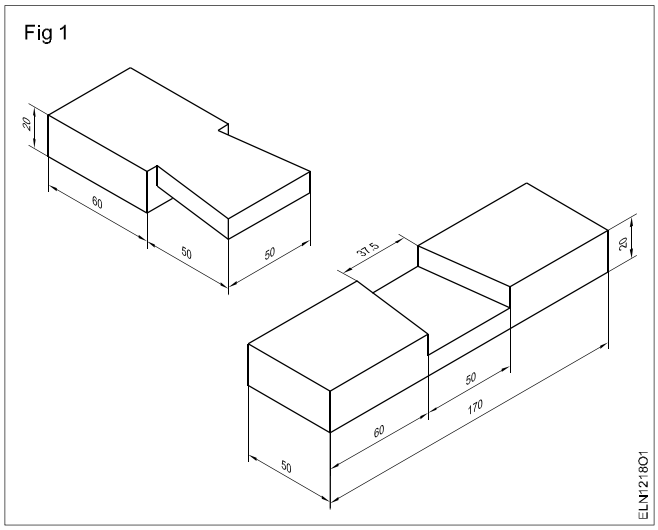
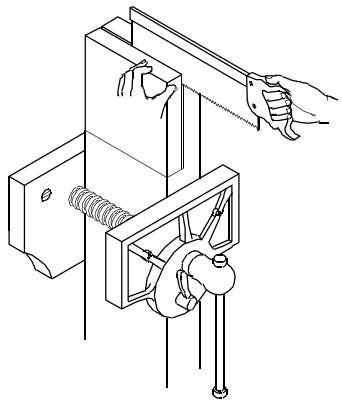
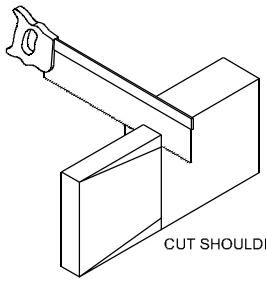


Fig 2



ELN1218O2

Fig 3

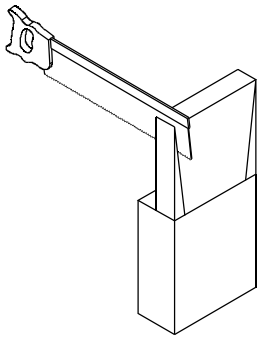


CUT SHOULDERS

ELN1218O3

6 Holding it vertically, cut the dovetail angle with Tenon saw. (Fig 4)

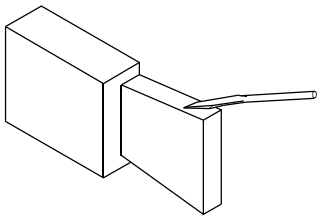
Fig 4



ELN1218O4

7 Pare the dovetail pin and smooth the surfaces using firmer chisel. (Fig 5)

Fig 5

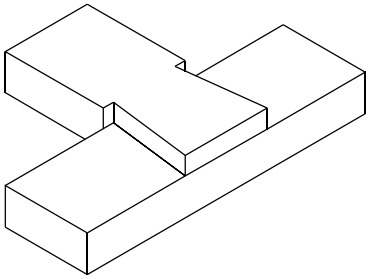


PARE DOVETAIL

ELN1218O5

8 Place the dovetail pin over the socket piece and check the marked dovetail socket as per drawing. (Fig 6)

Fig 6

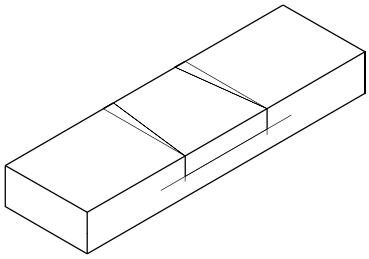


ELN1218O6

9 Hold the socket piece in the vice.

10 Cut the shoulder lines down to the centre line. (Fig 7)

Fig 7



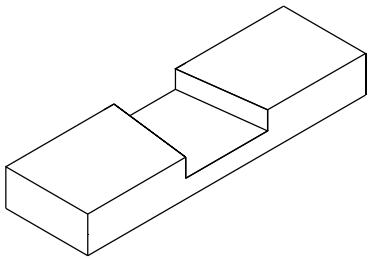
SQUARE EDGES AND GAUGE DEPTH

ELN1218O7

11 Cut on the waste side of the line.

12 Chisel off waste materials. (Fig 8)

Fig 8

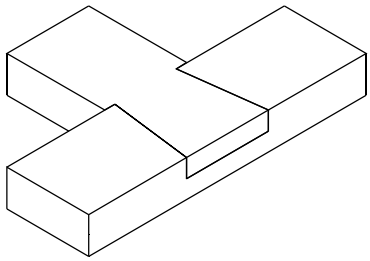


ELN1218O8

13 Smooth the trench surface with firmer chisel.

14 Fit the pin piece with the socket piece. (Fig 9)

Fig 9



ELN1218O9

15 Finish it by chiselling excess material, plane it if necessary.

Skill sequence

Half lapped dovetail joint

Objective: This shall help you to
- **mark the job for half lapped dovetail joints.**

Marking

Pin

Mark 50 mm from one end in the pin piece.

Mark 6.25 mm (1/8th of total width) from both the face ends.

Mark shoulder line on the pin piece all around the end.

Mark sloping sides by joining 6.25 mm line to the extreme the corner of the end of the pin piece. (Fig 1)

Set marking gauge to half thickness, gauge the thickness of the pin from the face side to all sides.

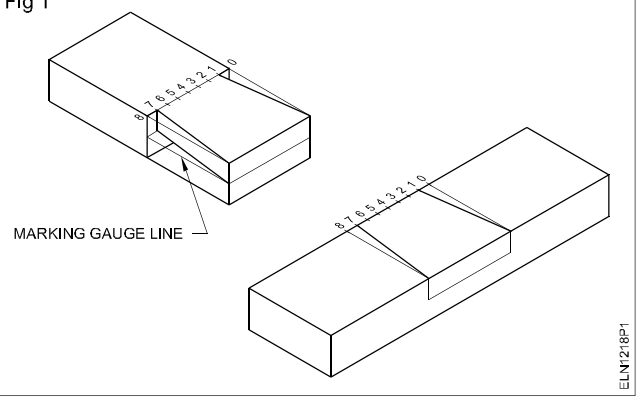
Socket

Mark 60 mm and 50 mm from one end in the socket piece.

Mark 6.25 mm (1/8th of total width) from both the ends of the trench.

Mark shoulder line on the socket piece all around the edges.

Fig 1



Mark sloping sides by joining 6.25 mm line to the extreme end of the socket piece.

Set marking gauge to half the thickness, gauge the thickness of the socket from the face side to the edges.

Mark the sinking line, edges and depth in the socket piece.

Practice sawing, planing, drilling and assembling for making a wooden switchboard

Objectives: At the end of this exercise you shall be able to
- **make the lines and saw on the grains on wooden blocks (R)**
- **set the jack plane, flat surfaces on wooden blocks plane**
- **drill holes on boards and battens using hand drill, electric hand drilling machine and ratchet brace**
- **make countersink holes in wood.**

Requirements

Tools / Instruments

- Steel rule 300 mm - 1 No.
- Try square 200 mm - 1 No.
- Marking gauge - 1 No.
- `G' Clamp No 6 - 1 No.
- Drill bit S.S 6 mm - 1 No.
- Hand drill machine 6 mm - 1 No.
- Ratchet brace - 1 No.
- Countersink bit 6 to 10 mm - 1 No.
- Drill bit SS 3 mm - 1 No.
- Four fold wooden rule 600 mm - 1 No.

Equipment/Machines

- Electric hand drilling machine (6 mm) - 1 No.

Material

- Battern prepared in previous exercises - 1 No.

PROCEDURE

Note: Sawing and planing operation exercises are already dealt with in the previous exercise (Ex.1.2.04 (joints)) in TASKS 1 & 2. The exercise (sawing and planing) need not be repeated. The jobs prepared in the previous exercise may be used for this exercise.

TASK 1: **Drill holes on the wooden batten**

1 Check the given material prepared in the previous exercise EX.1.2.18 (planing practice TASK 2) as in Fig 1.

2 Set the marking gauge for 15 mm.

3 Draw the centre line along the edge on both faces using the marking gauge.

4 Mark points at 151 mm from one end of the batten and 102 mm from the other end, using a steel rule and scriber or pencil.

5 Draw lines across the points using a Try square and scriber or pencil.

6 Extend the lines all round the batten with the Try square and scriber or pencil.

7 Cut the batten with a Tenon saw between the lines.

8 File the cut ends and finish to the lines marked.

Mark hole centres from any end as per drawing with a steel rule and pencil on the centre line on both battens. (Fig 1)

9 Punch the hole centres with centre punch/sharpened nail at the markings that have already been made.

10 Fix the batten on the workbench top using a `G' clamp. Use a waste piece under the batten while clamping.

11 Drill 6 mm holes on the marked centres of the holes.

Use well sharpened drill bits.

Hold the drill machine vertically.

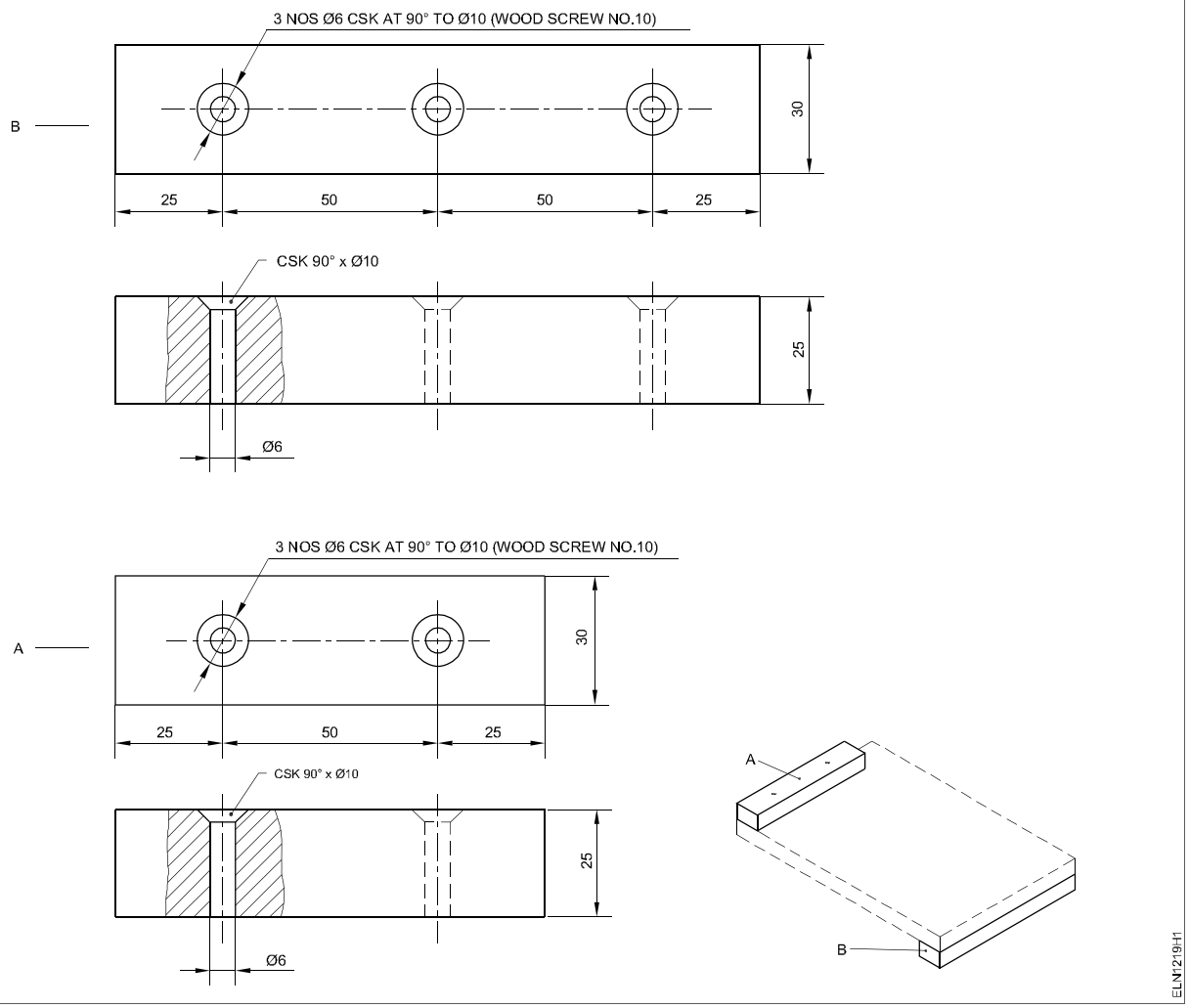
12 Fix the countersink bit in the ratchet brace.

13 Countersink all the drilled holes.

Do not cut too deep.

14 Check the diameter of the countersunk holes with the screw head.

Fig 1



TASK 2: **Drill the pilot holes on the wooden board**

1 Collect the piece prepared in Ex.No.1.2.18, on sawing practice in TASK 1.

2 Mark lines with a marking gauge, 15 mm from each end, as per the drawing for the centre line of pilot holes. (Fig 2)

3 Mark hole centres as per the drawing with a steel rule and pencil from one edge on these already drawn central lines on both the faces.

Mark hole locations within ± 0.5 mm accuracy.

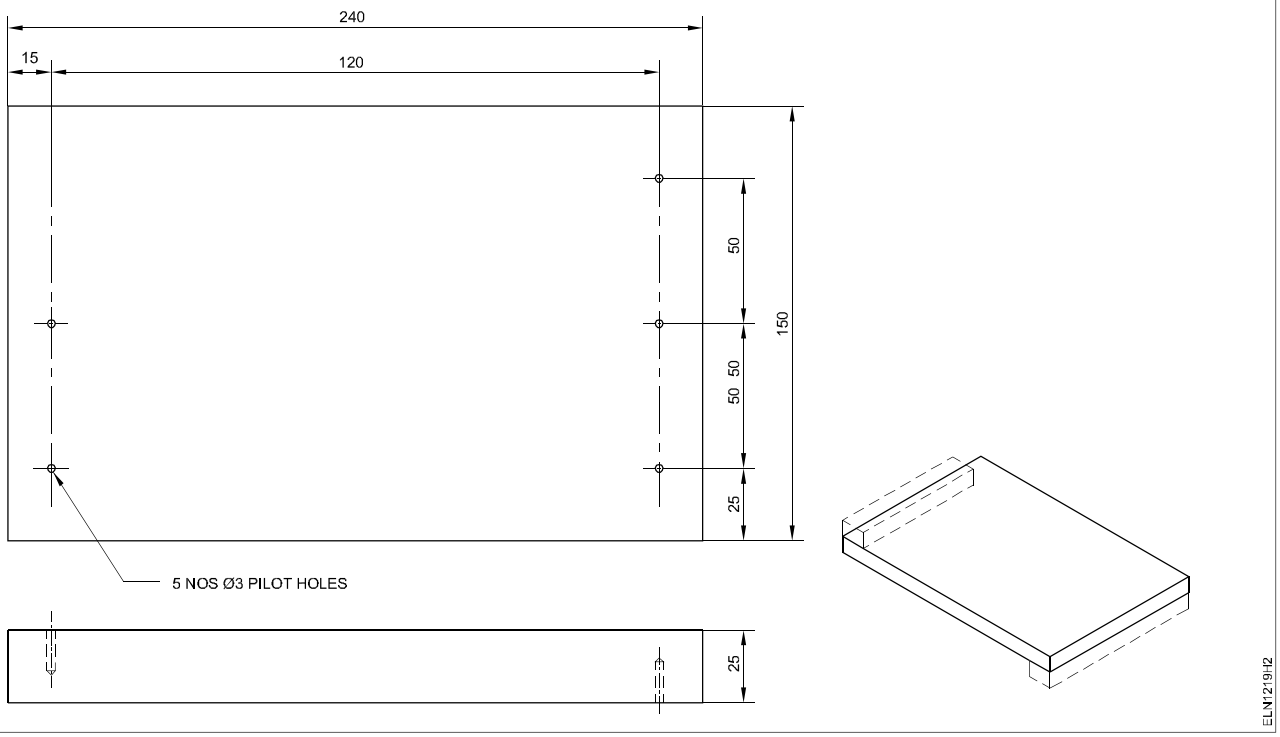
4 Punch the hole centres with the centre punch / sharpened nail.

5 Fix the board on the workbench with the `G' clamp.

6 Drill 3 mm diameter pilot holes to a depth of 15 mm in the locations already marked.

Do not drill holes deeper than specified.

Fig 2



Sub Exercise (S.Ex.) 1.2.19 - 1

Make a frame for the test board

Objecitves: At the end of this exercise you shall be able to

- **mark perfect lines on wooden planks or battens using a Try square, steel rule and marking gauge (R)**
- **cut boards or battens to size by a hand saw or by a tenon-saw**
- **plane the surfaces and edges of the planks/battens by a jack plane or iron plane to the marked lines (R)**
- **plane the surfaces of the battens using a smoothing plane**
- **chisel to remove materials**
- **mark and prepare half-lap joints using any given size of the batten.**

Requirements

Tools/Instruments

• Tenon-saw 350 mm	- 1 No.
• Firmer chisel 6 mm	- 1 No.
• Mallet	- 1 No.
• Try square 150 mm	- 1 No.
• Steel rule 300 mm	- 1 No.
• Jack plane	- 1 No.
• Marking gauge	- 1 No.

Materials

• Teak wood or any hardwood	
260 x 35 x 30 mm	- 2 Nos.
295 x 35 x 30 mm	- 2 Nos.

PROCEDURE

1 Check the material for its size.

2 Plane all the 4 pieces to size.

260 x 30 x 25 = 2 Nos A

295 x 30 x 25 = 2 Nos B

3 Take the part `A' pieces and mark a centre line across on one face with a Try square, steel rule and pencil.

Take all the measurements carefully and accurately.

4 Measure and mark 95 mm on either side on the centre line.

5 Draw lines across the points where 95 mm is measured.

6 Extend the same line to both the edges.

7 Repeat the same for the other piece.

8 Repeat steps 3 to 7 with the `B' pieces but taking 110 mm on either side of the centre line.

9 Set the marking gauge for 1/2 thickness i.e. 12.5 mm. Draw lines parallel to one face with the marking gauge on both the edges, starting from the ends up to the shoulder line.

10 Repeat the same for the remaining three pieces.

11 Cut the shoulders with a Tenon saw up to the gauge line keeping the saw thickness on the waste side.

Always saw on the waste side of the line.

12 Repeat the same for the remaining three pieces.

13 Fix each piece in the vice.

14 Remove the waste material with the saw.

15 Repeat the same for the remaining 3 pieces.

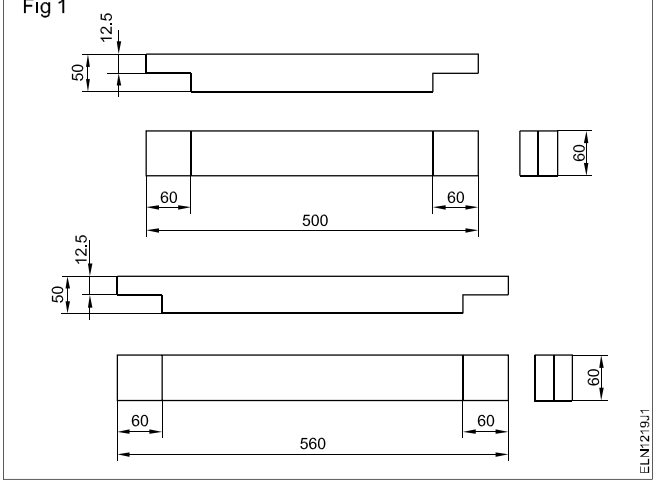
16 Finish all the end-laps with a firmer chisel.

Never use a hammer on a chisel. Use only a mallet.

Use well sharpened cutting tools.

17 Test for accuracy with a Try square.

Fig 1



Sub Exercise (S.Ex.) 1.2.19 - 2

Make the back cover of the test board

Objectives: At the end of this exercise you shall be able to
- **mark lines perfect on wood with a Try square, straight edge, steel rule, marking gauge (R)**
- **set and plane the surfaces and edges of T.W. battens/boards with a jack plane (R)**
- **cut rebates on the edges of planks/boards with a rebate plane**
- **mark dimensions on planks with a steel rule. (R).**

Requirements

Tools/Instruments

- Try square 150 mm - 1 No.
- Steel rule 300 mm - 1 No.
- Marking gauge - 1 No.
- Handsaw 450 mm - 1 No.
- Jack plane - 1 No.
- Rebate plane - 1 No.

Materials

- Teak wood plank.
  275 x 130 x 25 mm - 1 No.
  275 x 190 x 25 mm - 1 No.

PROCEDURE

1 Check the material for size.

2 Plane both pieces to size

275 x 130 x 25 and

275 x 190 x 25

250 x 120 x 20 mm - (1)

250 x 180 x 20 mm - (2).

3 Test the pieces for flatness, squareness and straightness.

4 Set the marking gauge to 10 mm.

5 Draw a line parallel to the face on one edge of each piece.

6 Extend the lines to end up to 20 mm length.

7 Set the marking gauge for 20 mm.

8 Draw a line parallel to the edge on one face of one piece and on another face of a second piece and extend these lines on both ends of each piece to half thickness.

9 Set the rebate plane.

Use a well sharpened blade with a straight cutting edge.

10 Place the piece on the workbench top and cut the rebate with a rebate plane to the marked lines.

11 Reset the rebate plane for smooth cut and finish the rebates.

Keep the plane upright while cutting the rebate.

12 Set the rebate edges together and check for accuracy.

Sub Exercise (S.Ex.) 1.2.19 - 3

Make the front panel for the test board

Objectives: At the end of this exercise you shall be able to

- **mark lines on wooden boards or laminates using a steel rule, Try square (R)**
- **mark profiles on laminates using dividers/compasses to fix electrical accessories**
- **make profiles with a fret saw/keyhole saw to house electrical accessories**
- **mark dimensions on laminates with a steel rule**
- **drill through holes using power drilling machines (R)**
- **file the laminate to the finished shape with a rasp file.**

Requirements

Tools/Instruments

- Steel rule 300 mm - 1 No.
- Try square 150 mm - 1 No.
- Dividers/compasses - 1 No.
- Smoothing plane - 1 No.
- Fret saw - 1 No.
- Drill bit 6 mm - 1 No.
- File half round 200 mm - 1 No.

Equipment/Machines

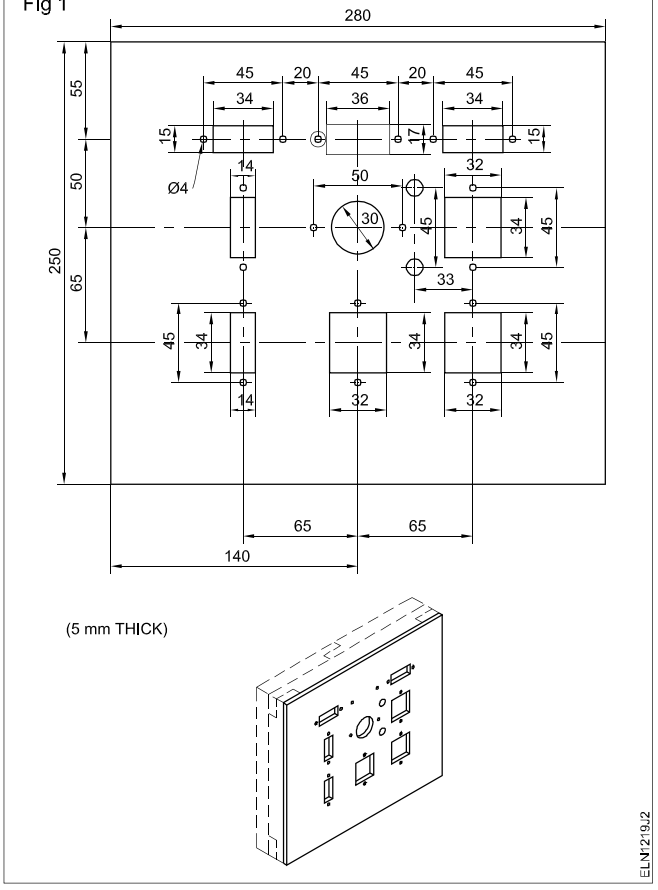
- Electric, portable drilling machine 6 mm. - 1 No.

Materials

- Laminated sheet 250 x 280 x 3 mm - 1 No.

PROCEDURE

Fig 1



1 Check the material for its size. 250 x 280 x 3 mm

2 Mark the necessary centre lines on the sheet.

3 Mark the profiles for fixing electrical accessories with dimensions as per the drawing.

Take all the measurements accurately.

4 Drill four 6 mm holes in each profile within the corners.

5 Drill one 6 mm hole in the circular profile near the marked area.

6 Insert a fret saw blade in one of the drilled holes of each profile, one by one.

Use a good saw blade.

Select the proper size of blade.

7 Cut along the lines precisely.

Keep the thickness of the blade on the waste side. Keep the blade under tension.

8 Repeat the same for all the profiles marked.

9 Cut and remove the waste material.

With the saw blade in motion, move the material being cut.

10 Finish each profile with a file for accuracy.

Saw with rhythmic strokes.

Sub Exercise (S.Ex.) 1.2.19 - 4

Assemble the test board

Objectives: At the end of this exercise you shall be able to
- **mark dimensions on boards with steel rule, marking gauge (R)**
- **make planks by joining with joint-nails for boards**
- **use proper size screws and nails according to the purpose**
- **drill through holes and pilot holes on boards or batten with a drilling machine (R)**
- **bore holes on planks using a ratchet brace**
- **file wooden materials for proper finishing with a rasp file (R).**

Requirements

Tools/Instruments

- Hammer 200 mm - 1 No.
- Screwdriver 200 mm - 1 No.
- Try square 150 mm - 1 No.
- Drill bit, 2, 4 and 6 mm - 1 No.
- Steel rule 300 mm - 1 No.
- G clamp - 1 No.

Equipment/Machines

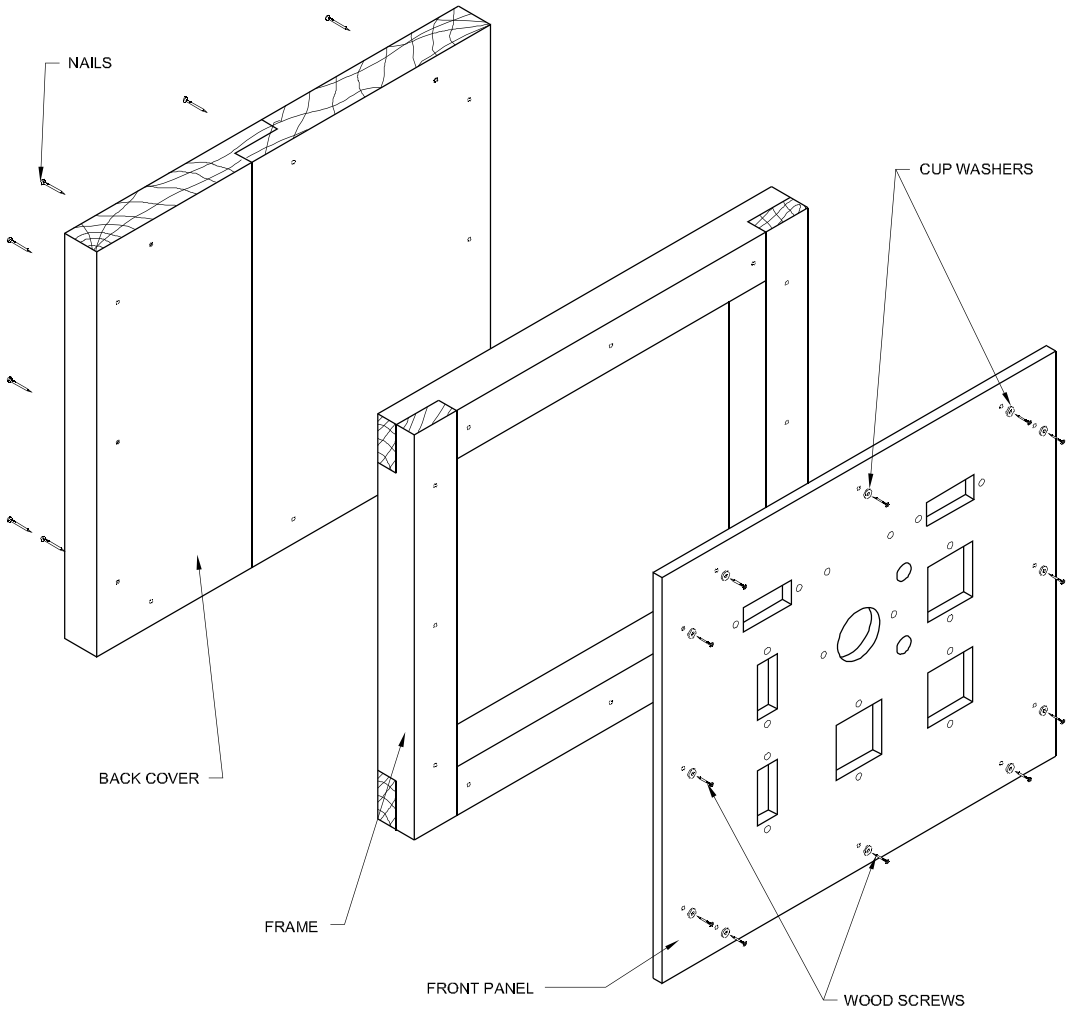
- Drilling machine 6 mm - 1 No.

Materials

- Materials prepared in the previous exercise.

PROCEDURE

Fig 1



1 Take all the four finished pieces already prepared for the frame.

2 Place the frame on a flat surface and position all the lap joints on the four corners.

3 Check for overall frame dimensions.

4 Put identification marks on both the joints and keep them separately.

5 Assemble each joint as identified in step 4 and drive nails for their permanent assembly.

6 Check the assembled frame for squareness in all the four corners with a Try square.

7 Check for the flatness of the frame by placing it on a flat surface.

8 Cut off excess material on each joint using a Tenon saw.

9 Mark pitch line for 15 mm from all the 4 edges on the face of the front panel.

10 Mark a point at 35 mm from each corner and the pitch line.

11 Mark centre points on the four sides of the front panel on the pitch line.

12 Keep the front panel on a flat wooden surface and fix with a clamp.

13 Drill 4 mm through holes and remove the clamp.

14 Keep the front panel on the frame and adjust the frame. Check if the edges are accurate and clamp them with a 'G' clamp.

15 Drill 2 mm pilot holes on the frame with the guidance of the drilled through holes on the front panel.

16 Fix the front panel to the frame with 20 mm screws and cup washers with a screwdriver.

17 Use the already prepared material in the previous exercise for the back cover.

18 Keep the back cover on the frame and adjust all the edges.

19 Fix the back cover to the frame using wire nails (35 mm x 14 G).

20 Mark the location for drilling a hole for cable on one edge of the board widthwise.

21 Firmly hold the board in the vice.

22 Drill a through hole on the marking already done, vide step No 20.

23 File and give proper finish and round off all sharp edges.

Practice in marking and cutting of straight and curved pieces in metal sheets, making holes, securing by screw and riveting

Objectives: At the end of this exercise you shall be able to
- **mark straight lines of given dimensions using steel rule and scriber**
- **shear MS sheet using straight snip**
- **mark curved lines of given dimensions using divider**
- **shear along curved lines using bent snip and cut 90° notch**
- **make holes using a punch**
- **mark for making holes with drilling machine**
- **drill holes in the sheet metal with drilling machine**
- **rivet with a rivet set.**

Requirements

Tools/Instruments

- Steel rule 300 mm - 1 No.
- Scriber 200 mm - 1 No.
- Straight snips 250 mm - 1 No.
- Bent snip 250 mm - 1 No.
- Divider 200 mm - 1 No.
- Hammer ball peen 200g - 1 No.
- Mallet (wood) - 1 No.
- Hatchet stake available size - 1 No.
- `G' clamp 250 mm - 1 No.
- Hand drilling machine - 1 No.
- Rivet set - 1 No.

Materials

- Sheet iron ISST 220 x 0.5 x 300.
- Sheet iron ISST 55 x 0.5 x 105 (for riveting Task - 4 same sheet can be used for Tasks 1 to 3)) - 2 Nos.
- Trimmers rivets No. 14 - 10 Nos.

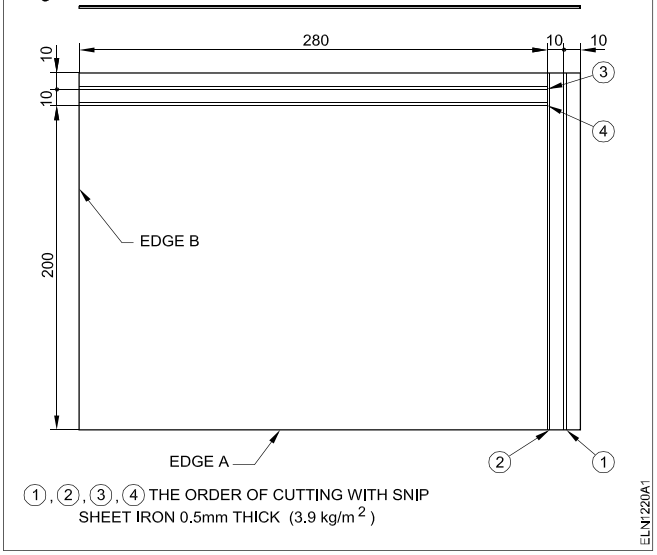
PROCEDURE

TASK 1: **Practice for marking in metal sheet**

1 Check the dimensions of the given raw material.

2 Take edges A and B as datum. Mark from edge B a measurement 'V', mark for cut No. 2. Make at least 3 such 'V' marks along cut No.2. (Fig 1)

Fig 1



3 Using a scale, draw a straight line with a scriber connecting all the 3 'V' marks made.

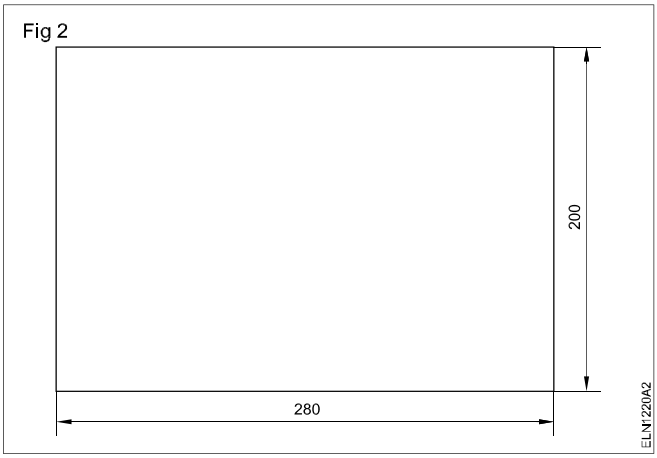
4 Draw a line parallel to the scribed line at a distance of 1 mm. (This line is drawn outside the measurement to guide the snip, while cutting sheet metal.)

5 Repeat steps 2 and 3 for marking to cut along line 1.

6 Keeping edge A as reference, mark straight lines for shearing along lines 3 and 4 respectively, repeating steps 2 and 3.

7 Shear along the marked guidelines for 1, 2, 3 and 4 in that sequence. The final piece is shown in Fig 2.

Fig 2



Skill sequence

Mark straight lines using steel rule and scribers

Objective: This shall help you to

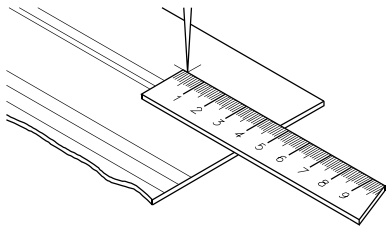
- **mark the given dimensions on the sheet metal using a scriber, steel rule, Try square and straight edge.**

Generally, marking media is not applied on sheet iron (metal) for marking lines. Instead, a scriber and steel rule are used.

A scriber is used to transfer measurement and to draw lines.

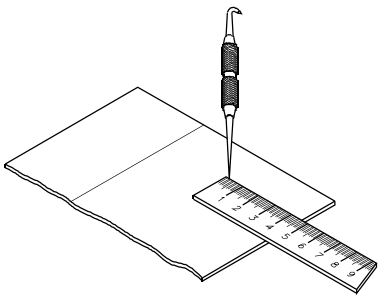
Place the steel rule on the sheet metal to transfer the dimension from the datum edge or line. (Fig 1)

Fig 1



ELN1220B1

Fig 2

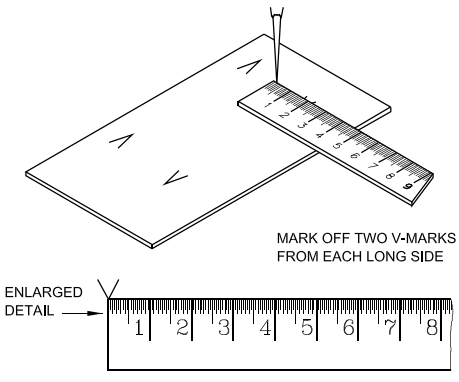


ELN1220B2

Scribe a V-mark for the required distance. (Fig 2)

Make at least two V-marks to draw a straight line parallel to the datum. (Fig 3)

Fig 3

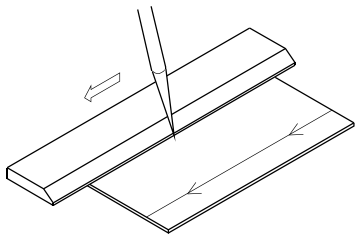


ELN1220B3

Scribe a line through both points of the V-marks (Fig 4), using the straight edge and the scriber.

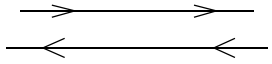
Draw the line exactly through the points of the V-marks. (Fig 5)

Fig 4



ELN1220B4

Fig 5

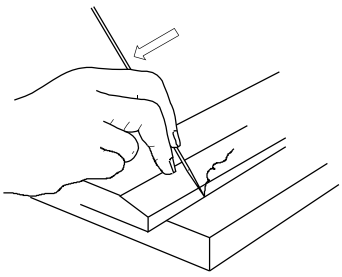


ELN1220B5

Lines that need not or must not be removed are scratched on the material with the sharp point of the scriber.

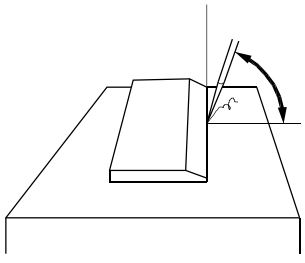
Hold the scriber in the correct angle to get into the corner when scribing along a straight edge. (Figs 6 & 7)

Fig 6



ELN1220B6

Fig 7



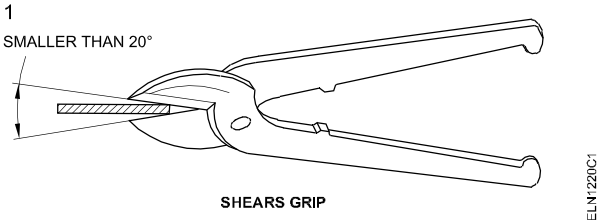
ELN1220B7

Cut sheet metal using straight snips

Objective: This shall help you to
- **cut thin sheet metals with the help of straight snips.**

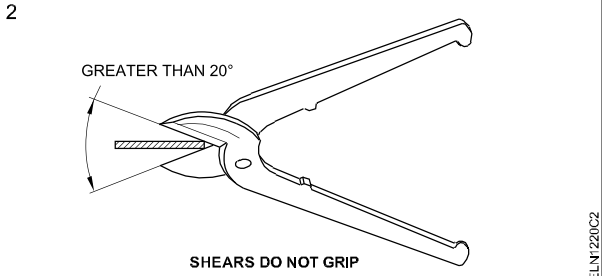
Hold the sheet in one hand, and with the other hand hold the snip handle at the end, and place the upper blade of the snip on the marked line with an initial angle measuring lesser than 20°. (Fig 1)

Fig 1



Open and grip the sheet by the blade. The opening angle of the blade should not be more than 20°. (Fig 2)

Fig 2

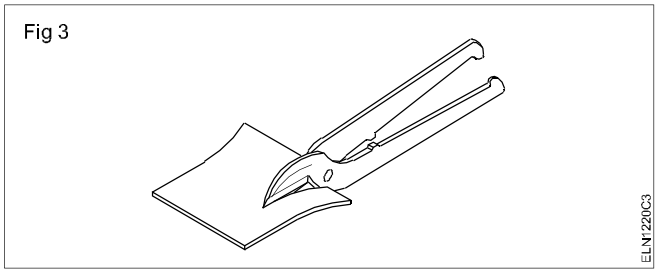


Keep the blade perpendicular to the surface of the sheet.

Hold the snips straight, up and down.

While holding the snips on the sheet, allow lesser width on your left side in every cutting, as shown in Fig 3.

Fig 3



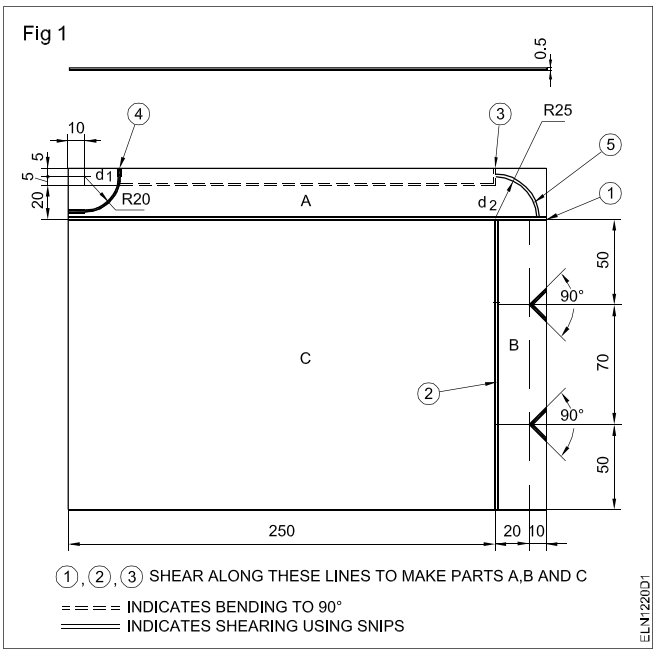
TASK 2: **Practice on cutting curved pieces in metal sheets**

1 Check the dimension of the given sheet iron.

2 Using the steel rule, mark the required dimension for straight lines as per the diagram. (Fig 1)

3 Locate centre d_1 for curve '4', as per the measurements in the drawing.

Fig 1



4 Make indent mark with prick punch (tip angle, 30°).

5 Transfer the radius measurement from steel rule to the divider.

6 With the point d_1 as centre, scribe the curve 4.

7 With the same centre and radius reduced by 1 mm, scribe the guide mark.

8 Repeat steps 3 to 7 for curve 5 with d_2 as centre.

9 Shear along line 1 using straight snips.

10 Shear along line 2 using straight snips.

11 Shear along line 3 in part A using straight snips.

12 Shear along curve 4 using bent snip.

13 Shear along curve 5 using bent snip.

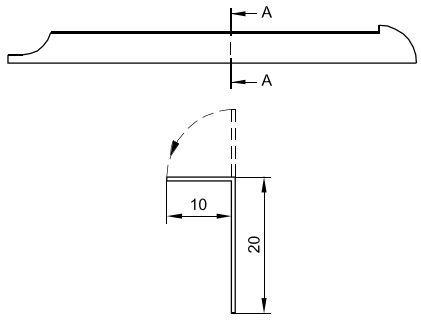
14 Mark the bending to 90° line as per the drawing. (Fig 1) Hold the part A along the bending line measurement marked in the angle plate (fixed in bench vice).

15 Clamp the extending end of the angle plate with G clamp.

16 Hammer the projecting portions in stages (15°, 30°, 45°, 60° and 90°) with a soft mallet. (Fig 2)

17 Cut both the notches with the straight snip in part B. (Fig 3).

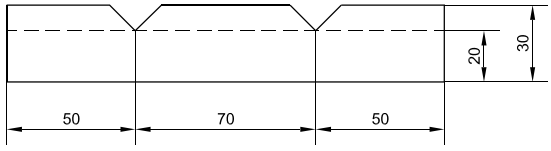
Fig 2



ENLARGED VIEW OF SECTION A-A
SHOWING THE STAGES OF FOLDING

ELN1220D2

Fig 3



ELN1220D3

Skill sequence

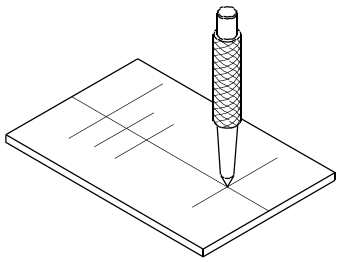
Marking curved lines using divider

Objective: This shall help you to
- **scribe curved lines using dividers.**

On the sheet, mark a centre line using the scriber and steel rule.

Hold the centre punch on the marked line. First keep the punch at an angle and then position it upright. Then hit on it with a hammer. (Fig 1)

Fig 1

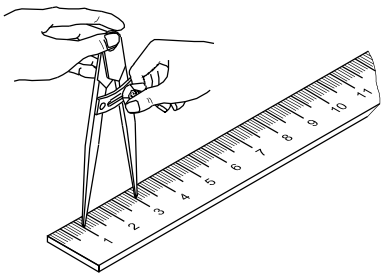


ELN1220F1

Set one point of the divider on the 1 cm mark of a rule, and adjust the second leg to the required radius.

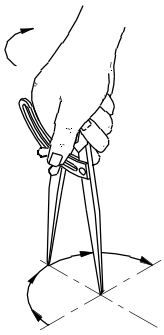
Place the divider on the sheet with the point of one leg on the centre punch mark. Hold the divider vertically. Swing the divider clockwise exerting a little pressure. Incline the divider in the direction of the line to be drawn to prevent slipping. (Fig 3)

Fig 2



ELN1220F2

Fig 3



ELN1220F3

Curve-cutting using bent snips

Objective: This shall help you to
- **shear internal and external curves in steel sheet using the bent snips.**

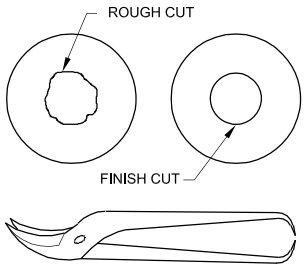
A bent snip can be used for cutting internal and external curves.

Bent snips are used for cutting holes. First, a rough cut is made. Then the hole is finished off. (Fig 1)

For circular cutting, rotate the sheet while making a continuous cut.

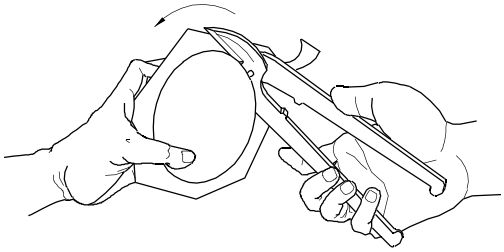
First, a rough cut can be made. (Fig 2) for trimming a cylinder, keep the lower blade outside the cut. (Fig 3)

Fig 1



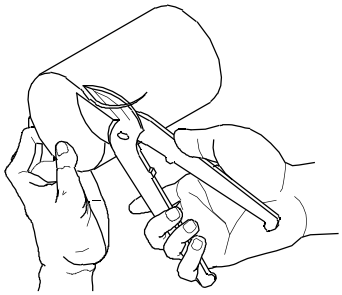
ELN'220G1

Fig 2



ELN'220G2

Fig 3

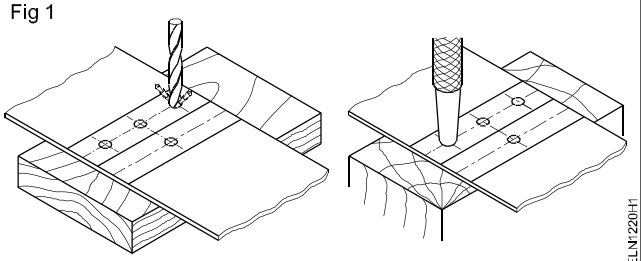


ELN'220G3

TASK 3: **Practice on making holes using a punch**

Holes in sheets are made either by drilling or by punching. (Fig 1)

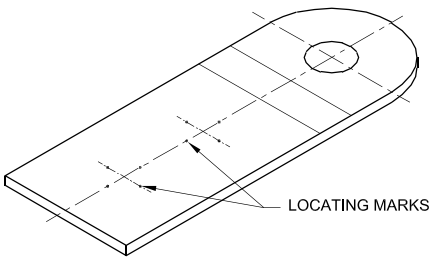
Fig 1



ELN'220H1

1 Make location points with the help of a scriber and punch on the sheet. (Fig 2)

Fig 2



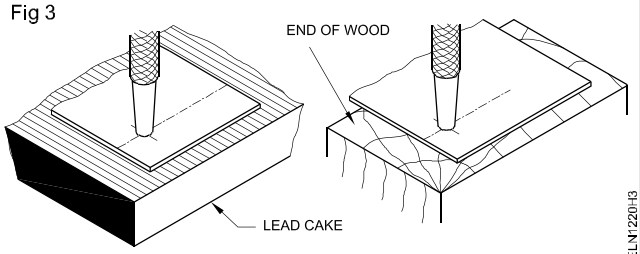
ELN'220H2

2 Use a lead slab as support. The end of a wooden block can also be used as a support. (Fig 3)

3 Make a hole on the sheet using centre punch Fig 3.

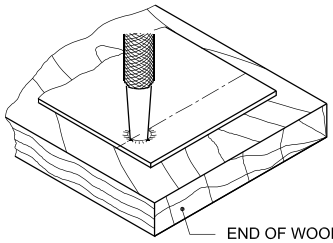
The sheet should be placed on the end of the wood. Otherwise, distortion may be caused as shown in Fig 4.

Fig 3



ELN'220H3

Fig 4

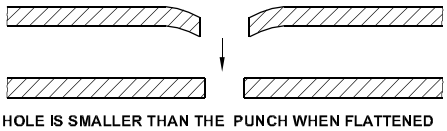


ELN'220H4

A hole can become smaller than the punch size when flattened. (Fig 5)

Keep the punch vertical. Ensure that the point of the punch coincides with the locating marks.

Fig 5



ELN'220H5

Skill sequence

Join sheet metal pieces

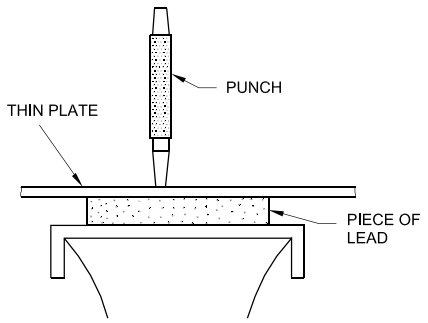
Objective: This shall help you to
- **join sheet metal using self-tapping screws.**

For joining two sheet metal pieces with the help of self-tapping screws. Make pilot holes with the use of a solid punch.

Then select a screwdriver according to the screw to be used.

Finally, insert a self-tapping screw in the pilot hole, and screw it using a screwdriver applying a downward force. (Fig 1)

Fig 1

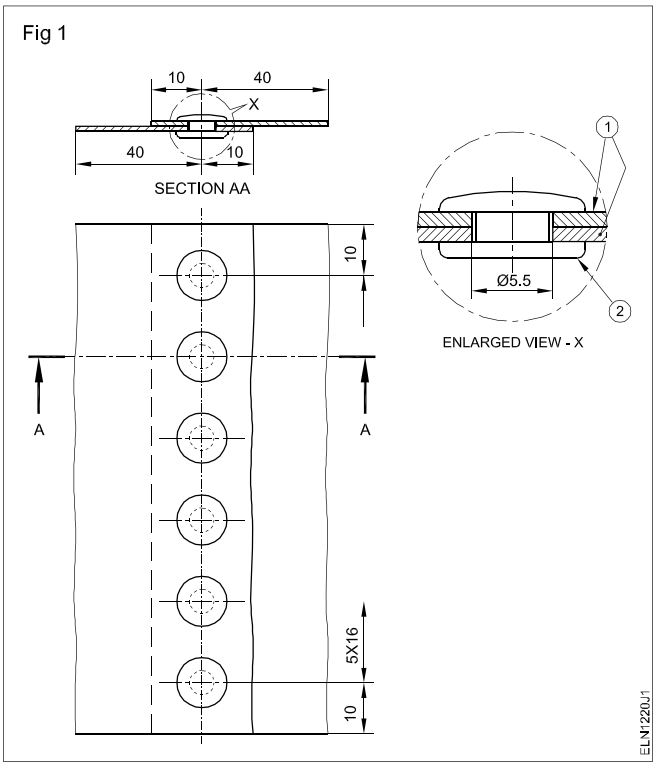


TASK 4: **Practice on rivetting with rivet sheet metal work**

1 Check the dimension of the given iron sheet.

2 Mark a straight line for centre line of the rivet. (Fig 1)

Fig 1



3 Mark centres for drilling with the centre punch.

4 Drill holes using a hand drilling machine.

5 Place the two pieces of sheet metal together on a suitable solid plate.

6 Insert the rivet in the hole.

7 Draw the material and the rivet together tightly by placing the hole in the rivet set and striking the set one or two sharp blows with hammer.

8 Place the cup shaped hole on the rivet and give the rivet set one or two sharp blows a the hammer to head the rivet.

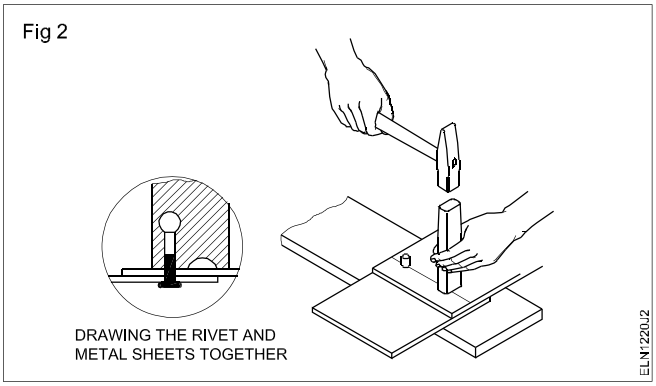
9 Rivet alternately in forward and reverse direction, beginning with the nearest centre hole.

10 Insert the rivet in the holes that have been made in the sheets.

11 Draw the rivet and the sheet together by striking one or two sharp blows with a hammer.

12 Perform heading the rivet with the cup shaped hole of the rivet set and hammer.

Fig 2



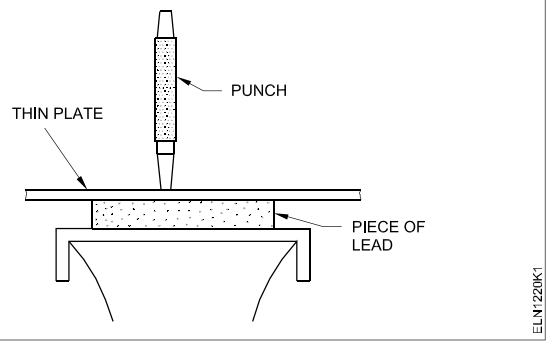
Skill sequence

Joining sheet metal by using rivet set and snap

Objective: This shall help you to
- **rivet the thin plates with a rivet set.**

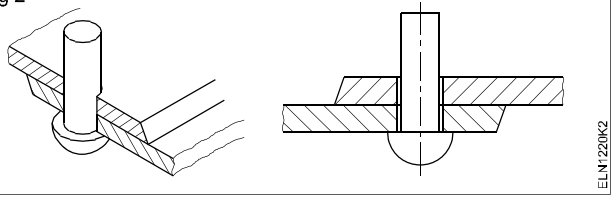
In thin plates the holes for rivets are punched as shown in Fig 1.

Fig 1



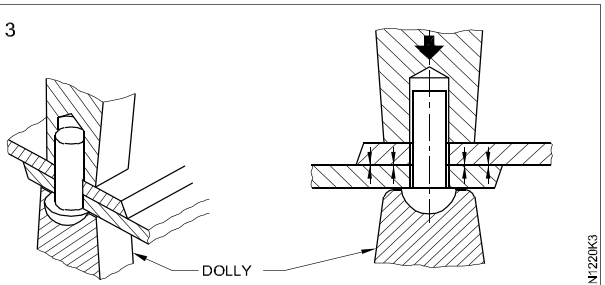
Pass the rivet through the punched hole in the sheet as shown in Fig 2.

Fig 2



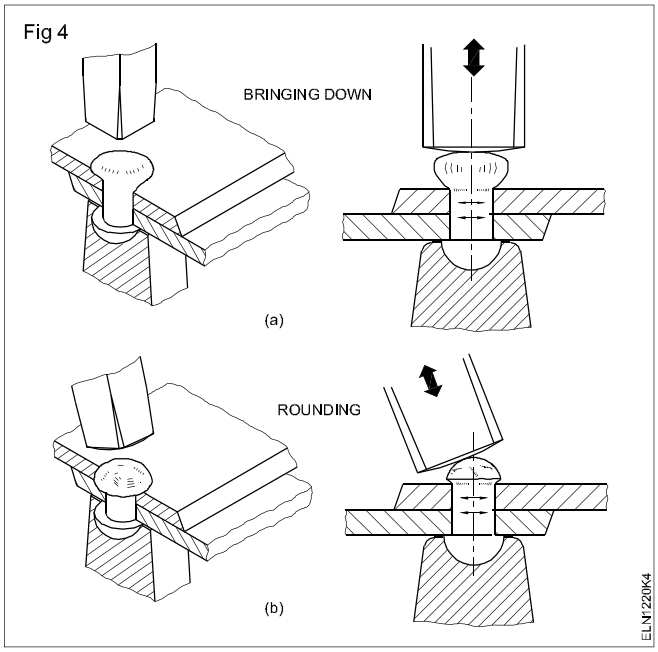
To firmly set the rivet in the sheet, use a rivet set. The rivet head is to be supported with a dolly. A dolly is used to prevent the rivet head from expanding when it is struck with the hammer.

Fig 3



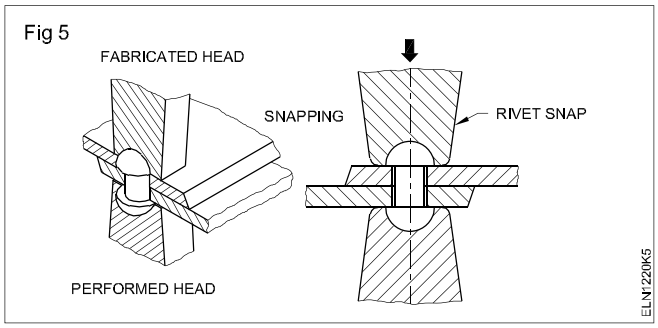
The shank is to be rounded by giving glancing blows with the hammer (as shown in Fig 4) for firming the head.

Fig 4



Finally, place the rivet snap on the rivet (as shown in Fig 5) and finish the work by giving a few blows with the hammer.

Fig 5



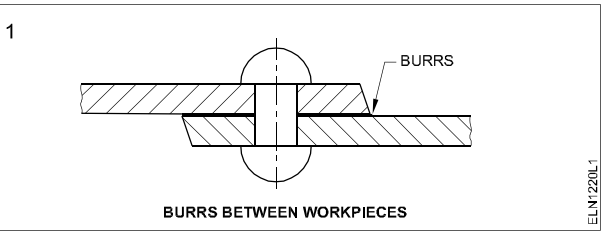
Faults in riveted joints

Objective: This shall help you to
- **identify the faults in riveted joints and the cause.**

The following faults may be noticed in riveted joints.

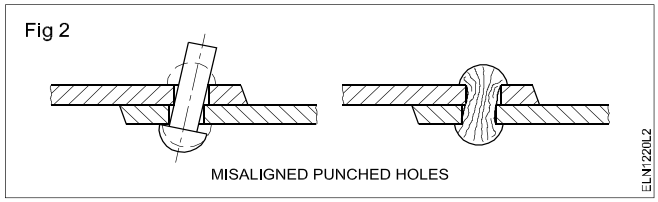
Burrs between workpieces as shown in Fig 1.

Fig 1



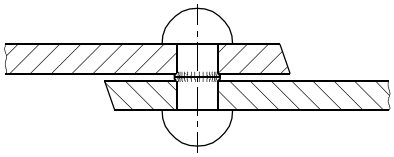
Incorrect alignment of punched holes in workpieces. (Fig 2)

Fig 2



Incorrect setting of the rivet with the rivet set. (Fig 3)

Fig 3

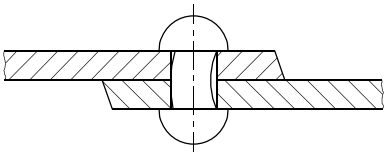


INCORRECT POSITION OF RIVET

ELN1220L3

Punched holes may be found to be too large. (Fig 4)

Fig 4

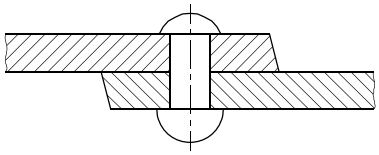


TOO LARGE PUNCHED HOLE

ELN1220L4

Rough rivet length may be found to be too short. (Fig 5)

Fig 5

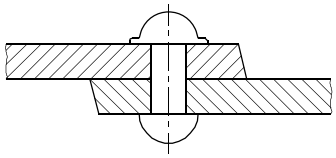


RIVET LENGTH TOO SHORT

ELN1220L5

Rough rivet length may be found to be too long. (Fig 6)

Fig 6

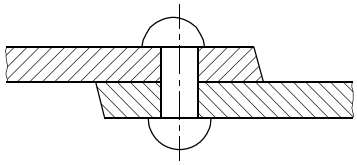


RIVET LENGTH TOO LONG

ELN1220L6

Closed head may be found to be displaced. (Fig 7)

Fig 7



DISPLACED HEADS

ELN1220L7

The rivet set and rivet snap must be free from burrs.

Removing rivets from metal sheet

Objective: This shall help you to

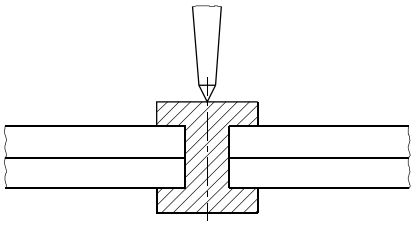
- **remove the rivet from the metal sheet.**

The most satisfactory method of removing a rivet on light gauge sheet metal is by drilling.

Carry out the following steps:

1 Flatten and centre punch exactly at the centre of the formed head. (Fig 1)

Fig 1

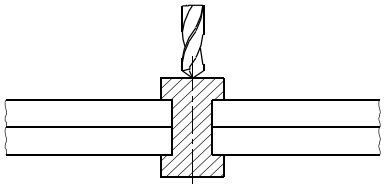


CENTER-PUNCH HEAD

ELN1220M1

2 Select a twist drill slightly smaller than the shank of the rivet. (Fig 2)

Fig 2



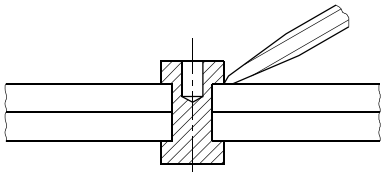
DRILL HEAD

ELN1220M2

3 Drill into the head of the rivet up to the surface of the metal. (Fig 3)

4 Remove the rivet head with a cold chisel. (Fig 3)

Fig 3

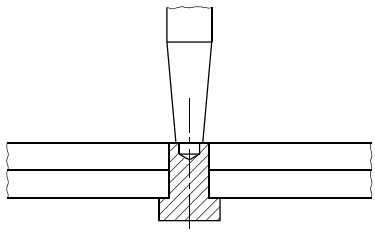


KNOCK HEAD OFF WITH CHISEL

ELN1220M3

5 Place the head of the rivet into a nut, a little larger than the head of the rivet with a solid punch slightly smaller than the size of the rivet shank. Punch the shank out of the head. (Fig 4)

Fig 4



DRIVE RIVET OUT WITH PUNCH

ELN1220M4

Another simple method of removing rivets is to cut off the formed head using a sharp cold chisel. The remaining portion of the rivet is removed by hammering, with a solid punch.

Precaution: The metal should not be distorted.

The rivet hole should not be enlarged.

Workshop practice on drilling, chipping, internal and external threading of different sizes

Objectives: At the end of this exercise you shall be able to
- **drill pilot holes matching the sizes of screws with a hand drill machine or an electric hand drilling machine**
- **drill holes of larger diameter after pilot drilling.**

Requirements

Tools/Instruments

- Steel rule 300 mm - 1 No.
- Try square 200 mm - 1 No.
- Marking gauge - 1 No.
- `G' Clamp No.6 - 1 No.
- Hand drill machine 6 mm - 1 No.
- Ratchet brace - 1 No.
- Bench vice 50 mm jaw - 1 No.

Equiment/Machines

- Portable electric hand drilling machine (6 mm) - 1 No.
- Pillar electric drill machine 12 mm capacity - 1 No.

Materials

- 58 ISP length 300 mm (Finished part of previous exercise)
- Drill bit S.S.6 mm - 1 No.
- Countersunk bit 6 to 10 mm - 1 No.
- Drill bit SS 3 mm - 1 No.

PROCEDURE

TASK 1: **Practice on drilling pilot holes using hand drilling machine**

1 Mark lines with a marking gauge, 15 mm from each end, according to the drawing for the central line of pilot holes. (Fig 1)

2 Mark hole centres as per the drawing with a steel rule and pencil from one edge on the central lines already drawn, on both the faces.

Mark hole locations within ± 0.5 mm accuracy.

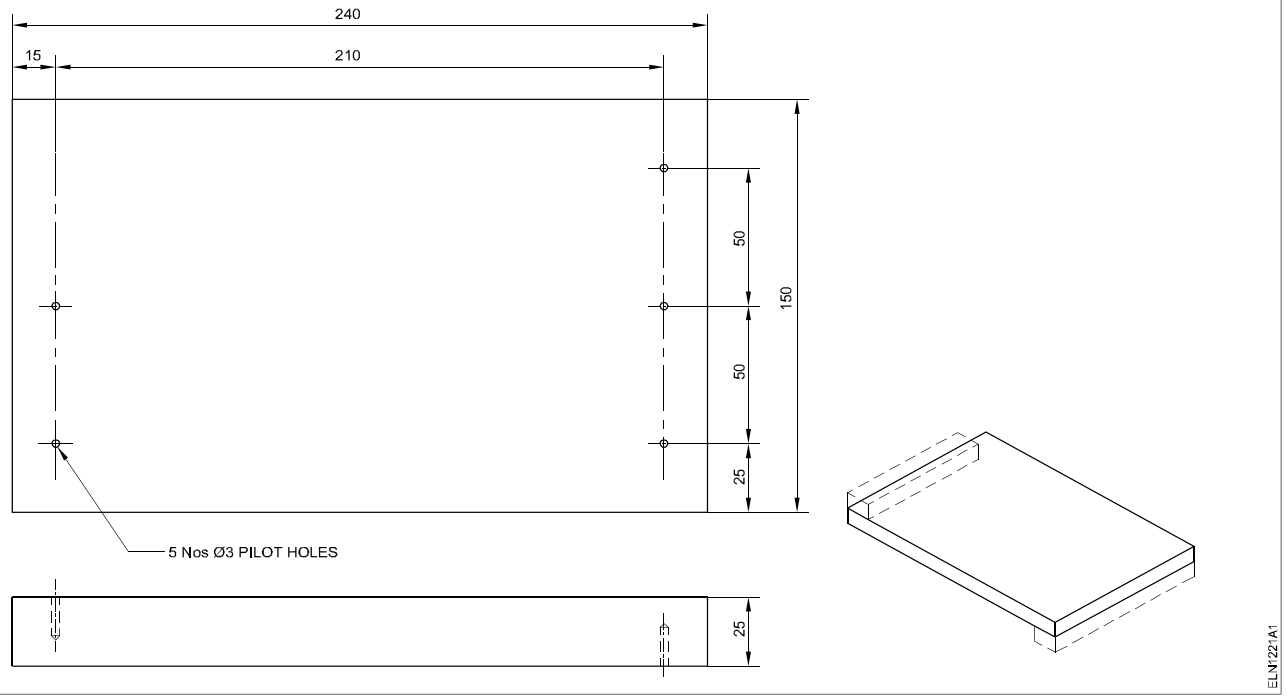
3 Punch the hole centres with the centre punch / sharpened nail.

4 Fix the job on the workbench with the bench vice `G' clamp.

5 Drill 3 mm diameter. pilot holes to a depth of 15 mm at the locations already marked by using hand drilling machine.

Do not drill holes deeper than specified.

Fig 1

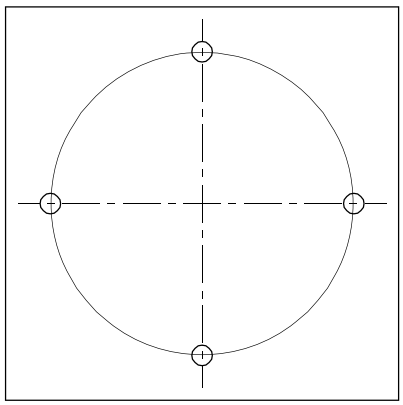


TASK 2: **Practice on drilling holes with larger diameter after pilot drilling**

1 Punch the centre of the hole to be drilled using a centre punch (90°).

2 Punch witness marks using a 60° prick punch on the periphery of the hole to be drilled. (Fig 2)

Fig 2

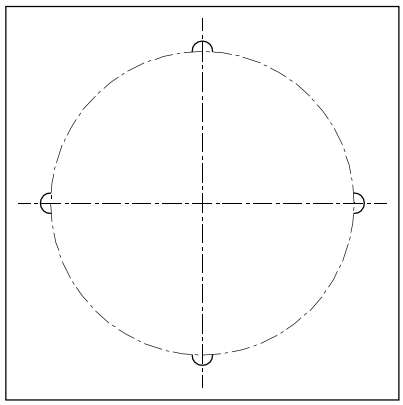


ELN1221A2

These witness marks guide to ensure that the hole drilled is exactly in its place.

If the drilled hole is perfectly located, half witness marks are visible at the circumference of the hole. (Fig 3)

Fig 3

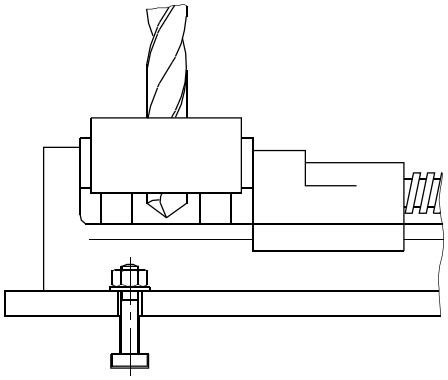


ELN1221A3

3 Set the job securely in the machine vice on the parallels.

Make sure that the largest size drill to be used must clear the parallel during drilling. (Fig 4)

Fig 4



ELN1221A4

4 Fix the drill chuck into the spindle of the drilling machine after cleaning the mating parts.

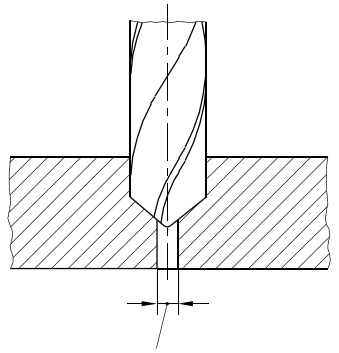
5 Select a smaller diameter drill as a pilot drill before using the required large size drill.

The diameter of the pilot drill/ hole should be at least equal to the web thickness of the large drill.

Since, the web of large diameter drills are thicker, the dead centres of those drills do not seat in the centre punch marks. This can result in the shifting of the hole location. Thick dead centres cannot easily penetrate into the material and will place severe strain on the drill.

These problems can be overcome when we drill pilot holes initially. (Fig 5)

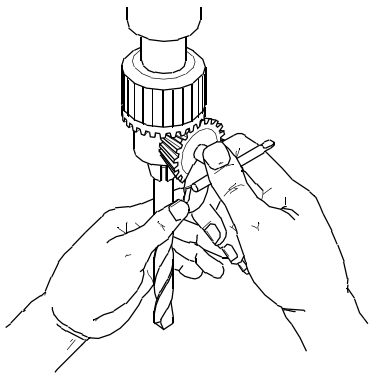
Fig 5



ELN1221A5

6 Securely fix the drill deep into the drill chuck. (Fig 6)

Fig 6



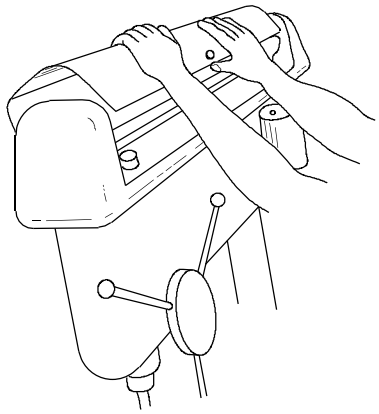
ELN1221A6

7 Determine the speed of the spindle (r.p.m.) from the recommended cutting speed and the diameter of the drill or use a table and get the r.p.m.

8 Open (or) remove the belt guard and change the belt to the pulley of the required cutting speed or to the nearest r.p.m. and replace the gaurd.

Do not change the belt when the spindle is rotating. (Fig 7)

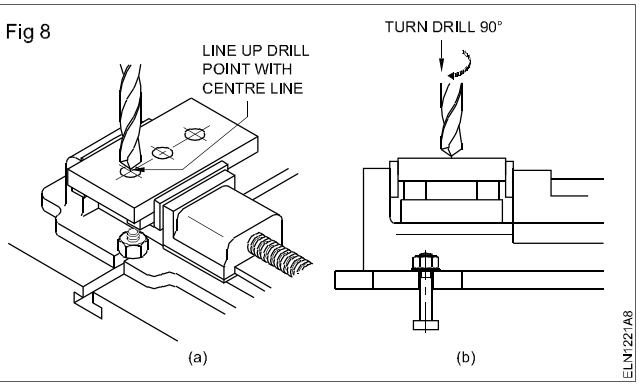
Fig 7



9 Run the spindle and check that the drill is rotating and in the clockwise direction (from right to left).

10 Bring the drill point and centre punch mark in line by adjusting the vice. When the alignment is satisfactory, clamp the vice to the machine table. (Fig 8a & b).

Fig 8



11 Recheck the alignment. Switch ON the machine and feed the drill gently on to the work. Recheck the starting of the drill.

12 Use a steady force and feed the drill gently into the job.

13 Provide continuous flow of cutting fluid to prevent overheating of the drill.

14 Gradually reduce the feed force as the drill reaches the bottom of the hole.

15 Withdraw the drill from the hole and switch OFF the machine.

16 Remove the pilot drill and the drill chuck from the machine. (Fig 6)

17 Fix a large diameter drill into the machine spindle directly.

18 Determine and reset the spindle speed (r.p.m.).

Note that the bigger the diameter of the drill is lesser than the r.p.m. and greater than the feed.

19 Drill to enlarge the hole with steady feed. Stop the machine, remove the job and clean the chips using a brush.

Skill sequence

Method of fixing drill bits in a drilling machine

Objective: This shall help you to
- **fix a drill bit and check for eccentricity.**

A drill bit should be firmly fitted for in the drilling machine, so that straight and circular holes can be drilled. This prevents accidents too.

The drill bit must be centrally located and held firmly in the chuck of the drilling machine.

Fixing a drill bit in a hand drill machine: Hold the gear of the drilling machine with one hand. (Fig 1)

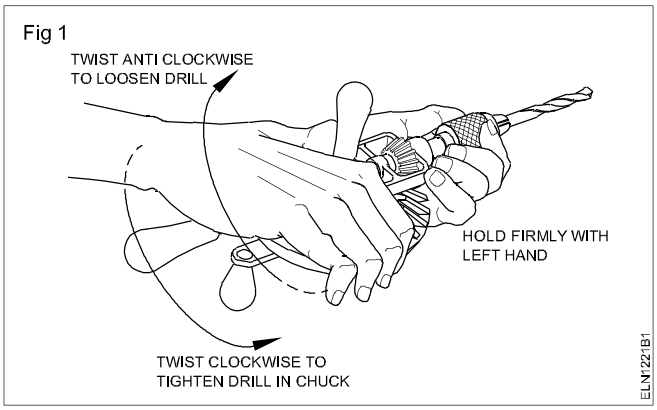
Unscrew, the sleeves of the chuck with the other hand to provide sufficient clearance for the drill shank in the jaws. (Fig 1)

Insert the drill shank into the chuck.

Keep the drill centrally seated, and tighten the chuck.

Twist the hand holding the gear to the right to further tighten the drill while firmly holding the chuck with the other hand. (Fig 1)

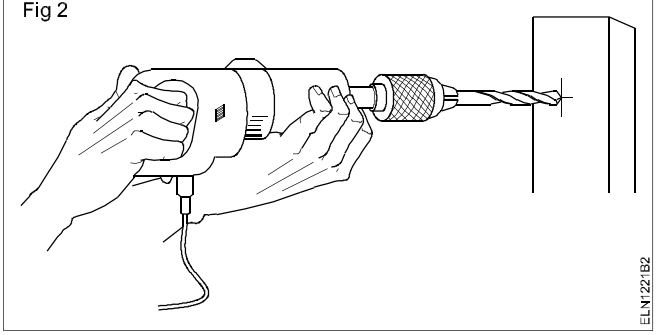
Fig 1



To remove the drill, slacken the jaws by twisting the hand in the opposite direction (from what was done for fixing).

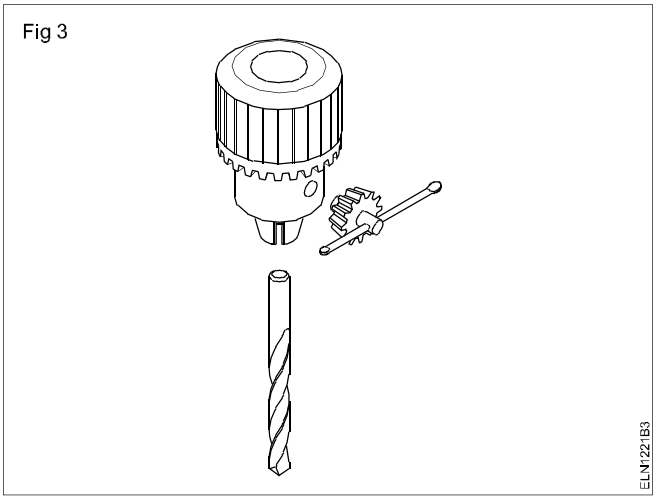
Fixing a drill bit in an electric hand drill machine : The same procedure used for fixing a drill bit in a hand drill machine is followed except in the case of slackening and tightening the jaws of the chuck.(Fig 2)

Fig 2



Slackening and tightening the jaws of the chuck is done using a special drill chuck key provided with the machine. (Fig 3)

Fig 3



When using a power drill, make sure that the material to be drilled is fixed firmly in a clamp/ vice.

To prevent accidents never attempt to hold the workpiece by hand.

Locating hole by drilling centre hole

Objective: This shall help you to
- **drill centre holes with a drilling machine.**

Drilling centre holes using combination drills is an accurate method of locating the position of the holes (i.e. within ± 0.25 mm). In drilling operations, this method will be helpful while drilling deeper holes, and holes in fairly accurate locations. For doing centre drilling, follows the steps given below.

1 Hold the combination centre drill in the drill chuck and check whether it runs true'. Adjust the spindle speed to suit the combination drill.

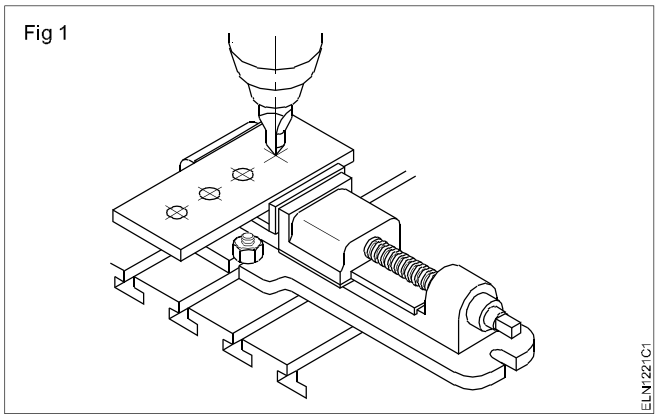
2 Adjust the job together with the vice and align it with the centre punch mark. (Fig 1)

3 Drill a centre hole up to a depth of 3/4th of the countersink. Do not apply undue pressure on the centre drill.

4 Apply sufficient quantity of cutting fluid.

5 Remove the centre drill, hold the twist drill of the required diameter. Check if it 'runs true'. Start drilling the through hole.

Fig 1



Sharpening of drills

Objective: This shall help you to
- **sharpen drills on an off hand grinder.**

A drill will loose sharpness of its cutting edges due to continuous use. Improper use of drills will also spoil the cutting edges.

Spoiled or blunt cutting edges of the drills must be sharpened on a grinder.

Check the grinding wheel for loading, glazing, trueness and cracks. Call your instructor for advice. Dress and true the wheel if necessary.

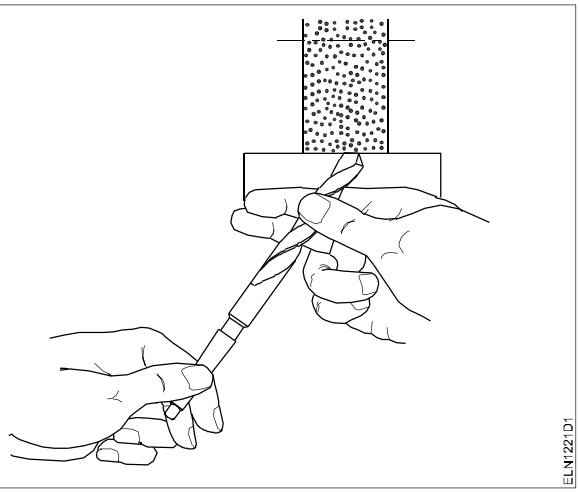
Protect your eyes either with goggles or by lowering the eye protecting shield near the tool rest and adjust the tool rest at 2 mm closer to the wheel, if necessary.

Check if enough coolant is there in the container.

Switch the grinder on.

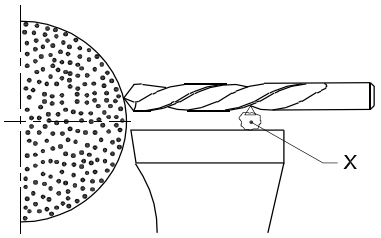
Hold the shank of the drill lightly in one hand between the thumb and the forefinger, and with the other hand hold the portion near the point. (Fig 1)

Fig 1



The hand near the point of the drill should be pivoted lightly on the tool rest at 'x' for easy manipulation. (Fig 2)

Fig 2



Hold the drill level (Fig 2) and turn it to 59° to the face of the wheel and swing the drill slightly downward and towards the left. (Fig 3 & 4)

Fig 3

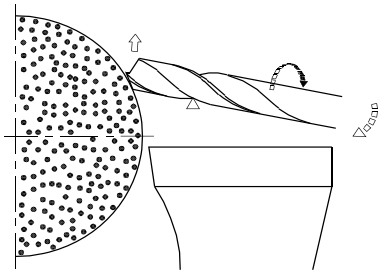
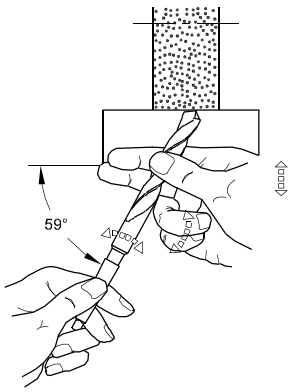


Fig 4



Rotate the drill to the right by turning it between the thumb and the forefinger. (Fig 4)

This turning movement is not necessary for drills of smaller diameters.

While swinging and turning the drill make sure you do not grind the other cutting edges.

All movements of the drill for angular turning, swinging and forward movements should be well coordinated. They should result in one smooth movement to produce a uniformly finished surface.

Repeat the process to re-sharpen the other cutting edges.

Check both the cutting edges with a drill angle gauge, for correctness of the lip angle and same in size of the lip lengths. (Figs 5 & 6)

Fig 5

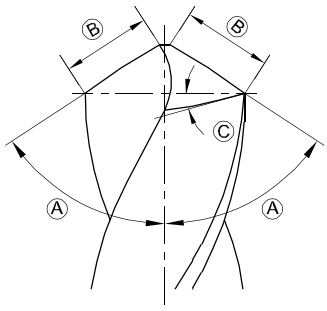
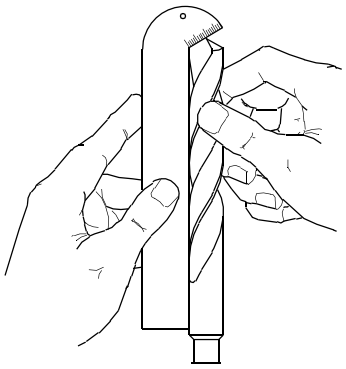


Fig 6



Check the lip clearance angle in Fig 5 visually. The angle should be between 8° to 12°.

Practice on chipping exercise has already been dealt in Ex. No. 1.2.17 as Sub Exercise 1.2.17- 1

Practice on making internal threading using hand taps

Objectives: At the end of this exercise you shall be able to
- **form internal threads by hand tap and using wrench.**

Requirements

Tools/Instruments

- Surface gauge - 1 No.
- Hacksaw frame 250 to 300 mm - 1 No.
- Ball pane hammer 200 gm - 1 No.
- M10 tap and wrench - 1 Set
- Steel rule 300 mm. - 1 No.
- Twist drill 8.5 and 11.5 - 1 No each.

Equiment/Machines

- Bench vice (100 mm) - 1 No.
- Drilling machine pillar type - 1 No.
- Angle plate - 1 No.
- Surface plate - 1 No.
- Drilling accessories chuck sleeve and drill - As required.

Materials

- Hexagonal nut (available size) - 1 No.
- Square nut (available size) - 1 No.
- Lubricant oil - As required.

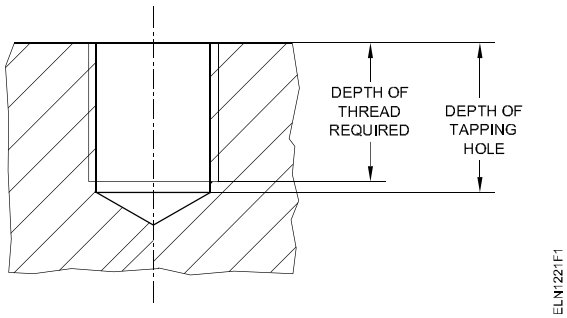
PROCEDURE

Drilling a hole

1 Determine drill size for tapping using the table for doing it.

2 Drill a blind hole using the depth stop arrangement. The depth of the tapping hole should be slightly more than the depth of the required thread. (Fig 1)

Fig 1



Procedure for threading

3 Remove metal chips, if any, from the blind hole by turning it upside down and slightly tapping it on the wooden surface.

Do not clear the chips by blowing as it can cause injury to your eyes.

4 Screw a matching hexagonal nut on the first tap to act as the depth stop. (Fig 2)

5 Thread the blind hole until the nut touches the plate surface.

6 Remove the chips from the hole frequently, using a flattened and bent wire. (Fig 3)

Fig 2

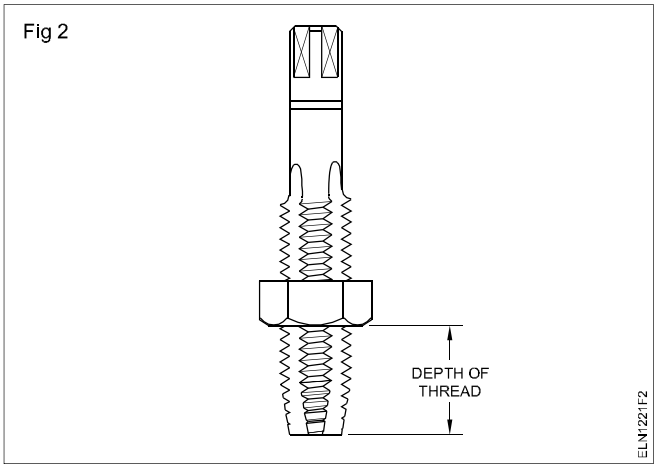
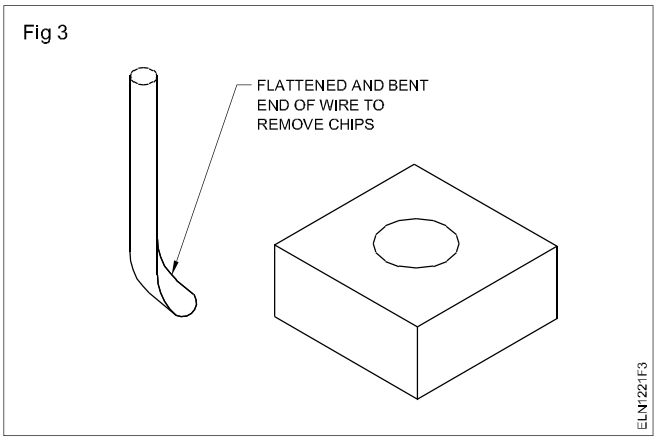


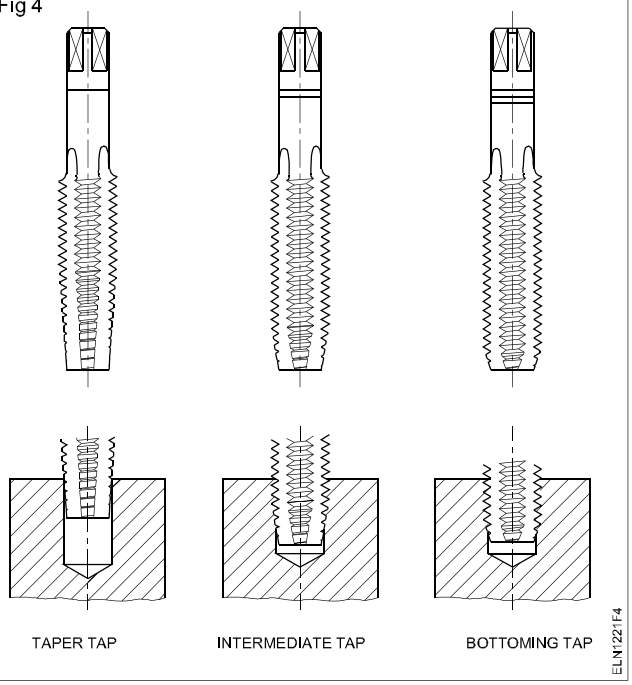
Fig 3



7 Finish tapping the hole with intermediate and bottoming tap (Fig 4). Set the nut to control the depth of the thread.

8 Repeat and practice steps 4 to 7 for forming internal thread on a square nut.

Fig 4



Skill sequence

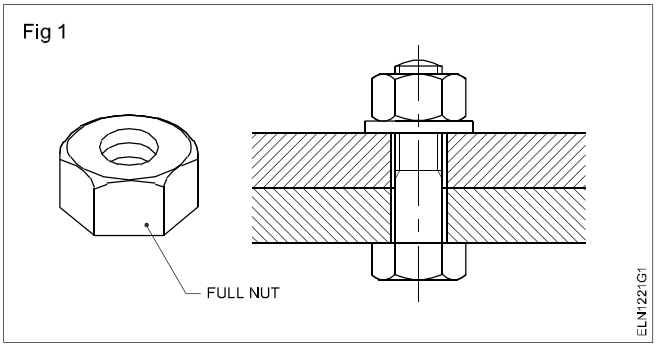
Hexagonal and square nut

Objective: This shall help you to
- **use of hexagonal and square nuts.**

Hexagonal nuts

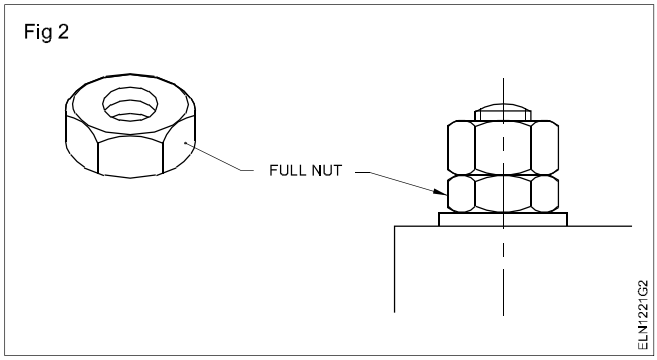
This is the most commonly used type of nut in sructural and machine tool constructions. (Fig 1)

Fig 1



Hexagonal nuts are available in different thicknesses. Thin nuts are used as lock-nuts. (Fig 2)

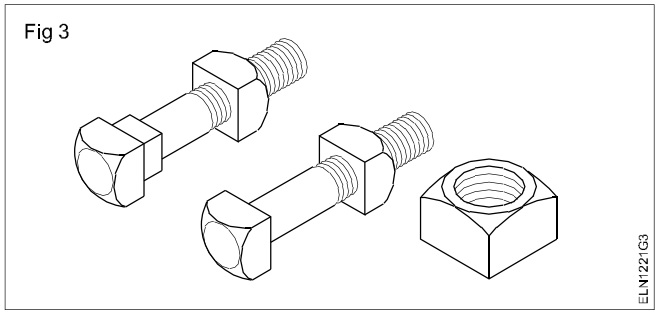
Fig 2



Square nut

Square bolts are provided with square nuts. In bolts for coaches, mostly, square nuts are used. (Fig 3)

Fig 3



Practice on making external threading by using stock & die set

Objectives: At the end of this exercise you shall be able to
- **measure and cut the conduit pipe according to the requirement**
- **prepare the conduit pipe ends for threading and fastening in a pipe vice**
- **cut the threads on heavy gauge metal conduit according to the requirement using a conduit die set**
- **mark the position of bending on conduit pipes.**

Requirements

Tools/Instruments

- Pipe vice 50 mm - 1 No.
- Steel rule 600 mm - 1 No.
- Hacksaw with a blade of 24 teeth per 25mm (25 TPI) - 1 No.
- Flat file bastard 200 mm - 1 No.
- Half round file bastard 20 0mm - 1 No.
- Reamer 16 mm - 1 No.
- Oil can 200 ml - 1 No.
- Conduit stock and dies for 18 mm conduit - 1 set.
- Wire brush 50 mm - 1 No.

Materials

- Conduit pipe 19 mm diameter1m long - 1 No.
- Lubricant - coconut oil (for a batch of 16 trainees) -100 grams
- Chalk piece - 1 No.
- Cotton waste - as required.

PROCEDURE

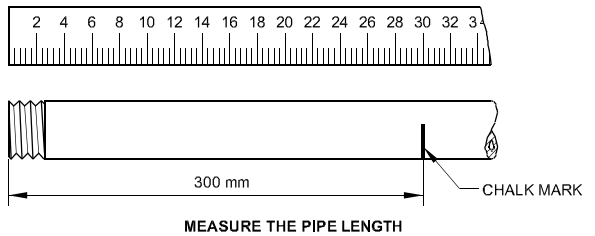
TASK 1: **Preparation of conduit pipe for cutting.**

Assume that the job needs a 300 mm long conduit drop while a 3000 mm standard length pipe is only available. Normally both the ends of a standard length pipe will have threads. To make the required conduit drop, the available 3000 mm pipe is to be cut for a length of 300 mm and threaded again at the end where it is cut.

Cutting could be done either using pipe cutters or with hacksaws. Cutting with a hacksaw is popular, and the method is explained below.

1 Measure 300 mm from the threaded end of the pipe and mark it with chalk as shown in Fig 1.

Fig 1

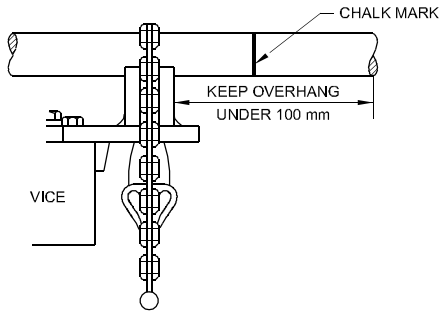


MEASURE THE PIPE LENGTH

2 Open the jaw of the vice and insert the pipe so that it is horizontal and parallel to the jaw serrations.

3 Keep the chalk mark of the pipe within 100 mm of the vice as shown in Fig 2.

Fig 2

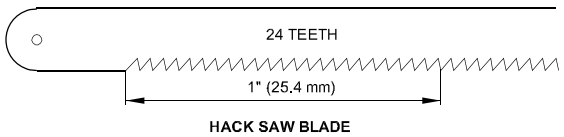


GRIP THE PIPE IN THE VICE FOR SAWING OPERATION

4 Close and tighten the vice jaw.

5 Select a hacksaw with a blade having 24 teeth per 25 mm (25 TPI), as shown in Fig 3.

Fig 3

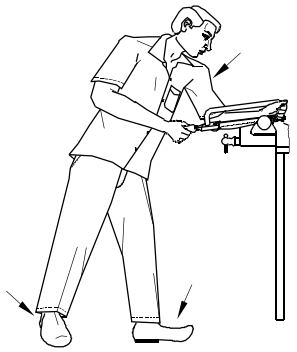


HACK SAW BLADE

Ensure that the hacksaw blade is firmly tightened in the frame and that the teeth point in the forward direction.

6 Take the hacksaw and position yourself, as shown in Fig 4, with your left shoulder pointing in the direction of the cut. Note the position of the feet, which allows for free and controlled movement of the body while cutting.

Fig 4



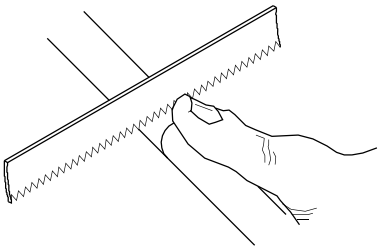
HACK SAWING - POSITION OF SAWING

ELN1221H4

7 Grip the hacksaw handle with the right hand and position the hacksaw blade on top of the cutting line.

8 Prepare to cut by guiding the blade with the thumb of your left hand exactly on the cutting line against the saw blade as shown in Fig 5.

Fig 5



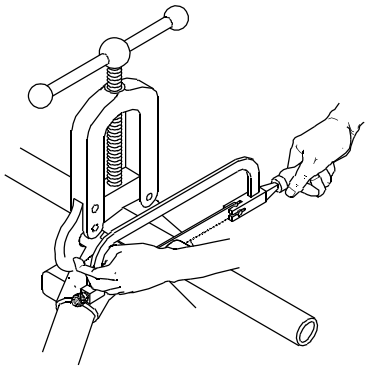
USE THUMB AS A GUIDE INITIALLY

ELN1221H5

9 When the initial cut has been made, move the left hand to the front end of the hacksaw frame and use both hands for the cutting operation as shown in Fig 6.

10 When sawing, use the full length of the blade, gradually increasing the pressure on the forward stroke, and releasing the pressure as the blade is drawn back. (Fig 6)

Fig 6

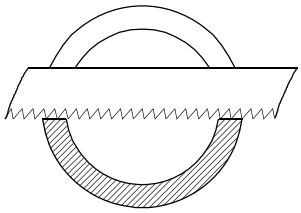


HOLDING SAW WHILE SAWING

ELN1221H6

11 Saw with steady, even strokes, keeping the blade upright and square to the cut as shown in Fig 7.

Fig 7

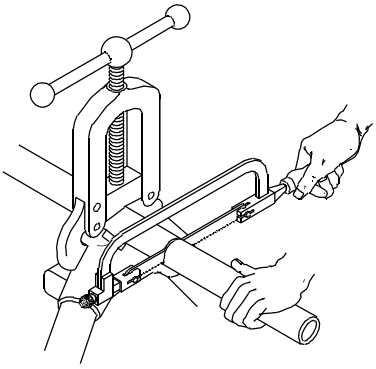


HOLD STRAIGHT

ELN1221H7

12 When getting near to the end of the cut, the conduit must be supported with your left hand as shown in Fig 8. Finish the cut.

Fig 8



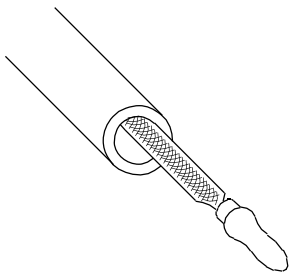
END OF SAWING

ELN1221H8

Support the free end of the conduit to prevent the blade of the hacksaw from being damaged.

13 Use a reamer or half round file to remove the inside burrs as shown in Fig 9.

Fig 9

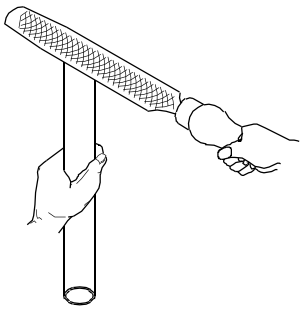


REMOVAL OF BURRS

ELN1221H9

14 Use the flat portion of the half round file to smoothen the sharp edges. (Fig 10)

Fig 10



REMOVAL OF SHARP EDGES

ELN1221HA

15 Clean the hacksaw and vice in the end and keep them in their respective places.

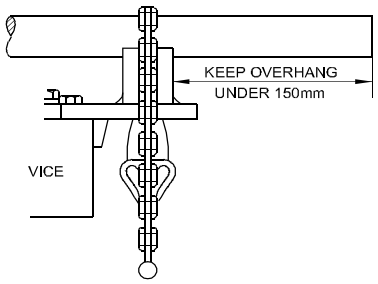
TASK 2: **Preparation of conduit pipe for threading.**

1 Open the jaw of the vice and insert the pipe so that it is horizontal and parallel to the jaw serrations.

2 Keep the end of the tube within 150 mm of the vice.

3 Close and tighten the vice as shown in Fig 11.

Fig 11

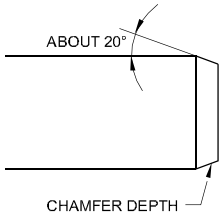


HOLD THE PIPE IN THE PIPE VICE FOR THREADING

ELN1221HB

4 File the end of the tube flat and chamfer the outer edge to an angle of about 20° as shown in Fig 12.

Fig 12



BEFORE THREADING, CHAMFER THE EDGE OF THE PIPE

ELN1221HC

Make the depth of the chamfer equal to the pitch of the thread (1.5 mm for conduit).

5 Choose the correct dies and stock suitable for the pipe to be threaded.

Assembly drawing for the quick cut stock and dies is given in Fig 13. The die size is engraved on the die itself. Check the size with that of the pipe. The handle of the stock is not shown in the picture for clarity.

6 Insert each half of the die in the cap(stock) with the chamferred threads positioned (leading faces) adjacent to the guide.

7 Screw the guide into position.

8 Adjust each adjusting screw equally to make the die halves centralized to the pipe axis.

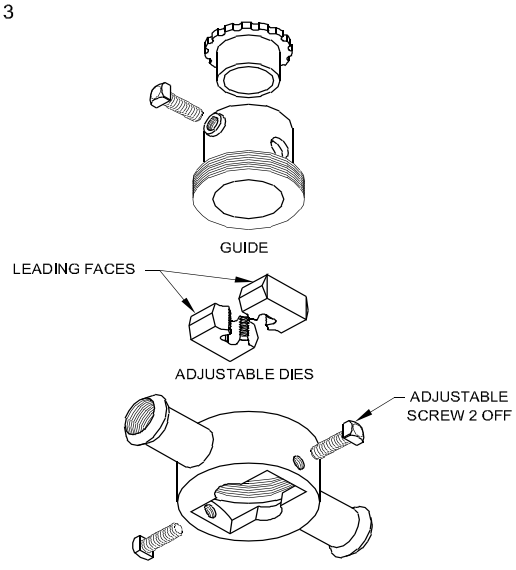
9 Slide the stock guide over the end of pipe, adjust the adjusting screws such that the dies grip the pipe evenly on both sides.

10 Apply pressure to the stock and keep the handles at right angles to the pipe as shown in Fig 14.

11 Rotate the handles clockwise in a plane at right angles to the pipe axis as shown in Fig 15.

12 Apply the lubricant to the part to be threaded after the thread has been started.

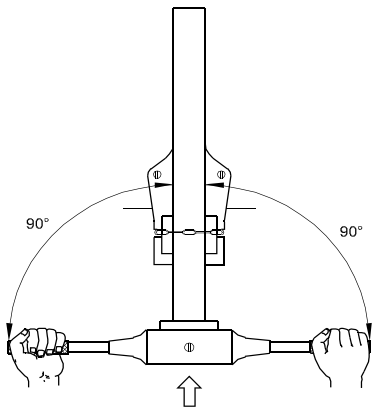
Fig 13



DIE SET (HANDLE NOT SHOWN)

ELN1221HD

Fig 14

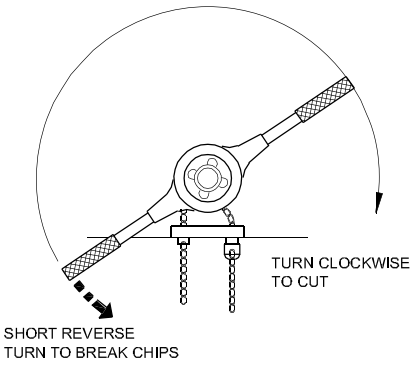


PRESS IN AS YOU ROTATE HANDLES CLOCKWISE

MOUNTING THE DIE SET IN THE CONDUIT

ELN1221HE

Fig 15



THREADING PROCESS

ELN1221HF

The lubricant allows the die to cool the heat developed and thereby helps the edges to stay sharp producing a better thread finish.

13 Make one or two complete turns in the clockwise direction.

Check whether the stock is at right angle to the pipe axis.

Practice of making square holes in crank handle

Note: This exercise is already dealt in Ex. 1.2.17 as Sub Exercise S.Ex. 1.2.17 - 4. Refer it.

Prepare an open box from metal sheet

Objectives: At the end of this exercise, you shall be able to
- **draw a development plan for a given open rectangular box in a single sheet**
- **drill hole of small diameter using hand drilling machine**
- **shear straight edge using straight snip**
- **make holes in sheet metal using cold punch**
- **make holes in sheet metal using hollow punch.**

Requirements

Tools/Instruments

- Steel rule 300 mm - 1 No
- Scriber 200 mm - 1 No
- Divider 150 mm - 1 No
- Snips 250 mm - 1 No
- Hammer 200 g - 1 No
- Hatchet stake - As available.
- Mallet wood - 1 No
- Hollow punches set 3 to 25 mm - 1 set

Equipment/Machines

- Hand drilling machine - 6mm

Materials

- Sheet iron ISST (in mm) - 52 x 0.5 x 150

PROCEDURE

1 Check the dimension of the given sheet iron.

2 Mark all the dimensions as per drawing (Fig 1) for cutting, bending and punching holes.

3 Drill 2 mm diameter holes on all corners of box using hand drilling machine.

4 Shear over a length of 8.5 mm for bending indicated by No. 1 in Fig 1.

5 Bend all the four corners to 90°. Bending width of 8 mm is indicated by No. 2 in Fig 1.

6 Bend the sides B & D to 90° using suitable stack. (Fig 2)

Ensure the overlapping parts are well within the bending line of side A and side C.

Fig 2

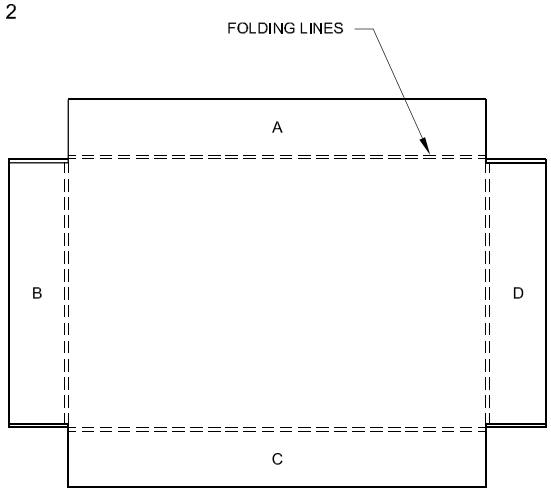
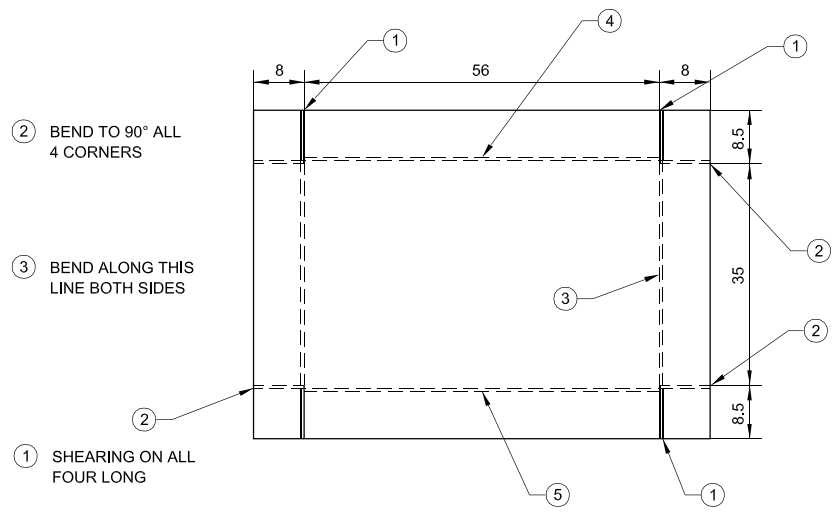


Fig 1



7 Bend the sides A and C to 90°. Use suitable stack. (Fig 3)

8 Repeat steps 1 to 8 and prepare another open box.

9 Mark the centre lines as per the dimensions given in (Fig 3), in one of the open end boxes.

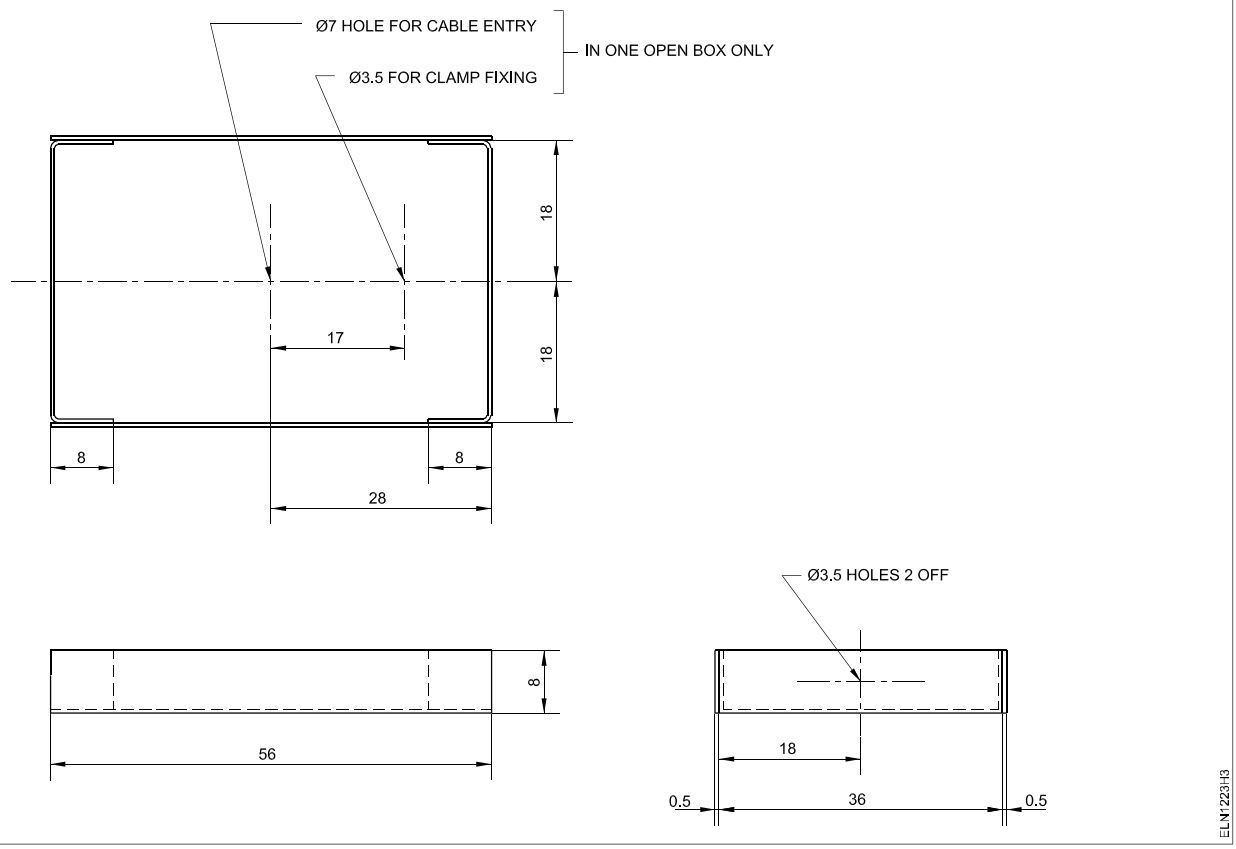
10 Make two marks on the holes of both the lines of at a distance equal to the radius to locate punches.

11 Place sheet at the end of wood or lead cake.

12 Punch holes with correct size punches after exactly locating their positions.

13 Flatten the surface by gently hammering with the soft mallet.

Fig 3



Skill Information

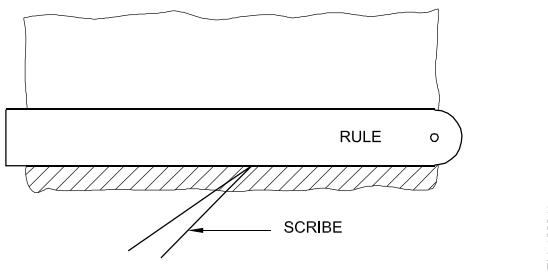
Laying out development pattern of rectangular open box directly on sheet metal

Objectives: This shall help you to
- **draw a pattern for making a single open box.**

The steps to lay out the pattern remain the same.

Check the sheet metal on which your pattern will be made. Check the bottom edge of the sheet with a straight edge. (Fig 1)

Fig 1



Square up the left hand end of the sheet. (Fig 2) The ends of the sheet seldom remain a perfect square at the edges. (Fig 3) The usual method is to draw a line about 5 mm from the end using a square. (Fig 4)

Always make your layout in the lower, left hand corner of the sheet.

Measurements should be from the bottom and left hand square line.

Never try to cut your metal to the exact size. Measure from all the four edges to make the layout.

Fig 2

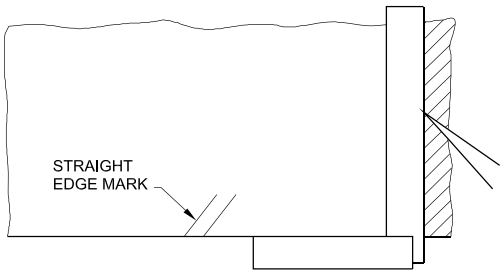


Fig 3

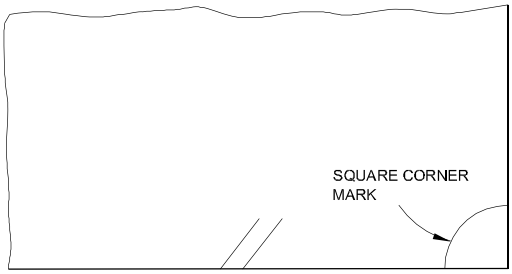
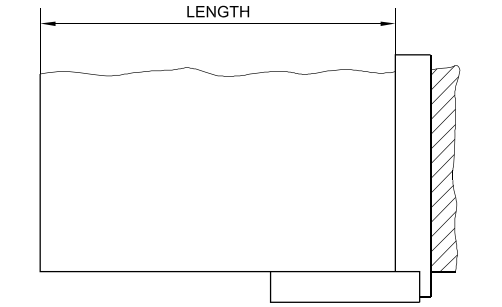


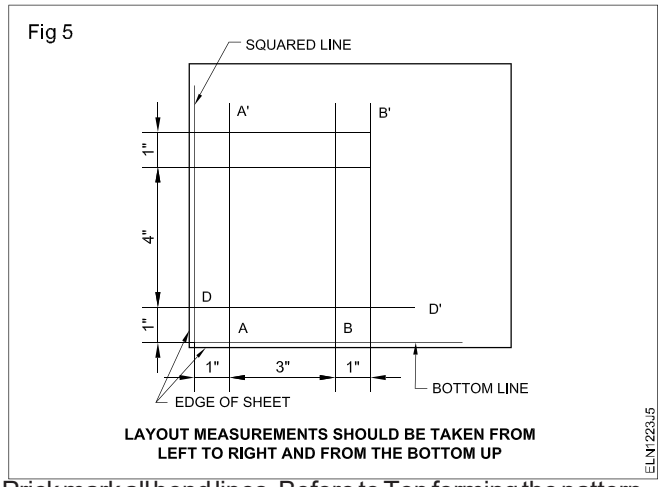
Fig 4



Make measurement at both ends of each line and draw a line through the two points.

Draw all the vertical and horizontal lines first. Then add lines for metres, notches, seams, edges and laps. (Fig 5)

Fig 5



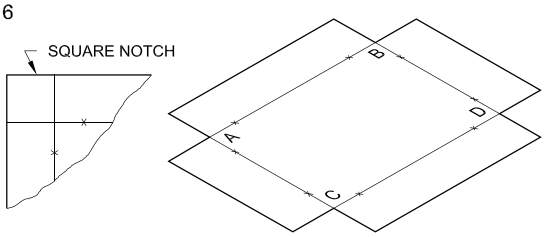
Prick mark all bend lines. Before to Top forming the pattern, prick mark all the bend lines about 5 mm from the end of the line.

Do not depend upon the corners of notches for bend locations.

Check the shape of the basic patterns.

When the layoutis ready check the overall dimensions on each side of the pattern. (Fig 6)

Fig 6



Making holes with a hollow punch in sheet metal

Objectives: This shall help you to
- **make a hole on sheet metal with a hollow punch.**

Hollow punches are used for punching holes of 4 mm diameter. or larger on soft sheet metal. First mark the centre. Now, draw the circle with diameter equal to the hollow punch.

Place the sheet metal on a lead block or on a block of wood with the end grains up. You should not use any other metal block. If you use a metal block other than lead, it will spoil the cutting edge of the hollow punch.

Position the hollow punch on the circle that has already been drawn.Hold the punch upright. Strike gently on the head of the hollow punch. Hit the punch until the disc is cut from the material.

Drilling holes in sheet metal using hand drilling machine

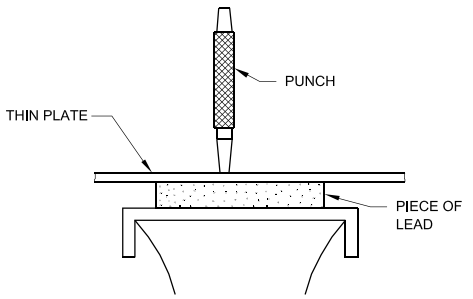
Objectives: This shall help you to
- **make holes on thin sheets using a solid punch**
- **drill holes using a hand drilling machine.**

In thin sheets, holes can be made using a solid punch. (Fig 1)

A punching machine can also be used for this work. (Fig 2)

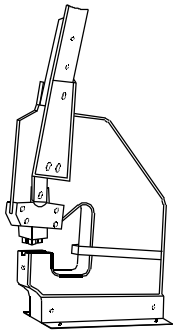
If the plate is thicker, about 1 mm, and hole diameter is about 5 mm, cracks may be formed while punching and ths may weakens the sheets. It is better to drill holes using

Fig 1



ELN1223X1

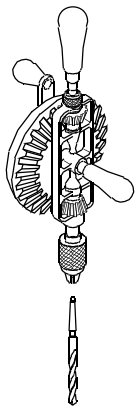
Fig 2



ELN1223X2

a hand drilling machine. The hand drilling machine (without electricity) is provided with a gear transmission (Fig 3) which helps in a greater speed during drilling.

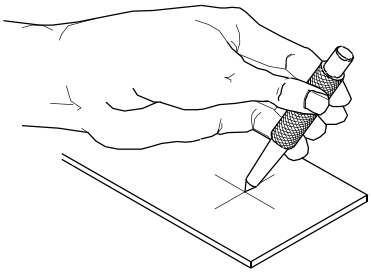
Fig 3



ELN1223X3

Centering is very important for using a hand drilling machine. It is done with a centre punch. The centre punch should be held in the inclined position. First check whether it has been correctly placed in the point where the two lines intersect.(Fig 4)

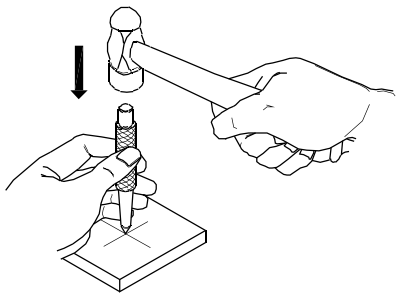
Fig 4



ELN1223X4

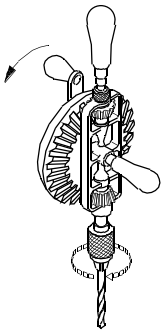
Hold the punch vertically and strike on the head of the punch using a hammer (Fig 5). Fix the required straight shank drill bit in the chuck of the drilling machine. The drill can be tightened in the chuck. (Fig 6)

Fig 5



ELN1223X5

Fig 6



ELN1223X6

Prepare terminations of cable ends

Objectives : At the end of this exercise you shall be able to
- **prepare a loop termination**
- **prepare the cable end of fine multistranded wire**
- **identify the connecting parts of the socket of an appliance and connect it to cable with earth contact**
- **connect the appliance to the cable with earth contact**
- **identify the connecting parts of a 3-pole (plug) pin and connect the cable.**

Requirements

Tools/Instruments

- Steel rule 300 mm - 1 No.
- Electrician's knife 100 mm - 1 No.
- Wire stripper (manual) 150 mm - 1 No.
- Combination pliers 200 mm - 1 No.
- Screwdriver 100/150 mm x 4 mm - 1 No.
- Screwdriver 100 mm x 2 mm - 1 No.
- Long round nose pliers 150 mm - 1 No.
- Side cutting pliers 150 mm - 1 No.

Materials

- Pieces of 250 to 300 mm long aluminium and copper - as reqd.
- Single conductor cable 1.5 sq.mm - as reqd.
- Single conductor cable 2.5 sq. mm - as reqd.
- Bare copper wire No.10 SWG - small pieces 300 mm long or as available.
- Multistrand cable14/0.2 mm - small pieces 300 mm long or as available. - as reqd.
- Multistrand cable 23/0.2 mm - as reqd.
- Multistrand cable 48/0.2 mm - 2 Nos.
- Single pole plug (double banana plug) 4 mm screw type connection - 4 Nos.
- Crocodile clips insulated 2A and 6A, 250 V - 2 Nos.
- Test lamp with bulb 40 W, 240 V - 1 No.
- PVC cable 3-core copper 23/0.2 mm - 5 m
- Socket 2-pole with earthing contact 6A, 250 V grade - each of different rating and make - 4 pairs
- Plug 2-pole with earthing contact - 4 pairs
- Socket 2-pole with earthing contact 6A - 5 Nos.
- PVC Cable 3-core 48/0.2 mm - 3.5 m
- Plug 3-Pole 6A, 250 V different makes - 2 Nos.
- Plug 3-Pole 16 A, 250 V different makes - 2 Nos.
- Meta/clad plug 2-pin with earth 20A - 2 Nos.

PROCEDURE

TASK 1: **Preparation of loop termination (Solid conductor)** (Fig 1)

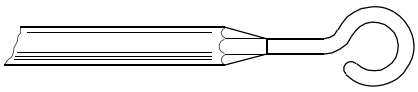
1 Collect a single conductor cable of 1.5 sq.mm (copper) about 250 to 300 mm long from scrap.

2 Mark on the insulation the length 'L' from the cable end. The length 'L' is five times the diameter of the terminal screw.

3 Loop in fine multistrand conductor. (Fig 2)

4 Make termination in screw on terminal. (Fig 3)

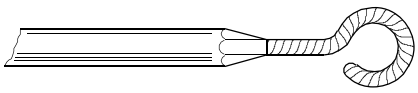
Fig 1



LOOP IN SOLID CONDUCTOR

ELN1324H1

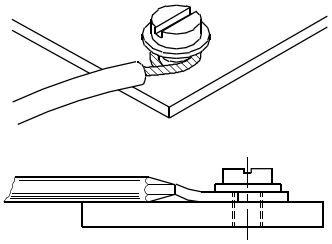
Fig 2



LOOP IN FINE MULTI-STRAND CONDUCTOR

ELN1324H2

Fig 3

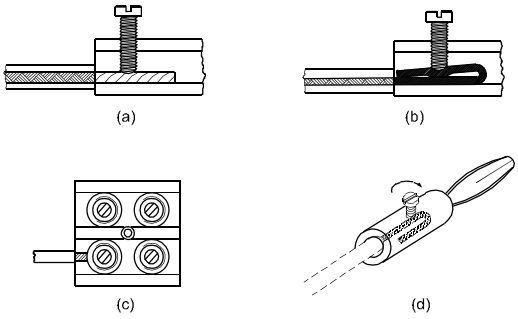


TERMINATION IN SCREW ON TERMINAL

ELN1324H3

5 Connect the terminated cable in different types of connectors. (Fig 4 a,b,c,d).

Fig 4



ELN1324H4

6 Skin the insulation over the length 'L'. (Fig 5)

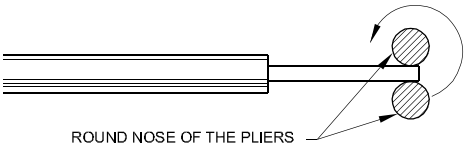
Fig 5

MAKING A LOOP IN THE WIRE

ELN1324H5

7 Grip the bare conductor with the round nose pliers as shown in Fig 6.

Fig 6



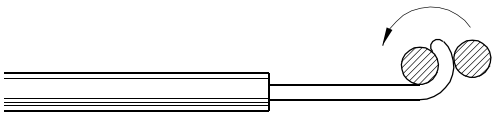
MAKING A LOOP IN THE WIRE

ELN1324H6

The diameter of the jaw at the gripping point of the round nose pliers is little more than the terminal screw diameter.

8 Turn the firmly gripped nose pliers to form the required loop. (Fig 7)

Fig 7



MAKING A LOOP IN THE WIRE

ELN1324H7

9 Finally set the loops with the nose pliers as shown in Fig 8.

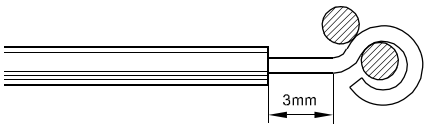
The hook (loop) should go at least about three quarters of the way around the screw.

Check the inner diameter of the loop with the terminal screw.

Never make the hook long as the conductor may overlap.

Keep the length of the exposed conductor to the minimum, not more than 3 mm, to prevent accidental contact with other wires. (Fig 8)

Fig 8



MAKING A LOOP IN THE WIRE

ELN1324H8

10 Repeat the task for 2.5 sq.mm copper single conductor cable.

11 Repeat the task for aluminium cable single conductor of 1.5 sq. mm and 2.5 sq. mm.

12 Repeat the task for bare copper wire of 10 SWG and other available sizes.

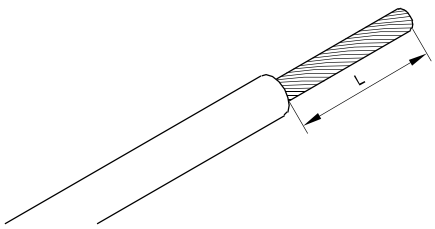
Preparing a fine multistrand cable end for termination to screw-on terminal of terminal blocks

13 Collect a piece of fine multistr and flexible copper cable, of size 14/0.2 mm.

14 Mark the length 'L' from the end of cable. Length 'L' is equal to five times the diameter of the terminal screw.

15 Remove the insulation to the length 'L' (Fig 9) using a pair of wire stripping pliers.

Fig 9

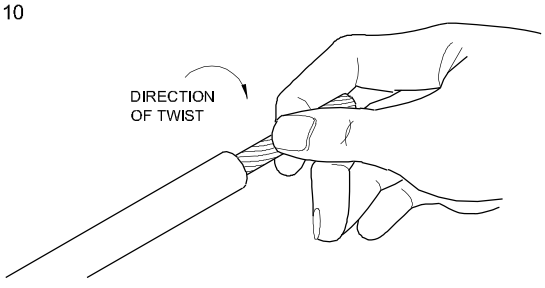


MULTI - STRAND CABLE

ELN1324H9

16 Retwist the bared strands in the same direction with your fingers. (Fig 10) Note, that the strands are twisted in the wire in a certain direction.

Fig 10



TWISTING THE MULTI-STRAND CABLE CORE

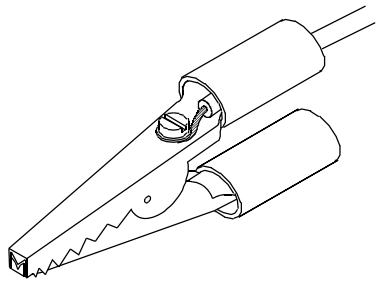
ELN1324HA

17 Repeat the steps No.4 to No.6 stated for solid conductor to finalise the termination.

18 Repeat the task with other sizes of cables.

19 Repeat the task for terminating flexible cable end on crocodile clips. (Fig 11)

Fig 11

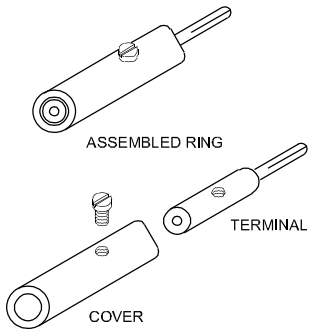


ELN1324HB

Prepare termination in a fine multistrand cable for single pole plug.

20 Open the given single pole plug. (Fig 12)

Fig 12

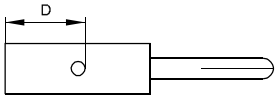


SINGLE POLE PLUG

ELN1324HC

21 Measure with a steel rule the distance 'D' between the outer edge of the terminal screw hole and the edge of the terminal. (Fig 13)

Fig 13



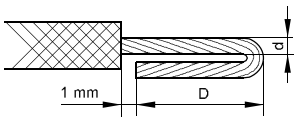
TERMINAL

ELN1324HD

22 Remove insulation to the length equal to (2D + 1) mm.

23 Bend a loop at the end of the wire to the required dimensions, with your fingers. (Fig 14)

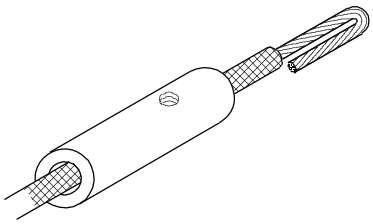
Fig 14



ELN1324HE

24 Push the wire through the cover of the plug. (Fig 15)

Fig 15

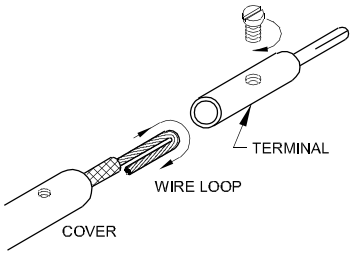


COVER OF THE PLUG

ELN1324HF

25 Insert the loop into the terminal (single pole plug). (Fig 16)

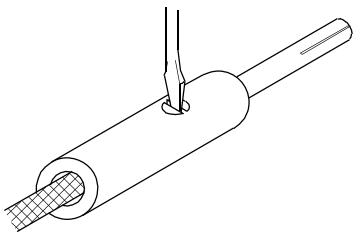
Fig 16



ELN1324HG

26 Assemble the plug by pushing its cover over the terminal and by inserting and tightening the terminal screw with a screwdriver. (Fig 17)

Fig 17



SCREWING THE TERMINAL OF THE PLUG

ELN1324HH

Practice on skinning, twisting and crimping

Objectives : At the end of this exercise you shall be able to
- **skin the cable insulation using the electrician's knife**
- **skin the cable insulation using manual stripper**
- **skin the cable insulation using auto-stripper**
- **practice on making a straight twist joint**
- **prepare termination of cable lugs using crimping tool.**

Requirements

Tools/Instruments

- Electrician tool kit - 1 No.
- Electrician's knife 100 mm blade - 1 No.
- Wire stripper, manual 200 mm - 1 No.
- Wire stripper auto–eject 150 mm - 1 No.
- Combination pliers 150 or 200 mm - 1 No.
- Steel rule 300 mm - 1 No.
- Diagonal cutter or side cutting pliers 150 mm - 1 No.

Materials

Aluminium cables of the following sizes:
- PVC single strand cable 1/1.4, 1.5 sq. mm - 3 m
- PVC single strand aluminium cable 1/1.8, 2.5sq. mm - 3 m

Flexible cables with copper conductor of size:
- PVC cable 14/0.2 mm - 3 m
- PVC cable 23/0.2 mm - 3 m
- PVC cable 48/0.2 mm - 3 m
- PVC cable 80/0.2 mm - 3 m
- PVC cable 128/0.2 mm - 3 m
- PVC cable,PVC sheathed cable – assorted small pieces -as reqd

PROCEDURE

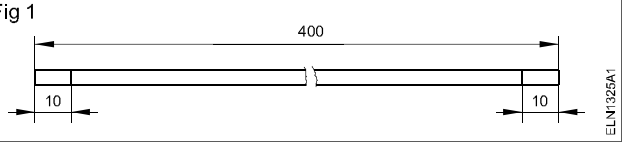
TASK 1 **: Skinning cable insulation using the electrician's knife**

1 Mark the length of the 1.5 sq. mm cable at 400 mm from its end.

2 Cut the cable using combination pliers on the mark.

3 Mark the length of insulation to be skinned from either end. (Fig 1)

Fig 1



4 Check the sharpness of the knife blade and re-sharpen, if necessary.

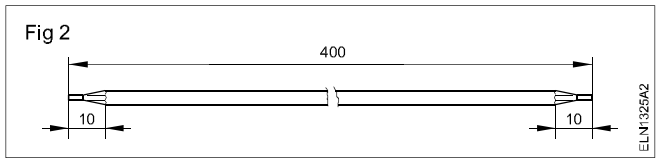
Use an oilstone to sharpen the knife's blade.

Visible thickness at the cutting edge of the knife blade indicates a blunt edge. In the case of a sharp edge, the thickness or end will not be visible.

5 Remove the insulation of the cable for about 10 mm at the ends using a knife. (Fig 2) Keep the knife blade at an angle less than 20° to the cable.

6 Check for nicking over the conductor. Also check if the cable is not shaved.

Fig 2



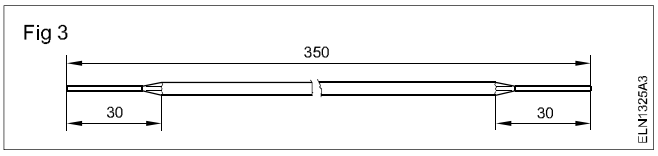
7 Clean the surface of the bare conductor and show it to the instructor.

8 Cut the cable at 12 mm from either end using a combination plier.

9 Repeat steps No.5 to No.8, until the cable is of 350 mm length

10 Mark the insulation that is to be removed as in Fig 3 and repeat steps 5 and 6.

Fig 3



11 Repeat the skinning of cable insulation of 2.5 sq. mm, 14/0.2 mm, 23/0.2 mm, 48/0.2 mm, 80/0.2 mm and 128/0.2 mm flexible cables.

The length of the cable after skinning both the ends shall be suitable for termination using crimping and screw.

12 The length of the finished skinned cable should be 300, 500, 600, 800, 1000 mm.

These cable pieces are to be used for later exercises.

In the case of flexible stranded cables to ensure that the strands are not cut is essental.

TASK 2**: Skinning cable insulation using a manual stripper**

1 Mark the length of the cable to be trimmed off.

2 Trim the cable at the mark using a combination plier diagonal cutter.

3 Straighten the ends where the insulation is to be skinned.

4 Mark the point where the insulation is to be skinned.

5 Adjust the jaws of the manual stripper and set them to suit the cable conductor.

6 Set the jaws at the mark, press the handle of the stripper and turn to cut the insulation.

Do not nick the conductor. For better practice try on a small waste piece.

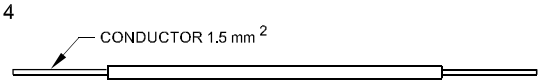
7 Pull the stripper to remove the insulation.

Partially cut insulation can be removed only with more force. Excessive force, indicates improper cutting of insulation.

8 Repeat the skinning of insulation for 10 mm to develop skill in the use of the wire stripper.

9 Remove insulation to the required extent at the ends as per Fig 4.

Fig 4



ELN1325A4

10 Be caeful with flexible cables to ensure that you do not nick even a single strand.

TASK 3**: Skinning cable insulations using auto-stripper**

1 Mark the length of the insulation to be removed from the ends.

2 Straighten the cable ends.

3 Select a proper set of stripper.

4 Locate the jaws of the stripper exactly on the mark.

5 Press the stripper.

Further pressing may damage the insulation from the cable end, that is also to be removed.

6 Check that the cable conductor is not nicked.

7 Repeat steps No 1 to 7 for different sizes of cables.

Skill sequence

Hand tools for skinning - knife

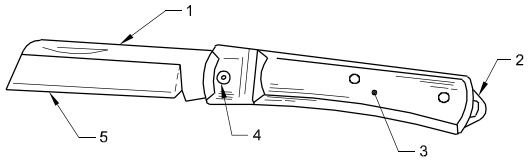
Objectives : This shall help you to
- **identify the parts of the knife used for skinning**
- **perform care and maintenance in using the knife.**

The most frequently used tool for skinning is the knife

A knife may have a single or double blade. A single blade knife is the most commonly used one. (Fig 1)

- back of the blade
- hanger
- haft
- hinge pin
- blade

Fig 1



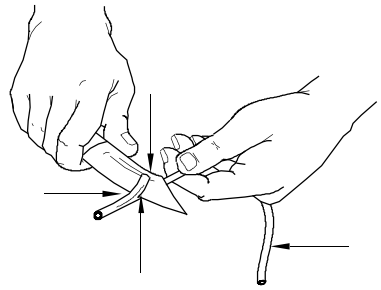
ELN1325B1

Becareful while using the knife.

Always cut keeping the object to be cut away from your body.

Slice the insulation at an angle of approximately 15° to avoid cutting into the conductor. (Fig 2)

Fig 2



ELN1325B2

Knives should not be used to remove insulation on very fine single or stranded conductors.

Knives should not be used to cut conductors.

Hand tools for skinning - manual wire stripper

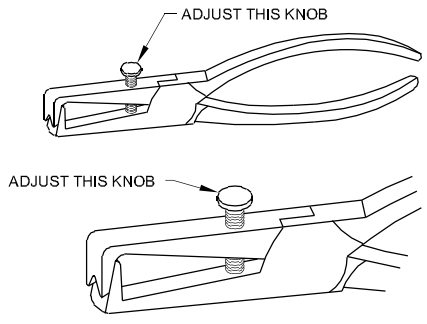
Objectives: This shall help you to
- **identify the parts of the manual wire stripper**
- **perform care and maintenance of manual wire stripper.**

Hand operated wire stripping tools can be used to remove P.V.C. or rubber insulation from a single core cable without damaging the conductor. They are of two types manual and auto-eject.

Manual wire stripper: The jaws have V shaped notches to cut the insulation.

The adjuster screw allows to cut a wide range of wire diameters. (Figs 1 and 2).

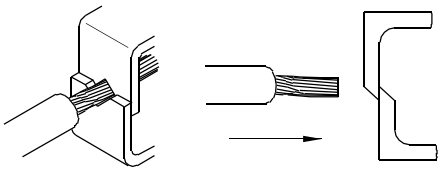
Fig 1



MANUAL STRIPPER

ELN1325C1

Fig 2



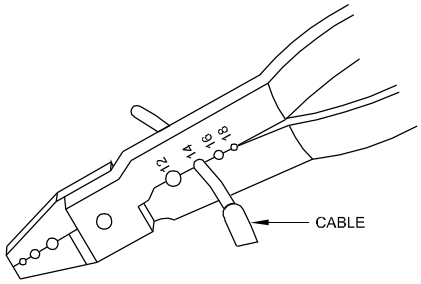
MANUAL STRIPPER

ELN1325C2

Often one cutter becomes sharper than the other, and cuts more than halfway through the wires, damaging the conductors. In such an event, the blunt cutter should be sharpened.

Fig 3 shows manual wire stripper.

Fig 3



MANUAL WIRE STRIPPER

ELN1325C3

This tool has a series of sharp openings in its scissor blade to allow stripping of wire in gauge of different sizes or diameters. The gauge size of the wire must match with the opening in the wire stripper to prevent cutting into the wire and weakening it.

Precautions:

- **When using this tool, make sure that it is correctly adjusted before trying to strip the insulation from the cable so that it does not damage the conductor.**
- **Do not use this tool to cut metallic conductors.**

Hand tools for skinning - auto-eject stripper

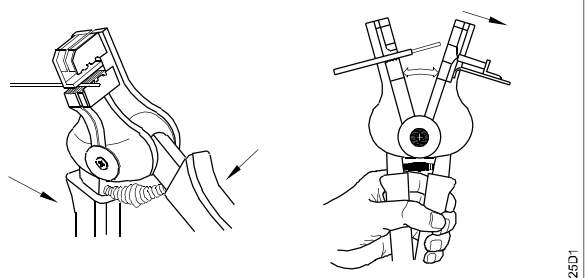
Objectives: This shall help you to
- **identify an auto-eject stripper**
- **take care while using an auto-eject stripper.**

Auto-eject strippers are used to cut the insulation from electrical wire without damaging the wire strands. They remove the insulation automatically. (Fig 1)

This stripper has two sets of jaws: one set grips the insulation while the other set has cutting edges.

When the handles are apart, both sets of jaws are open. (Fig 2)

Fig 1



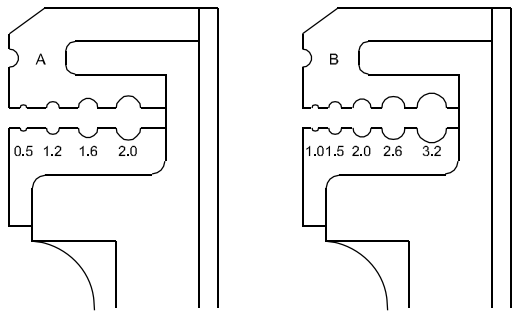
AUTO - STRIPPER

ELN1325D1

This stripper operates automatically when the correct position on the blade matching the diameter of conductor in mm is selected, and the handles are compressed together.

In an auto-eject stripper, we can select different of blades sizes to match different sizes of conductors.

Fig 2



JAWS OF AN AUTO STRIPPER

ELN1325D2

Precautions: While using this stripper the cable insulation should be put in the proper slot to avoid damage to the conductor.

Skinning - Using a knife

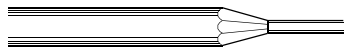
Objective : This shall help you to

- **strip the wire insulation with the electrician's knife.**

Material: PVC insulated the wire 2.5 sq. mm - 1 metre.

Tools: Electrician's knife (100 mm) - 1 No.

Fig 1



PENCIL CUT

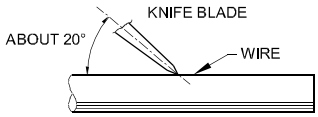
ELN1325F1

Pencil cut using a knife (Fig 1)

1 Set the knife to the wire

- Hold the section to be stripped on the ball of your index finger.
- Hold the knife at about 20 degrees angle. (Fig 2)

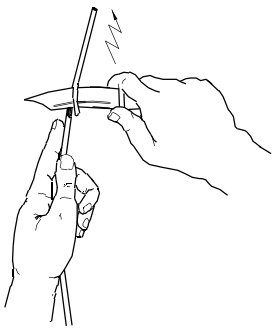
Fig 2



ELN1325F2

2 Cut the insulation. (Fig 3)

Fig 3



ELN1325F3

- Move the knife forward as you saw it back and forth.

Be sure not to damage the core.

- Move your index finger along the direction of cutting.

Sub Exercise (S.Ex.) 1.3.25 - 1

Prepare termination of cable lugs by using crimping tool

Objectives: At the end of this exercise you shall be able to
- **skin the cable end**
- **select the pressure terminal (compression connector) that suits the size of the wire and that of the terminal**
- **select the pressure pliers that match the size of the pressure terminal**
- **use the crimping tool to crimp the lugs at the cable end.**
- **use an eyelet crimping plier for eyelet termination.**

Requirements

Tools/ Instruments

- Pressure pliers 200 mm - 1 No.
- Electrician's knife 100 mm - 1 No.
- Wire stripper (manual) 200 mm - 1 No.
- Combination pliers 200 mm - 1 No.
- Crimping pliers 150/200 mm - 1 No.
- Wire stripper auto-eject 200 mm - 1 No.
- Steel rule 300 mm - 1 No.
- Side cutting pliers 150 mm - 1 No.
- Eyelet closing pliers 200 mm with eyelets having inner diameter of 3,4,5,6,7 mm. - 1 No.

Materials

- Crimping eyelet, eye hole dia. 6 mm - 12 Nos.
- Crimping ferrule 4 mm,10 mm long - 6 Nos.
- Crimping spade lug 6A - 6 Nos.
- Crimping spade lug 10A - 6 Nos.
- Crimping spade lug 16A - 2 Nos.
- Conducting paste - 1 tube

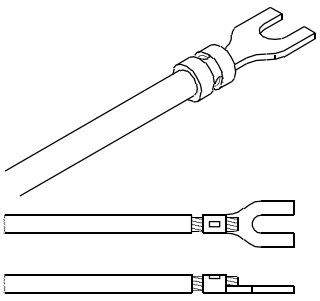
PROCEDURE

TASK 2 **: Crimping of lug connector**

1 Collect the cable (fine multi-strand copper conductor).

2 Collect the spade connector suitable for the wire thickness and terminal size of 6 mm diameter (Fig 1, 2 & 3).

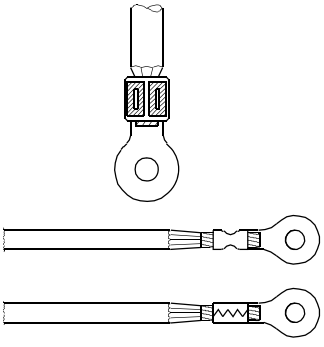
Fig 1



CRIMPED ON SPADE CONNECTOR

ELN1325G1

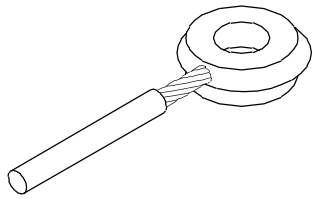
Fig 2



CRIMPED ON EYELET LUG USING PRESSURE PLIERS

ELN1325G2

Fig 3

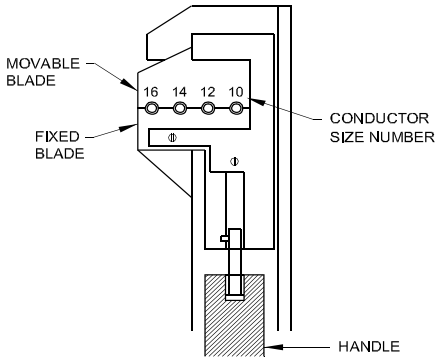


CRIMPED ON CLOSED LUG CONNECTOR

ELN1325G3

3 Select the wire stripper blade size to match the wires thickness (auto-eject) or adjust the jaws of the stripper. (Fig 4)

Fig 4



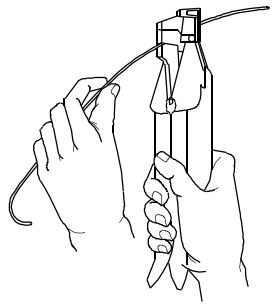
AUTO - WIRE STRIPPER

ELN1325G4

4 Strip a length of insulation that suits the terminal size (spade connector) (Fig 5)

Be sure not to cut or damage the wire core.

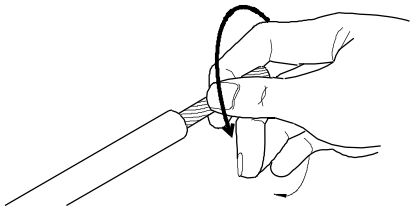
Fig 5



ELN1325G5

5 Twist the strands of the wire lightly in the direction of strands. (Fig 6)

Fig 6



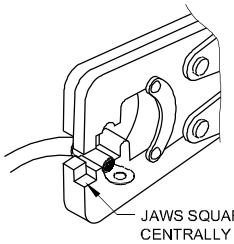
ELN1325G6

6 Select the crimping pliers that matches the terminal size.

7 Clamp the spade connector with the crimping pliers with the matching position of jaws.

8 Insert the wire far enough in the compression connector. (Fig 7)

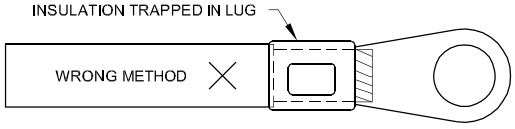
Fig 7



ELN1325G7

Do not clamp the insulation in the terminal. (Fig 8)

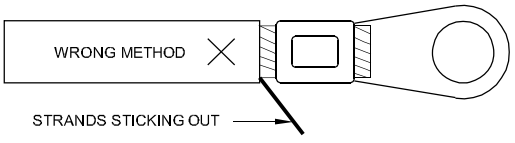
Fig 8



ELN1325G8

Strands must not stick out of the connector. (Fig 9)

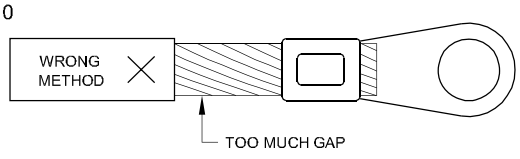
Fig 9



ELN1325G9

Do not strip too much insulation. (Fig 10)

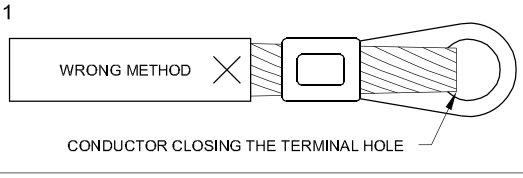
Fig 10



ELN1325GA

Adjust the length of the wire so that it does not interfere with the terminal hole. (Fig 11)

Fig 11



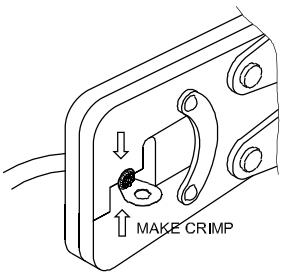
ELN1325GB

9 Apply light pressure to create a light impression on the compression connector.

10 Check whether the press is located in the middle of the band of compression connector and, if necessary, make final adjustment.

11 Apply sufficient pressure in the handle to press the compression connector fully, as shown in Fig 12.

Fig 12



ELN1325GC

12 Check whether the prepared compression/crimping joint is firm by pulling the cable and compression connector.

13 Repeat the crimping of compression in the connectors of various sizes of copper and aluminium conductors of different lengths.

Trim the appropriate length of the skinned cable ends to suit the compression connectors.

The types of compression connectors to be fixed at the cable ends will be as prescribed by your instructor. Fig 2 shows the eyelet lug compression connected/crimped on to the flexible cable.

TASK 3**: Crimping an eyelet**

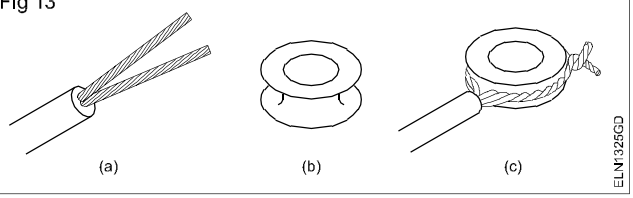
1 Collect the multi-strand cable.

2 Split the number of strands into two equal parts and twist them. (Fig 13a)

3 Collect the eyelet. (Fig 13b)

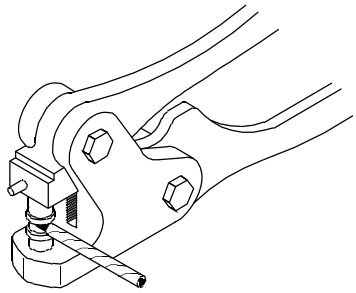
4 Fix the eyelet by placing the eyelet between the grouped strands close to the insulation and twist the free ends of the strands as shown in Fig 13c.

Fig 13



The eyelet is then pressed on to the wire end by the two formers of the eyelet closing pliers. (Fig 14)

Fig 14



5 Trim the excess length of the multi-strand wire after closing the eyelet using side-cutting pliers.

6 Repeat the exercise with different sizes of eyelets for cable end termination.

7 Get it checked by your instructor.

TASK 4**: Practice on twisting of single strand wires**

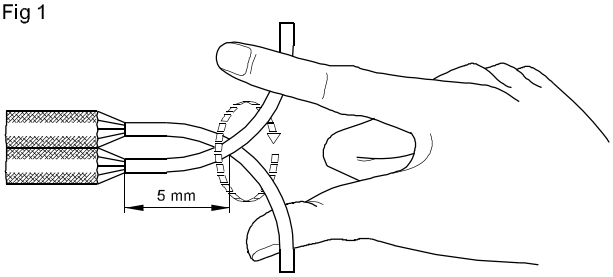
1 Take 30 mm of 1/1.5 mm^2 aluminium wire, or 1/1.2 mm P.V.C copper cable.

2 Cut it into two pieces of 150 mm each.

3 Remove the insulation of 50 mm in each piece by using stripper and clean it with cotton cloth.

4 Cross the bare wires at 45º and at a distance of 45 mm from the cable end. (Fig 1)

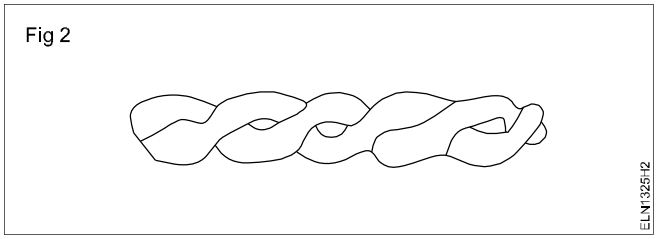
Fig 1



5 Twist the ends tightly at least 6-8 twists. (Fig 2)

While twisting 2 wires together avoid gaps between the twists. If it twisted with gap, it will trigger sparks and overheat as shown in Fig 2.

Fig 2



6 Finish twisting the wires as shown in figure 3 & 4.

Fig 3

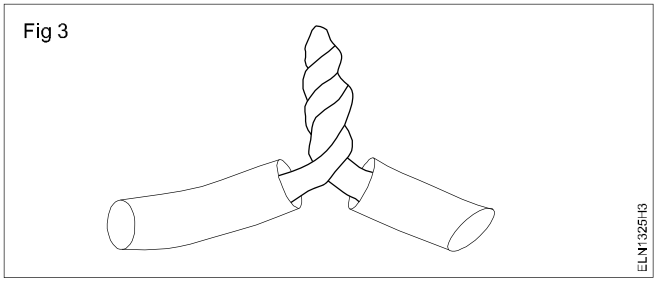
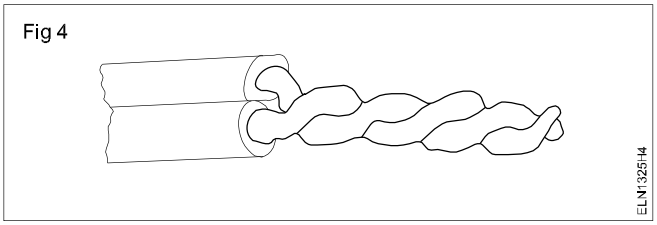


Fig 4

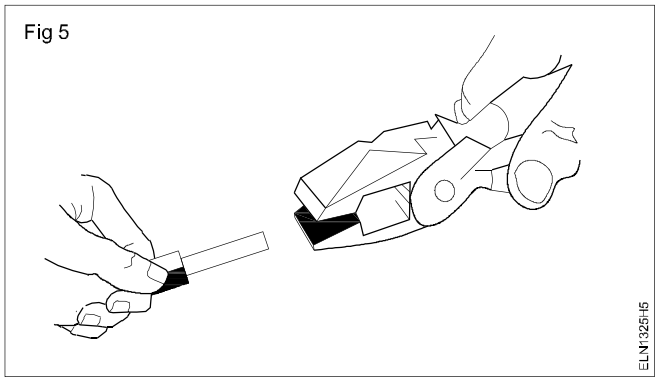


7 Get it checked by your instructor.

Joining of wires by twisting using plier.

8 Hold wires together near the plier. (Fig 5)

Fig 5



9 Grab both the copper ends with pliers.

10 Rotate your wrist while using pressure on pliers.

When joining three large wires, strip the insulation more.

Connecting a stranded wire to a solid wire.

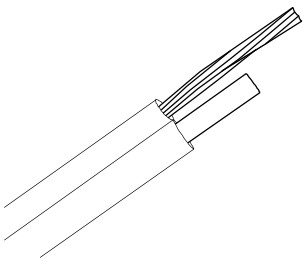
If the stranded wire is thinner than the solid wire

- Strip the stranded wire so that there is more copper visible than solid wires.
- Wrap the stranded wire around solid copper
- Leave the solid wire straight

When connecting two solids that are stranded,

- First,twist the solids together
- Wrap the stranded wire around the solids.
- Apply the wire nut tight. (Fig 6)

Fig 6



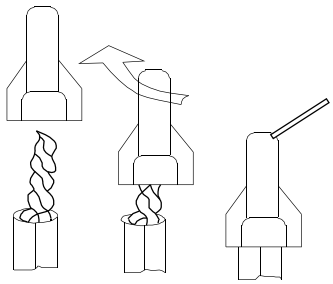
ELN1325H6

- Pull the stranded wire to make sure it is tight.

If the surrounded wire is of the same diameter,

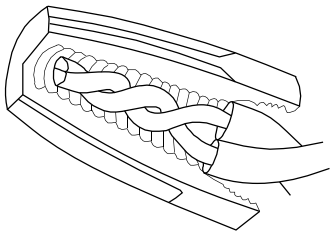
- Cut both to the same length.
- Cover the wire with wire nut and twist it. (Fig 7 & 8)

Fig 7



ELN1325H7

Fig 8



ELN1325H8

Scan the QR Code to view the video for this exercise

Identify various types of cables and measure conductor size using SWG and micrometer

Objectives: At the end of this exercise you shall be able to
- **identify types of wires and cables**
- **verify their specifications referring to the data book**
- **measure wire sizes using SWG**
- **measure wire size using micrometers.**

Requirements

Tools / Instruments

- Standard Wire Gauge (SWG 0-36) - 1 No.
- Micrometer (0-25) - 1 No.
- Electrician's knife - 1 No.
- Manual wire stripper 150 mm - 1 No.
- Combination pliers 150 mm - 1 No.

Materials

- Wires (assorted size) - as required.
- Cables (underground armoured and unarmoured cable) - as required.
- Wire/ cable specification data book - 1 No.

PROCEDURE

TASK 1: **Identify types of wires and cables**

The instructor will arrange and provide the various types of cable and wire pieces (assorted sizes) on the table and label them with alphabets and explain them to trainees on, how to identify the types of insulation, conductors, size of wires. Demonstrate how to measure the size of wires using SWG and micrometer.

1 Take any one wire from the table, note down its aplhabet in Table 1.

2 Identify the type of insulation, type of conductor material and size of wires. Note it down in Table 1.

3 Take at least five different types of wires and repeat steps 1 and 2 Note down the details in Table 1.

4 Verify the specifications of the wires by referring with the data book.

5 Take any one cable from the table, note down its alphabet.

6 Identify the type of cable (unarmoured and armoured cable) and note down in Table 1.

7 Identify the type of insulation, core and record in Table 1.

8 Verify the specifications of the cable by referring with the data book.

9 Repeat steps 1 to 8 for various wires and note the data in Table 1.

Table 1

Sl. No.	Alphabet	Type of insulation	Type of conductor material	Type of cable		Type of core single/3/3½	Core size in mm
				Armoured	Unarmoured		
1	A						
2	B						
3	C						
4	D						
5	E						

— — — — — —

TASK 2: **Measuring the wire sizes by SWG in gauge number**

1 Skin the insulation of the cable.

Exercise care to prevent from nicking.

2 Clean the surface of the wire with a cotton cloth. Remove insulation particles and any adhesive coating from the surface of the conductor.

Do not use abrasives to clean the conductor. Use of abrasive material, reduces the size of the conductor.

3 Straighten the end of the conductor to be measured.

Do not straighten conductors by directly using hand tools on them.

4 Insert the conductor in the slot of the wire gauge and determine its close fit. (Fig 1)

5 Read the marking at the slot, Fig 2. It gives the wire size in SWG. The other side will give you the diameter. of the wire in mm.

6 Record the measured size in Table 1.

Fig 1

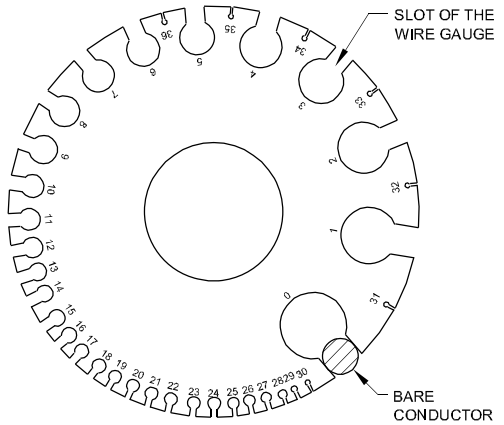
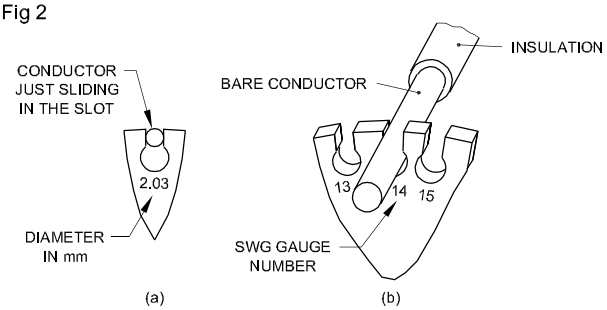


Fig 2



TASK 3: **Measuring the wire size, using micrometer**

1 Repeat steps 1-3 of TASK 2.

2 Check the micrometer for zero error by operating the spindle.

3 Record the error value with the sign- +ve or –ve.

4 Place the cleaned, straight portion of the conductor between the jaws (anvil and spindle) of the micrometer. (Fig 3)

5 Close the spindle of the micrometer by turning the thimble.

Use the ratchet drive to avoid overtightening.

6 Read and record the diameter in Table 1 after computing zero error.

7 Refer to the conversion table (Table 2) to get the size of the conductor in the standard wire gauge.

8 Repeat the steps to find the measurement for the given cables.

Fig 3

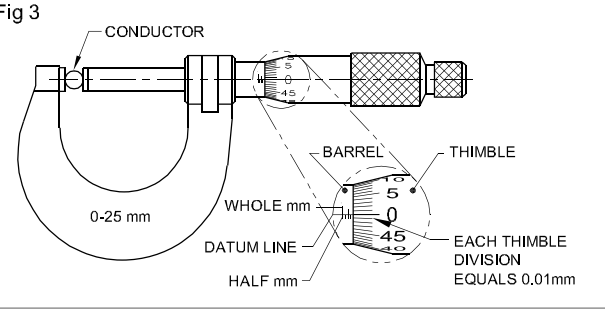


Table 2

Conversion table : SWG to inch/mm

No.	Inch	mm
7/0	0.500	12.7
6/0	0.464	11.38
5/0	0.432	10.92
4/0	0.400	10.16
3/0	0.372	9.44
2/0	0.348	8.83
0	0.324	8.23
1	0.300	7.62
2	0.276	7.01
3	0.252	6.40
4	0.234	5.89
5	0.212	5.38
6	0.192	4.88
7	0.176	4.47
8	0.160	4.06
9	0.144	3.66
10	0.128	3.25
11	0.116	2.95
12	0.104	2.64
13	0.092	2.34
14	0.080	2.03
15	0.072	1.83
16	0.064	1.63
17	0.056	1.42
18	0.048	1.22
19	0.040	1.02
20	0.036	0.91
21	0.032	0.81
22	0.028	0.71

No.	Inch	mm
23	0.024	0.61
24	0.022	0.56
25	0.020	0.51
26	0.018	0.46
27	0.0164	0.42
28	0.0148	0.38
29	0.0136	0.34
30	0.0124	0.31
31	0.0116	0.29
32	0.0108	0.27
33	0.0100	0.25
34	0.0092	0.23
35	0.0084	0.21
36	0.0076	0.19
37	0.0068	0.17
38	0.0060	0.15
39	0.0052	0.13
40	0.0048	0.12
41	0.0044	0.11
42	0.0040	0.10
43	0.0036	0.09
44	0.0032	0.08
45	0.0028	0.07
46	0.0024	0.06
47	0.0020	0.05
48	0.0016	0.04
49	0.0012	0.03
50	0.0010	0.02

Make simple twist, married, Tee and western union joints

Objectives : At the end of this exercise you shall be able to
- **mark the length of the insulation to be removed**
- **skin the insulation**
- **prepare simple twist joint**
- **prepar married joint in stranded conductor**
- **prepare 'T' joint in multistranded conductor**
- **prepare western union joint in bare conductor.**

Requirements

Tools/Instruments

- Electrician's knife with two folding steel blades of 75 mm and 100 mm - 1 No.
- stainless steel rule 300 mm, with graduations on either edge cm/mm and inches - 1 No.
- Diagonal cutting pliers 150 mm with 660 volts grade insulated handle suitable for cutting hard wires - 1 No.
- Combination pliers 200 mm with 660 volts grade insulated handles with pipe grip, side cutter and two joint cutters - 1 No.
- Wooden mallet 75 mm - 1 No.
- Flat file - bastard 250 mm - 1 No.
- Hard vice 58 mm - 1 No.

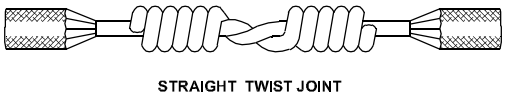
Materials

- PVC insulated copper cable 1/1.12 - 2 m.
- PVC insulated aluminium cable 1/1.40 - 2 m.
- Cotton cloth 30 cm square - 1 No.
- Sandpaper `OO' (smooth) - 1 sheet
- PVC insulated copper cable 7/0.914/600V - 1 m.
- PVC insulated copper cable 3/0.914/250V - 1 m.
- Bare copper wire 4 mm 30 cm - 2 Nos.
- GI wire 4 mm 30 cm - 2 Nos.
- Sand Paper 'O' grade - 1 sheet

PROCEDURE

TASK 1: **Make simple (straight) twist joint as shown in Fig 1**

Fig 1



STRAIGHT TWIST JOINT

ELN1327H1

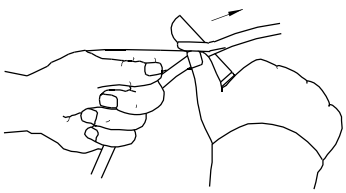
1 Collect 2 pieces of 1/1.12 PVC copper cable of 0.5 m length.

2 Straighten the cables.

3 Mark 80 mm length on one end of each piece of the cable.

4 Use the knife at 20° as shown in Fig 2.

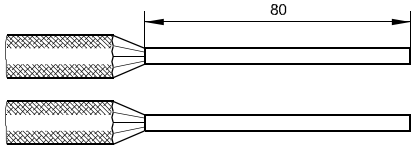
Fig 2



ELN1327H2

5 Remove the insulation from each conductor for a length of 50 mm. (Fig 3)

Fig 3



ELN1327H3

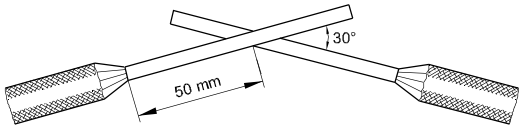
Avoid nicks in the conductor.

6 Clean the ends with the help of a cotton cloth.

Use smooth sandpaper, if necessary, to clean the conductor.

7 Place the conductors together, about 50 mm from the ends. (Fig 4)

Fig 4



ELN1327H4

8 Twist them tightly around each other in the opposite directions. (Fig 1)

Pliers can be used to just grip the crossed conductors.

Each side should contain about 6 turns.

Each turn of the conductor should closely fit to the adjacent turn.

9 Cut the excess length of the conductor using side cutters.

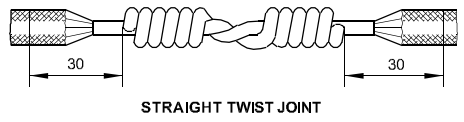
10 Press the sharp edge of the conductor end and smooth it.

Soldering the joint and insulating it with tape should be completed before putting the jointed cable in use.

11 Show the joint to your instructor.

12 Cut the joint after leaving 30 mm cable from the joint. (Fig 5)

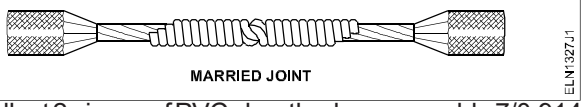
Fig 5



13 Repeat steps 3 to 9 and make at least 4 more joints for practice, using the remaining cable.

TASK 2: **Prepare married joint in 7/0.914 stranded conductors as shown in Fig 1**

Fig 1



1 Collect 2 pieces of PVC sheathed copper cable 7/0.914 0.5 metre in leagth.

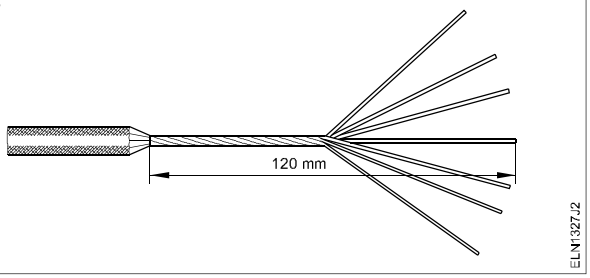
2 Mark both the the cables at 120 mm from the cable ends.

3 Remove the insulation for 120 mm on both the cables.

Carefully remove the insulation. Do not nick or shave the conductor.

4 Open the strands, clean the wires, and re-twist the strands in the original direction up to 50 mm from the cable insulation. (Fig 2)

Fig 2



5 Cut the centre strand of both the cables close to the twist (about 70 mm from the free end).

6 Bind on the twisted part of one cable end as shown in Fig 3.

7 Interlace the strands keeping the centres butt. (Fig 4)

Fig 3

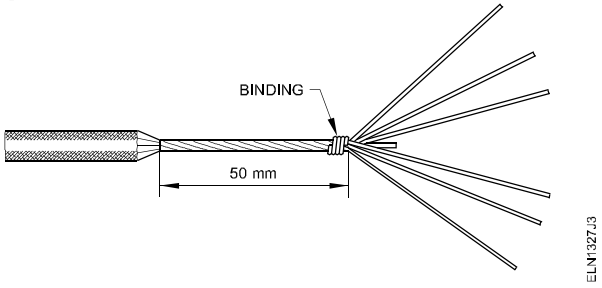
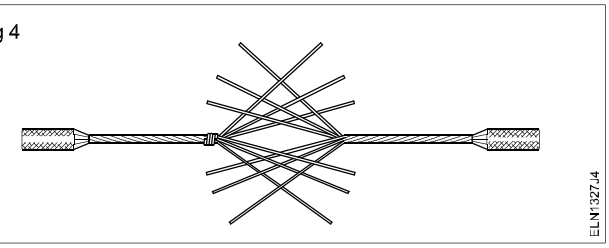


Fig 4



8 Hold the cable end (that is without the binding) in one hand and twist the strands of the other cable end over it, one by one, closely and tightly. Each strand has to be twisted half a turn at a time.

The direction of twist to form the shoulder should be the same as that of the cable twist .

9 Remove the binding made in step 6.

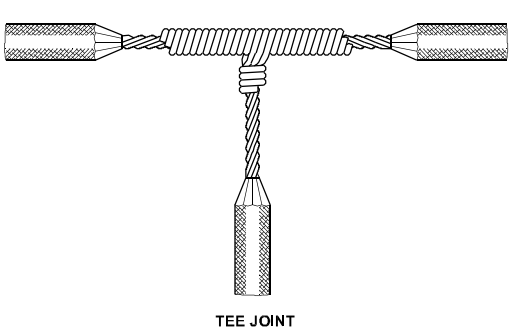
10 Repeat the operation as in step 8 on the other side with the 2nd cable end.

11 Complete the joint as shown in Fig 1 by rounding off the twisted strands with a mallet or pliers, and cut the excess wires.

TASK 3: **Prepare 'T' joint in multi-stranded conductor**

Fig 1 shows a completed Tee joint in standard conductors.

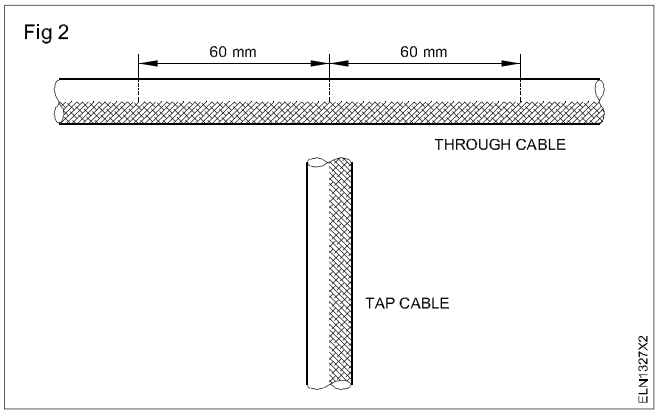
Fig 1



1 Collect two pieces of PVC insulated stranded copper cable 7/0.91. Indicate one piece as `through cable' and the other one as `tap cable'.

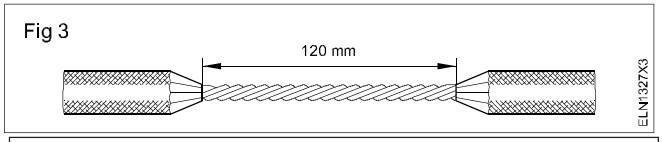
2 Mark the point of tap in the `through cable' and mark 60 mm on either side of the tap point for the insulation to be removed as shown in Fig 2.

Fig 2



3 Remove 60 mm insulation on either side of the `through cable' from the point of tap. (Fig 3)

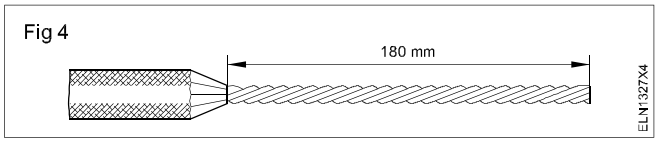
Fig 3



Do not nick or shave the conductor while removing insulation.

4 Remove the insulation for 180 mm at the end of the `tap cable'. (Fig 4)

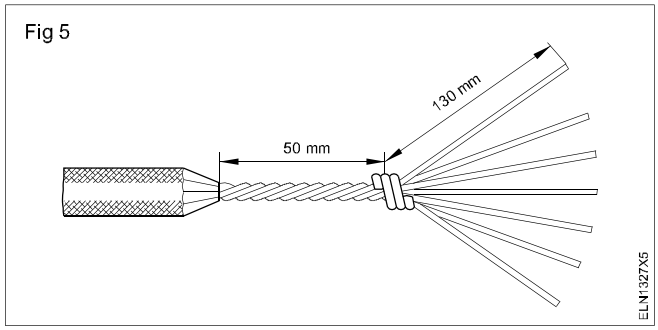
Fig 4



5 Open the strands of the `tap cable' and clean it. Use smooth `00' sandpaper, if necessary.

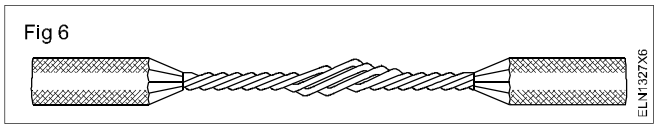
6 Re-twist the strands in the original direction up to 50 mm from insulation, and make a binding on the twisted part of the `tap cable' as shown in Fig 5.

Fig 5



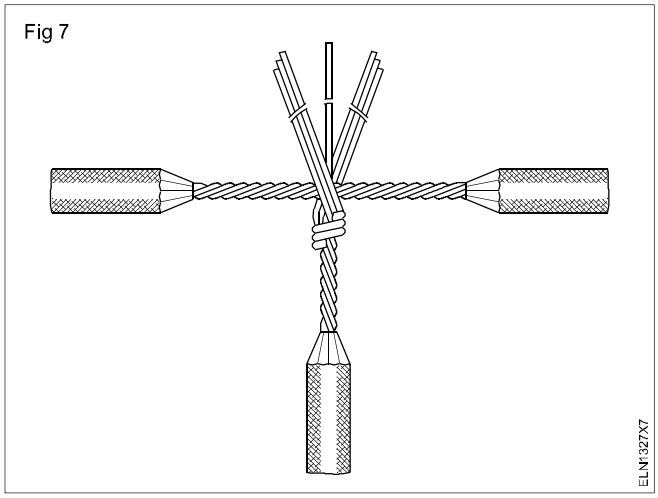
7 Untwist the `through cable' to provide opening at the point of tap. (Fig 6)

Fig 6



8 Insert the centre (middle) strand of the `tap cable' in the opening of the 'through cable' as shown in Fig 7.

Fig 7



9 Wrap 3 strands of the `tap cable' around the `through cable' on either side of the tap point to form shoulder on `through cable'.

10 Wrap the strands up to 50 mm to leave a 10 mm gap between insulation and shoulders (Fig 1) and trim the excess length of strands.

11 Remove the binding from the `tap cable', wrap the centre strand of the `tap cable' around the `through cable' and wrap it in the place of the binding. (Fig 1)

12 Round the ends with the combination pliers or mallet to avoid sharp edges of the strands.

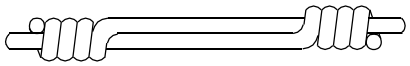
13 Collect two pieces of PVC stranded aluminium cable 19/1.12, or 19/1.63, 500 mm long and repeat working steps 2 to 12.

With 19/1.2, 19/1.63 mm cable, 9 strands of the `tap cable' are to be wrapped on either side of the `through cable'. Insulation that has to be removed is 170 mm on the `through cable' and 250 mm on the `tap cable'.

TASK 4: **Prepare western union joint in bare conductor**

(A completed western union joint is shown in Fig 1.)

Fig 1



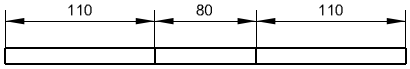
ELN1327Z1

1 Collect two pieces of bare copper conductor of 4 mm diameter. and 30 cm long.

2 Straighten the conductor with a mallet.

3 Mark the conductor as shown in Fig 2.

Fig 2

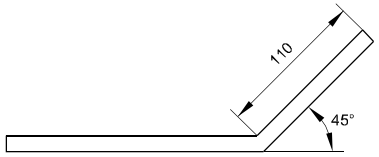


ELN1327Z2

4 Clean both the conductors with `00' grade sandpaper to a length of 250 mm from one end.

5 Bend both the pieces of conductors at a distance of 110 mm from one end to 45° as shown in Fig 3.

Fig 3

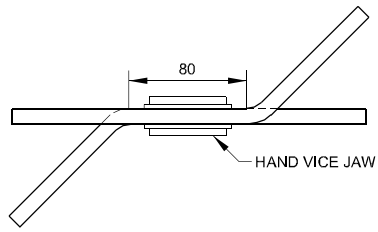


ELN1327Z3

6 Hold the conductors in the hand vice as shown in Fig 4.

To avoid nicks on the conductors while gripping in a hand vice, always use soft materials like aluminium sheets between the jaws.

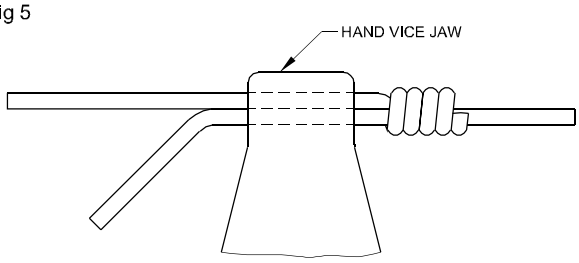
Fig 4



ELN1327Z4

7 Wrap one conductor over the other conductor using combination pliers. Make at least 5 to 6 turns as shown in Fig 5.

Fig 5



ELN1327Z5

8 Repeat the same procedure in the other end of the conductor, but wrap the conductor in the opposite direction.

9 Cut the surplus conductor ends with a diagonal cutter.

10 Use a mallet to mesh the ends with the straight conductor.

11 Smoothen the ends of the conductors with a flat file to avoid sharp edges.

12 Repeat the Western union joint with G.I. wire of diameter 4 mm.

Scan the QR Code to view the video for this exercise

Make britannia straight, britannia 'T' (Tee) and rat tail joints

Objectives : At the end of this exercise you shall be able to
- **make britannia straight joint in solid copper conductor**
- **make britannia 'T' (Tee) joint in solid copper conductor**
- **make rat tail joint.**

Requirements

Tools/Instruments

• Steel rule 300 mm	- 1 No.
• Diagonal cutting plier 150 mm	- 1 No.
• Combination plier 200 mm	- 1 No.
• Hand vice 50 mm jaw	- 1 No.
• Flat file bastard 200 mm	- 1 No.
• Wooden mallet 75 mm diameter.	- 1 No.

Materials

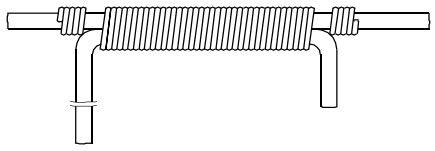
• Hard drawn bare copper wire 4 mm diameter 0.2 metre	- 4 Nos.
• Tinned copper wire of dia. 0.91 mm	- 4 m.
• Sandpaper `0 0'	- 1 sheet
• Cotton cloth 300 x 300 mm	- 1 No.
• PVC copper cable 1/1.2 mm 8.5 m	- 2 Nos.

PROCEDURE

TASK 1: **Make brittannia straight joint**

(A completed britannia straight joint is shown in Fig 1.)

Fig 1



BRITANNIA TEE JOINT

ELN1328H1

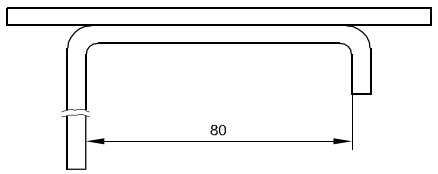
1 Collect two pieces of 4 mm diameter Hard Drawn Bare Copper (H.D.B.C) . wire, 0.2 m long.

2 Straighten the conductors using a mallet and clean it using fine sandpaper and cotton cloth.

Use the mallet to make the wires straight. The two pieces should be free from twists over the entire length of the joint.

3 Bend each piece at one end for about 20 mm length at 90° as shown in Fig 2.

Fig 2



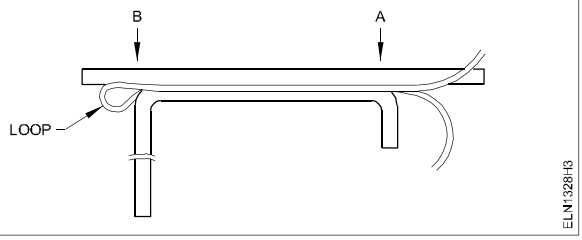
ELN1328H2

4 Collect the binding wire and straighten it without any kink.

5 Hold the two ends of the bare copper wire to be joined in the hand vice as shown in Fig 2.

6 Form a loop of binding wire leaving one end about 250 mm at the right side of the joint. Place the binding wire in the groove formed in between the main conductors as shown in Fig 3.

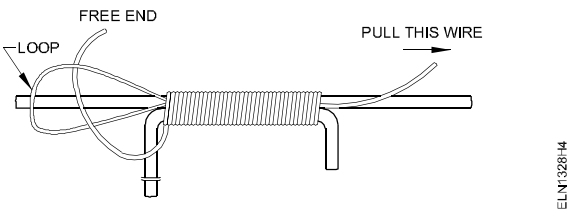
Fig 3



ELN1328H3

7 Start binding the wire tightly over the joint from position `A' and continue till position `B'. (Fig 4)

Fig 4



ELN1328H4

8 Insert the free end of the wire inside the loop as shown in Fig 4.

9 Grip the 250 mm loose end of the wire with a pair of pliers, and carefully pull it so that the loop and the free end of the wire go inside the joint.

10 Wrap the free end and the loose end over the conductors as shown in Fig 1.

11 Press the ends of the binding wire to the conductors with pliers .

12 Smooth the sharp edges of the protruding wire ends with a flat file.

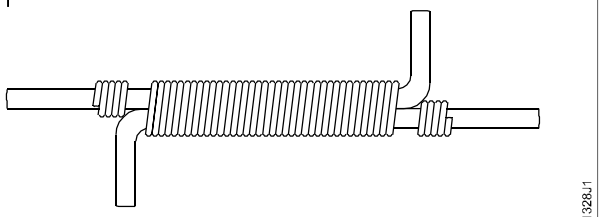
13 Repeat the above steps and make two or more joints to get more practice.

After completion the joint must be soldered before putting it to use.

TASK 2: **Make britannia 'T' joint**

(A completed britannia `Tee' joint is shown in Fig 1.)

Fig 1

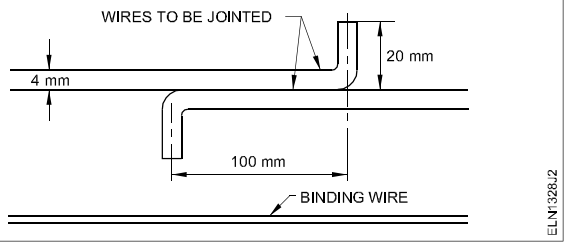


1 Collect two pieces of 4 mm diameter Hard Drawn Bare copper (H.D.B.C) 0.2 m long.

2 Straighten the conductors using a mallet and clean it with fine sandpaper and cotton cloth.

3 Bend and shape of one of the conductors according to the size shown in Fig 2, with the help of combination pliers.

Fig 2



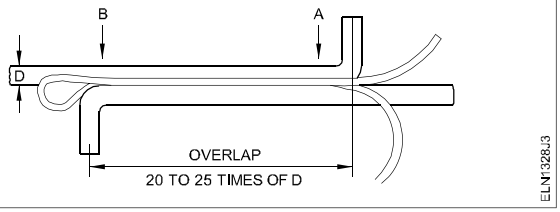
4 Straighten the (0.914 mm diameter.) binding wire.

5 Hold the two copper conductors to be joined with the help of a hand vice as shown in Fig 2 .

6 Form a loop of binding wire leaving one end about 250 mm at the right side of the joint. Place the binding wire in the groove formed between the conductors as shown in Fig 3.

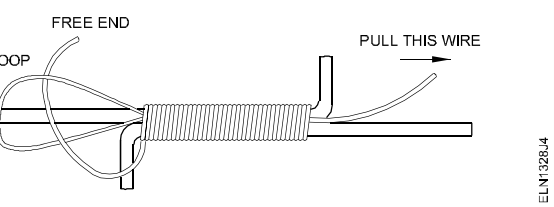
7 Start binding the wire tightly over the joint from position `A' and continue till the position `B'. (Fig 3)

Fig 3



8 Insert the free end of the wire inside the loop as shown in Fig 4.

Fig 4



9 Grip the 250 mm loose end of the wire with a plier, and carefully pull it so that the loop and the free end of the wire go inside the joint.

10 Wrap the free end and the loose end over the conductors as shown in Fig 1.

11 Press the ends of the binding wire to the conductors with plier.

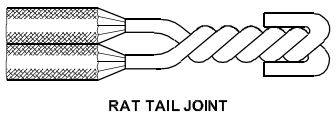
12 Smooth the sharp edges of the binding wire ends with a flat file.

13 Repeat the above procedure to make two or more joints to get more practice.

The joints need to be soldered before putting them into use.

TASK 3: **Make rat-tail joint** (Fig 1)

Fig 1



RAT TAIL JOINT

ELN1328X1

1 Collect 2 pieces of 1/1.2 mm PVC copper cable of 0.5 m length.

2 Straighten the cables.

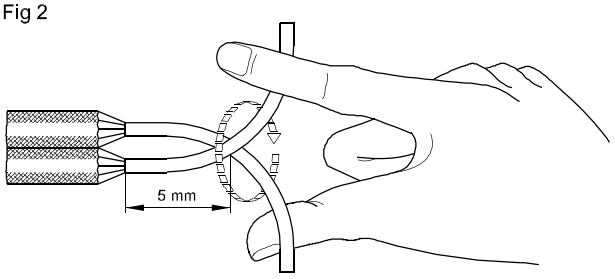
3 Skin both the cable ends for 50 mm.

4 Clean the conductor ends with the help of cotton cloth.

5 Cross the bare wires at of 45° and at a distance of 45 mm from the cable end.

6 Tightly twist the ends as shown in Fig 2.

Fig 2

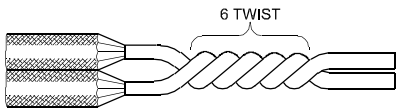


ELN1328X2

The twist on the wire should be uniform and close.

7 Make at least 6 twists. (Fig 3)

Fig 3



ELN1328X3

8 Fold the remaining wire back on the twists. (Fig 1)

9 Press the ends of the wire with the help of combination pliers (Fig 1) to avoid sharp ends, and cut the excess wire.

10 Repeat the steps.3 to 8 of TASK 3 for at least 4 more joints for practice, using the remaining cable.

Practice in Soldering of joints/lugs

Objectives : At the end of this exercise you shall be able to
- **solder the copper conductor joints using a soldering iron and rosin solder**
- **solder the lugs in copper conductor with the help of a blow lamp.**

Requirements

Tools/Instruments

- Electrician tool kit - 1 No.
- Combination piler 200 mm - 1 No.
- Electric soldering iron 125W, 250V, 50Hz - 1 No.
- Flat file bastard 250 mm - 1 No.
- Electrician's knife 100 mm - 1 No.
- Steel rule 300 mm - 1 No.
- Diagonal cutting plier 150 mm - 1 No.
- Blowlamp 1 litre capacity - 1 No.
- Tongs 300 mm - 1 No.
- Sheet steel tray 150 x 150 x 20 mm - 1 No.

Materials

- Finished simple twist joint - 1 No.
- Sandpaper 'OO' grade - 9 Sq.cm
- Resin-cored solder - 25 gms
- VIR or PVC copper cable 7/1.06 mm or 7/0.914 - 250 mm long - 2 pieces
- Lug 30 amperes - 1 No.
- Resin flux - 10 gms.
- Solder stick 60/40 - 100 gms.
- Matchbox - 1 No.
- Cotton tape or cloth - as required.
- Sandpaper `O' grade - 9 sq. cm.
- Blowlamp pin - 1 No.
- Kerosene - 1 litr.

PROCEDURE

TASK 1: **Solder the copper joints**

(A finished soldered joint will look like Fig 1.)

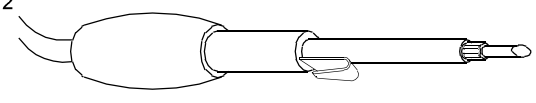
Fig 1

SOLDERED JOINT

ELN:329-H1

1 Select a 60W, 240V AC 50 Hz. soldering iron (Fig 2) and check that the iron has no physical damage, the body is well insulated from the element and is of the correct voltage and power rating.

Fig 2



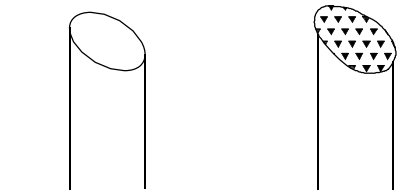
ELECTRIC SOLDERING IRON

ELN:329-H2

A soldering iron should show continuity between its terminals. Insulation resistance between the terminal and the body should not be less than 2 megohms. Report to your instructor in case the insulation resistance is less than 2 megohms. Do not use the iron unless it is cleared by your instructor.

2 Check the bit (Fig 3) to see whether the surface is smooth and clean.

Fig 3

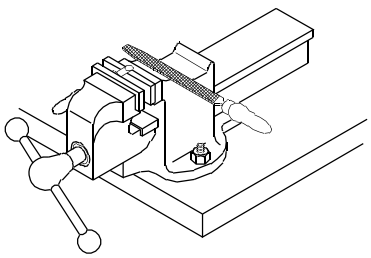


SOLDERING BITS

ELN:329-H3

3 If found corroded, file the tip with a flat file, so that the surface is smooth and clean. (Fig 4)

Fig 4

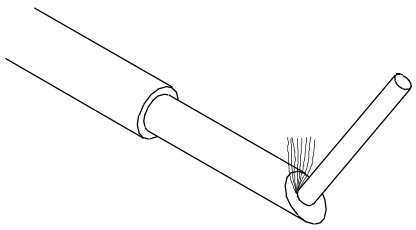


ELN:329-H4

4 Connect the soldering iron to the supply and switch it `ON'.

5 When the bit becomes sufficiently hot, apply a small quantity of rosin-cored solder, and tin the bit. (Fig 5)

Fig 5



TINNING THE SOLDERING BIT

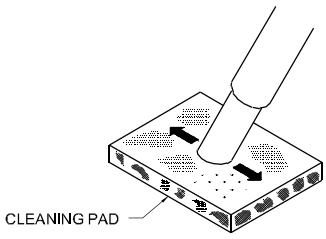
ELN1329H5

If the bit is not completely and evenly covered with solder, clean and tin it again.

Never flick excess solder off the bit. The hot solder may cause burns to someone or fall 0n the work and cause a short circuit.

6 Wipe the bit gently on the cleaning pad to remove excess solder as shown in Fig 6.

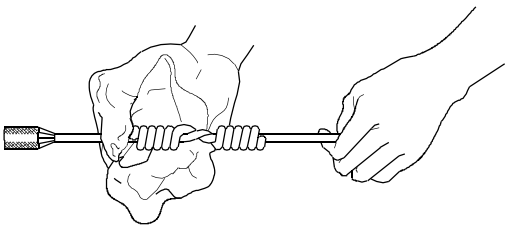
Fig 6



ELN1329H6

7 Clean the joint to be soldered with the help of sandpaper `0 0', grade as shown in Fig 7, and wipe the dust with a wire brush.

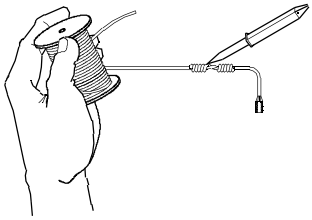
Fig 7



ELN1329H7

8 Keep the soldering iron bit on the joint and heat it for soldering as shown in Fig 8.

Fig 8

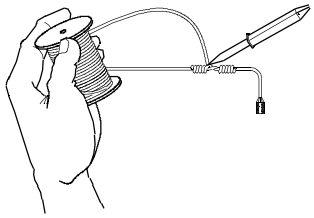


SOLDERING A SMALL SIZED JOINT

ELN1329H8

9 Keep the rosin-cored solder on the wire joint and allow it to melt as shown in Fig 9.

Fig 9



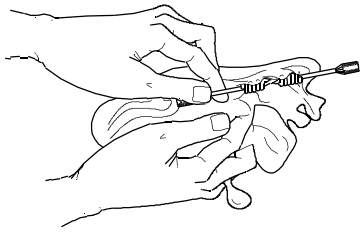
SOLDERING A SMALL SIZED JOINT

ELN1329H9

10 Melt the solder with the heat of the bit and make sure that the solder flows freely and evenly on the joint.

11 Remove the soldering iron. use cotton cloth to wipe off the excess solder from the surface of the joint when it is still hot as shown in Fig 10.

Fig 10



ELN1329HA

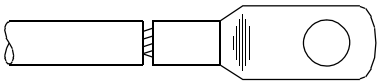
12 Allow the joint to cool naturally. Do not blow air for cooling.

A shining solder surface indicates good soldering. Do not move the joint until the solder solidifies.

TASK 2: **Solder lug to a copper conductor**

(A soldered lug should look as shown in Fig 1.)

Fig 1



SOLDERED LUG

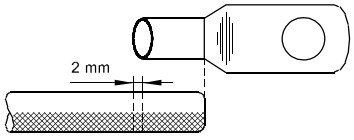
ELN1329J1

1 Collect a 30 amps cable lug, copper cable 7/1.06 or 7/ 0.914(6 sq.mm) of 250 mm length, blowlamp, match-box, cotton cloth, solder stick, tray and flux.

2 Clean the inner and outer surfacses of the 30 amps cable lug using `00' grade sandpaper.

3 Put the cable lug to one end of the cable and mark the cable according to the depth of the cable lug, as shown in Fig 2.

Fig 2

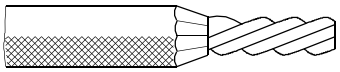


MEASURING CABLE FOR FIXING LUG

ELN1329J2

4 Add about 2 mm to the marking, remove the insulation from the cable (Fig 3) and clean the strands.

Fig 3



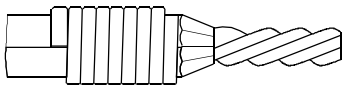
CABLE WITH REMOVED INSULATION

ELN1329J3

Avoid damage to the strands of the cable while skinning. Clean the tray thoroughly. The tray should be free from dirt and water.

5 Wrap a cloth/cotton tape on the insulation of the cable to a length of 30 mm as shown in Fig 4, and wet it with water.

Fig 4



WRAPPED WITH WET CLOTH

ELN1329J4

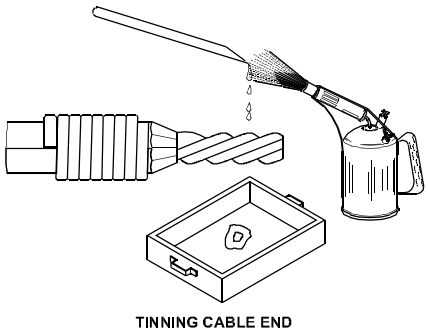
Use minimum water to wet the cloth/tape. Do not allow water to drip.

6 Light the blowlamp and let it emit a blue flame.

7 Apply a thin coat of flux to the cable end.

8 Tin the cable end by monitoring the blowlamp on the solder stick and allowing the molten solder to fall on the bare stranded cable end as shown in Fig 5.

Fig 5



TINNING CABLE END

ELN1329J5

A thin coating of tin should be on the stranded cable end.

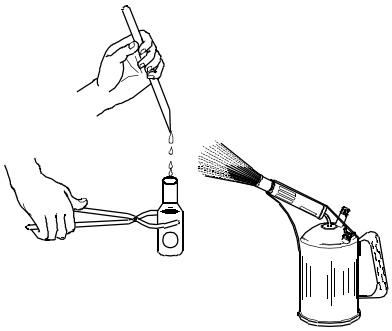
9 Apply a small quantity of flux inside the lug socket. Tin the lug by melting the solder stick to fill the socket and pour the molten solder in the tray.

Pouring out the molten solder from the lug socket a couple of times will make the tinning perfect.

10 Apply some flux to the cable end and the interior of the socket.

11 Fill the socket of the lug with molten solder. (Fig 6)

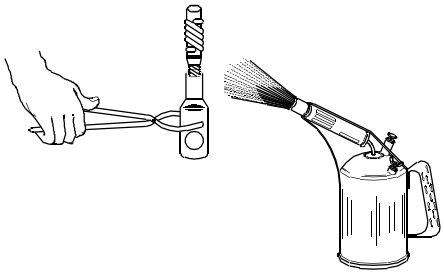
Fig 6



ELN1329J6

12 Monitor the blowlamp flame on the socket, insert the cable in the socket and hold the cable vertically as shown in Fig 7.

Fig 7



ELN1329J7

13 Remove the blowlamp and firmliy hold the cable and socket without shaking.

14 Remove the extra solder from the lug and cable by wiping it with a piece of cotton cloth while the solder is still hot.

15 Keep on holding the cable and lug as in Fig 7 and allow the solder to solidify.

Do not use water to cool the lug. This will crystallize the solder and make it weak.

Scan the QR Code to view the video for this exercise

Identify various parts, skinning and dressing of underground cable

Objectives: At the end of this exercise you shall be able to
- **identify the voltage grade of the cable**
- **skin the UG cable**
- **dress the UG cable.**

Requirements

Tools/Instruments

- Insulated combination piler 200 mm - 1 No.
- DE Electrician's knife 100 mm - 1 No.
- Hacksaw adjustable 300 mm with blade - 1 No.
- Handvice 50 mm jaw - 1 No.

Materials

- UG cable multicore eu/Al. 30 cm - 1 piece
- Binding wire 16 SWG - as required.

PROCEDURE

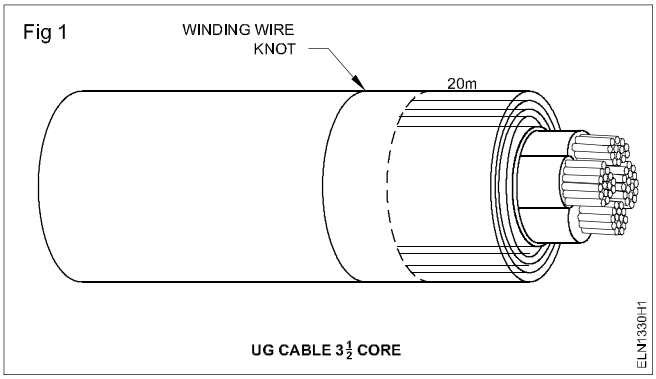
Paper insulated 3, 31/2 core cable may taken. This instructor has to demonstrate the steps for skinning and dressing of cables in this exetcise.

1 Collect the UG cable piece and examine it for physical damage.

2 Bind the winding wire at 20 cm (20 m at one side) of the UG cable.

3 Mark 18 cm at one end near the binding wire knot from the end where skinning is to be done, as shown in Fig 1.

Fig 1



UG CABLE 3 1/2 CORE

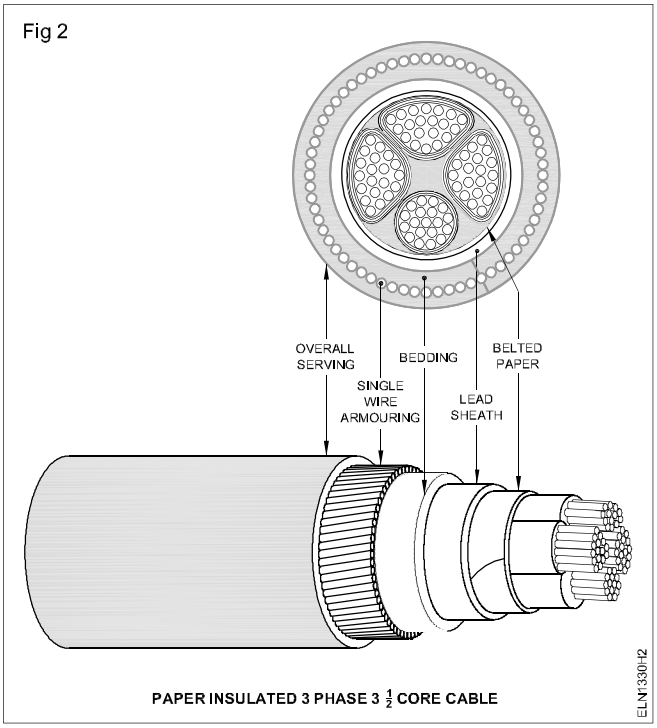
4 Cut the overall serving using the knife and remove the overall serving.

5 Mark 3 cm from the cutting edge and cut the single wire armouring using hacksaw.

6 Mark 3 cm from cutting edge and cut the bending using knife/hacksaw.

7 Repeat steps 2-6 to skin all other layers till it is visible as shown in Fig 2.

Fig 2



PAPER INSULATED 3 PHASE 3 1/2 CORE CABLE

Carefully examine the skinned portion for any damage/excess cutting.

8 Dress the protruding parts of the cable using a knife for a better finish.

9 Get your work approved by your instructor.

Make straight joint of different types of underground cable

Objectives: At the end of this exercise, you shall be able to
- **cut the cable according to requirement**
- **prepare the cable as per measurement**
- **join the cables using split sleeves or ferrules and epoxy compound**
- **insulate the wires, cable joints.**

Requirements

Tools/Instruments

- Insulated combination plier 200 m - 1 No.
- Screwdriver 200 mm - 1 No.
- D.E. Spanner 6mm to 25 mm - 1 set
- DE Electrician's knife 100 cm - 1 No.
- Melting pot with 1 set of ladles - 1 No.
- Blow lamp 1/2 litre capacity - 1 No.
- Tongs 300 mm - 1 No.
- Triangular file smooth 200 mm - 1 No.
- Hacksaw adjustable 300 mm with 32 TPI blade
- Hammer ball pein 250 g - 1 No.
- Plier round nose 150 mm - 1 No.
- Hand vice 50 mm - 1 No.

Materials

- UG cable multi-core copper/ aluminium - as required.
- Binding wire 16 SWG - 200 g
- Lead and tin alloy 60/40 - asrequired
- Kerosene oil - 2 litre.
- Cotton tape 25 mm10mm long - 1 roll
- Bitumen compound ('epoxy'compound) - as required
- Jute thread 3 mm - 100 g.
- Impregnated cotton tape - as required.
- Porcelain barrier - as required.
- Coupling sleeve of suitable size - as required.
- Metal connectors of suitable size - as required.
- Slit sleeve of suitable size - as required.
- Insulating paste board or yarn tape - as required.
- Match box - 1 No.
- Asbestos thread - 50 g.
- Alca 'P' solder - 1/2 kg.
- Soldering flux - 100 g.
- Bricks - as required.
- Cotton cloth - as required.
- Eyre flux - 100 g.

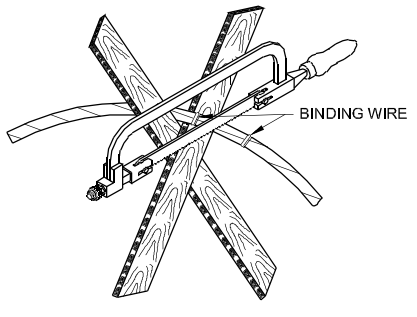
PROCEDURE

TASK 1 : **Make straight joint using sleeves in U.G cable**

1 Cut the given cable into two pieces as in Fig 1.

Fig 2 is given here for your guidance. Actual measurement for the cable insulation removal depends upon the type of cable joint box and cable sealing compound. Conventional method of cable jointing is done with bitumen compound for sealing the joint , brass glands at the ends of the joint box for sealing the joint entry and plumbing to finish the job. Modern joints with epoxy compounds are done by sealing the joint entry either with special tapes or with special compounds. According to the method chosen, the measurement has to be made and the insulation has to be removed at specified points. For procedural convenience in this sheet, L_1 is taken as 200 mm and so on.

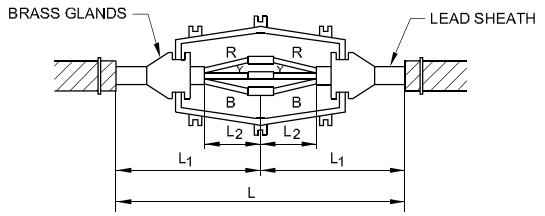
Fig 1



2 Bind 16 SWG GI binding wire on the serving (PILC cable) of the cables at a distance of 210 mm from one end as shown in Fig 3 to avoid loosening of the serving and damaging of the armour.

3 Remove the armour and serving of the cables to a length of 200 mm from the end of each cable as shown in Fig 4.

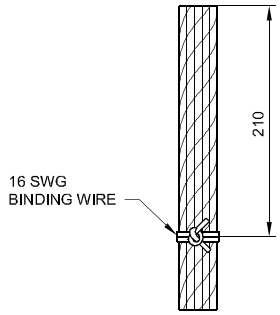
Fig 2



CONVENTIONAL JOINT USING FERRULE SLEEVE BRASS GLAND FOR SEALING

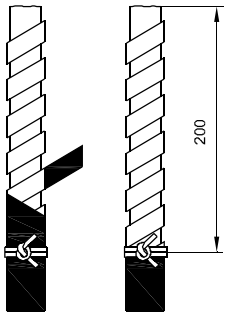
ELN1331J2

Fig 3



ELN1331J3

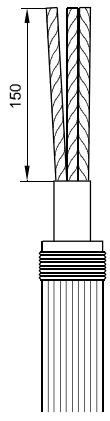
Fig 4



ELN1331J4

4 Remove the lead sheath to a length of 150 mm from the end of each cable as shown in Fig 5 and also remove the impregnated paper.

Fig 5



ELN1331J5

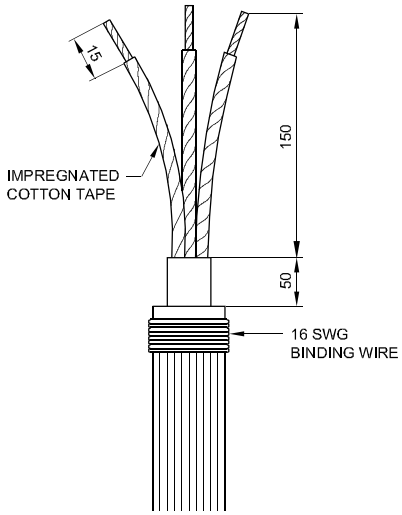
Avoid nicks or cuts on the core. Do not remove the paper insulation of individual cables.

5 Remove the paper insulation from both the cables to a length of 15 mm from the end.

Some prefer staggering of the joint position to have maximum efficiency of the joint. In such cases, the cable insulation should be removed accordingly. Fig 8 shows such a joint.

6 Twist the bare conductors tightly and tin the conductors. (Fig 6)

Fig 6



ELN1331J6

Wrap the end of the paper insulation near the bare conductor with lightly wetted cotton tape or asbestos tape to protect against excess heat.

7 Wrap the portion of the paper insulated cable with impregnated cotton tape to protect it from moisture and hot solder. (Fig 6)

Provide colour coding marks on cables at this stage.

8 Clean the split copper sleeves and the brass glands thoroughly and tin them.

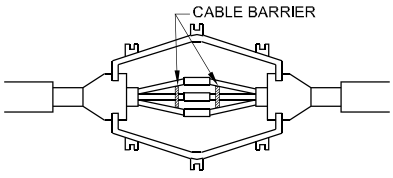
9 Clean the joint box and keep the bottom cover on the floor.

10 Insert the brass glands in the cables and position the bare end of the cable and gland inside the joint box as shown in Fig 2.

11 Insert the tinned portion of the cable ends into the split sleeve with the help of the colour code of the cables. (Fig 2)

12 Insert barriers (separators) between the three individual cables at both sides of the cable as shown in Fig 7.

Fig 7

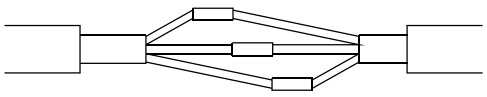


ELN1331J7

13 Turn the split portion of the sleevves in the upward position to facilitate pouring of the solder.

14 Remove the bottom cover of the joint box and push the brass glands apart and keep it in staggered position as in Fig 8.

Fig 8



STAGGERED POSITION OF JOINT

ELN1331J8

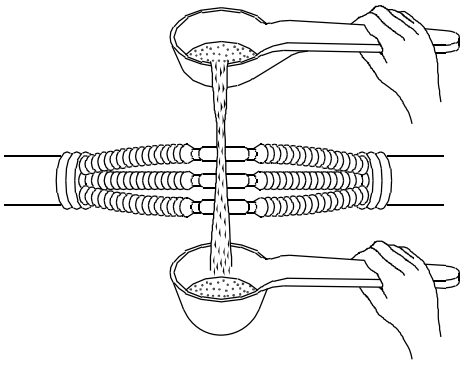
15 Apply soldering flux to the split sleeves and the bare portion of the conductor.

16 See that the ladles are dry and then start alternately scooping the molten solder with the ladles till the ladles are sufficiently hot.

17 Keep one of the empty ladles underneath the split sleeve that has to be soldered.

18 Pour the molten solder on the sleeve such that the solder enters the joint through the split as shown in Fig 9.

Fig 9



A THROUGH - TYPE JOINT ON PAPER INSULATED CABLES USING POT AND LADLE

ELN1331J9

After the joint is sufficiently heated, increase the time between the pourings to allow the solder to solidify inside the joint.

19 Stop pouring the solder when the sleeve is filled up, and the colour of the solder is bright.

20 Repeat this procedure to other joints one after another.

Do not shake or disturb the position of the cables during the soldering process as it will result in dry joints.

21 After the joint is cold, wrap with at least 2 layers of impregnated PVC tape over the joints.

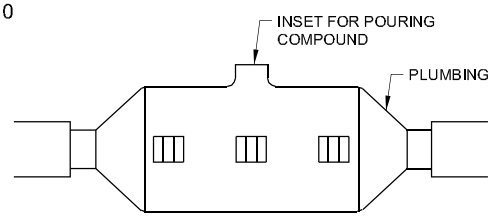
22 Preheat the joint box before filling the preheated sealing compound.

23 Close the top and bottom parts of the joint box together and, position the brass glands.

24 Use the solder lead to make proper plumbing joints between the lead sheath and the brass gland.

25 Pour molten sealing compound through the cover inlet as shown in Fig 10.

Fig 10



ELN1331JA

When the compound is filled up to the mouth of the inlet, stop pouring and allow it to cool.

After sufficient cooling, the compound will shrink, and now fill the available space with more molten compound.

26 Fix the cover inlet of the joint box after the joint is sufficiently cooled.

27 Cheek for cracks, melting due to heat or any other mechanical damage.

TASK 2 : **Make joints with epoxy compound in U.G cable**

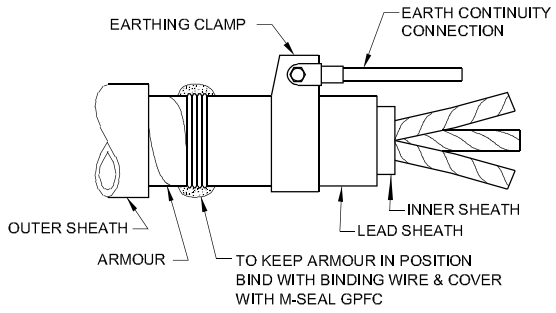
1 Use the joint box, compound and crimping tool specified by the manufacturer.

2 Repeat the same procedure as in TASK 1 and note the additional points stated below:

- Joint box is of special PVC material.
- A solder rarely is used for joints. Mostly, joints are crimped with the help of a crimping tool using special copper sleeves.
- No heating of compound or boxes is necessary as the epoxy compound serves both as a jointing compound and hardener. Both of these are to be mixed thoroughly in specified quantities just before it is poured into the joint box.
- No plumbing work is necessary as there is no brass gland. However, to maintain continuity of earthing a special jumper fitting is to be made between lead sheath of the cables which will be supplied on request. Refer Fig 11.

3 Follow the rest of the procedures outlined in TASK 1 to complete the joint.

Fig 11



EARTHING FOR PILC CABLES

TASK 3: **Aluminium cable joint**

1 Follow the procedure as explained in Tasks 1 and 2 except that the solder to be used is Alca 'P' and the flux is Eyre '7'.

Test insulation resistance of underground cable using Megger

Objectives : At the end of this exercise, you shall be able to
- **measure the insulation resistance between conductors of an armoured cable using Megger**
- **measure the insulation resistance between earth and conductors of an armoured cable.**

Requirements

Tools/Instruments

- Insulation resistance tester (Megger) 500 V - 1 No.

Materials

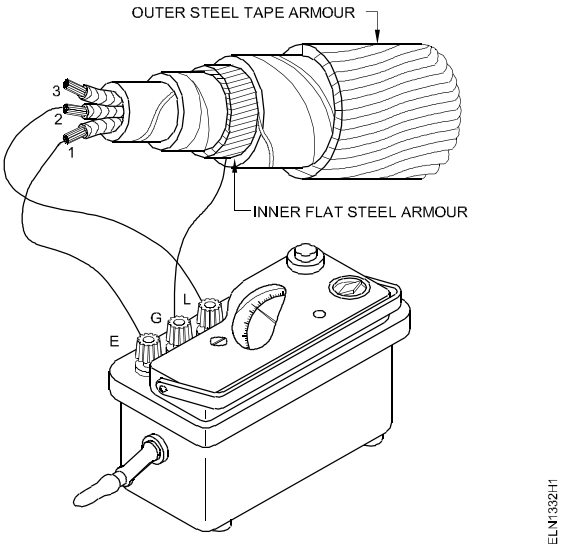
- Testing prods - 3 Nos.
- Armoured cables of different sizes and length - 2 Nos.

PROCEDURE

TASK 1: **Measure the insulation resistance between conductors of an armoured cable**

1 Connect the armoured cable as shown in Fig 1.

Fig 1



Connect the guard terminal of the meter with the armour (metal sheath) of the cable.

2 Measure the insulation resistance between the conductors and record the readings in Table 1.

Table 1

Measurement	Insulation resistance in megohms
Between conductors	
Conductor 1 and conductor 2	
Conductor 2 and conductor 3	
Conductor 1 and conductor 3	
Between earth and conductors	
Conductor 1 and earth	
Conductor 2 and earth	
Conductor 3 and earth	
Conductor 1, 2, 3 shorted and earth	

Steadily rotate the insulation tester's handle at a constant speed (160 r.p.m) at least for one minute duration before recording the meter reading.

TASK 2: **Measure the insulation resistance between earth and conductors of an armoured cable**

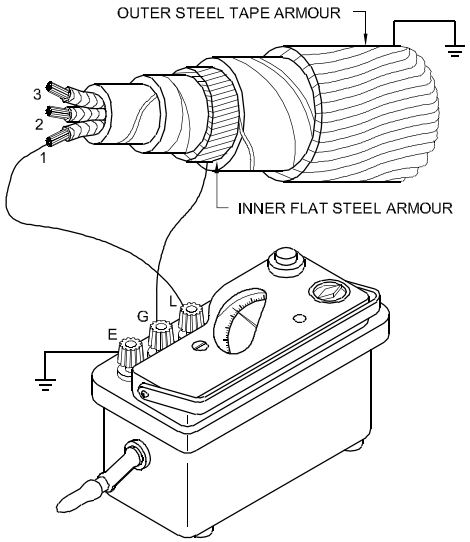
1 Connect the armoured cable as shown in Fig 2.

If the armoured cable is buried in the ground, connect the Megger as shown in Fig 2. If the cable is not buried but kept at the ground level or on the working table, the earth connection should be made as shown in Fig 3.

2 Measure the insulation resistance between earth and each conductor and record the readings in Table 1.

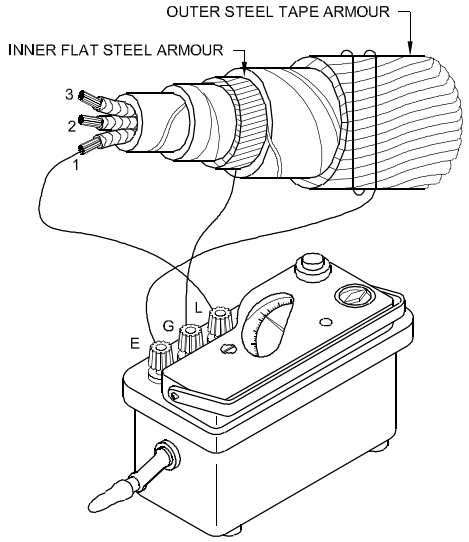
3 Measure the insulation resistance between earth and all the three conductors by shorting them together and record the reading in Table 1.

Fig 2



Discuss the required insulation resistance value of the cable with your instructor

Fig 3



The Instructor may demonstrate the use of transistorised Megger for various tests.

Test underground cables for faults, and remove the fault

Objectives: At the end of this exercise you shall be able to
- **locate open circuit faults in the cable**
- **locate short circuit faults in the cable**
- **locate the leakage fault in the cable and rectify the fault.**

Requirements

Tools/Instruments

- Combination plier 200 mm - 1 No.
- Connector Screw driver 100 mm - 1 No.
- Screw driver 200 mm with blade of 4 mm width - 1 No.
- D.E electrician's knife 100 mm - 1 No.
- Megger 500V - 1 No.

Equipments/Machine

- Wheatstone bridge - 1 No.

Materials

- Connecting Prod for Megger - 1 set
- Connecting Prod for Wheatstone bridge - 1 set
- Connecting Cables (flexible, uniform, cross sectional area) - as reqd.

PROCEDURE

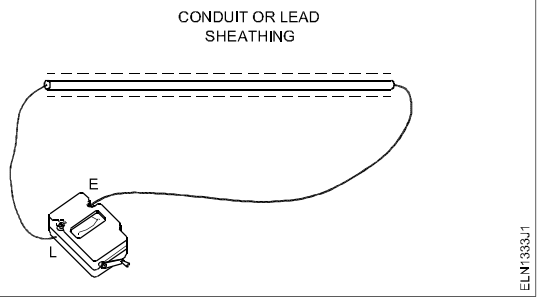
TASK 1: **Locate open circuit faults in underground cable**

This test is made to check whether the cable insulation is in open condition and to identify the exact location of the open circuit.

1 Switch 'OFF' the mains. Remove the fuse and the neutral links in the main switch and keep them in safe custody.

2 Select 500 V Megger and connect one terminal of the Megger, say L, to the one end of cable as shown in Fig 1.

Fig 1



3 Connect the other terminal of the Megger say 'E' to the other end of the cable.

4 Rotate the megger at 160 r.p.m.

5 Observe the megger reading. If the megger shows infinity, there is open circuit in the cable.

Open circuit may be due to open in the cable.

If the megger shows '0' reading, it indicates no open in the cable.

6 Connect the 'E' terminal near the middle of the cable and repeat the above procedure for open circuit.

If it shows '0' reading, there is no open in between 'L' and the middle of the cable.

7 Repeat the above procedure, connecting the 'E' terminal to beyond the middle point of the cable at varied distances.

When the megger shows infinity in a parhcilar place, that is the point of open.

8 Locate the faulty portion and make fresh straight joint to the UG cable.

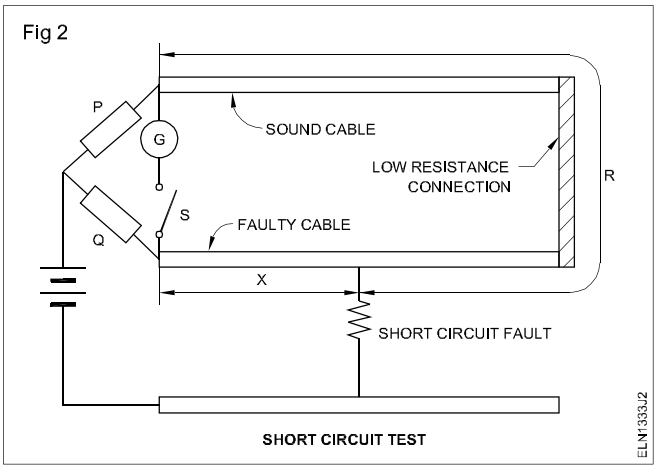
TASK 2: **Locate the short circuit fault in U.G cable**

This test is made to locate the short circuit in the cable by Murray loop test.

1 Switch 'OFF' the main switch. Remove the fuse of the main switch and keep it in safe custody.

2 Select a Wheatstone bridge and connect one end of the cable to the meeting point of P and Galvanometer and another cable end to the meeting point of Q and Galvanometer as shown in Fig 2.

Fig 2



SHORT CIRCUIT TEST

3 Measure the length of each cable.

4 Connect the other two ends of both the cables by means of low resistance wire.

5 Take the battery terminal (negative) wire and place it at any point of the cable and observe the deflection in the Galvano meter.

The area of the cable where the Galvanometer shows '0' reading is the exact location of the short circuit. It can be calculated with the formula given below.

$$(i.e)\ \frac{x}{p} = \frac{Q}{P} \text{ or } \frac{X}{R+X} = \frac{Q}{P+Q}$$

where X is the length of the fault from the test end.

L is length of each cable.

6 Locate the fault while measuring the length of the cable and clear the short circuit in the UG cable.

TASK 3: **Locate the ground fault in U.G cable**

This test is also done to locate ground fault in the cable by Murray Loop test.

1 Connect the cables as shown in the Fig 3 and repeat the steps explained in the short circuit test (TASK 2).

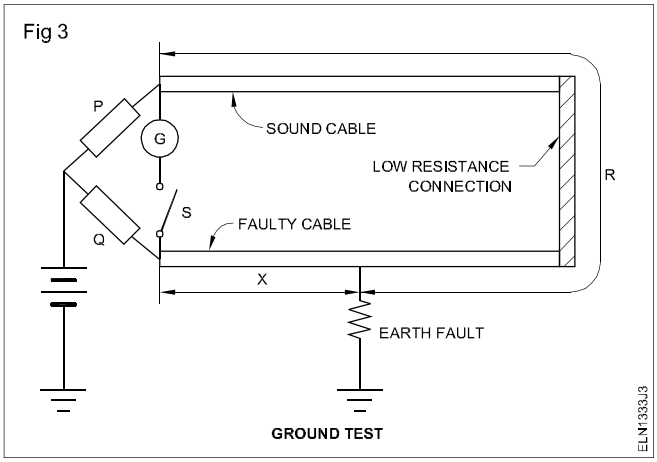
The area of the cable where the Galvanometer shows '0' reading is the exact location of the ground fault.

2 Calculate and locate the place of the ground fault as given below.

$$X = \frac{Q}{P+Q} \times 2L$$

Where 'X' is the length of the fault from the test end.

Fig 3



GROUND TEST

3 Locate the place where the ground fault is by measuring the length from the test end and repair the fault.

Practice on measurement of parameters in combinational electrical circuit by applying Ohm's Law for different resistor values and voltage sources and analyse by drawing graphs

Objectives: At the end of this exercise you shall be able to
- **verify the relation between voltage and current when resistance is constant**
- **verify the relation between current and resistance when keeping voltage is constant**
- **plot the graph in both conditions illustrating the behaviour of current with respect to resistor.**

Requirements

Tools/Instruments

- Screwdriver 150 mm - 1 No.
- MC Ammeter 0 to 500 mA - 1 No.
- MI Ammeter 0 to 1A - 1 No.
- MC Voltmeter 0 15 V - 1 No.

Equipment/Machines

- 12 Volts battery 60 AH capacity OR - 1 No.
- DC variable power supply 0 - 30 V 2 amperes - 1 No.
- Rheostat 20 ohms - 3.7A - 1 No.

Materials

- S.P.Switch, 6A, 250V - 1 No.
- Resistors 10, 20, 50 Ohms 5 watts - 1 each.
- Resistor 20 ohms,2W - 1 No.
- Connecting leads 14/0.2 mm - 1 No.
- P.V.C. insulated copper wires of assorted length - 8 Nos.
- Graph sheet - 1 No.

PROCEDURE

TASK 1**: Verify the relation between current and voltage when resistance is constant**

1 Check the voltmeter from the dial marking 'V'.

2 Check the ammeter from the dial marking 'A'.

3 Identify the fixed and variable terminals of the rheostat.

4 Connect the circuit elements as shown in Fig 1.

Fig 1

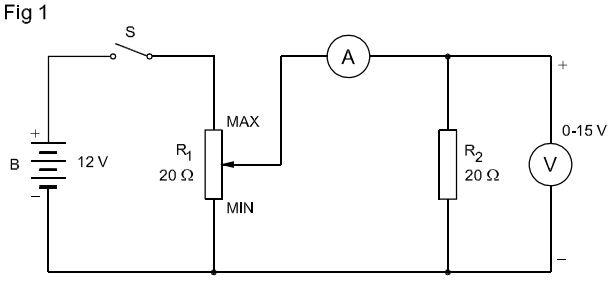


TABLE 1

No.	VOLTAGE (VOLTS)	CURRENT (AMPS)	I∝V / I∝V

ELN1434-H1

5 Check the value of each major division and minor division of the scales of the meters.

6 Close the switch keeping the variable rheostat at the minimum value of output.

7 Apply different voltages by varying the rheostat arm of the potential divider in succession across the resistance.

8 Measure the voltage and the corresponding current from the instruments.

9 Record the measured values in Table 1.

To avoid parallax error:

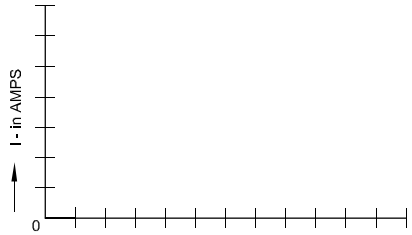
Position your eye in line with the pointer and also in front level of the instrument

Position your eye to coincide with the mirror image of the pointer in instruments having anti-parallax mirror.

10 Refer the recorded value and plot a graph. Write your conclusion considering the calculated R values.

V in Y Axis; I in X axis as shown in Fig 2.

Fig 2



Conculsion

Write your findings and conclusion by interpreting the current and voltage

_____

_____

TASK 2**: Verify the relation between current and resistance: Voltage is constant and resistance is variable.**

1 Connect the circuit elements as shown in Fig 3 with 0 -1A ammeter. Adjust V at 10 volts keep it constant.

Fig 3

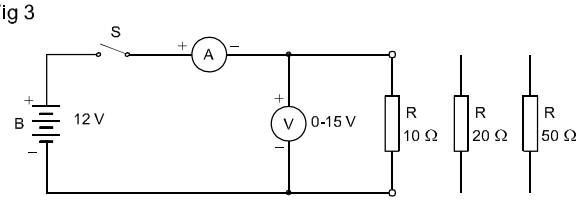


TABLE 2

No.	VOLTAGE (VOLTS)	RESISTANCE (OHMS)	CURRENT (AMPS)	I∝R / I∝R

ELN1434I3

2 Close the switch 'S' and measure the current and voltage.

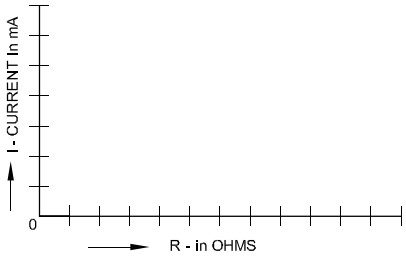
3 Read and record values in the given Table 2.

4 Open the switch (OFF). Change the ammeter to 0-500 mA and repeat steps 2 and 3 by replacing 10 - ohm resistance by 20 and 50 ohms.

5 Refer the recorded value and plot the graph. Write your conclusion considering the calculated I values.

R in Y Axis; V in X Axis as shown in Fig 4.

Fig 4



Write your findings and conclusion by interpreting the current and resistance.

Conculsion

_____

_____

Measure current and voltage in electrical circuits to verify Kirchhoff's Law

Objectives: At the end of this exercise you shall be able to
- **verify Kirchhoff's current Law in two and three branch currents**
- **verify Kirchoff's voltage Law with one voltage and two voltage source.**

Requirements

Tools/Instruments/Equipment

- Trainees kit - 1 No.
- Variable DC power supply unit 0-30V/1A - 2 Nos.
- Milliammeters 0 - 500 mA - 3 Nos.
- Milliammeters 0 - 30 mA - 1 No.
- Power supply unit 0 - 30 V - 1 No.

Materials

- Resistors 1K - 4 Nos.
- Resistors 2.2K - 1 No.
- Resistors 3.3K - 1 No.
- Resistors 4.7K - 1 No.
- Lug board - 1 No.
- Toggle switch, SPST, 1amp. - 2 Nos.
- Patch cords - as required.
- SPST switch 6A, 250V - as required.

PROCEDURE

TASK 1: **Verify the Kirchhoff's current law with two branch currents**

1 Connect the PSU, milliammeters, SPST switch and resistors as illustrated in the schematic circuit and the layout diagram as shown in Fig 1.

Keep the SPST and PSU in the OFF position while making circuit connections.

2 Switch 'ON' PSU and set output to 12 volts.

3 Simplify the circuit in Fig 1 and calculate the theoretical total circuit current and branch currents of the circuit for a set DC supply of 12 volts. Record values in Table 1.

Check if the connected ammeters can measure the calculated current. Change the meter, if necessary.

4 Get the circuit connections checked by your instructor.

5 Switch ON SPST.

6 Measure and record the total circuit current (I_T) and branch currents I_{S1} and I_{S2} in Table 1.

7 Switch OFF the SPST.

8 Set the output of the RPSU to 9 volts.

9 Calculate the theoretical circuit currents for the set supply voltage of 9V.

10 Record values in Table 1.

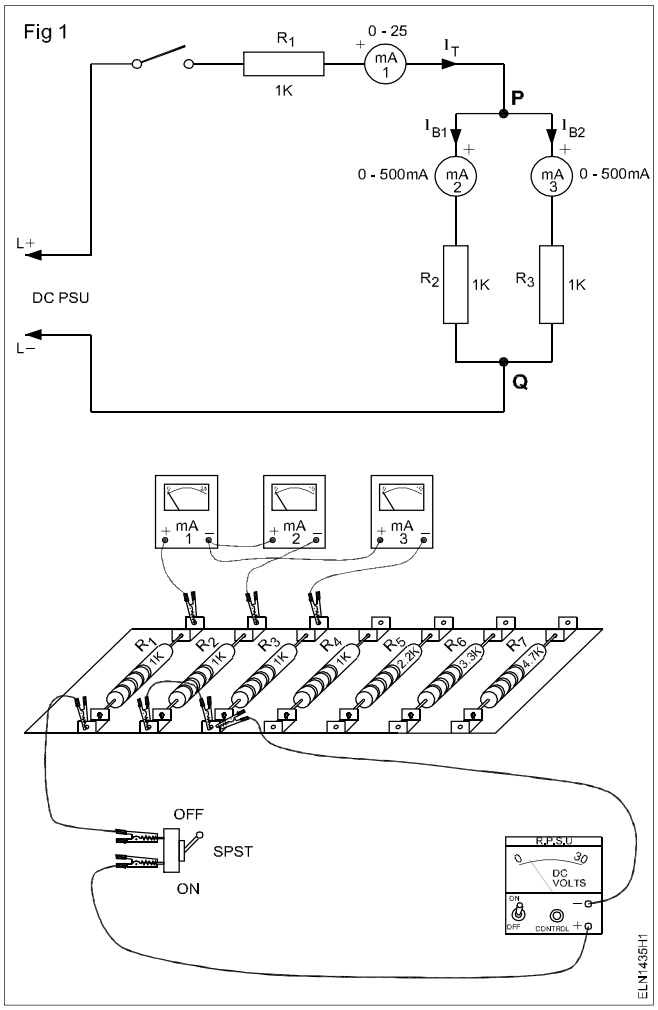
11 Repeat steps 4 and 6.

12 Switch OFF SPST and PSU.

13 Write Kirchhoff's current equations for the nodes P and Q.

14 Verify the equation substituting the measured current values.

Fig 1



15 Get the readings and equations checked by your instructor.

Table 1

Set circuit voltage	Calculated values of circuit current			Measured values of circuit currents		
	Total circuit current (I_T) $I_T = I_{B1} + I_{B2}$	I_{B1}	I_{B2}	Total circuit current (I_T) $I_T = I_{B1} + I_{B2}$	I_{B1}	I_{B2}
12V						
9V						

TASK 2 : **Verify the Kirchhoff's current Law with three branch currents**

1 Make circuit connections on the lug board as per the schematic circuit in Fig 2.

Make it a practice to keep the SPST and PSU switches in the OFF position while making circuit connections.

2 Get the wired circuit checked by your instructor.

3 With the SPST in OFF position, set the output of PSU to 12 volts.

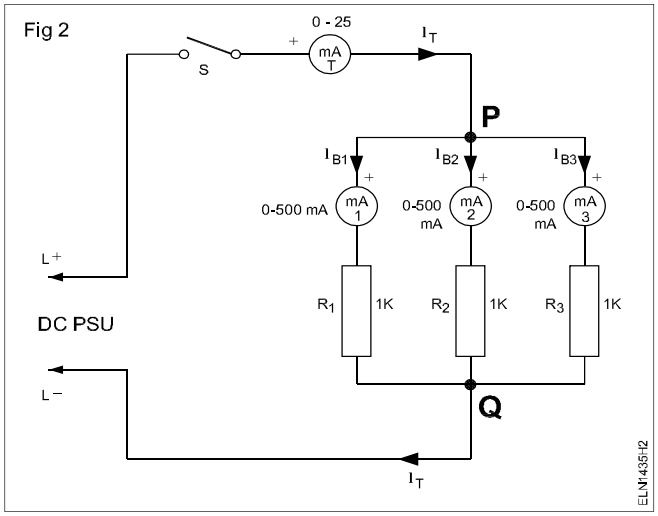
4 Switch ON the SPST switch. Measure and record currents I_T, I_{B1}, I_{B2} and I_{B3} in Table 2.

5 Switch OFF SPST and PSU.

6 Write Kirchhoff's current equations at nodes P and Q. Verify the equation using measured current values.

7 Get the readings and equations checked by your instructor.

Fig 2



8 Record your findings and conclusions after verifying the recorded and calculated values and check if it is same as per the theoretical conclusions.

Table 2

Set circuit voltage	Total circuit current (I_T) $I_T = I_{B1} + I_{B2} + I_{B3}$	Branch currents		
		I_{B1}	I_{B2}	I_{B3}
12 V				

TASK 3: **Verify the Kirchhoff's voltage Law with one voltage source**

1 Measure and record in Table 3, values of resistors R_4, R_5 and R_6 soldered on the lug board.

2 Make the circuit connections as shown in Fig 3.

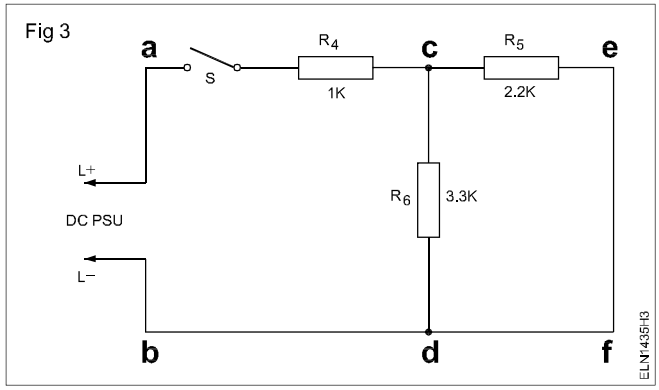
3 Mark the polarity of the voltage drops across resistors R_4, R_5 and R_6 in the copy of Fig 3.

4 Get the circuit connections and polarities marked and checked by your instructor.

5 Switch ON PSU and set output to 12V. Switch ON SPST. Following the voltage polarities marked across the resistors, measure and record the drop in voltage across resistors R_4, R_5 & R_6 in Table 3.

6 Switch OFF SPST and PSU.

Fig 3



7 Write Kirchhoff's loop equations for the closed paths a-c-d-b-a, a-e-f-b-a and c-e-f-d-c. Substitute the voltage readings recorded in Table 3 in the equations for verification.

8 Get your readings and equations checked by your instructor.

Table 3

Set circuit voltage	Measured values of			Voltage measured across		
	R_4	R_5	R_6	V_{R4}	V_{R5}	V_{R6}

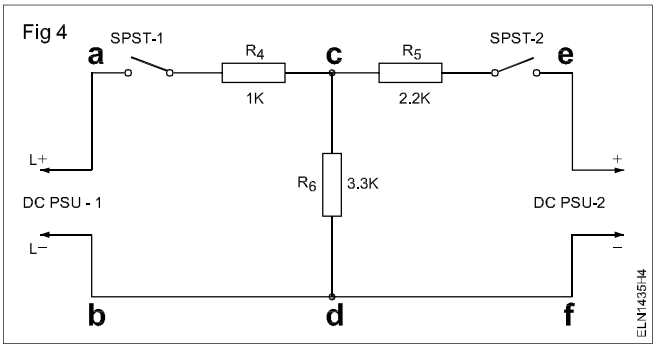
TASK 4: **Verify the Kirchhoff's voltage Law with two voltage sources**

1 Modify the circuit connections made in TASK 3, to obtain a circuit as shown in Fig 4.

Keep both the PSU's and the two SPST's in the OFF position while making circuit connections.

2 Mark the polarity of the voltage drops across the resistors R_4, R_5 and R_6 in the copy of Fig 4.

Fig 4



3 Set the output of PSU-1 to 12 volts and PSU-2 to 6 volts.

4 Switch ON both SPSTs. Following the voltage polarities marked across the resistors, measure and record the voltage drop across the resistors R_4, R_5 & R_6 in Table 4.

Note: While measuring voltage across resistors, if the meter deflects below zero, recheck the polarity marked at step 2 and repeat step 4.

5 Switch OFF the SPSTs and PSUs.

6 Write Kirchhoff's voltage equations for the closed paths a-c-d-b-a, a-e-f-b-a and c-e-f-d-c.

7 Get your readings and equations checked by your instructor.

8 Record your findings and conclusion after verifying the recorded and calculated values and check if it is same as per the theoretical conclusions.

Table 4

Set output of RPSU 1	Set output of RPSU 2	Voltage measured across		
		V_{R4}	V_{R5}	V_{R6}

Verify law's of series and parallel circuits with voltage source in different combinations

Objectives: At the end of this exercise you shall be able to
- **verify the laws of series circuits**
- **verify the laws of parallel circuits**

Requirements

Tools/ Instruments

- Electrician tool kit - 1 Set
- Ammeter MC 0-500 mA - 3 Nos.
- Rheostat - 100 ohms, 1A - 1 No.
- Voltmeter MC 0-15V - 1 No.
- Multimeter - 1 No.
- Rheostat 0 - 25 ohm, 2A - 2 Nos.
- Potentiometer 60 ohm, 1A - 1 No.
- Rheostat 0 - 300 ohm, 2A - 2 Nos.
- Rheostat 0 - 10 ohm,5A - 2 Nos.

Equipment/ Machines

- DC source, 0 - 6V/30AH (battery), Battery 12V, 90AH - 1 No. OR DC 0-30V variable voltage supply source with current limiting facility 0-1 ampere - 1 No.

Materials

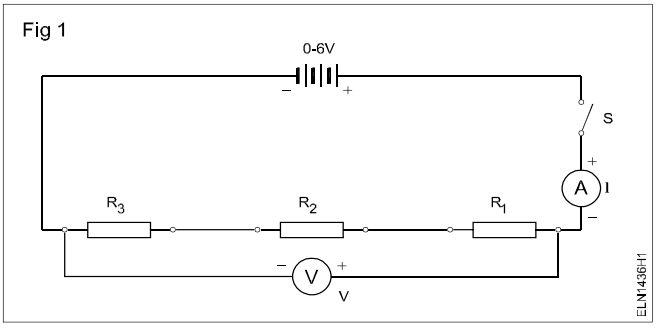
- Switch SPT 6A 250V - 1 No.
- Resistor 10 ohm 1 W - 2 Nos.
- Resistor 20, 30, 40 & 60 ohm 1 W - 1 No. each
- Connecting cables - as required.

PROCEDURE

TASK 1: **Verify the characteristics of series circuits**

1 Construct/ assemble the circuit as shown in Fig 1. (R_1 = 10 Ω, R_2 = 20 Ω , R_3 = 10 Ω)

Fig 1

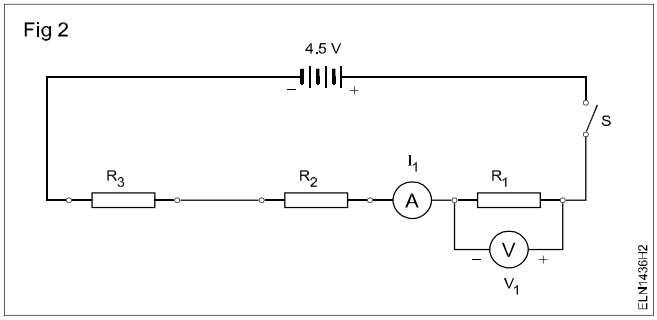


2 Close the switch 'S', measure the current (I) and voltage (V).

3 Enter the measured value in Table 1.

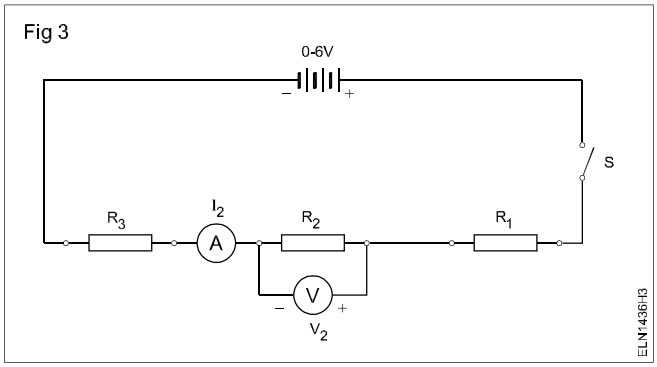
4 Switch OFF the supply. Reconnect the ammeter and voltmeter as shown in Fig 2 and measure voltage (V_1) and current I_1 through R_1.

Fig 2



5 Switch OFF the supply. Reconnect the voltmeter and ammeter as shown in Fig 3 and measure the voltage (V_2) and current (I_2) in R_2.

Fig 3



6 Draw the circuit diagram showing the position of A and V in the circuit to measure the current (I_3) and voltage (V_3) across R_3.

7 Connect and measure the I_3 and V_3 across R_3.

8 Enter the measured values in Table 1.

9 Record the relationship between I_1, I_2, I_3 and I.

_____

_____

10 Write down the mathematical form of current law of a series circuit.

11 Record the relationship between V_1, V_2, V_3 and V.

12 Write down the mathematical form of voltage law of a series circuit.

V =

13 Calculate resistance from the measured values, record the results with the values indicated on the resistors.

14 Record the relationship between R and R_1, R_2, R_3.

15 Write down the mathematical form of resistance law of a series circuit.

R =

16 Get it checked by the instructor

Table 1

Values	Total	R_1=10	R_2=20	R_3=10
Current	I =	I_1 =	I_2 =	I_3 =
Voltage	V=	V_1 =	V_2 =	V_3 =
Resistance	R = _____ =	R_1=_____ =	R_2=_____ =	R_3=_____ =

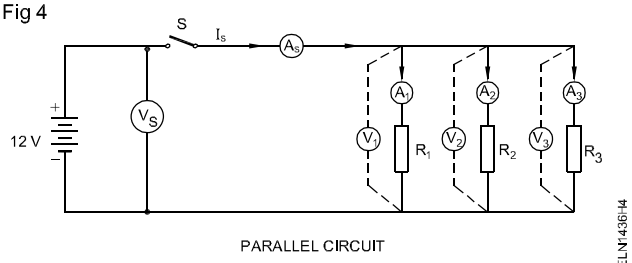
TASK 2 : **Verify the characteristics of parallel circuits**

1 Use an Ohm meter to set the values of a rheostat or resistor R_1 = 40 ohms, R_2 = 60 ohms and R_3 = 30 ohms.

While using multimeter to measure resistance values see that the supply is OFF and the supply source is disconnected from the circuit.

2 Connect the resistors (Rheostats) in parallel with the switch S, ammeter A, voltmeter V and battery B as in Fig 4 and measure the current I_s and V_s. Record the valuesin Table 2.

Fig 4



3.Get it checked by the instructor

Table 2 Measured Value of R_T = ----------Ohms

Sl.No.	R_1	R_2	R_3	Calculated $R_T = \frac{1}{\frac{1}{R_1}+\frac{1}{R_2}+\frac{1}{R_3}}$	I_s	V_s	$R_T = \frac{V_S}{I_S}$

4 Measure the voltages V_S, V_1, V_2 & V_3 and record them in Table 3.

5 Calculate the current through each resistor taking into consideration V_S, applying Ohm's law and enter the values in Table 3.

6 Measure the currents I_S, I_1, I_2 & I_3 and record them in Table 3.

7 Compare the calculated values with the measured values. Record your observation. _____

Table 3

V_s	V_1 Measured	V_2 Measured	V_3 Measured	Calculated				Measured			
				I_S	I_1	I_2	I_3	I_S	I_1	I_2	I_3

7 Calculate the value of total resistance R_T, from the above measured values.

8 Compare the measured and calculated values of total resistance R_T.

Verification

Current Characteristics $I_S = I_1 + I_2 + I_3$

Voltage Characteristics $V_S = V_1 = V_2 = V_3$

Total Resistance $$R_T = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}}$$

Conclusion

_____

_____

9 Get the work checked by the instructor

Measure the voltage and current against individual resistance in electrical circuit

Objectives: At the end of this exercise you shall be able to
- **connect individual resistor in series and measure current and voltage**
- **connect individual resistor in parallel and measure current and voltage**
- **compare the theoretical values with actuals in the circuit.**

Requirements

Tools/ Equipments

- Cutting plier 150 mm - 1 No.
- Screw driver 150 mm - 1 No.
- Voltmeter MI 0-300V - 1 No.
- Ammeter MI 0 - 1A - 1 No.
- Multimeter - 1 No.
- AC source 240V/6A - as required.

Materials

- Connecting leads - as required.
- Lamp 250V/ 40W - 2 Nos.
- Lamp 250V/ 60W - 2 Nos.
- Switch 240V/6A - 2 Nos.

PROCEDURE

TASK 1: **Measure the voltage and current of resistors in series**

1 Construct the circuit as shown in Fig 1.

2 Record the cold resistor value of lamps in Table 1.

3 Connect two 40W lamps in series and switch 'ON" AC 240V/6A. Measure and record the current and voltage V_1 and V_2 in Table 1 as per Fig 1A.

4 Switch 'OFF' and replace One 40W lamp and connect 60W lamps in series and repeat the step 3 process after switch 'ON' (Fig 1B).

5 Switch OFF and connect 2 lamps of 60W in series and repeat step 4. (Fig 1C).

6 Get the work checked by the instructor

Fig 1

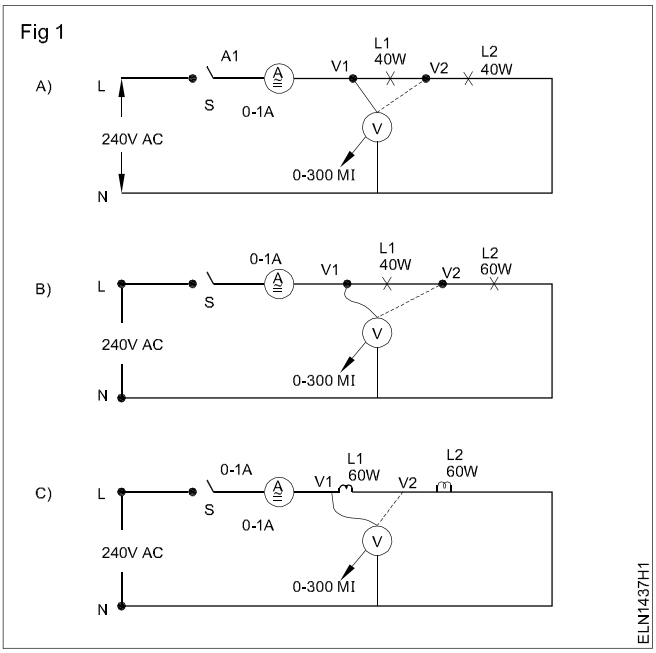


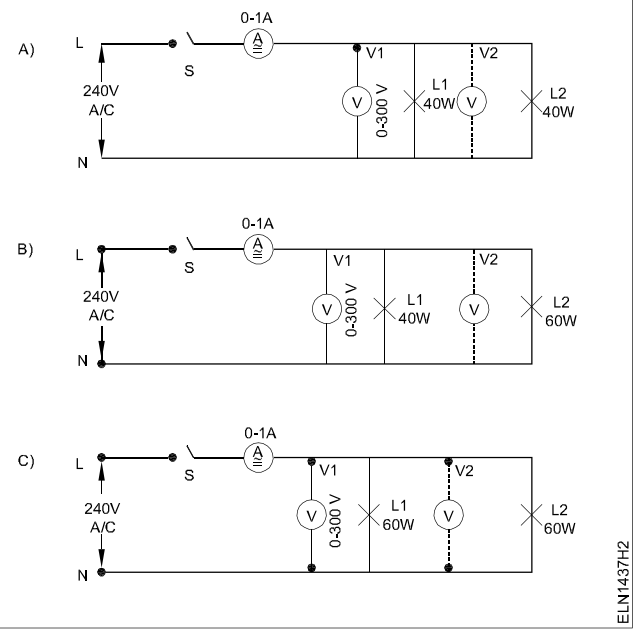
Table 1

Cold resistor		40W - 40W In series			40W - 60W In series			60W - 60W In series		
40W	60W									
		A	V1	V2	A	V1	V2	A	V1	V2
Value Measured										
Value Calculated										

TASK 2: **Measure the voltage and current of resistors in parallel**

1 Connect the circuit as shown in Fig 2.

Fig 2



2 Connect two 40W lamps in parallel and switch 'ON' AC 240V/6A. Record the current, voltage V_1 and V_2 in Table 2 as per Fig 2A.

3 Switch 'OFF' and replace one 40W Lamp with 60W Lamp. Switch 'ON'and repeat the step 2 (Fig 2B).

4 Switch OFF and use two 60W Lamps and repeat step 3 (Fig 2C).

5 Record the reading in Table - 2 and write the conclusion.

6 Get the work checked by the instructor.

Table 2

Cold resistor		40W - 40W In parallel			40W - 60W In Parallel			60W - 60W In Parallel		
40W	60W	A	V1	V2	A	V1	V2	A	V1	V2
Value measured										
Value calculated										

Measure current and voltage and analyse the effects of shorts and opens in series circuits

Objectives: At the end of this exercise you shall be able to
- **examine the effects of short circuited resistors in series circuits**
- **analyse the effects of open circuited resistors in series circuits.**

Requirements

Tools/ Instruments

- Screwdriver 150 mm - 1 No.
- Voltmeter MC 0-15V (Sensitivity 20K Ω/V) - 1 No.
- Voltmeter 0 - 15V MC - 1 No.
- Ammeter 0 - 500mA - 1 No.
- Multimeter - 1 No.
- Rheostat 100/120 Ω, 300 Ω,1A - 1 No.
- DC voltage source variable 0-15V, 1 amp or Battery lead acid 12V, 60AH - 1 No.

Materials

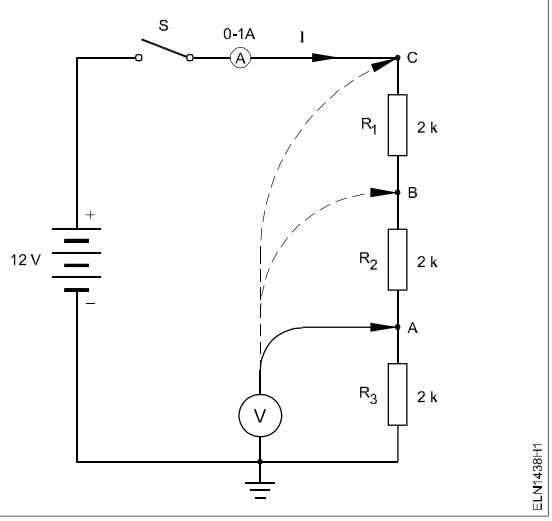
- Resistors 2K, 1 Watt - 3 Nos.
- Connecting leads - as required
- Switch 6A 250V - 2 Nos.

PROCEDURE

TASK 1: **Examine the effects of short and open circuitated resistors in series circuits**

1 For the circuit in Fig 1, calculate the nominal values for the voltages V_A, V_B and V_C and record them in Table 1.

Fig 1



Note: All voltages are with respect to ground.

2 Considering resistor R_1 as shorted, calculate and record the resulting voltages at A, B and C, if this were to occur.

3 Enter the calculated values in the first column of Table 1 under the heading `Fault conditions'.

4 Repeat steps 3 and 4 for each resistor in turn.

5 Consider now removing R_1, calculate and record the resulting voltages at A, B and C.

6 Enter the calculated values in the fourth column of Table 1 under the heading `Fault conditions'.

7 Repeat this for each resistor in turn.

Note: Only one fault is simulated.

8 Verify your calculations in steps 3 and 6 by connecting a piece of wire across each resistor in turn, simulating a short circuit across that resistor, and then removing each resistor, simulating an open at the location.

10 Measure voltage for each fault condition and be sure to check consistency with the calculated values.

11 Record all measured data in the corresponding columns of Table 1.

12 Analyse the readings in healthy condition (normal condition) and faulty (OC and SC) condition and record the findings.

13 Get the work checked by your instructor.

Table 1

Voltages	Nominal Value	Fault conditions											
		R_1 Cal	S/C Meas	R_2 Cal	S/C Meas	R_3 Cal	S/C Meas	R_1 Cal	O/C Meas	R_2 Cal	O/C Meas	R_3 Cal	O/C Meas
V_A													
V_B													
V_C													

Cal - Calculated S/C - Short circuited

Meas - Measured O/C - Open circuited

Measure the current and voltage and analyse the effects of shorts and open in parallel circuits

Objectives: At the end of this exercise you shall be able to
- **examine the effects of short and open circuited resistors in parallel circuits**
- **analyse the effects of short and open circuited resistor in parallel circuits.**

Requirements

Tools/ Instruments

- Screw driver 150 mm - 1 No.
- MC Voltmeter 0-15V (Sensitivity 20K Ω/V) - 1 No.
- MC Voltmeter 0 - 15V - 1 No.
- MC Ammeter 0 - 500mA - 1 No.
- Multimeter - 1 No.
- Rheostat 0 - 300 Ω, 2A - 1 No.
- DC voltage source variable 0-15V, 1 amp or Battery lead acid 12V, 80AH - 1 No.

Materials

- Connecting leads - as required
- Switch 6A 250V - 2 Nos
- Resistors, carbon composition 62KΩ 1/4 W, ± 5% - 1 No.
  - 33KΩ - 1 No.
  - 22KΩ - 1 No.
- Resistors, carbon composition
  - 220Ω - 1 No.
  - 1/2 W, ± 5%
  - 330 Ω - 1 No.
  - 470 Ω - 1 No.

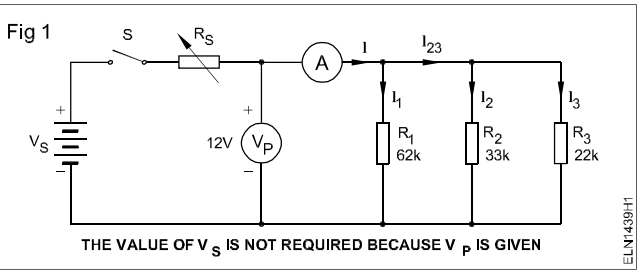
PROCEDURE

TASK 1: **Analyse the effect of short and open circuited resistors in parallel circuits**

1 Calculate the nominal values for the currents I, I_1 and I_{23}, I_2 and I_3 for the circuit in Fig 1 and record them in Table 1.

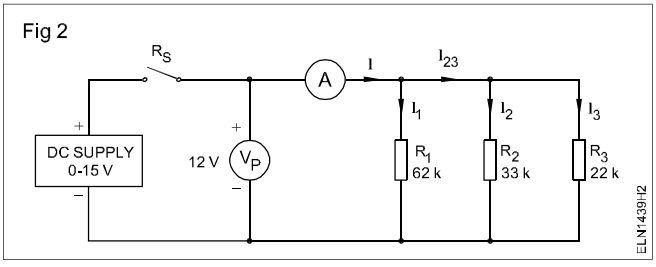
2 Construct the circuit (shown in Fig 1) and adjust R_S, source voltage series resistor, to a value that produces 12 volts across the parallel set of resistors.

Fig 1



3 Set the current limit to 100mA, if the DC power supply with current limiting feature is used as V_s. Omit the series resistor R_S. (Fig 2)

Fig 2



4 Measure and record the values of currents (I, I_1, I_{23}, I_2, and I_3). (Use Multimeter DC milliamperes range). Record them in the 'nominal' column in Table 2.

5 Now consider a shorted R_1. Estimate and record the resulting currents if this were to occur. Enter the calculated values in the first column in Table 1 under the heading `Short resistor'.

6 Repeat step 5 for each resistor in turn.

7 Now consider removing R_1. Calculate and record the resulting currents if this were to occur. Enter the calculated values in the last column in Table 1 under the heading `Open resistor'.

8 Repeat step 7 for each resistor in turn.

Only one fault is simulated.

9 Verify the calculations in steps 5 and 6 by connecting a piece of wire across each resistor in turn to simulate a short circuit across that resistor. Measure and record the current for each fault condition in Table 2.

10 Check the measured value of current consistency with the calculated values in Table 1.

11 Verify the calculation in steps 7 and 8 by removing each resistor in turn to simulate an open circuit at that location.

12 Measure and record the current for each fault condition in Table 2 .

13 Check for the measured value of currents consistency with the calculated values in Table 2.

14 Analyse the readings in healthy condition (normal) and faulty (OC & SC) condition and record the findings.

15 Get it checked and approved by the instructor.

Table 1

Currents	Nominal	Calculated value of current					
		Short resistor			Open resistor		
		R_1	R_2	R_3	R_1	R_2	R_3
I							
I_1							
I_{23}							
I_2							
I_3							

Table 2

Currents	Nominal	Measured value of current					
		Short resistor			Open resistor		
		R_1	R_2	R_3	R_1	R_2	R_3
I							
I_1							
I_{23}							
I_2							
I_3							

Measure resistance using voltage drop method

Objectives: At the end of this exercise you shall be able to
- **determine unknown high resistance by voltage drop method**
- **test unknown low resistance by voltage drop method.**

Requirements

Tools/Equipments

- Cutting plier 150 mm - 1 No.
- Screwdriver 100 mm - 1 No.
- Ammeter MC 0-500 mA - 1 No.
- Multimeter - 1 No.
- DC power supply unit 0-30V (RPS) - 1 No.

Materials

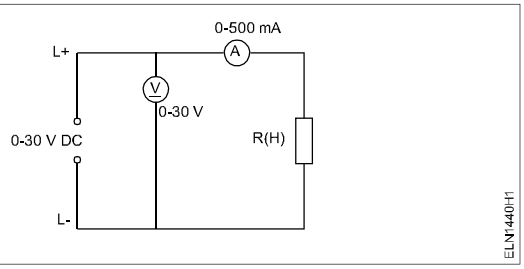
- Resistor high value - 2 Nos.
- Resistor low value - 2 Nos.

PROCEDURE

TASK 1: **Measure the high value resistance by voltage drop method.**

1 Construct the circuit as diagram. shown in Fig 1 and connect the high value resistor.

Fig 1



2 Switch ON power supply and adjust the DC volt to 30V.

3 Note the current and record it in Table 1.

4 Replace with another high value resistor and repeat step 3.

The true value and the measured value of R will be equal if we provide "0Ω resistance" ammeter and infinite voltmeter resistance.

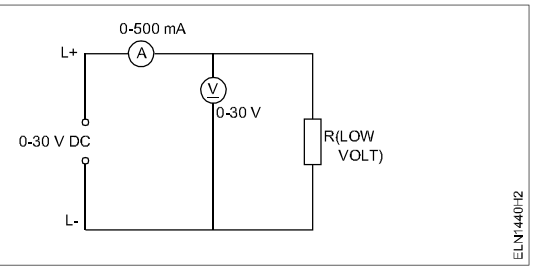
Table 1

Sl.No.	V	I	$R_m = \frac{\text{V reading}}{\text{A reading}}$
1			
2			

TASK 2: **Measure low value resistance by voltage drop method**

1 Costruct the circuit as per shown in Fig 2 and connect the low value resistor.

Fig 2



2 Repeat step 2 in TASK 1.

3 Record the current and voltage in Table 2.

Table 2

Sl.No.	V	I	$R_m = \frac{\text{V reading}}{\text{A reading}}$
1			
2			

The true value and measured value of R will be equal if we provide "0Ω resistance" ammeter and infinite voltmeter resistor.

4 Write your conclusion _____.

5 Get the work approved by the instructor.

Measure resistance using wheatstone bridge

Objectives: At the end of this exercise you, shall be able to
- **identify the terminals of a Wheatstone bridge**
- **complete the bridge with resistors**
- **operate a wheatstone bridge to get 'Null' deflection**
- **calculate the value of unknown resistance using the wheatstone bridge.**

Requirements

Equipment/Machines

- Wheatstone bridge - 1 No.

Materials

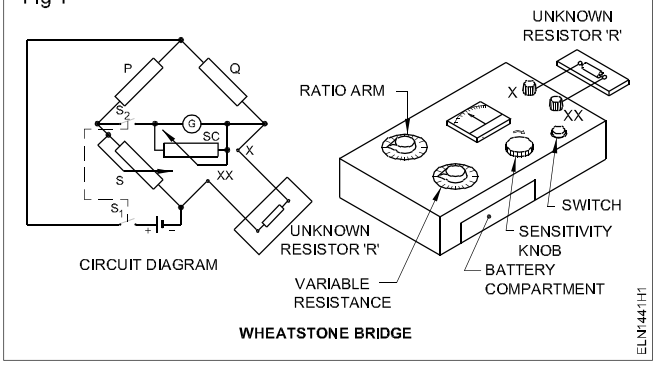
- Resistor 2 ohms 5 W - 1 No.
- Resistor 50 ohms 5W - 1 No.
- Resistor 10 ohms 5W - 1 No.
- Resistor 1K ohms 2W - 1 No.
- Resistor 330K ohms 2W - 1 No.
- Torch cells/battery for Wheatstone bridge - as reqd.

PROCEDURE

TASK 1: **Measuring an unknown resistance using Wheatstone bridge**

1 Identify the ratio arm (PQ), variable resistance (S), sensitivity control (SC), switch (S1), galvanometer (G), connecting terminal (x, xx) and battery compartment of the Wheatstone bridge and correlate it with the schematic diagram in Fig 1.

Fig 1



2 Check the battery for its condition.

3 Check the values of the ratio arm.

4 Check the minimum and maximum values of the variable resistance.

5 Connect the unknown resistor across terminals x and xx.

6 Set the ratio arm to the approximate value of the unknown resistor.

7 Set the variable resistor knob in the middle.

8 Set the sensitivity control to `Low'.

9 Close the switch and watch the deflection of the galvanometer.

10 Adjust the variable arm by closing the switch, to get a minimum deflection in the galvanometer. (In case the galvanometer needle overshoots, reset the ratio arm.)

11 Increase the sensitivity and repeat step 10.

12 When `Null' deflection is achieved in the galvanometer, note the value of the ratio arm and position of the variable resistance. Enter the values in Table 1.

13 Apply the formula given below and calculate the resistance.

Unknown resistance in ohms = _____

Reading of ratio arm setting X value of variable resistance

$$\frac{P}{Q} = \frac{S}{R}$$

$$R = \frac{S}{P} \times Q$$

14 Enter the values in Table 1.

15 Repeat the procedure for measuring at least four unknown resistors and enter their respective values in Table 1.

16 Get the work approved by the instructor.

Table 1

Sl.No.	Type of resistor	Setting of ratio arm	Value of variable resistance	Resistor value in ohms = Ratio arm x value of variable resistance

Determine the thermal effect of electric current

Objectives: At the end of this exercise you shall be able to
- **connect the ammeter in circuit**
- **read the ammeter**
- **connect the circuit element in series**
- **test the electrical continuity**
- **analyse the effects of electric current - thermal effect.**

Requirements

Tools/Instruments

- Ammeter 0-15A MC - 1 No.
- Battery lead acid 90 AH 12 V - 1 No.
- Rheostat 10 ohms, 2A - 1 No.

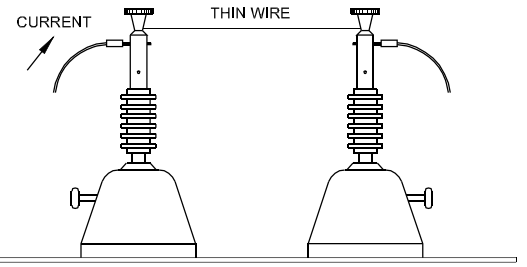
Materials

- Connecting leads
  48/0.2mm 1m - 8 Nos.
  80/0.2mm 1m - 8 Nos.
  128/0.2mm 1m - 8 Nos.
- Resistance wire Nichrome/constantine diameter. 0.2 to 0.3mm 250 to 500 mm.
- S.P.T.Switch 16A 250V - 1 No.
- Connecting terminal post 16A - 2 Nos.

PROCEDURE

1 Connect the resistance wire to the connecting terminal post. (Fig 1)

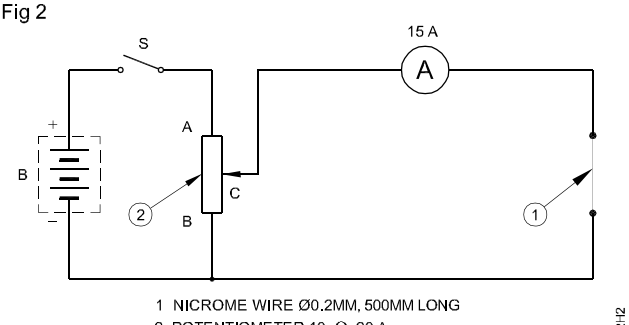
Fig 1



ARRANGEMENT OF RESISTANCE WIRE

2 Form the circuit with the resistance wire, ammeter, switch potential divider and battery. (Fig 2)

Fig 2



1 NICROME WIRE Ø0.2MM, 500MM LONG
2 POTENTIOMETER 10 Ω, 20 A

CIRCUIT DIAGRAM

3 Keep the potential divider point C at B.

4 Close the switch and adjust the potential divider for current. (Approximately.1 ampere.)

5 Observe the ammeter reading.

6 Touch the resistance wire and feel.

7 **Conclusion**

When the current flows in a resistive wire _____ is generated.

8 Gradually increase the current by varying the potential divider.

Note: For every change in current value - switch OFf and allow the wire to cool down to the room temperature.

For every change of current, the time duration to feel the heat must be the same, say 5 minutes.

9 Observe the value of the current through the resistance wire.

Note: Feel the heat at a distance without touching the wire. Be cautious not to burn your fingers.

10 **Conclusion**

When current increases _____ increases in the resistive wire.

11 When current is too high the resistance wire becomes _____.

Determine the change in resistance due to temperature

Objectives: At the end of this exercise you shall be able to
- **measure cold resistance of the incandescent lamp using ohmmeter**
- **measure hot resistance of the incandescent lamp with supply by voltmeter and ammeter**
- **identify the colour of the filament with respect to the voltage variation**
- **determine the relation between resistance and changes in temperature.**

Requirements

Tools/Instruments

- Connector screwdriver 100 mm - 1 No
- MI Voltmeter 0-300V - 1 No.
- MC Ammeter 0-1A - 1 No.
- Ohmmeter (shunt type) - 1 No.
- MC Voltmeter - 5 volts or multimeter (digital) - 1 No.

Materials

- Double-pole switch 250V,6A - 1 No.
- Lamp 15W, 250V - 1 No.
- Lamp-holder B.C.batten - 1 No.
- Candle - 1 No.
- Potentiometer 500 ohms, 0.5A - 1 No.
- Iron wire 0.2 mm diameter. - 2.5m.
- Connecting leads -11 Nos.
- Terminal post 16A - 2 Nos.
- Lamp 40W, 250V - 1 No.

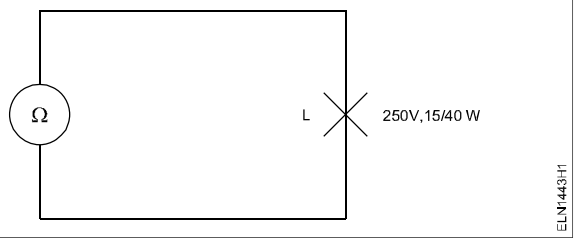
PROCEDURE

TASK 1: **Measuring of cold resistance of the incandescent lamp by using ohmmeter**

1 Set the ohmmeter to 'zero' and touch the two leads on the pins of the lamp.

2 Measure the resistance of the given incandescent lamp using ohmmeter (Fig 1).

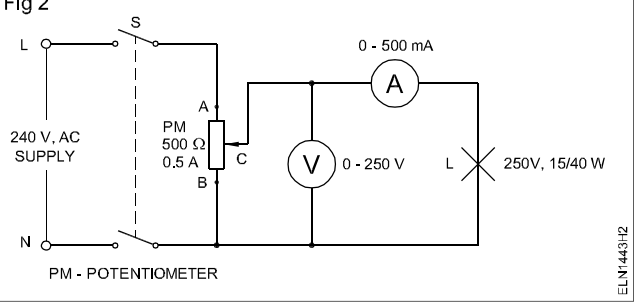
Fig 1



3 Record the value in Table 1.

4 Form the circuit with the lamp-holder, voltmeter, ammeter, potentiometer, D.P.S.T. switch and supply as per the circuit diagram. (Fig 2)

Fig 2



5 Get the circuit checked by the instructor. Keep the potential divider point C at B.

6 Fix the incandescent lamp in the lamp-holder and close the switch.

Note: Switch off the supply before fixing the lamp.

7 Adjust the potentiometer at 50 volts.

8 Close the switch and read the voltmeter and ammeter.

9 Record the values in Table 1.

10 Observe the colour of the filament and feel the temperature on the lamp's glass.

Table 1

Measurement			R in Ω	Colour of filament
1	Cold resistance of bulb measured by ohmmeter			
	V in volts	I in mA		
2	50 V			
3	100 V			
4	150 V			
5	240 V			

10 Repeat steps 6 to 8 for 100V, 150V and 240V.

11 Calculate the resistance using the formula $R = \frac{E}{I}$ for every set of reading.

12 Record the calculated values of resistance in the Table.

Conclusion

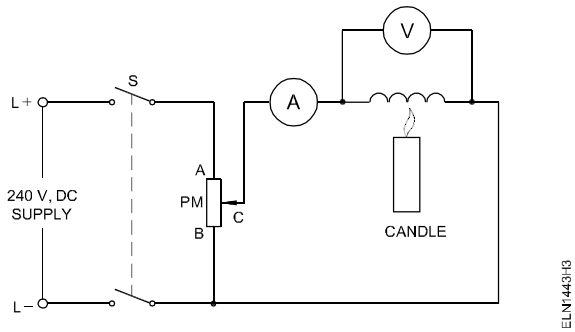
TASK 2: **Determine the relation between resistance and changes in temperature using a candle**

1 Make a coil of iron wire of length 0.5 m and diameter 0.2 mm.

2 Fix the coil between the two terminal posts mounted on a piece of insulating board.

3 Build the circuit according to Fig 3.

Fig 3



4 Increase the supply voltage to the iron coil by adjusting the potentiometer so that the current (I) reaches a value of 450mA.

5 Measure the voltage drop V_D across the coiled wire.

6 From both the values (I and V_D) calculate the resistance of the coil.

7 The result is: I = ____ A

V_D = ____ V.

Therefore, $R_D = \frac{V_D}{I}$

8 Now, warm the coil by heating it in candle flame record and the measurement for calculation of resistance. Do not change the potential divider movable arm position.

9 This now results in : I ____ A

V_D ____ V.

Therefore, $R_D = \frac{V_D}{I}$ = ... ohms

The result may vary considerably due to different temperatures of the wire.

Conclusion

What is the relationship between resistance and temperature?

Verify the characteristics of series parallel combination of resistors

Objectives: At the end of this exercise you shall be able to
- **form series parallel combination circuits**
- **verify characteristics of series and parallel circuits.**

Requirements

Tools/ Instruments

- Electrician tool kit - 1 Set
- MC Ammeter 0-500 mA - 3 Nos.
- Rheostat - 100 ohms, 1A - 1 No.
- MC Voltmeter 0-15V - 1 No.
- Multimeter - 1 No.
- Potentiometer 60 ohm 2A - 1 No.
- Rheostat 25 ohms 2A - 1 No.
- Rheostat - 40 ohms,2A - 2 Nos.
- Rheostat - 300 ohms, 2A - 1 No.

Equipment/ Machines

- DC source,Battery 12V,80AH or DC 0-60V variable voltage supply source with current limiting facility 0-1 ampere - 1 No. - 1 No.

Materials

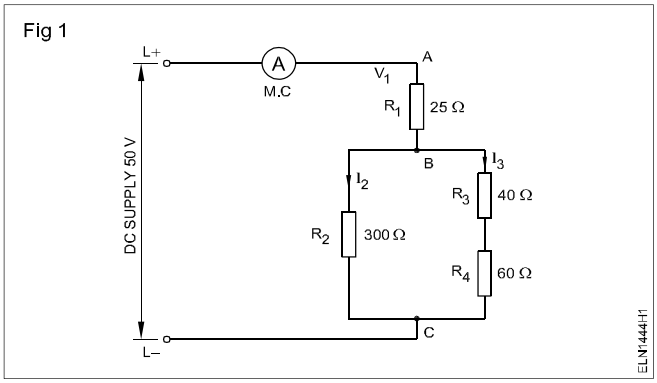
- Switch SPT 6A 250V - 1 No.
- Resistor 22 ohms 1 W - 1 No.
- Resistor 10 ohms 1 W - 1 No.
- Connecting cables - as reqd.

PROCEDURE

TASK 1: **Verify the characteristics of series parallel combination of resistors.**

1 Calculate the voltage and currents for the series parallel circuit shown in Fig 1. Enter the values in Table 1.

Fig 1



2 Calculate the total resistance R_T and total current I_S for V_S = 50V and enter in Table 2.

3 Set the value of the rheostat resistances equal to the values given in Fig 1 (i.e. R_1 = 25 ohms, R_2 = 300 ohms, R_3 = 40 ohms and R_4 = 60 ohms) by measuring the resistance value between one end and the variable point of the rheostat.

4 Form the circuit and measure the voltages and current. Record them in Table 1.

5 Calculate the value of R_T from V_s and I_s and enter in Table 2. Compare with the value obtained in step 2.

Table 1

		V_{RI}	I_S	I_2	V_{R2}	I_3	V_{R3}	R_3+R_4	$R_2 \| (R_3+R_4)$
V_S = 50V R_1 = 25Ω R_2 = 300Ω R_3 = 40Ω R_4 = 60Ω	Calculated Values								
	Measured Values								

Table 2

Calculated Values	$R_T = R_1 + \{R_2 \| (R_3 + R_4)\}$ =
Measured Values	$R_T = \frac{V_S}{I_S}$ =

Determine the poles and plot the field of a magnet bar

Objectives: At the end of this exercise, you shall be able to
- **identify the polarity of the magnetic compass**
- **determine the polarity of a permanent magnet**
- **trace the magnetic field of the given magnetic bar**
- **trace the magnetic lines with the aid of a compass needle and iron fillings.**

Requirements

Tools/Instruments

- Bar magnet 12 x 6 x 100 mm - 2 Nos.
- Compass needle 10 mm diameter. - 1 No.

Materials

- M.S.bar 12 x 6 x 100 m or (make a M.S. bar to the size of the bar magnet available) - 1 No.
- Thread (tensionless) - 1 m
- Iron fillings - 25 gms
- Iron nails - 25 gms.
- Aluminium wire - a few pieces
- Copper wire - a few pieces
- Cotton thread sleeve - a few pieces
- Wood chips - a small quantity.
- Paper pins - as required.

PROCEDURE

TASK 1: **Trace the magnetic field of the given magnetic bar**

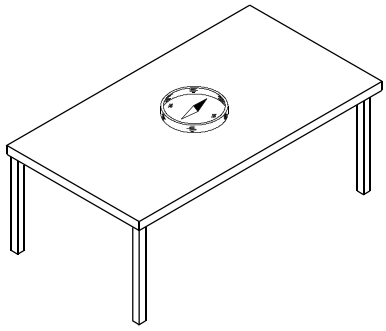
1 Keep the magnetic compass on the table as shown in Fig 1.

2 Observe the needle ends.

3 Turn the position of the compass and observe the position of the needle.

4 Result: The needle end seeking the geometrical north direction is the north seeking pole, or in general called a _____pole. The other end is called a _____pole.

Fig 1



ELN1545H1

TASK 2: **Determine the polarity of a permanent bar magnet**

1 Suspend the magnet as shown in Fig 2 with a tensionless thread.

2 Observe the direction of the poles of the suspended magnet.

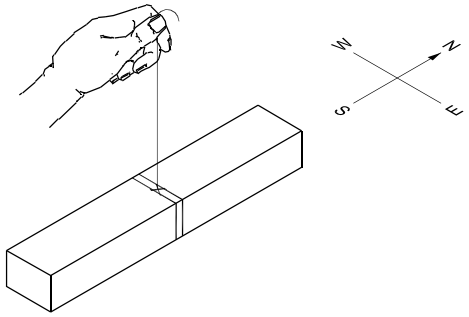
3 Mark the polarity N on the free end of the suspended magnet that points (seeks) at the north direction of the earth.

4 Reorient the position of the suspended magnet to cofirm the polarity.

5 Check the identified polarity with a magnetic compass.

The compass needle must not be taken near the poles of the bar magnet.

Fig 2

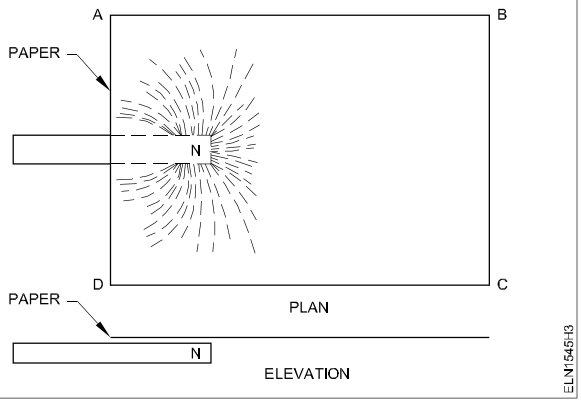


ELN1545H2

TASK 3: **Trace the magnetic path of the given magnetic bar**

1 Place the bar magnet's north pole underneath the paper as shown in Fig 3. Sprinkle some iron filings on the paper.

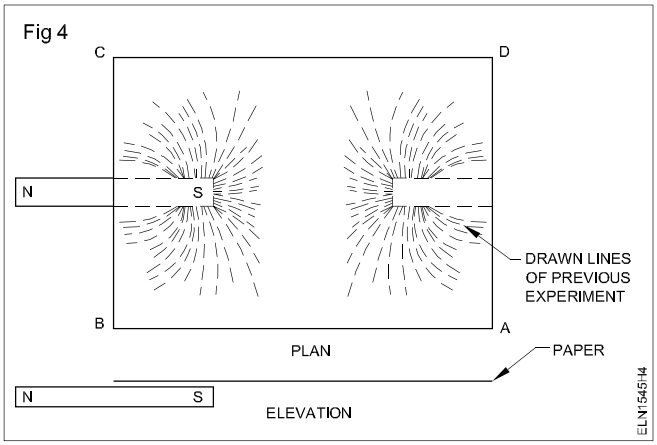
Fig 3



2 Tap the paper gently on all the corners. Observe the random filings getting oriented into a definite pattern.

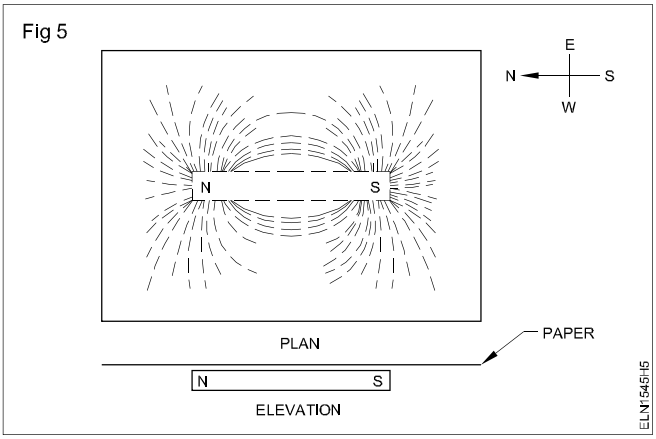
3 Gently draw lines along the orientation of the iron filings with a pencil. Repeat the expriment for the other pole as shown in Fig 4.

Fig 4



4 Place the bar magnet underneath a thin cardboard as shown in Fig 5. Sprinkle some iron filings. Gently tap the paper to orient the iron filings and trace the magnetic path with a pencil.

Fig 5

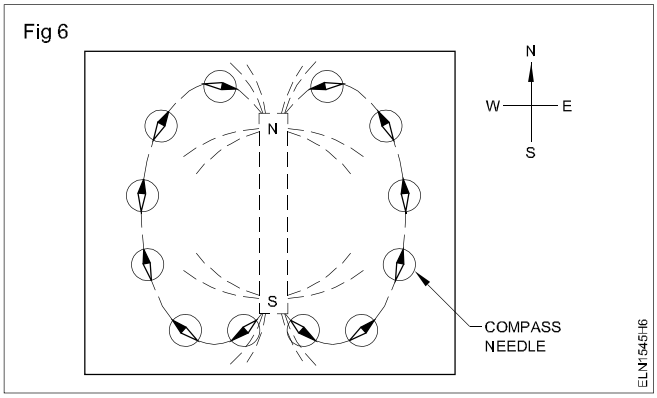


5 Place another thin card over the bar magnet as shown in Fig 6. Trace the magnetic lines using a compass needle by positioning the needle in the required areas..

For steps 4 and 5, the bar magnet should be oriented in the geometrical north-south direction.

Do not use a strong bar magnet for mapping the field with a compass.

Fig 6



Wind a solenoid and determine the magnetic effect of electric current

Objectives: At the end of this exercise you shall be able to
- **prepare a bobbin**
- **select the suitable wire and make the winding for solenoid**
- **determine the pulling strength of a solenoid.**

Requirements

Tools/Instruments

- Combination pilers 150 mm - 1 No.
- Screwdriver 100 mm - 1 No.
- Screwdriver 150 mm with 3 mm blade - 1 No.
- Magnetic compass 12 mm diameter - 8 Nos.
- Rheostat 10 Ohms, 20A - 1 No.
- MC Ammeter 0-10A - 1 No.
- MC Ammeter 0-30A - 1 No.
- MC Voltmeter 0-15/0-25V - 1 No.

Equipment/Machines

- Battery 12V, 80 or 100AH or variable voltage source DC 0-25V, 30A - 1 No.

Materials

- Iron filings - 50 gms
- Connecting leads - as reqd.
- DPST knife switch 16A/ 250V - 1 No.
- Enamelled copper wire 16SWG - 50 cm
- Paper pins - a few
- Terminal post 16A - 2 Nos
- SPST knife switch 16A / 250V - 1 No.
- PVC insulated cable 4 sq.mm 250V grade - 4 m.
- Barrator resistor 0.48 ohms 250W - 1 No.
- Cardboard A4 (R 48) size - 1 No.
- Bare copper wire 4 sq.mm - 1 m.
- Porcelain connectors 2-way 32A - 2 Nos.
- Transparent sheet of plastic, A4 size, 3 mm thick - 1 No.
- PVC saddles 50mm - 2 Nos.
- PVC pipe 25 mm 100 mm long - 1 piece.
- PVC washer 25mm inner diameter. 50 mm outside dia. - 2 Nos.
- PVC adhesive tape - as reqd.
- Super-enamelled copper wire 22 SWG - 50m.
- 4–way terminal pad - 1 No.
- T W plank 150 mm x 300 mm - 1 No.
- Soft iron piece 22 mm dia 75 mm long with hook on one end - 1 No.
- SPST Knife switch 16A - 1 No.
- Adhesive paste for fixing washers - as reqd.
- PVC/Empire sleeve 2 mm - as reqd.

PROCEDURE

TASK 1: **Make the solenoid and determine its polarity for the given direction of current**

1 Fix the PVC washers at both ends of the PVC pipe to make the bobbin. (Fig 1)

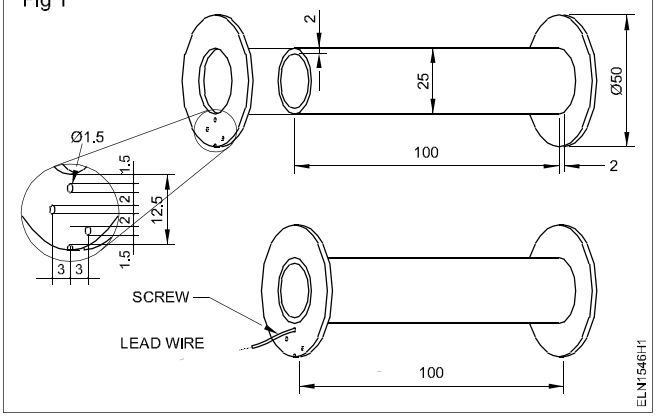
2 Fix the bobbin suitably in a hand drilling machine.

3 Secure the lead-out wire to the bobbin by means of an adhesive tape after inserting the lead wire with sleeve through the hole in the side wall of the bobbin.

4 Find the number of turns wound over the bobbin for one rotation of the drilling machine handle.

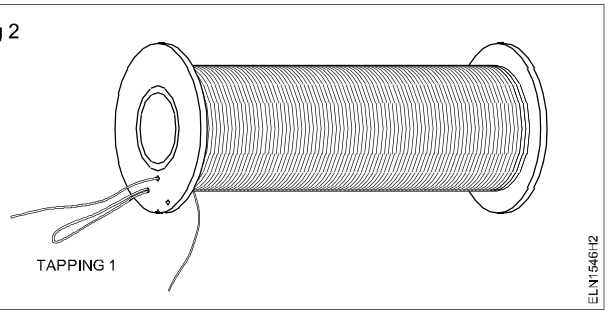
5 Calculate the number of handle rotations required for winding 200, 400 and 600 turns.

Fig 1



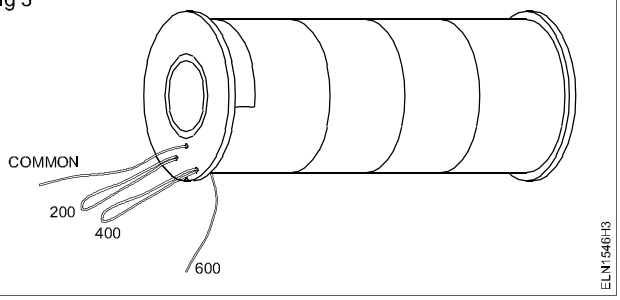
6 Complete the windings by taking tapping at an interval of every 200 turns (200, 400 and 600) such that the common and three terminals are taken out through the holes provided in the side wall (PVC washer). (Fig 2)

Fig 2



7 Insulate the top layer with an adhesive insulation tape. (Fig 3)

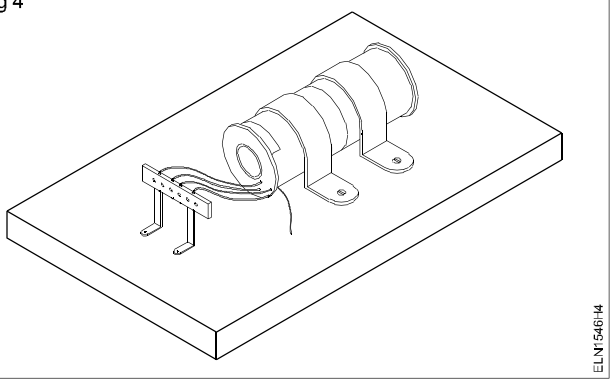
Fig 3



8 Fix the solenoid on a 150 mm x 300 mm wooden board using a plastic saddle. (Fig 4)

9 Connect the drawn out ends with sleeves to the 4-way terminal pad, fixed on the board. (Fig 4)

Fig 4

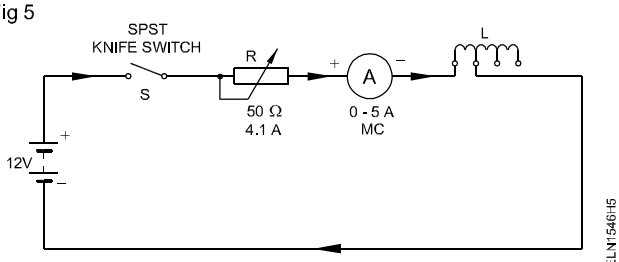


Carefully remove the enamel insulation without damaging the conductor.

10 Check the continuity with an Ohmmeter.

11 Connect the ends of the solenoid to the 12V battery through switch S, variable rheostat and ammeter 0 - 10A. (Fig 5)

Fig 5



12 Close the switch S and test the polarity of the solenoid with a bar magnet which is, suspended with a thread.

TASK 2: **Determine the magnetic effect of electric current**

1 Vertically mount the coil on a stand.

2 Suspend the spring balance from the stand and hook it vertically to the (plunger) soft iron piece. (Fig 6)

Check for the free movement of the plunger inside the solenoid.

3 Take the initial reading of the spring balance.

4 Connect the solenoid to the first tapping, say 200 turns, through an ammeter, knife switch and rheostat as shown in Fig 5. Get the circuit checked by the instructor.

5 Close the switch and adjust the current to 5 amperes.

6 Note the reading of the ammeter and spring balance and record in Table 1.

7 Open the switch.

8 Repeat operations 4 to 7 for tappings 400 and 600 by keeping the current constant at 5A, adjusting the rheostat.

9 Calculate the pulling power for strength in all the 3 cases.

10 Ascertain the relationship between the number of turns and magnetic strength when the solenoid carries the same current, and record the conclusion accordingly.

11 Connect the coil to 600 turns tappings.

12 Close the switch.

13 Keep the current at 1 ampere by adjusting the rheostat. (Fig 6)

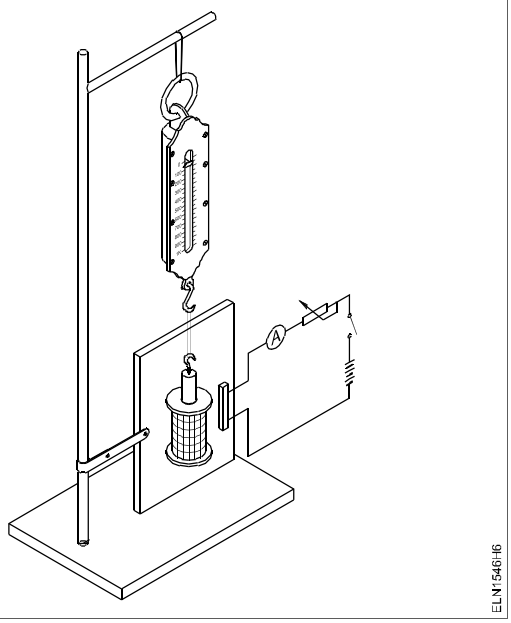
14 Note and record the spring balance readings in Table 2.

15 Repeat step 14 for different current values (in steps of 1 ampere up to 5 amperes).

16 Calculate the pulling power for strength in all the 5 cases.

17 Ascertain the relationship between the current and the magnetic strength when the number of turns of the solenoid is constant. Record the conclusion accordingly.

Fig 6



18 Get it checked by the instructor.

Conclusion

Table 1

Magnetic strength with respect to the number of turns (Current kept constant)

Sl.No.	No.of turns	Current	Initial reading of balance W1	Spring balance reading W2	Strength of pulling power (W3 = W2 - W1)
1	200	5 amps			
2	400	5 amps			
3	600	5 amps			

Table 2

Magnetic strength with respect to the current
(Turns kept constant = 600 turns)

Sl.No.	Current	Initial reading of the balance W1	Spring balance reading W2	Strength of pulling power (W3 = W2 - W1)
1	1 amp			
2	2 amps			
3	3 amps			
4	4 amps			
5	5 amps			

Measure induced E.M.F due to change in magnetic field

Objectives: At the end of this exercise you shall be able to
- **test and install a solenoid**
- **select a bar magnet and insert it into the solenoid**
- **measure the e.m.f for the change in magnetic field.**

Requirements

Tools/Equipment

- Voltmeter (100 mv - 0 - 100 mv) (centre zero) - 1 No.
- Bar magnet 100 mm - 1 No.
- Solenoid (Assembled) (prepared in previous exercise) - 1 No.

Materials

- Connecting wires - as required.
- Wooden board with stand - 1 No.

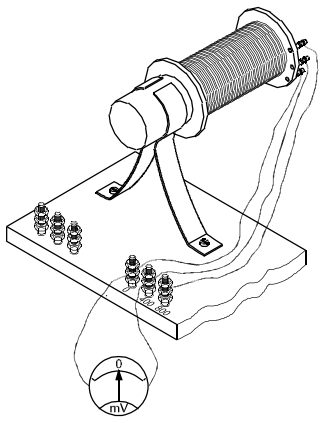
PROCEDURE

1 Check the physical condition of the solenoid and check the continuity of the coil.

2 Fix it on a board on shown in Fig 1.

3 Connect the galvanometer to the solenoid terminals as shown in Fig 1.

Fig 1



4 Insert the bar magnet into the solenoid and slowly initiate to and fro movement as shown in Fig 2.

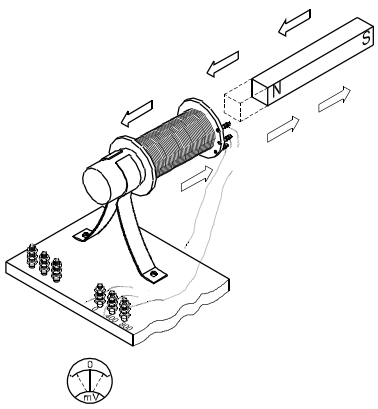
5 Record the corresponding reading in Table 1.

6 Gradually Increase the movement of the bar magnet. (Medium speed)

7 Record the reading in Table -1.

8 Increase the speed of bar magnet to the maximum, to get higher voltage reading.

Fig 2



9 Record the voltmeter reading in Table 1.

10 Tabulate all the readings and show it to the instructor for approval.

Table 1

Sl. No.	Speed of bar magnet	Voltages reading
1.	Slow	
2.	Medium	
3.	High	

Determine direction of induced E.M.F and current

Objectives: At the end of this exercise you shall be able to
- **determine the direction of e.m.f induced in the circuit**
- **determine the direction of the current by the induced e.m.f.**

Requirements

Tools/Equipment

- Voltmeter (100 mv - 0 - 100 mv) - 1 No.
- Bar magnet 4” - 1 No.
- Solenoid (Assembled) fitted on board (prepared in previous exercise) - 1 No.
- Multimeter - 1 No.
- Magnetic campass - 1 No.

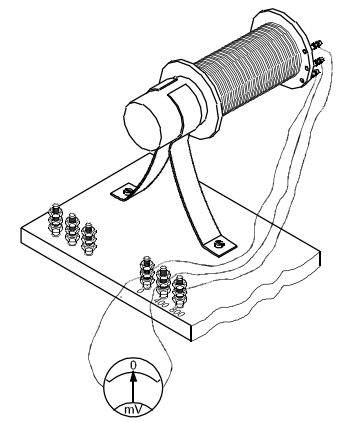
Materials

- Connecting leads - as required.
- PVC transparent sheet with drilled holes (4” x 3”) - 1 No.

PROCEDURE

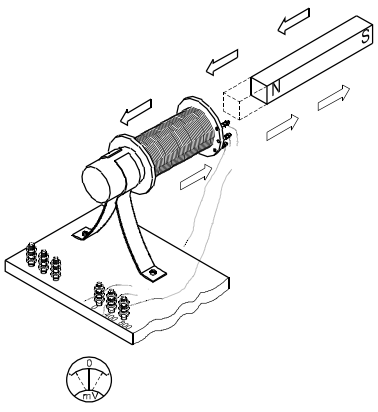
1 Connect the centre zero voltmeter to the solenoid and test the continuity of the coil as shown in Fig 1.

Fig 1



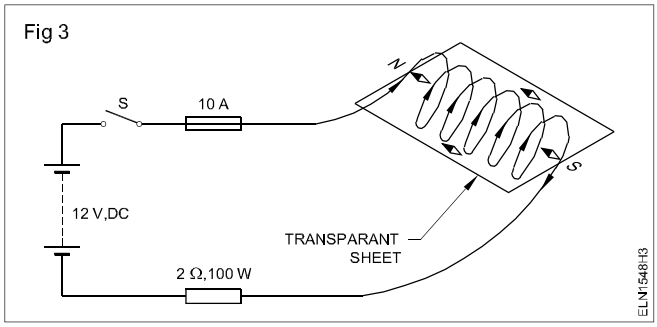
2 Check whether the induced voltage is present in the coil by mounting bar magnet as shown in Fig 2.

Fig 2



3 Extend one end of the coil wire and make 10 turns at equal distance in a drilled hole made on a transparent sheet on it as shown in Fig 3.

Fig 3



4 Place the compass at one entry point of the conductor by pointing ‘N’ to the entry of the coil as shown in Fig 3. Record your findings in Table 1.

5 Insert the magnet into the coil and move the magnet to and fro as in the earlier exercise. Note the deflection in the compass needle.

6 Change the polarity of the magnet and repeat step 4. Note the deflection in the compass needle.

The current direction shown in Fig 4 is for your reference.

The direction of the current in a conductor’s cross-section is shown by the (+) plus symbol inside a conductor or a (.) dot symbol outside a conductor. (Fig 4)

7 Interpret your findings and record the conclusion in Table 2. (A sample result is given for reference)

Fig 4

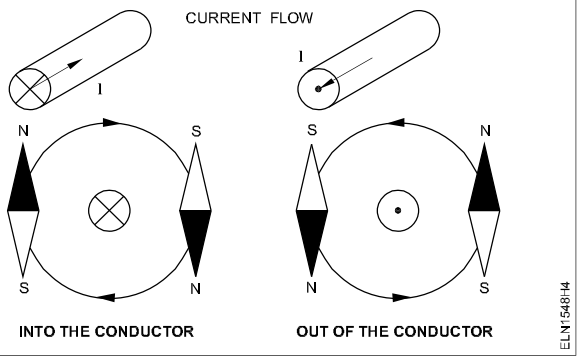
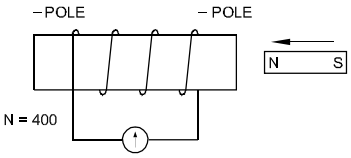
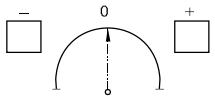
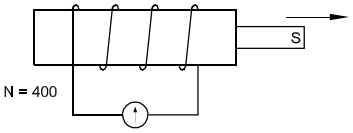
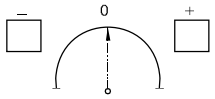
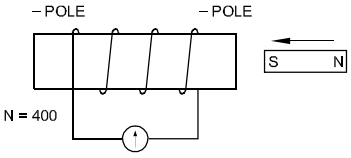
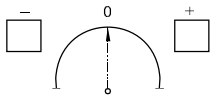
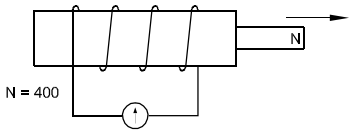
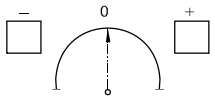


Table 1

Sl. No.	Compass N towards entry	Compass S towards entry
1		
2		
3		

Table 2

(POLARITY OF INDUCED EMF)

Case	Operation	Figure	Polarity of induced voltage
1.	Magnet is moved inside the coil		
2.	Magnet is moving away from the coil		
3.	Magnet with changed polarity is moved inside the coil		
4.	Magnet with changed polarity is moving away from the coil		

Practice on generation of mutually induced E.M.F

Objectives: At the end of this exercise, you shall be able to
- **prepare a solenoid having two sets of winding**
- **wind the solenoid with both primary and secondary windings**
- **measure the induced voltage in the secondary wrinding.**

Requirement

Tools/Equipments

- Voltmeter (100 MV - 0 - 100 MV) - 1 No.
- Bar magnet 100 mm - 1 No.
- Solenoid (Assembled) fitted on board (prepared in previous exercise) - 1 No.
- Multimeter - 1 No.
- Magnetic compass - 1 No.

Materials

- Connecting wires - as reqd.
- PVC transparent sheet with drilled holes 100 x75 mm - 1 No.
- Super Enamelled copper wire 22 SWG - 25 m
- Supporting stand - 1 Pair.

PROCEDURE

Use the solenoid, used in exercise 1.5.47 and 1.5.48.

1 Take the two ends of the coil, and check its resistance using ohmmeter and record in table 1.

2 Wrap the tape over the solenoid from one end.

3 Wind the copper wire (22 SWG) over the solenoid from one end to the half the length of the coil and wrap it with the tape.

4 Take the two terminals of the copper wire and check its resistance and record in table 1.

5 Fix the solenoid, which already has two windings in the board using clamps and screws as shown in Fig 1.

6 Set the secondary winding of step down transformer tapping to 10V.

7 Apply 10V AC to the inner winding (primary) and measure the secondary winding voltage as shown in Fig 1.

8 Note down the reading of the voltmeter in table 1.

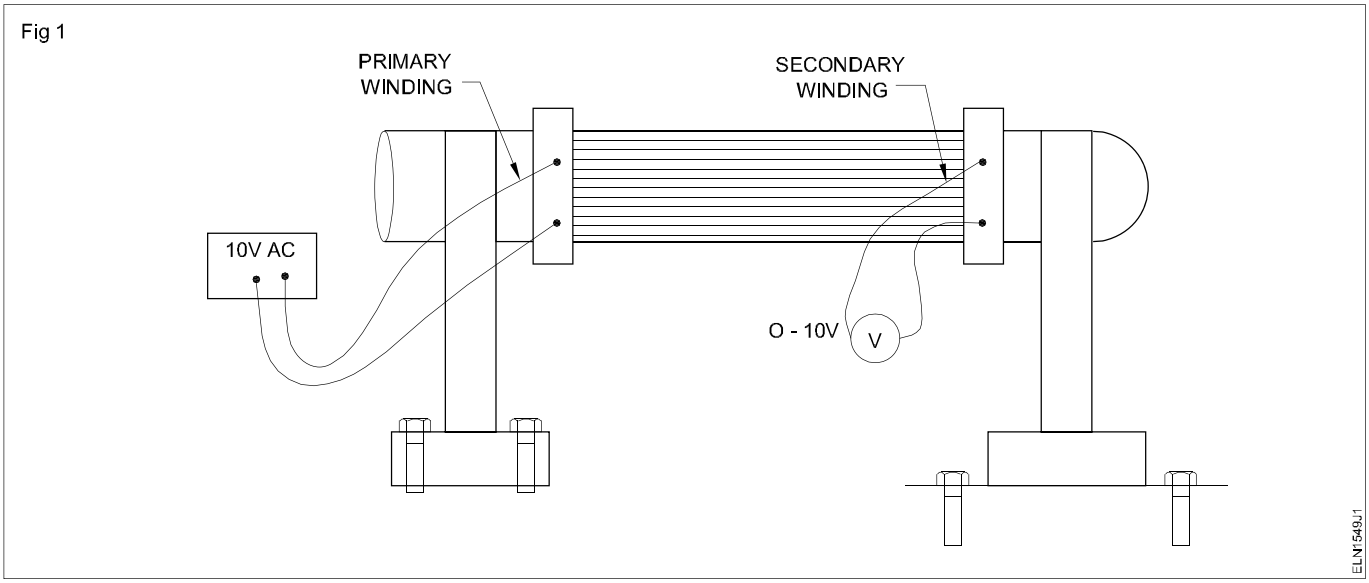
The voltmeter may show a very minimal reading. If the reading does not increase when the primary wrinding is used, set it to the secondary winding

9 Insert the soft iron core into the solenoid. Now the voltage will increase. Note down the voltage in Table 1.

10 Switch OFF and insert a non-magnetic cylindrical core inside the coil. Switch ON the 10V supply. Note down the voltage in Table 1.

11 Switch OFF and tabulate all the readings.

Fig 1



12 Get the work approved by the instructor.

13 Note down the result and conclusions.

Note down the primary and secondary number of turns in Table - 1 Measure the value of the resistance in primary and secondary windings and record in Table 1

Table 1

Primary Turn	Secondary Turn	Without soft iron core		With soft iron core		Any other core	
		Primary Voltage	Secondary Voltage	Primary Voltage	Secondary Voltage	Primary	Secondary
		10		10		10	

— — — — — —

Measure the resistance, impedance and determine the inductance of choke coils in diffrerent combinations

Objectives: At the end of this exercise, you shall be able to
- **measure the resistance of the coil**
- **measure the impedance in AC circuit using the voltmeter and ammeter**
- **determine the inductance of the coil.**

Requirements

Tools/Instruments

- MC Voltmeter 0-15V - 1 No.
- MI Voltmeter 0-300V - 1 No.
- MC Ammeter 0-500mA - 1 No.
- MI Ammeter 0 500mA - 1 No.
- Ohmmeter 0 - 2 K ohms - 1 No.

Materials

- SPT switch 6A 250V - 1 No.
- Connecting leads - 7 Nos.
- Wound choke (Solenoid coil) - 2 Nos.
- Tube light choke 40W, 240V - 2 Nos.

Equipment/Machines

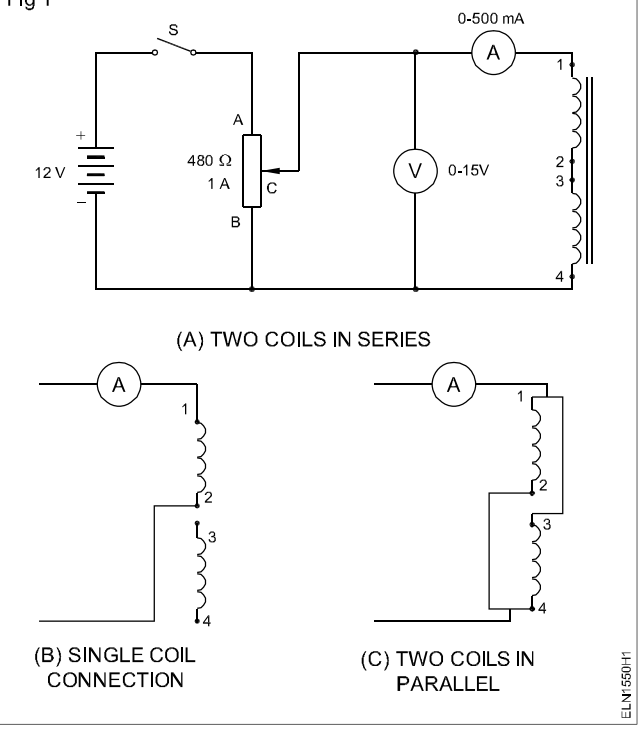
- Potential divider 480 ohms 1A - 1 No.
- 12 volts DC source (RPS)
- 240 volts AC source

PROCEDURE

TASK 1: **Measure the resistance of the coil**

1 Connect the elements and form a circuit as shown in Fig 1.

Fig 1



Keep terminal `C' at `B' in the potentiometer/ voltage divider for minimum output voltage

2 Show the connections to the instructor and get it approved.

3 Close the switch `S' and adjust the potentiometer for 100mA current. Record the value of I and V in Table 1.

4 Adjust the potentiometer to obtain the current, 200 and 300mA. Record I and the corresponding voltages.

5 Calculate the resistance of the coil applying Ohm's Law. Record the result in Table 1. Find the average value of resistance in ohms ie. R = V/I

6 Disconnect one coil i.e. terminals 3 and 4. Repeat the experiment to get the resistance measured for single coil with terminals 1 and 2. (Fig 1b)

7 Connect terminal 3 at 1 and 4 at 2. Read and record the V and I in Table 1. (Fig 1c)

8 **Result:** Resistance of the 2 choke coils in series = ... ohm

Resistance of one choke coil = ... ohm

Resistance of two coils chokes in parallel = ... ohm

.....

9 Verify the above results with the help of an ohmmeter.

Table 1

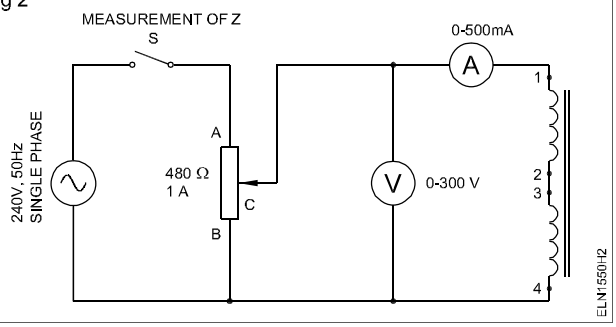
Sl.No.	DC voltatge across coils	current in mA	Resistance R = V/I	Coils connected
1				Two in series
2				
3				One coil only
4				
5				Two in parallel
6				
7				

Average resistance of both coils = _____ ohms
Average resistance of the single coil = _____ ohms
Average resistance of the parallel coils = _____ ohms

TASK 2: **Measure the impedance of the coil in AC supply**

1 Replace the voltmeter and ammeter with MI of type 0-300V and 0.5 ampere respectively. Connect the circuit to AC 240V 50 Hz supply source as shown in Fig 2.

Fig 2



Keep the terminal of the potentiometer `C' at `B' for the minimum output voltage.

2 Show the connections to the instructor and get his approval.

3 Close the switch `S' and adjust the potentiometer to obtain a current of 100mA. Record the I and V in Table 2.

4 Adjust the potentiometer for a current of 200mA. Record the corresponding voltage. Repeat it for 300mA.

5 Calculate the value of R = V/I for each case. Record the value under the column ` impedance ' and find the average value of impedance _____ ohm

6 Disconnect one coil (i.e. terminals 3 and 4). Repeat steps 2 to 4 to determine impedance of one coil.

Conclusion

i) When both coils are in series the impedance is

_____

_____

_____

ii) Impedance of one coil is _____ ohms.

TASK 3: **Determine the inductance of the choke**

Calculate the inductance (L) in the method shown below:

Average value of resistance (R) of the choke from Table 1 = _____ ohms.

Average value of impedance (Z) of the choke from Table 2 = _____ ohms.

Impedance $= Z^2 = R^2 + X_L^2$ ohms

$X_L = Z^2 - R^2$ ohms.

$X_L = 2p\,fL$

$$\therefore \quad L = \frac{X_L}{2\pi f}$$

where p = 3.142 (22/7)

f = Frequency of supply in Hz

L = Inductance in Henry

Inductance of the choke coil is $L = \frac{X_L}{2\pi f}$ Henry (H)

L = _____ Henry

Table 2

Sl.No.	AC voltage across coils	AC current in mA	Impedance Z = V/I	Coils connected
1				Two in series
2				
3				One coil only
4				
5				
6				

Average value of impedance of both coils = _____ ohms
Average value of impedance of single coil = _____ ohms

TASK 4: **Verify the effect of the direction of the current in coils with a common core**

1 Connect the elements and the terminal of the circuit as shown in Fig 3. Get the approval of the instructor and then close the switch and adjust the potentiometer to get 100mA.

2 Read and record the values for I and V in Table 3. Calculate the impedance and record in Table 3.

3 Switch OFF the supply and interchange the terminals 3 and 4 as shown in Fig 3.

Fig 3

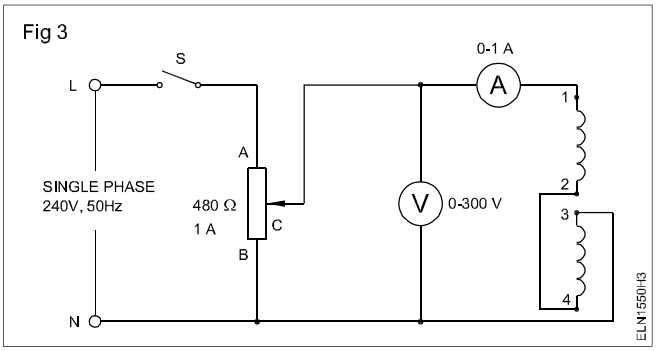


Table 3

Sl.No.	AC voltatge across both the coils	AC current in mA	Impedance Z = V/I	Direction of current
1				Two coils with current in the same direction
2				Two coils with current in the opposite coils

By interchanging the terminal connection, the direction of the current is reversed in the coil.

4 Close the switch `S' and record the new values of I at Sl.No.2. of Table 3.

Ensure that the voltage remains at the set value.

5 Calculate the value of impedance by the formula Z = V/I. Do you observe any change in the value of impedance from the previous value? _____ Is the value close to the resistance value calculated in Task 1? _____.

6 Verify and compare the impedance with the previous values.

7 Compare the impedance values in to following two conditions

– coils carrying current in the same direction
– coils carrying current in the opposite direction.

Conclusion

1 The impedance value when coils carry current in same direction.

_____

_____

2 The impedance value when coils carry current in the opposite direction.

_____

_____

Identify various types of capacitors, charging/discharging and testing

Objectives: At the end of this exercise, you shall be able to
- **identify the type of capacitor by visual inspection**
- **identify the capacitor's value and rating from the marking**
- **test the capacitor with DC supply for insulation and leakage**
- **test the capacitor for charge and discharge.**

Requirements

Tools/Instruments

- Ohmmeter (multimeter - ohms range) - 1 No.
- MC Voltmeter (0 - 15V) - 1 No.
- MC Ammeter (100mA - 0 - 100mA) - 1 No.

Equipment/Machines

- DC source 12 V or 0-30V variable (R.P.S) - 1 No.

Materials

- Capacitors - paper, mica, electrolytic, mylar, tantalum,variable air core and mica – assorted values and different voltage ratings - as required.
- Potentrometer 100 k ohm - 1 No.
- Single pole, double throw switch 16A 250V - 1 No.

PROCEDURE

TASK 1: **Identification of capacitors**

1 Look at Figs 1(a) to 1(t). Identify the capacitors and record your observations in Table 1.

2 Read the value of capacitance and working voltage from the markings, if indicated, and record in Table 2.

3 From the capacitor provided by the instructor read the value of the capacitor and identify its type.

Fig 1

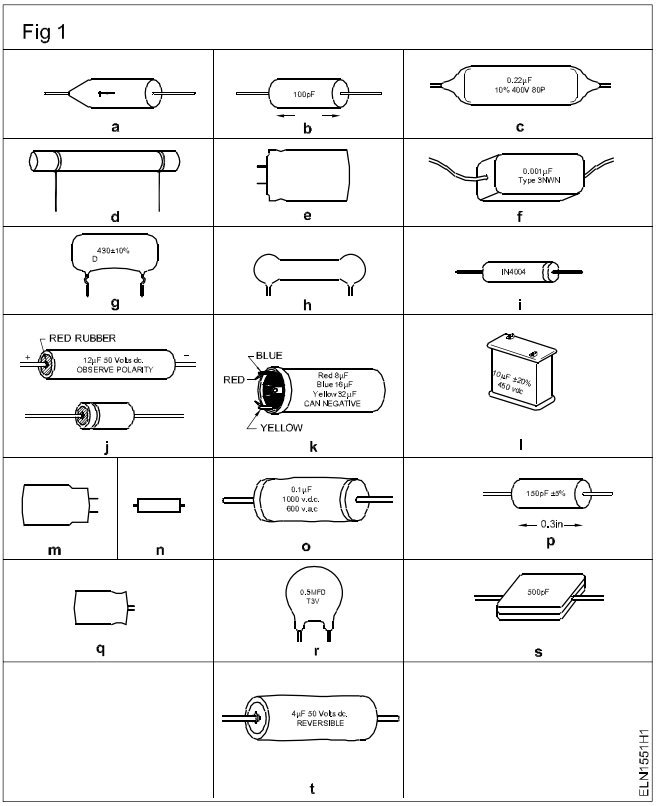


Table 1

Fig.No.	Name of component	Symbol	Type	Capacitance value	Voltage rating

Table 2

Sl.No.	Type	Value of C in µf	Voltage V

TASK 2: **Test the capacitor for charge and discharge**

1 Initially touch both leads of the capacitor with the voltmeter (suitable range).

If there is any deflection, contact both leads through a resistance for sufficiently a long time.

Do not touch the capacitor leads by hand. High voltage retained by a charged capacitor will give a severe shock.

2 Form the 12V circuit for testing the capacitor circuit elements as shown in Fig 2. Keep the switches open.

3 Keep the switch S connected to the battery. Observe the deflection in the ammeter and voltmeter.

4 Record the deflection in the ammeter when the switch S is closed to position 1.

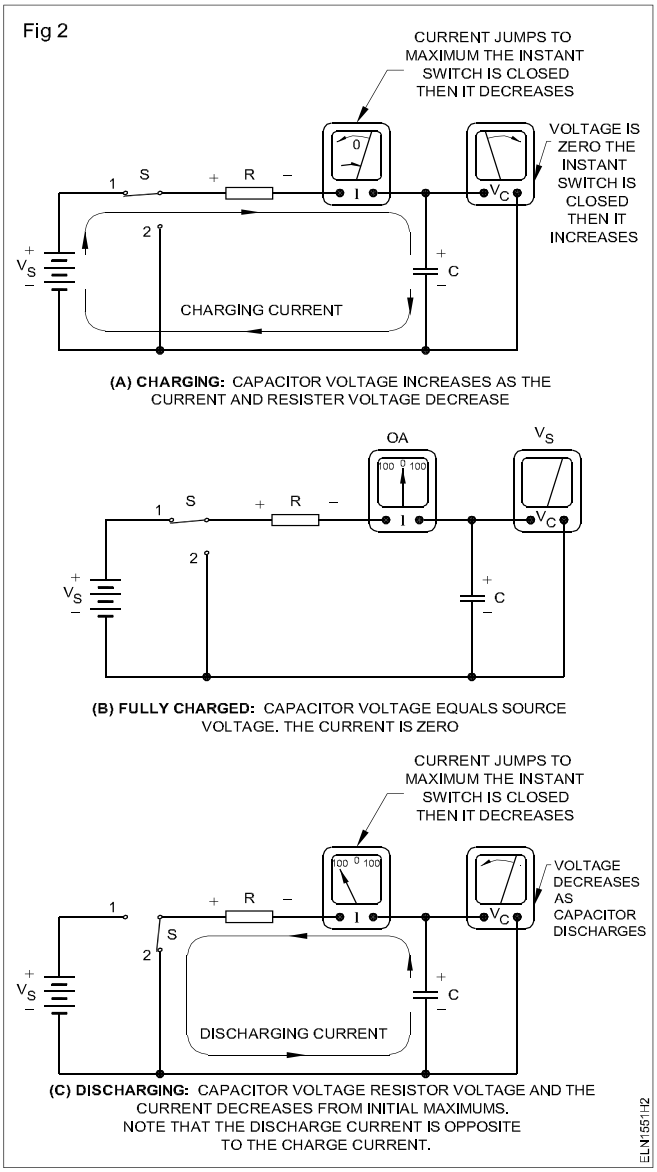
5 Observe the voltmeter reading at equal intervals of time. (At least 4 readings from zero to the maximum deflection.)

6 Record the time and voltage in Table 3.

7 Repeat steps 1 to 5 by changing the value of the series resistor 'R' (increasing the value of R increases the time).

8 Open the switch 'S' and observe the voltmeter reading for 5 minutes.

Fig 2



9 Result

The voltage across the capacitor remains _____ because of _____ condition of the capacitor.

10 Close the switch S to position 2 and observe the voltmeter and ammeter readings.

11 Observe the deflection of the voltmeter:

(a) The voltage of the capacitor gradually decreases.

(b The current shoots to maximum at the instant switch S is closed to position 2, then it decreases gradually, indicating that the capacitor is losing charge.

12 Repeat the test for different values of capacitance rated for different voltages.

The testing voltage should be close to the voltage rating of the capacitor.

Table 3

Sl. No.	Value of		Time in seconds	Voltage volts
	Capacitor µF	Resistor kW		
1	470	500		
2				
3				
4				
5	4370			
6				
7				
8				
9	470			
10				
11				
12				

TASK 3: **Testing of capacitor with ohmmeter**

1 Discharge the given capacitor.

2 Connect the ohmmeter to test the capacitor (Fig 3) and observe the deflection in the meter.

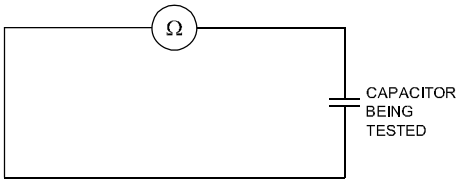
Set the ohmmeter selector switch at a higher range.

While testing with a polarised capacitor, the positive terminal of the capacitor is to be connected to the positive terminal of the ohmmeter and the negative terminal to the negative terminal of the ohmmeter.

While testing with non-polarised capacitor (mica, ceramic, etc) the low values in fractions of micro-farad will not show any deflection in the ohmmeter.

3 Assess the condition of the capacitor under test, using the information available in Fig 3 and record the findings in Table 4.

Fig 3



INDICATION OF TEST INSTRUMENT	CONDITION OF CAPACITOR UNDER TEST
METER INDICATES SOME RESISTANCE	LEAKAGE
NO DEFLECTION	OPEN
DEFLECTS AND RETURN BACK SLOWLY	GOOD CONDITION
CONTINEOUSLY SHOWS ZERO READING	SHORT

TESTING OF CAPACITOR WITH OHMMETER

ELN1551H3

4 Discharge the capacitor.

5 Perform the test in different capacitors.

Table 4

Sl. No.	Value of Capacitor	Meter reading	Result
1			
2			
3			
4			
5			

For electrolytic capacitor only.

Group the given capacitors to get the required capacity and voltage rating

Objectives: At the end of this exercise you shall be able to
- **identify the capacitor's value and rating from the markings**
- **test the capacitor with DC supply for its insulation and leakage**
- **determine the capacitive reactance**
- **select capacitors and connect in series**
- **select capacitors and connect in parallel**
- **test combinations of capacitors.**

Requirements

Tools/Instruments

- MI Voltmeter 0 to 300V - 1 No.
- MI Ammeter 0 to 500mA - 1 No.
- Rheostat, about 300 ohms 2A - 1 No.

Equipment/Machines

- 240V AC source.

Materials

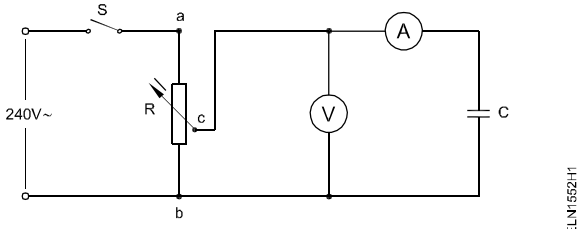
- Switch SPT 6A 250V - 1 No.
- 2 MFD 240V/400V - 2 Nos.
- 4 MFD 240V/400V - 1 No.
- 8 MFD 240V/400V 50 Hz. - 1 No.
- Connecting leads - as required.

PROCEDURE

TASK 1: **Measure capacitive reactance (Xc)**

1 Form the circuit as shown in Fig 1 with a 2 - µF capacitor. (Fig 1)

Fig 1



Discharge the capacitor before handling.

2 Close the switch S and adjust the potential divider for the rated voltage of the capacitor (240 V).

3 Note the voltmeter and ammeter readings and record in Table 1.

4 Calculate the reactance $X_C = \frac{V}{I}$ and record the result in Table 1

Table 1

Sl.No.	Value of Capacitor	Voltage	Current	$X_C = \frac{V}{I}$

5 Compare the calculated value using the formula

$$X_C = \frac{1}{2\pi fC}$$

6 Find the capacitive reactance value for 4 µF repeating steps 1 to 5.

7 **Conclusion**

i When capacitance increases the capacitive reactance _____

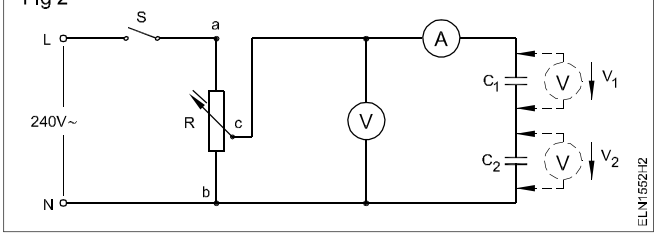
ii Increased reactance means _____ capacitance.

TASK 2: **Connect capacitors in series**

1 Form the circuit with two capacitors in series as shown in Fig 2. (2 MFD, 2 MFD)

2 Determine the X_C value for the series combination performing steps 2 to 5 of TASK 1. Fill X_C values in Table 2 under the appropriate columns.

Fig 2



3 Calculate the total capacitance C_{total} as

$$\frac{1}{C_{total}} = \frac{1}{C_1} + \frac{1}{C_2}$$

4 Calculate the C_{total} from the X_c. Check for its confirmity.

Result

When capacitors are connected in series

i the total reactance _____

ii the net capacitance value _____

5 Measure the voltage across each capacitor and record it in Table 2 under column 3.

6 Repeat steps 1 to 5 for series grouping of capacitors.

a) 2 & 4 MFD b) 4 & 8 MFD

7 Get it checked by the instructor.

Conclusion

The voltage across the capacitor and the value of capacitor in series.

_____

_____

Table 2

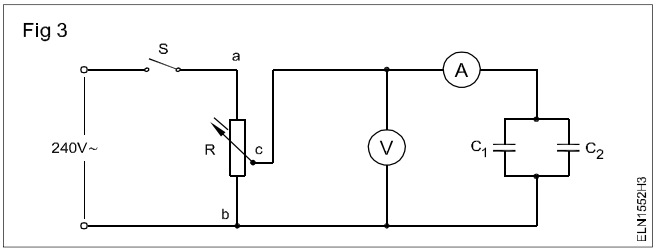
Sl. No.	Value of Capacitor C_1 in µf	Value of Capacitor C_2 in µf	Voltage across C_1 V_1	Voltage across C_2 V_2	Current in mA	Voltage V	Total $\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2}$	Capacitive reactance $XC = \frac{1}{2\Pi fc}$
1	2	2						
2	2	4						
3	4	8						

TASK 3: **Connect capacitors in parallel**

1 Form the circuit with two capacitors in parallel as shown in Fig 3 (2 MFD, 2 MFD).

2 Determine the reactance X_C of the parallel combination performing steps 2 to 5 of TASK 1. Fill up X_C in Table 3.

Fig 3



3 Calculate the total capacitance $C_{total} = C_1 + C_2$. Record C_{total} in table 2.

4 Calculate the C_{total} from X_C. Check for its confirmity.

Result

In parallel combination of capacitance

i the total reactance _____

ii the total capacitance _____.

Discharge the capacitors at the end of each experiment / test

5 Repeat steps 1 to 5 for parallel grouping of capacitors.

TABLE 2

Sl. No.	Value of Capacitor C_1 in mf	Value of Capacitor C_2 in mf	Voltage across C_1 V_1	Voltage across C_2 V_2	Current in mA	Voltage V	Total $C_{total} = C_1 + C_2$	Total reactance $XC = \frac{1}{2\Pi fc}$
1	2	2						
2	2	4						
3	4	8						

Measure current, voltage and PF and determine the characteristics of the RL, R-C, R-L-C in AC series circuits

Objectives: At the end of this exercise, you shall be able to
- measure the current, voltage, power and P.F in R-L series circuits
- measure the current voltage, power and P.F in R-C, series circuits
- measure the current voltage, P.F in R-L-C series circuits
- measure the power and P.F. in R-L-C series circuits

Requirements

Tools/Instruments

• MI voltmeter 0 - 300 V	- 3 Nos.
• MI ammeter 0 - 1.5 A	- 1 No.
• Wattmeter 250 V, 2.5 amps	- 1 No.
• Power factor meter (0.5 lag to 0.5 lead) 250 volts, 2.5 amps	- 1 No.

Equipment/Machines

• Auto transformer 0-270V/8A	- 1 No.

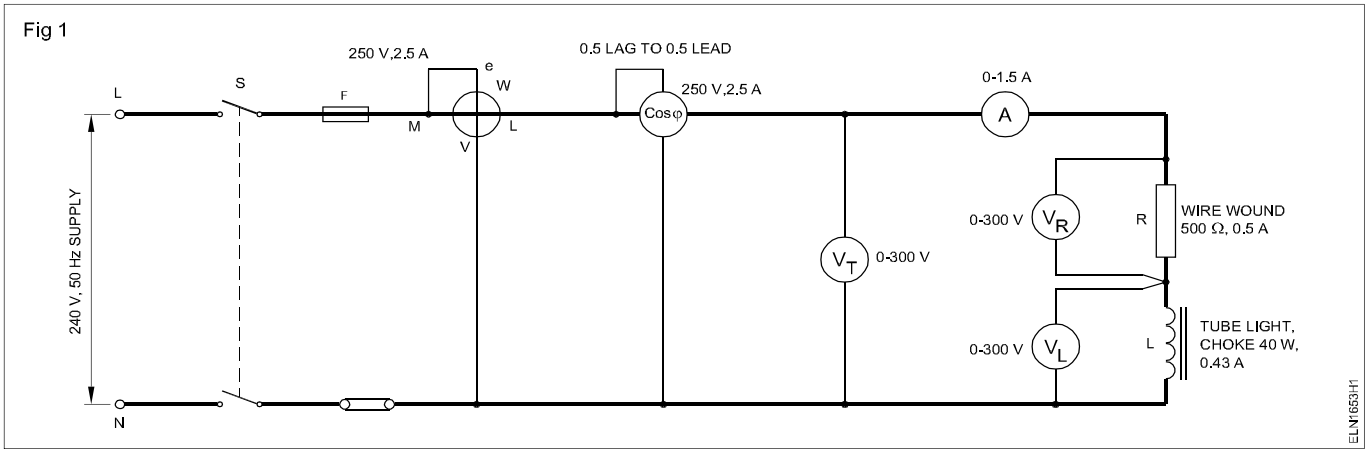
Materials

• Connecting cables	- as required.
• Choke (tube light) 40 W, 0.43 A, 250 V	- 1 No.
• I.C.D.P. switch - 16 amps, 250 volts	- 1 No.
• Wire wound resistor 500Ω/0.5A	- 1 No.
• Wire wound resistor 100Ω/1.5A	- 1 No.
• Electrolytic capacitor 8μFd/400V	- 1 No.
• Electrolytic 1μFd, 2μFd, 4μFd/400V	- 1 each

PROCEDURE

TASK 1: **Measure the current, voltage, power and P.F in R-L series circuit**

Fig 1



1 Assemble the circuit by connecting instruments, resistor R, inductor L as in Fig 1. Switch ON the supply.

2 Measure the voltage V_R, V_L, supply voltage V_T and the circuit current and record in Table 1.

3 Read power (W_1) and power factor ($\cos \phi$) and record it in Table 1.

4 Calculate the apparent and the true power consumed in the circuit and compare them.

5 Calculate the power factor and compare it with the measured power factor.

6 Draw the vector diagram to add the voltage drops across R and L.
- Keep current as the reference vector.
- Select a suitable scale for the voltage.
- Draw the voltage vector (V_R) in-phase with current (I).
- Draw the voltage vector V_L leading-current I by 90°.
- Add vector V_R and V_L to get V_{T1}

7 Compare the above with the measured supply voltage.

8 Calculate the power factor from the true power and apparent power $\text{Cos } \phi_2 = \dfrac{W}{V_T \times I}$ = ...W

9 Compare the calculated power factor with the measured power factor.

10 Repeat the steps changing two values for the resistor and inductor and record them in Table 1 in columns 2 and 3.

11 Get it checked by the instructor.

Table 1

Measured value							Calculated value			
Sl. No.	Circuit current	Supply voltage	Power consumed (Wattmeter reading)	Voltage across resis-tance	Voltage across induc-tance	Power factor (reading of P.F. meter)	Vector addition of VR and VL	Difference in VT_1 and VT_2	Power consumed in circuit	Difference between measured & calculated power factor
	I	V_{T1}	W_1	V_R	V_L	Cos ϕ_1	V_{T1}	$V_T - V_{T1}$	W2= V_T X I X Cos ϕ_1	Cos ϕ_1 – Cos ϕ_2
1										
	Resistance =				Inductance =					
2										
	Resistance =				Inductance =					
3										
	Resistance =				Inductance =					

Conclusion

The difference between vector addition of V_R and V_L with respect to V_T is due to _____

_____

TASK 2: **Measure the current voltage, power and P.F in R-C series circuit**

1 Test the capacitor with an ohmmeter for its condition.

Discharge the capacitor before testing.

2 Check the value of the given resistance with a digital multimeter for its value.

Check the suitability of the selected wattmeter and P.F. meter with respect to the circuit specifications.

3 Construct the circuit as per diagram. (Fig 2) Keep the switch 'S' open.

Set the auto-transformer output to zero voltage.

4 Close switch 'S' and adjust the auto-transformer output voltage to 100V.

5 Measure the circuit current, voltage power consumed and power factor and note the readings in Table 2.

6 Calculate cosϕ and impedance.

7 Compare the calculated P.F with measured P.F.

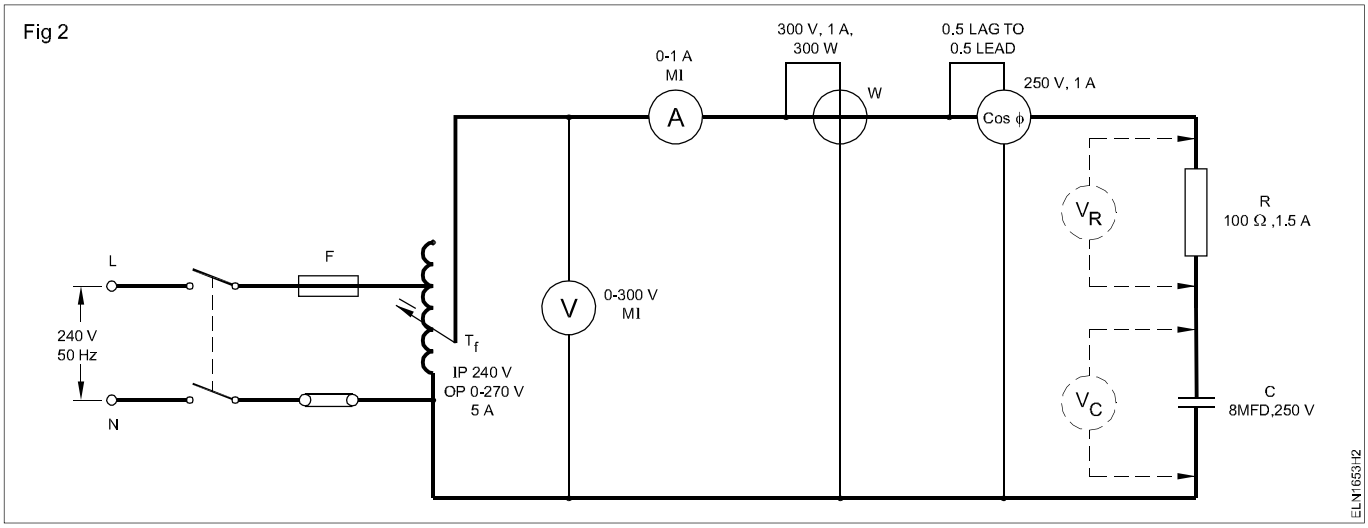
8 Measure the voltages across R and C and note in Table 3.

9 Compare the arithmetical sum of V_R and V_C with the supply voltage and observe that this is a wrong procedure.

10 Add V_R and V_C by the vector method (graphically) selecting a suitable scale and compare with the measured supply voltage.

11 Adjust the output voltage to 200 V and repeat steps 5 to 10.

Fig 2



12 Get it checked by the instructor.

Conclusion

Table 2

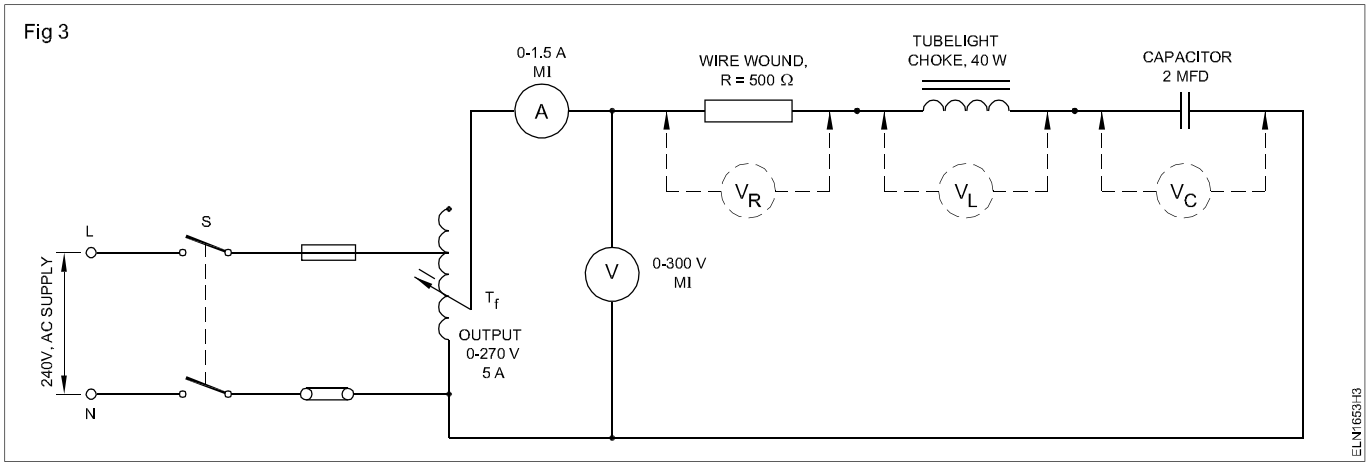
Measured				Calculated	
V supply	**I**	**W**	**PF**	$PF = \frac{W}{VI}$	$Z = \frac{V}{I}$
100 V					
200 V					

Table 3

V supply	V_R	V_C	$V_R + V_C$ (Arithmetic)	$V_R + V_C$ (Vector)
100 V				
200 V				

TASK 3: **Measure the current voltage, P.F, in R-L-C series circuit**

Fig 3



1 Assemble the circuit as per circuit diagram (Fig 3) with the instruments and components collected.

Before forming the circuit, confirm that the capacitor is discharged.

2 Switch 'ON' the supply and adjust the auto-transformer until the voltmeter indicates 240 volts.

3 Measure the voltage across each element and note it in the Table 4.

Table 4

Supply	V_R	V_L	V_C	I
240 v				

4 Measure the current and note the same in Table 4. Switch off the circuit.

5 Draw the vector diagram (say 1cm = 50 V and 1cm = 0.1A) taking the current as the reference vector.

6 Determine the supply voltage from the vector diagram.

Supply voltage (vector sum) =.....V

Assumption: The resistance of the choke is negligible in this case.

7 Compare the value of the resultant vector voltage with reading of the voltmeter across the mains.

If the vector sum of voltages V_R V_C V_L is not exactly equal to the measured supply voltage, it may be due to---

- **observation error**
- **drawing of the vector diagram incorrectly**
- **assumptions made.**

8 Replace the capacitor with another value, say 8.0 MFD and repeat the steps 2 to 7.

9 Replace the capacitor with another value, say 1.0 MFD and repeat the steps 2 to 7.

10 **Result:** Total measured voltage is_____

_____

11 Get it checked by the instructor.

Conclusion

A The voltage across individual component and total supply voltage_____

_____

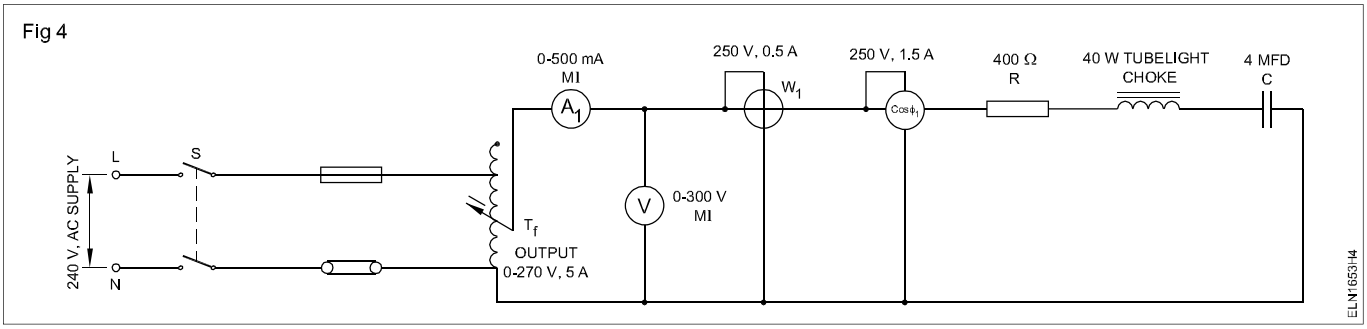
B The circuit current_____

_____

C The phase angle of current with supply voltage (from voltage vector)_____

TASK 4: **Measure the power and P.F. in R-L-C series circuit**

Fig 4



1 Form the circuit as shown in Fig 4.

Discharge the capacitor. With an ohmmeter check the resistance for its value, the inductor for its continuity and the capacitor for leakage.

2 Set the auto-transformer to have zero output. Switch 'ON' the supply.

3 Gradually increase the output voltage until it is 100V.

4 Measure the corresponding current. Note down the readings in Table 5. Also read the Wattmeter and the power factor meter and record it in Table 5.

5 Calculate the apparent power from voltmeter and ammeter reading.

Apparent power = V x I in volt amp (VA)

6 Determine the power factor by using the formula and record it in Table 5.

$$\text{Cos } \phi = \frac{\text{True power}}{\text{Apparent power}}$$

7 Verify the measured power factor with the calculated power factor.

8 Increase the voltage to 200 volts and repeat steps 4 to 7.

Do not increase the voltage beyond 200V for this circuit.

9 Reduce the output voltage back to zero and switch off the supply.

10 Repeat the experiment (steps 2 to 9) with

i) the capacitor removed

ii) a 2 micro-farad capacitor connected

iii) a 8 micro-farad capacitor connected keeping the voltage at 200 V.

11 Compare the readings of the power factor in all the four cases. Record your observation.

12 **Result**

The change of the capacitor in the R-L-C series circuit for given R-L (value)

_____

_____

_____

TABLE 5

Sl. No.	**V Volt**	**I Amp.**	**W True power**	**AP = V xI in VA Apparent power**	**cos ϕ = $\frac{W}{AP}$**	**P.F. Meter reading**	**Capacitor value in MFD**
1	100 V						4
2	200 V						4
3	200 V						0
4	200 V						2
5	200 V						3

13 Get it checked by the instructor.

Measure the resonance frequency in AC series circuit and determine its effect on the circuit

Objectives: At the end of this exercise you shall be able to
- **determine the resonance frequency of a given LC series circuit and circuit current**
- **plot a graph of frequency versus circuit current**
- **test the working of a series LC as a wave trap**
- **determine the effect of the resonance on the circuit.**

Requirements

Materials/Components

• General purpose Lug board	- 1 No.
• Capacitor 0.1 µF	- 1 No.
• Inductor coil, around 40mH (Use the solenoid coil made in Ex. 1.5.46)	- 1 No.
• LED with holder	- 1 No.
• Hook-up wires	- as reqd.

Tools/Equipments/Instruments

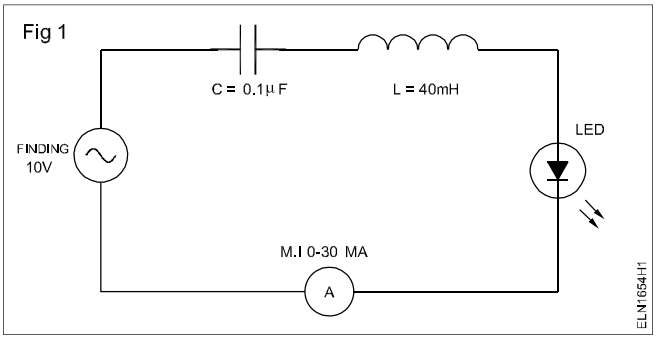
• Trainees kit	- 1 No.
• CRO, 20 MHz	- 1 No./batch
• Function generator	- 1 No./batch
• MI Ammeter 0 - 30 mA	- 1 No.

PROCEDURE

TASK 1: **Finding Resonance frequency and circuit current**

1 Solder the components as shown Fig 1 to obtain a simple series resonance circuit. Connect instruments as shown in Fig 1.

Fig 1



The LED in the circuit is to get a visual indication of the current through the circuit at different frequencies.

3 Calculate and record the resonance frequency of the series resonance circuit with known values of L and C

4 Set the output of the signal generator to $10V_{rms}$ and frequency to 1KHz. Record the current, I through the circuit in Table 1.

LED may not be glow or may be very dim, because the set frequency of 1 KHz may not be the resonance frequency of the circuit.

5 Gradually increase the frequency and record the resonance frequency f_r at which the circuit current becomes maximum (LED glows brightly).

This is the resonance frequency of the series resonance circuit because at series resonance, current I through the LC circuit will be maximum.

6 Compare and record the difference in the resonance frequency calculated in step 3 and that measured in step 5.

7 Vary the input frequency in steps of 500 Hz around the resonance frequency and in each step record the value of circuit current in Table 1.

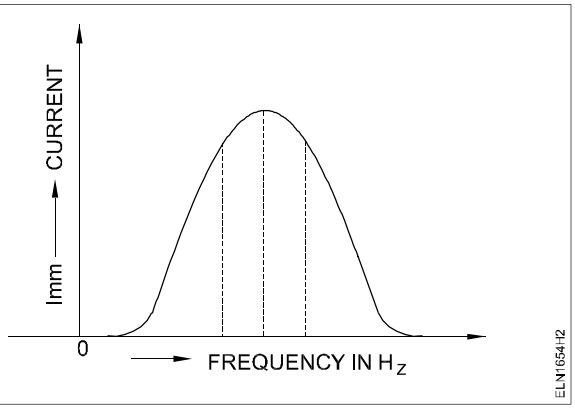
8 From the recorded readings of current in step 6, plot a graph of frequency versus current and mark the resonance frequency of the LC series circuit. (Fig 2)

9 It may appear as in Fig 2 working of the circuit, Record readings and plot the graph and get it checked by the instructor.

Table 1

Frequency	+500HZ	+1KHZ	+1.5KHZ	+2KHZ
Sine wave				

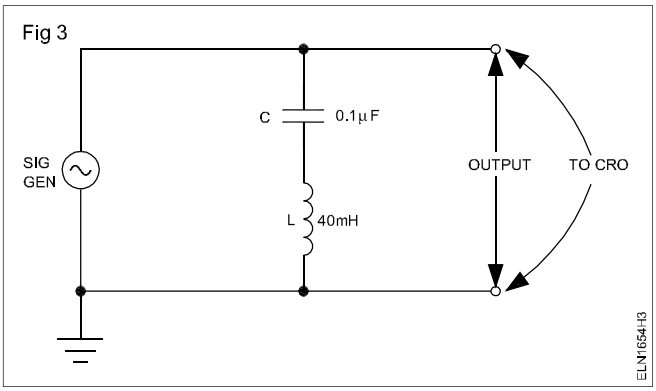
Fig 2



TASK 2: **To use series LC circuit as wave-trap to determine the effect on the circuit**

1 Using known values of L and C make the circuit connections as shown in Fig 3.

Fig 3



2 Set the output of the signal generator to 3 volts, 50KHz, sine wave.

3 Increase the frequency till the output of the trap circuit is minimum. Record this frequency as the trap frequency and its the effect on the circuit.

At trap frequency, which is the resonance frequency of the Shunt connected LC circuit, the impedance of the circuit will be minimum and hence the voltage across the circuit will be minimum. Ideally, this should be zero. But, because of the internal resistance of the coil, the output voltage will not be zero but, will be minimum.

4 Get your work checked by the instructor.

LAB ASSIGNMENT: Change the value of the capacitor used in the LC circuit to 0.01µF and redo TASK 2 to find the new wave-trap frequency.

Measure current, voltage and PF and determine the charactertics of R-L, R-C and R-L-C in AC parallel circuits

Objectives: At the end of this exercise you shall be able to
- **measure the current, voltage in R-L parallel circuit**
- **measure the current and voltage in each branch circuit of R-C parallel circuits**
- **determine the characteristics of R-L-C in parallel circuits.**

Requirements

Tools/Instruments

- Digital multimeter - 1 No.
- MI Ammeter 0 to 2 ampere (0-5A) - 2 Nos.
- MI Ammeter 0 to 3 amperes (0-5A) - 1 No.
- MI Voltmeter 0-250 V - 1 No.
- Frequency meter 50Hz/±5 - 1 No.

Equipment/Machines

- Auto-transformer - input 240 V - output 0 to 270 V, 8 amps - 1 No.
- Rheostar 400Ω/1A - 1 No.

Materials

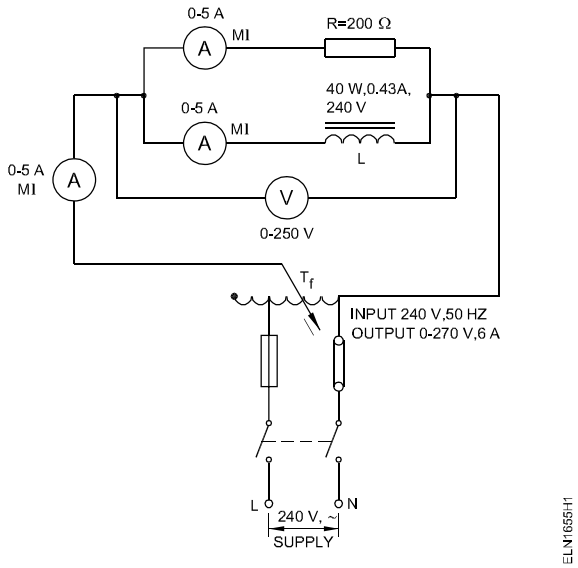
- Connecting cables - as reqd.
- I.C.D.P switch 250V, 16 A - 1 No.
- Wire wound resistor - 200 ohms - 1 No.
- Choke coil of 40 watts, 240V 50 Hz. tube light - 1 No.
- E.capacitor 8μFd/4μFd/400V - 1 each.
- E.capacitor 2μFd/400V - 1 each.

PROCEDURE

TASK 1: **Measure the current, voltage in R-L parallel circuit**

1 Assemble the circuit with the instruments, inductance coil and resistance. (Fig 1)

Fig 1



2 Set the auto-transformer output at zero position.

3 Switch 'ON' the supply and gradually increase the output voltage to 50V.

4 Measure the branch and total currents and record in Table 1. Repeat this step for different voltages say 100V, 125V, 150V, and 175V.

Table 1

Sl.No.	Measured				Graphical
	V	I_R	I_L	I_T	I_T Value
1	50				
2	100				
3	125				
4	150				
5	175				

5 Draw the vector diagram with suitable scale for currents taking voltage as reference vector in your practical record.

6 Determine the total current graphically.

The calculated values of total current and the actual measured value of current may vary due to instrument error, observational error and non-availability of pure inductance. Hence, about 5% error is permissible.

7 Compare the total current measured with the calculated value entered in table 2.

TABLE 2

Sl.No.	Measured		Calculated	
	V	I_T	$I_T = \sqrt{(I^2_R + I^2_L)}$	$Z = \frac{V}{I_T}$
1	50			
2	100			
3	125			
4	150			
5	175			

8 Find the Impedance of the circuit from the supply voltage and measured current. Calculate $Z = \frac{V}{I_T}$

Conclusion

Total current in an AC parallel circuit is the vector _____ of I_R and I_L and not _____ addition.

TASK 2: **Measure the current and voltage in each branch circuits of R-C parallel circuits**

1 Test the capacitor with an ohmmeter for its condition.

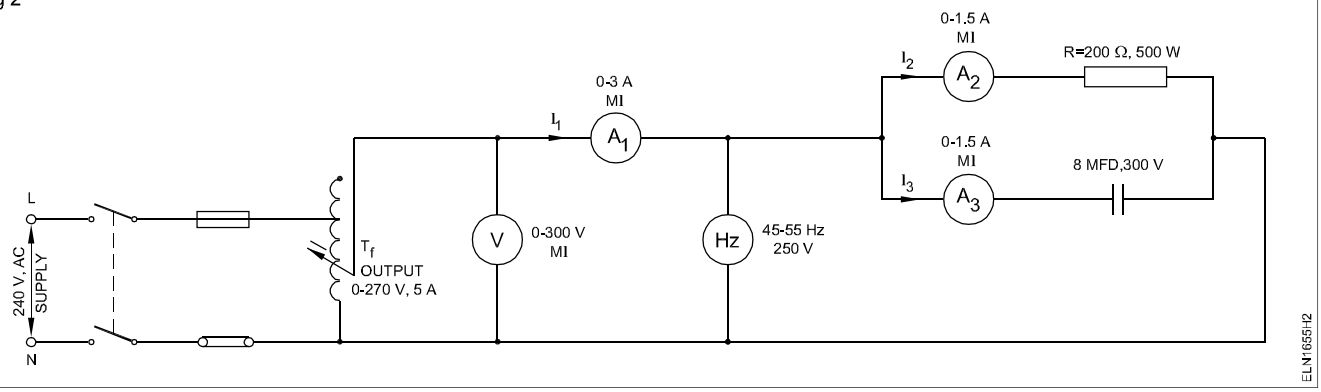
Discharge the capacitor before testing.

2 Test the resistor with an ohmmeter for its value.

6 Calculate the impedance 'Z' and record in Table 3.

7 Calculate the capacitive reactance ($X_c = V/I_3$) and record your result in Table 3.

Fig 2



3 Build the circuit as per diagram. (Fig 2) Keep the switch open. Set the auto-transformer to the minimum output voltage.

4 Switch ON the supply. Adjust the auto-transformer for an output voltage of 200V.

5 Record the frequency, voltage and the three ammeter readings in Table 3.

8 Calculate the capacitance from the values recorded in Table 3.

9 Establish that the arithmetical sum of the branch current is not equal to the main circuit current.

10 Graphically add the currents I_2 and I_3 and determine the value of I_1. Compare this value with the measured value.

11 Calculate the power factor from the recorded readings and enter the value in the space given below.

Table 3

Sl.No.	V	f	I_1	I_2	I_3	$Z = \frac{V}{I_1}$	$X_C = \frac{V}{I_3}$	$C = \frac{1}{2\pi f X_c}$

12 Adjust the supply voltage to about 100 V and repeat steps 5 to 10.

Discharge the capacitor after the experiment.

13 Repeat the exercise for changed values of R and C in the circuit.

Conclusions

i The calculated value and the indicated value of the capacitor

ii The arithmetic sum of the branch current and the measured value of total current.

iii The vectorial sum of the branch currents and the measured value of the total current.

iv The determination of PF from the vector diagram

$$\text{Cos}\,\phi = \frac{I_2}{I_1} = \ldots\ldots\ldots\ldots\ldots\ldots = $$

Cos^{-1} = P.F. =

TASK 3 : **Determine the characteristics of R-L-C in parallel circuits**

1 Form the circuit as shown in Fig 3.

2 Repeat steps 2 to 13 of TASK 2 and record the readings in Table 4.

3 Compare the readings of the power factor in all the cases. Record your observations.

Conclusion

i Effect of change of supply voltage in R-L-C parallel circuit as regards power factor of circuit

ii Effect of change in capacitance in RLC parallel circuit.

Fig 3

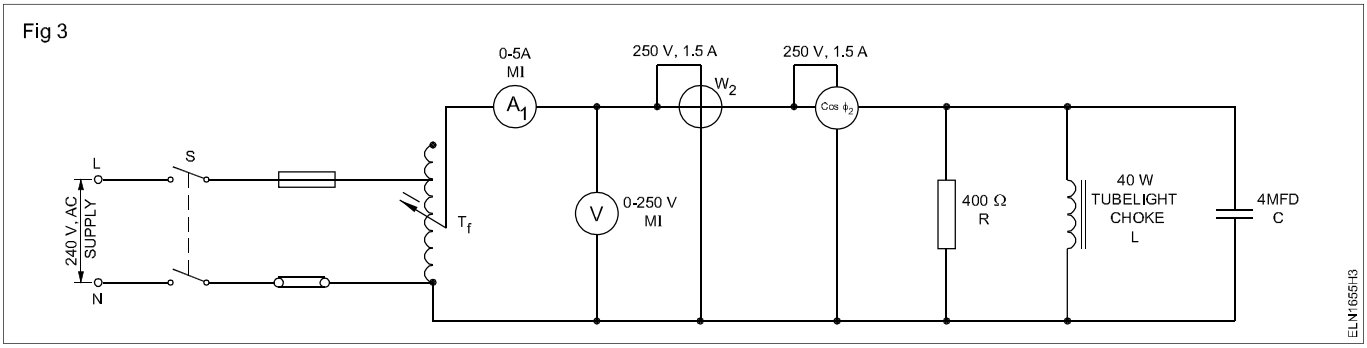


Table 4

Sl. No.	V Volt	I Amp.	W True power in Watt	AP = V xI Apparent power in VA	cos ϕ =	P.F. Meter reading	Capacitor value in μFD
1	100 V						4
2	200 V						4
3	200 V						0
4	200 V						2
5	200 V						3

Measure the resonance frequency in AC parallel circuit and determine its effects on the circuit

Objectives : At the end of this exercise you shall be able to
- **determine the resonance frequency of a given LC parallel circuit**
- **determine the circuit current for different frequencies**
- **plot a graph of frequency versus circuit current**
- **calculate the value of unknown C using LC parallel resonance**
- **determine the effect of LC parallel circuit on the circuit.**

Requirements

Tools/Equipment/Instruments

- Trainees kit
- CRO, 20 MHz - 1 No./batch
- Function generator - 1 No./batch
- MI Ammeter 0-50mA - 1 No.

Materials/Components

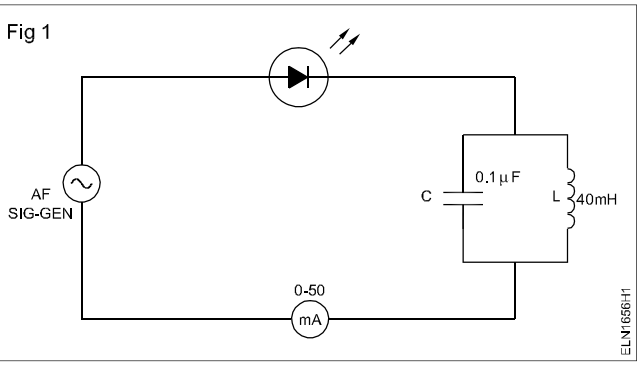
- General purpose Lug board - 1 No.
- Capacitor 0.1 µF - 1 No.
- Inductor coil, around 40mH - 1 No.
  (Use the solenoid coil made in unit 5) - 1 No.
- LED with holder - 1 No.
- Hook-up wires - as reqd.

PROCEDURE

TASK 1: **Determine parallel resonance frequency and circuit current**

1 Solder the components as shown Fig 1 to obtain a simple parallel resonance circuit. Connect the instruments as shown in Fig 1.

Fig 1



The LED in the circuit is to get a visual indication of the current through the circuit for different frequencies.

2 Calculate and record the resonance frequency of the parallel resonance circuit from the value of L and C.

3 Set the output of the signal generator to $4V_{rms}$ and frequency to 1KHz in Table 1. Record the current, I through the circuit.

Ensure that the current through the circuit is around 10 to 12 mA and not more. If current flowing is more, reduce the output level of the signal generator. LED will glow at all frequencies except at the resonant frequency.

Table 1

Frequency	+500HZ	+1KHZ	+1.5KHZ	+2KHZ
Sine wave				

4 Gradually increase the frequency and record the resonance frequency f_r at which the circuit current becomes minimum (LED does not glow or glows very dimeter).

This is the resonance frequency of the parallel resonance circuit because at parallel resonance, current I through the parallel LC circuit will be minimum.

5 Compare and record the difference in the resonance frequency calculated in step 2 and that measured in step 4.

6 Vary the input frequency in steps of 500 Hz around the resonance frequency and in each step record the value of circuit current in Table 1.

7 From the recorded readings of current in step 6, plot a graph of frequency versus current and mark the resonance frequency of the LC parallel circuit.

8 Mark the -3dB points on the plotted graph. Find the bandwidth (BW) and quality factor Q.

9 Get the working of the circuit, recorded readings and the graph checked by the instructor.

— — — — — — — —

TASK 2: **Determine the inductance value of an unknown inductor**

Note : You may use the solenoid coil used by another trainee in Task,1 in Ex. 1.5.46 as an unknown value inductor.

1 Connect the unknown value inductor in the place of the coil.

2 Set the output level of the signal generator around $4V_{rms}$. gradually increase the output frequency from 50 Hz and record the resonance frequency f_r at which the circuit current becomes minimum (LED does not glow or glows very dim).

This is the resonance frequency of the parallel resonance circuit formed by the unknown values of C and L.

3 Calculate and record the inductance value of the unknown inductor using the formula given below with known values of L and C.

At resonance, $X_L = X_C$

or $2\pi f_r l = \frac{1}{2\pi f_r c}$ or $L = \frac{1}{4\pi^2 f_r{}^2 C}$

4 From the found value of L recalculate the resonance frequency f_r to reconfirm the found value of L.

5 Get your work checked by the instructor.

Lab Assignment: Connect a known value inductor in circuit as in Fig 1 and a capacitor of unknown value. Repeat Task 2 to find the value of the unknown capacitor.

Note : The value of an unknown capacitor can be found using series resonance circuit too.

— — — — — — — —

Measure power, energy for lagging and leading power factors in single phase circuits and compare the characteristics graphically

Objectives: At the end of this exercise you shall be able to
- **measure power and energy for lagging P.F.**
- **measure power and energy for leading P.F.**
- **draw a graph to compare lagging and leading P.F.**

Requirements

Tools and Instruments

- M.I Ammeter 0-5A/10A - 1 No.
- M.I Voltmeter 0-300V - 1 No.
- Wattmeter 250V/5A - 1 No.
- P.F. meter 250V/ 2A - 1 No.
- Variac 0-270/5A - 1 No.
- AC source 0-240V/5A - 1 No.
- Energy meter 5A 250 V - 1 No.
- Stop watch - 1 No.
- Lamp load 240 V/5A - 1KW - 1 No.

Materials

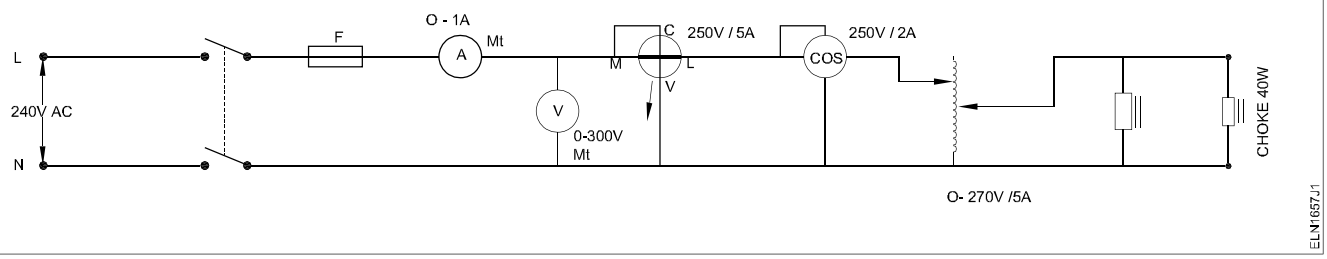
- Choke (T.L) 40W/250V - 2 Nos.
- Electrolytic capacitor, 2.5µFd/415V - 2 Nos.
- Connecting leads - as reqd.

PROCEDURE

TASK 1: **Measure the power for lagging P.F**

1 Assemble the circuit as shown in Fig 1.

Fig 1



2 Before giving supply disconnect one end of both the chokes and set the variac ouput voltage at 250V.

3 Switch 'ON' and note down the wattmeter and P.F. meter readings in Table 1.

4 Switch 'OFF' and connect one choke and record the readings (W and P.F.).

5 Switch 'OFF' and connect the second choke, record the readings in Table 1.

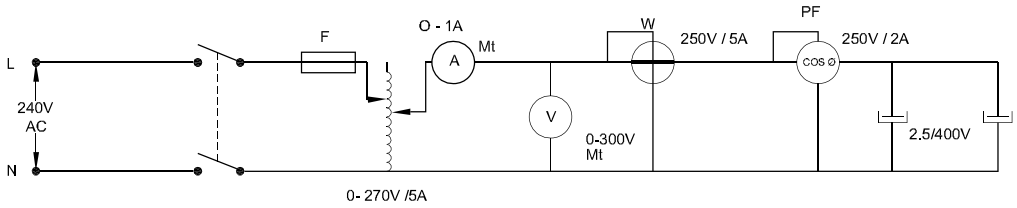
Table 1

S.No.	Voltage (V)	Current (I)	W (w)	PF +/- Lag/Lead	No. of Chokes
1					With one choke
2					With two chokes

TASK 2: **Measure the power for leading P.F.**

1 Switch 'OFF' and modify the circuit as shown in Fig 2.

Fig 2



2 Disconnect one end of both the capacitor and switch 'ON'. Record the W and P.F. reading in the Table 2.

3 Switch OFF and connect one capacitor and switch 'ON'. Record the W and P.F. reading in the Table 2.

4 Switch 'OFF' and connect second capacitor and switch 'ON'.

5 Record the W and P.F. reading in the Table 2.

Table 2

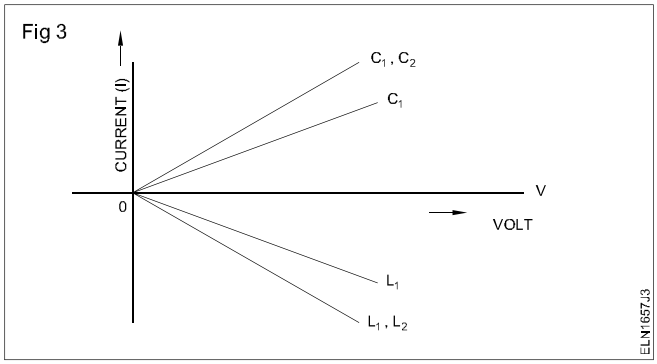
S.No.	Voltage V	Current I	W w	PF +/-	Condition
1					With one capacitor
2					With two capacitor

6 Compile all the readings and plot a graph with volt to current for both leading and lagging PF.

Note: A sample graph is shown for reference. in Fig 3.

7 Get your work approved by the instructor.

Fig 3



TASK 3: **Measurement of energy with lagging and leading P.F.**

1 Identify the energy meter terminals - line and load, after removing the terminal cover.

Always mount the meter vertically.

2 Associate the circuit diagram (inside) with the terminal markings of the instrument.

3 Connect the energy meter terminals (line and load) in the circuit as shown in Fig 4.

4 Note the meter constant from the nameplate of the energy meter. (Fig 5)

5 Record the initial meter readings.

6 Switch ON the circuit with load.

7 Record the reading after 30 minutes in Table 3.

Fig 4

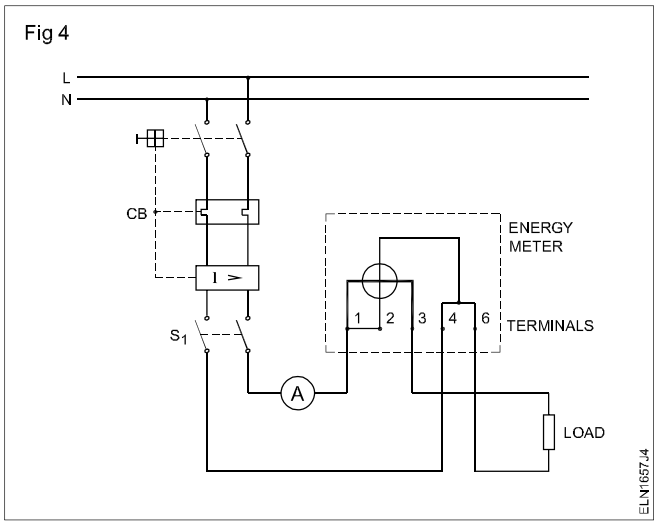
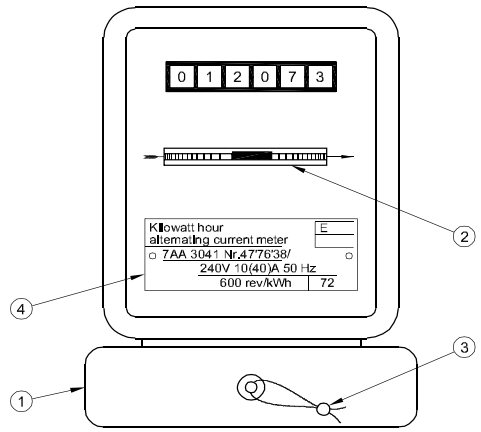


Fig 5



1 TERMINAL COVER 3 METAL SEAL
2 DISC 4 NAME-PLATE

ELN1657J5

Table - 3

Sl. No.	Volt (V)	Current (I)	Rev. Constant	Time (Secs)	Energy	
					Wh (Measured)	Wh (Calculated)

8 Connect the inductive load (Lagging power factor) and record the reading (Fig 6) in Table 4

9 Calculate the energy for lagging PF.

Fig 6

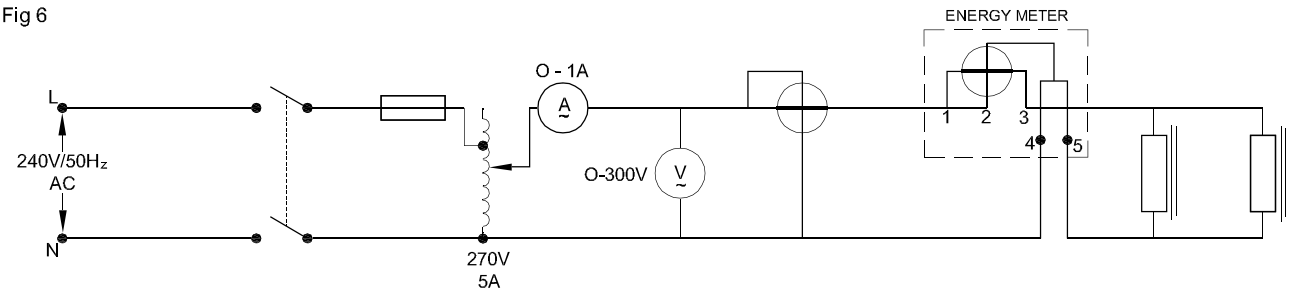


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Table 4

Sl. No.	Volt (V)	Current (I)	W	Rev. Constant	Time (Secs)	Energy	
						Wh (Calculated)	Wh (Measured)

9 Switch Off the power and remove the inductive load.

10 Connect the capacitive, reactance (Fig 7) load and record the reading in Table 5.

Fig 7

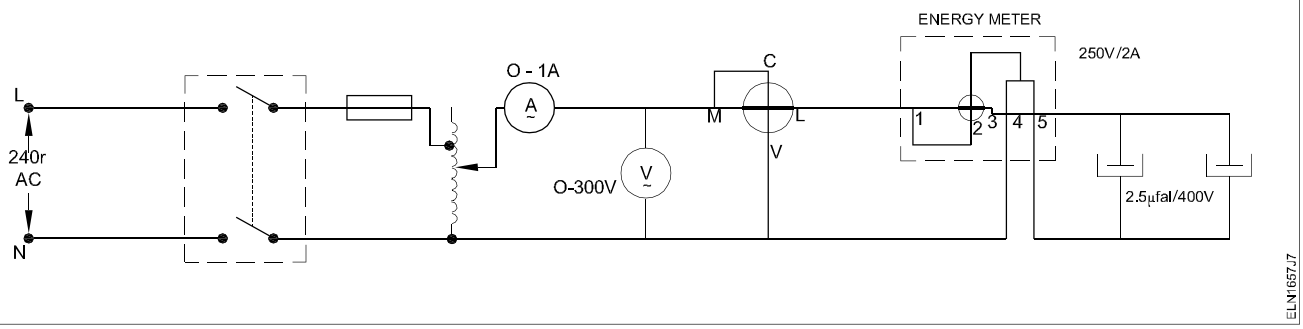


Table 5

Sl. No.	Volt (V)	Current (I)	W	Rev. Constant	Time (Secs)	Energy	
						Wh (Calculated)	Wh (Measured)

11 Calculate the energy for leading P.F. compile all the values and record the findings.

12 Plot the graph for lagging and leading P.F. for energy with respect to load current in the space provided

13 Get it checked by the instructor.

Result :

Space for Graph

Measure current, voltage, power, energy and power factor (PF) in 3 phase circuits

Objectives: At the end of this exercise, you shall be able to
- **connect voltmeter, ammeter, wattmeter and power factor meter and 3 phase energy meter in 3 phase circuits**
- **measure the voltage, current, power and power factor and 3 energy in 3 phase circuits with lamp load**
- **measure the voltage, current, power and P.F and energy in 3 phase circuits with inductive lead (Induction motor).**

Requirements

Tools and Instruments

- Insulated screw driver 200 mm - 1 No.
- Insulated cutting plier 150 mm - 1 No.
- M.I Voltmeter 0-300V/600V - 1 No.
- M.I Ammeter 0-5A/10A - 1 No.
- Wattmeter 250V/500V, 5A/10A - 1 No.
- Power Factor meter 415V/20A - 1 No.
- 3 phase 4 wire energy meter 415V/20A - 1 No.

Equipment/Machines

- 3-phase induction motor 415V, 50 Hz, 5 HP (3.75 KW) - 1 No.
- 3-phase lamp load 100 W - 6 Nos.

Materials

- PVC insulated copper cable 2.5 mm^2 650V grade TPIC 16A/500V - 20 m.
- 200 Watt/250V, lamps - 6 hrs.

PROCEDURE

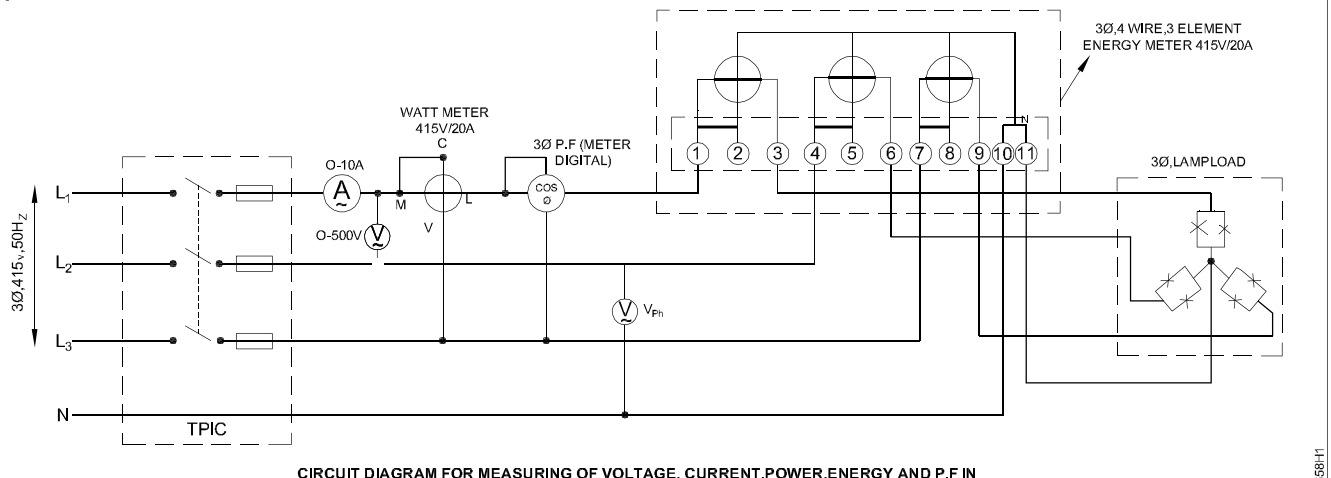
TASK 1: **Measure three phase current, voltage, power and power factor in 3** phase **circuit with lamp load**

1 Select and collect the proper range of meters and lamp load for 3 phase circuit.

The lamp load should have equal wattage in all three phases

3 Switch 'ON' the power supply momentarily after getting the approval of the instructor and observe all themeter deflections. Keep the switch closed if nothing is abnormal.

Fig 1



CIRCUIT DIAGRAM FOR MEASURING OF VOLTAGE, CURRENT,POWER,ENERGY AND P.F IN 3 PHASE CIRCUIT

2 Make the connections of the meters and load as per the circuit diagram (Fig 1).

Connect the current coils of wattmeter, energy meter and P.F meter in series with the load.

4 Note down the initial reading of the energy meter.

5 Note down the meter readings and enter in Table 1.

6 Keep the load in 'ON' position for at least 10 minutes and then note and record the final reading and calculate the energy consumption (i.e) F.R - I.R.

Table 1

Load	Line Voltage V_L	Phase Voltage V_{ph}	Line Current I_L	Phase Current I_{PH}	Power in Watt	Power factor	Initial reading in energy meter	Final reading after 10 min in energy meter F.R	Energy consumption F.R - I.R in KWh I.R
Lamp load for 100W									
Lamp load for 200W									
3ϕ Ind. meter load									

7 Swtich 'OFF' the power supply.

8 Replace the 100 Watt lamp with 200V lamp load.

9 Repeat steps 3 to 6 and record the readings in Table 1.

10 Switch 'OFF' power supply and disconnect the lamp load and connect 3 phase induction motor 3.75 KW/ 4.5V/50 Hz to the circuit.

11 Repeat steps 3 to 6 and record the readings in Table 1.

12 Get it checked by the instructor.

Practice improvement of PF by use of capacitor in three phase circuit

Objectives: At the end of this exercise you shall be able to
- **connect 3 phase balanced inductive load and measure the P.F.**
- **connect 3 phase capacitor bank to inductive load and measure the P.F.**
- **calculate and record the improvement of P.F, after connecting the capacitor bank.**

Requirements

Tools and Instruments

- Insulated combination pliers 200 mm - 1 No.
- Insulated screwdriver 200 mm - 1 No.
- 3 ϕ P.F. meter 240V/440V ; - 1 No.
- Wattmeter 250/500 V, 5A/10A - 2 Nos.
- M.I Ammeter 0-5A/10A - 1 No.
- M.I Voltmeter 0-300V/600V - 1 No.
- Power factor improving capacitor bank 3 phase 415V, 1.5 KVAR - 1 No.

Equipment/Machines

- 3-phase induction motor 415V, 2.25 KW (with loading arrangement) - 1 No.
- 3-phase lamp load 0-3KW - 1 No.

Materials

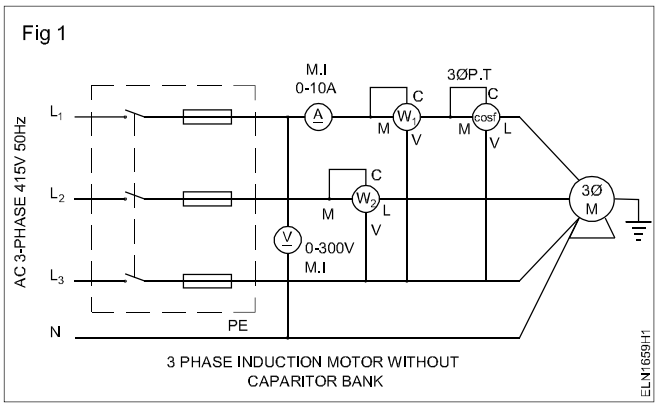
- PVC insulated copper cable 2.5 Sq, MM, 650V grade - 20 m.
- T.P.I.C.Switch 16A, 500V - 2 Nos.

PROCEDURE

TASK 1: **Connect 3 phase unbalanced inductive load and measure the P.F.**

1 Connect two Wattmeters to 3 phase P.F. meter, voltmeter and ammeter to 3 phase motor with load as shown in Fig 1.

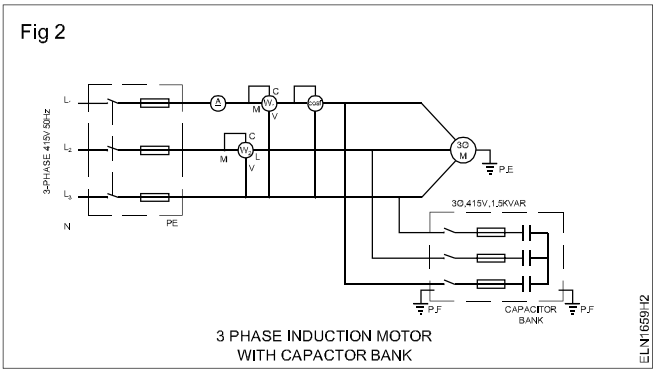
Fig 1



2 Get the connection checked by the instructor.

3 Switch 'ON' and load the motor to 60% of its load capacity and note the readings in Table 1.

Fig 2



4 Switch OFF and connect the capacitor bank as shown in Fig 2.

5 Switch ON and adjust 60% of the load and verify the readings as in step 3. The readings will be same.

6 Switch ON the capacitor bank and record the readings in Table 1 for the load conditions.

7 Calculate the P.F. in each case using the following formula.

a) P.F. calculated 1 = $\cos \varphi = = \dfrac{W_1 + W_2}{3E_{PH}\, I_{PH}}$

b) P.F. calculated 2 = Cos • where the angle • is derived from the formula $\text{Tan} \bullet = \sqrt{3}\, \dfrac{W_1 - W_2}{W_1 + W_2}$

8 Enter the values in Table 1. Determine the percentage of error.

$$\%\,\text{error} = \frac{(\text{Calculated P.F.} - \text{Measured P.F.}) \times 100}{\text{Calculated P.F}}$$

Write your conclusion and reasons for if any.

9 Get it checked by your instructor.

Table 1

Condition	Ammeter reading I_{PH}	Voltmeter reading E_{PH}	3-phase apparent power in volt amperes $3 \times E_{PH} \times I_{PH}$	Wattmeter reading W_1 watts	Wattmeter reading W_2 watts	3-phase true power $W_1 + W_2$	P.F. Calculated 1 $\text{Cos}\,\varphi$ P.F. $= \frac{W_1 + W_2}{3E_{PH} I_{PH}}$	P.F. Calculated 2	P.F. measured	Percentage of error
Motor with load										
Motor with load and capacitor bank										

Conclusion:

After connecting the capacitor bank, the effect in value of P.F. is _____

– – – – – – – – –

Ascertain use of neutral by identifying wires of a 3-phase 4 wire system and find the phase sequence using phase sequence meter

Objectives: At the end of this exercise, you shall be able to
- **test the phase wire and identify neutral with the use of test lamp**
- **identify, check and confirm the neutral wire with a meter**
- **connect and verify the phase sequence with 3-phase sequence meter.**

Requirements

Tools and Equipment

- Connector/Screw driver 100 mm - 1 No.
- Combination plier 150 mm - 1 No.
- Test lamp (40W/250V) - 2 Nos.
- Voltmeter 0-600V M.I. - 1 No.
- Phase sequence meter - 1 No.

Materials

- Connecting wires - as reqd.

PROCEDURE

TASK 1: **Test the phase line and identify the neutral with the use of test lamp**

1 Prepare a line test lamp by connecting two lamps in series.

2 Mark the terminals as 1, 2, 3 and 4 and connect one lead of lamp to the marked 1 and other lead of the earth point provided in the frame as shown in Fig 1 and record the condition of lamp in Table 1.

Fig 1

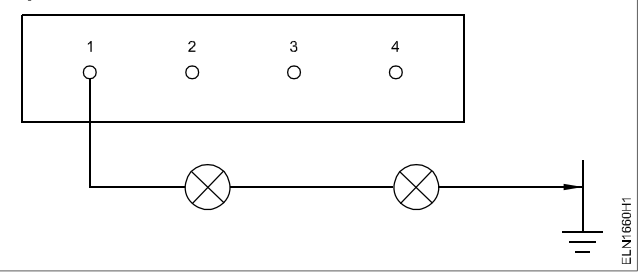


Table 1

Terminals	Glowing	Not glowing
1 to E		
2 to E		
3 to E		
4 to E		

3 Repeat the above step for other terminals 2, 3 and 4 and record the conditions in Table 1.

4 Mark the terminal where the lamp is not glowing as neutral. (N)

The three terminals at which the test lamp glows are the phase leads.

5 Connect one lead, No:4 (Identified as N) and connect the other lead of test lamp to 1, 2, 3. (Fig 2). Record the glow condition of the lamp in Table 2.

Fig 2

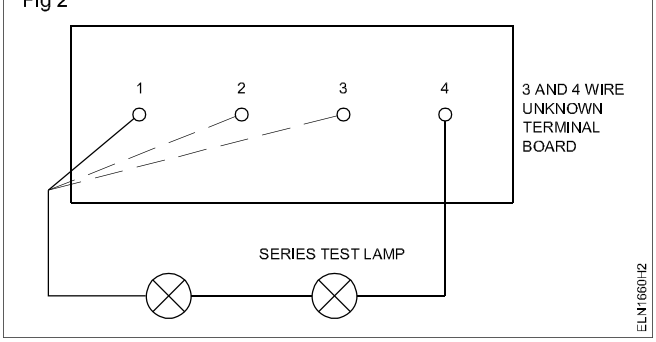


Table 2

Sl.No.	Terminals	Lamp condition	
		Glowing	Not glowing
1	4 - 1		
2	4 - 2		
3	4 - 3		
	1 - 2		
	1 - 3		
	2 - 3		

6 Refer to Table 2, mark the terminals where the lamp is glowing dim as neutral. If the lamp glows bright in the other three terminals i.e. 1-2, 1-3, 2-3 are phase terminal

7 Repeat steps 1 to 5 by replacing lamps in series by connecting the voltmeter (0-600v) and record the readings in Table 3 as shown in Fig 3.

Fig 3

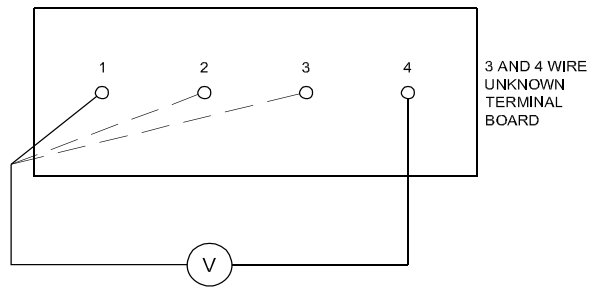


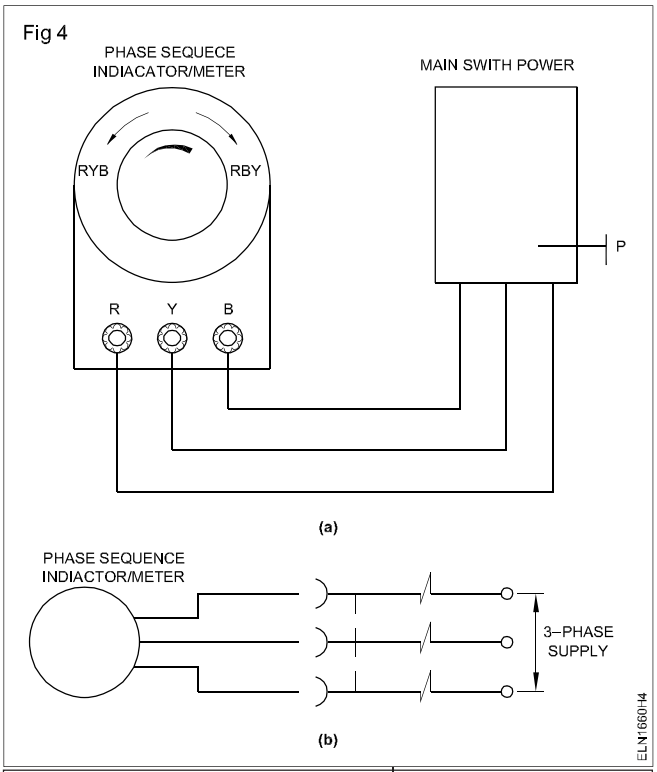
Table 3

Sl.No.	Test terminals	Voltage	
		High	Low
1	4 -1		
2	4 - 2		
3	4 - 3		
4	1 - 2		
5	1 - 3		
6	2 - 3		

TASK 2: **Identify the phase sequence in 3-phase 4 wire system by using phase sequence meter**

1 Read and record the marking of the phase sequence indicator direction: (Fig 4)

Fig 4



Rotation	Remarks
Same as arrow of the disc	
Opposite to the arrow of disc	

RYB Sequence
RBY Sequence
} Arrow marking to be indicated

Arrow in clockwise - ↱

Arrow in anti-clockwise - ↰

2 Switch 'OFF' the supply and connect the corresponding terminals (R, Y & B) to the phase sequence Indicator .

3 Mark leads as I, II, III. Connect them, such that I is connected to R, II to Y, III to B,

You can connect any lead (phase) to any terminal in the sequence indicator.

4 Switch 'ON' and observe the rotation of the disc and record the direction of rotation.

5 If the direction is anticlockwise switch 'OFF' the supply and interchange the terminals 1 and 2. Switch 'ON' and see that the rotation is reversed.

6 Mark the leads corresponding to the letters on the Phase Sequence Meter. (PSM)

If you connect any wire to any terminal, the disc will rotate anticlockwise if the RYB sequence is reversed, and it will be in the clockwise direction when RYB is connected in sequence.

7 Get it checked by your instructor.

Determine effect of broken neutral wire in three phase four wire system

Objectives: At the end of this exercise you shall be able to
- **test a healthy neutral wire in the 3-phase 4 wire system**
- **check the effect of broken neutral wire in 3-phase 4 wire system.**

Requirements

Tools and Instruments

- Combination plier 150 mm - 1 No.
- Connector screw driver 150 mm - 3 Nos.
- Three phase test board with netural link - 1 No.
- Lamp 40/240 V - 3 Nos.
- M.I Voltmeter 0-600V - 1 No.
- M.I Ammeter 0-5A - 3 Nos.
- Line tester 500V/5A - 1 No.

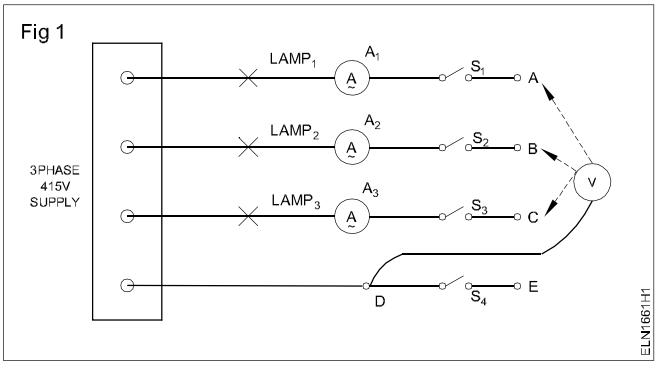
Materials

- Connecting wires - as reqd.
- ON-OFF switch - 4 Nos.

PROCEDURE

1 Connect the circuit as shown in Fig 1.

Fig 1



2 Switch 'OFF' all the switches S_1, S_2,S_3,S_4 and switch ON the 3-phase supply.

3 Check whether the lamps are glowing. Lamps do not glow

4 Switch 'OFF' 3-phase supply. Connect the terminal 'B to D', 'C to D' and 'A to E'

5 Switch 'ON' 3-phase supply. Switch 'ON' S_1, S_2, S_3. Switch 'OFF' S_4. Check if the lamps are glowing. Record all the readings in the Table 1. (L_1 will not glow L_2 and L_3 will glow - Step 2)

6. Switch 'OFF' 3-phase supply. Link 'B-E'. Follow the step 3 in Table - 1. Record the readings

7. Repeat the above step while linking 'C-E' (step 4 in Table 1). Record all the readings

It is evident that when neutral is broken the current does not flow So lamp will not glow, even though supply is available.

Table 1

S. No.	Switch position	A_1	A_2	A_3	V_1	V_2	V_3	Links	Links
1	**S_1,S_2, S_3, S_4 OFF**	0	0	0	0	0	0	–	–
2	**S_1,S_2, S_3 ON S_4 OFF**	0			0			A - E	B to D C to D
3	**S_1,S_2, S_3 ON S_4 OFF**		0			0		B - E	A to D C to D
4	**S_1,S_2, S_3 ON S_4 OFF**			0			0	C - E	A to D B to D

Determine the relationship between Line and Phase values for star and delta connections

Objectives: At the end of this exercise you shall be able to
- **verify the relationship between Line and Phase values in star connection**
- **verify the relationship between Line and Phase values in delta connection.**

Requirements

Tools/Instruments

• Screw driver 150 mm	- 1 No.
• Combination plier 150 mm	- 1 No.
• M.I Ammeter type 0-1 amp	- 2 Nos.
• M.I Voltmeter type 0-500V	- 2 Nos.
• ICTPN switch 16A 500V	- 1 No.

Materials

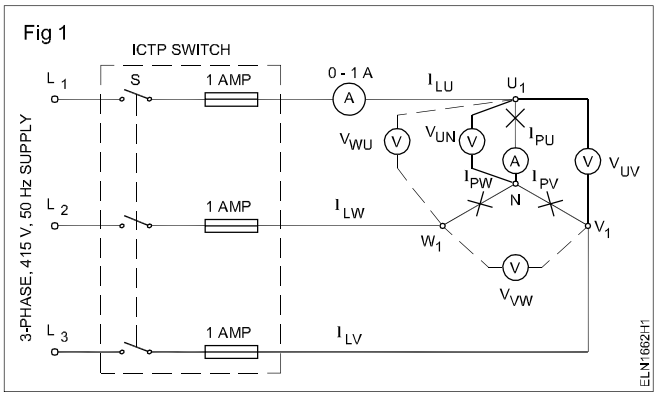
• Connecting leads	- as reqd.
• Lamp BC - 40W 240V	- 6 Nos.
• 100W 240V	- 6 Nos.
• 200W 240V	- 6 Nos.

PROCEDURE

TASK 1: **Verify the relationship between Line and Phase values in star connection of three phase system**

1 Form the circuit as per the given circuit diagram. (Fig 1) with one lamp each connected to all the 3 phases (40/100/200 W).

Fig 1



2 Identify the 3-phase (L_1, L_2, L_3) and neutral (N) of supply terminals.

3 Switch 'ON' the 3-phase supply.

4 Measure the line voltage V_{UV} by placing the voltmeter leads between the two lines and enter the reading in Table 1.

5 Repeat for the other line voltages V_{VW}, V_{WU}.

6 Measure the phase voltages by placing the voltmeter leads between one line and star point N, and enter the readings in Table 1.

7 Measure the Line and Phase current and enter the readings in Table 1.

Switch 'OFF' supply before effecting any change in load.

8 Repeat steps 3 to 7 for different loads.

9 Calculate the ratio between the Line voltage and Phase voltage.

$$\frac{V_{UV}}{V_{UN}} =$$

$$\frac{V_{VW}}{V_{VN}} =$$

$$\frac{V_{WU}}{V_{WN}} =$$

10 Verify the ratio between Line current and Phase current, i.e.

$$\frac{I_{LU}}{I_{PU}} = \frac{I_{LV}}{I_{PV}} = \frac{I_{LW}}{I_{PW}} =$$

11 Get it checked by the instructor.

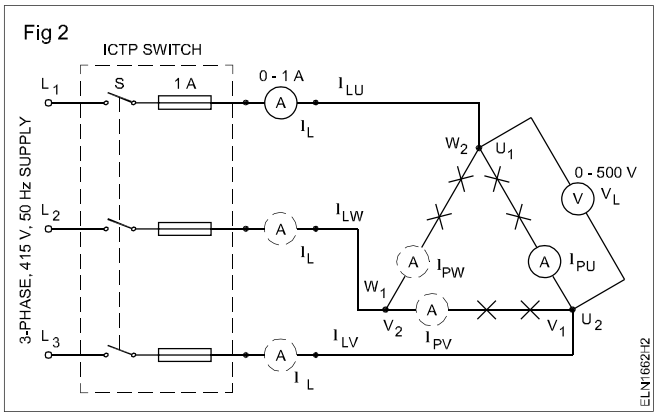
Table 1

Sl. No.	Load in watts per phase	Line voltage			Phase voltage			Line current			Phase current		
		V_{UV}	V_{VW}	V_{WU}	V_{UN}	V_{VN}	V_{WN}	I_U	I_V	I_W	I_{UN}	I_{VN}	I_{WN}
1	40W												
2	100W												
3	200W												

TASK 2: **Verify the relationship between Line and Phase values in delta connection in three phase system**

1 Form the circuit as per the given circuit diagram. (Fig 2) Two lamp in series to be connected between two phases of same voltage.

Fig 2



2 Switch ON the 3-phase supply. Measure the line voltages by connecting the voltmeter leads between two of the terminals U_1, V_1, W_1.

3 Measure the phase voltage by placing the voltmeter leads across the lamps, i.e. U_1, U_2 or V_1, V_2 or W_1, W_2.

4 Record the Line voltages and Phase voltages measured, under the appropriate column in Table 2.

5 Measure the Line and Phase currents and enter the readings in Table 2.

An ammeter connected between supply and load indicates Line current. An ammeter connected in series with single load (two lamps in series) indicates Phase current.

6 Repeat steps 2 to 5 for different loads.

Switch off the supply before effecting any change in the load.

7 Verify the relationship between Line and Phase value of current and voltage. Enter in Table 3.

Result

In star : Line current and Phase current are _____

whereas Line voltage =_____ x Phase voltage.

In delta :Line voltage and Phase voltages are _____

whereas Line current =_____ x Phase current.

8 Get it checked by the instructor..

Table 2

Sl. No.	Load in watts per phase	Line voltage			Phase voltage			Line current			Phase current		
		V_{U1V1}	V_{V1W1}	V_{W1U1}	V_{U1U2}	V_{V1V2}	V_{W1W2}	I_U	I_V	I_W	I_{U1U2}	I_{V1V2}	I_{W1W2}
1	40W												
2	100W												
3	200W												

Table 3

Load	$\frac{V_{U_1V_1}}{V_{U_1U_2}}$	$\frac{V_{V_1W_1}}{V_{V_1V_2}}$	$\frac{V_{W_1U_1}}{V_{W_1W_2}}$	$\frac{I_{LU}}{I_{PU}}$	$\frac{I_{LV}}{I_{PV}}$	$\frac{I_{LW}}{I_{PW}}$
40W						
100W						
200W						

Measure the power of 3-phase circuit for balanced and unbalanced loads

Objectives: At the end of this exercise, you shall be able to
- **identify and connect the terminals of a single-phase Wattmeter**
- **connect single wattmeter in star, balanced load and measure the power**
- **connect two wattmeters in the circuit as per the given diagram**
- **connect two wattmeters in unbalanced, star-connected load and measure the power**
- **identify and connect 3-phase wattmeter and measure the power in star.**

Requirements

Tools/Instruments

- Single-phase wattmeter 250V/5A - 1 No.
- Wattmeter 500V/5A - 2 Nos.
- PF meter, single phase 250V,5A - 1 No.
- Voltmeter 0-500 V M.I. - 1 No.
- Ammeter 0-5A M.I. - 1 No.

Materials

- 200W, 250V lamps - 3 Nos.
- 100W, 250V lamps - 3 Nos.
- Capacitor 400V AC 4 MFD - 2 Nos.
- Connecting leads - as reqd.
- Pendent-holders 6A 250V - 6 Nos.

Equipment/Machines

- 3-phase, 415V AC induction motor 3 HP coupled with DC generator - 1 No.

PROCEDURE

TASK 1: **Connect balanced load in star and measure the power with one single element Wattmeter.**

1 Form the circuit as per the given circuit diagram. (Fig 1)

Connect proper voltage and current ranges of Wattmeters suitable to the given load.

2 Switch ON the 3-phase supply and read the wattmeter and record the wattmeter readings in Table 1.

3 Measure the power in the other two phases by connecting the wattmeter in turns and record the redings.

4 Total the readings of the wattmeters and check its confirmity with the calculated total power.

5 Repeat steps 1 to 4 for different load conditions.

Fig 1

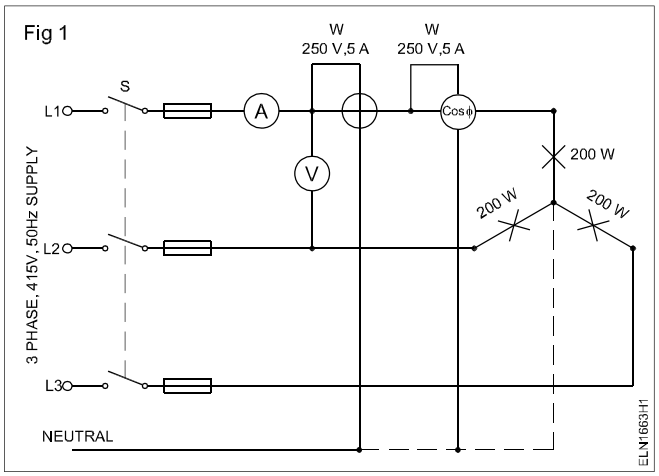


Table 1

Type of Load	Wattmeter connected in the line			V_L	I_L	P.F	Calculated Total power	Total power = Total of three wattmeter readings
	W_{L1}	W_{L2}	W_{L3}				$W=\sqrt{3}\ V_L I_L \cos\theta$	$W_{L1} + W_{L2} + W_{L3} = W$
1								
2								
3								
4								

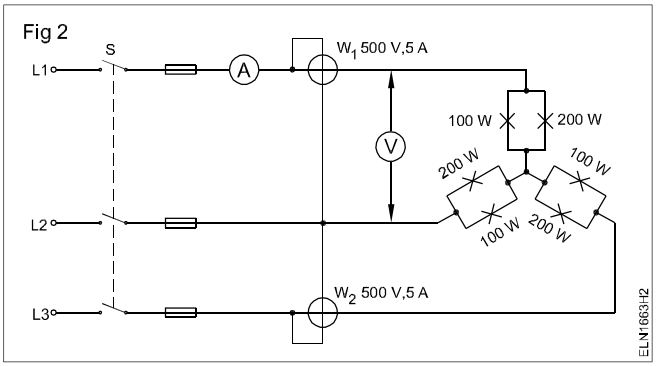
TASk 2: **Power measurement by two-wattmeter method in 3-phase load**

1 Form the circuit as per the given circuit diagram.

(Fig 2)

Connect proper ranges of meters suitable for the given load.

Fig 2



2 Switch 'ON' the 3-phase supply and check whether the deflection of wattmeter is correct. If both wattmeters deflect properly, go to step 4, otherwise continue from step 3.

3 Switch 'OFF' the supply, if any one wattmeter deflects in the reverse direction. Change the connection of the potential coil of the reverse deflection wattmeter. Go to step 5.

4 Read the wattmeters W_1 and W_2 and record in Table 2. Add the readings W_1 and W_2 and record the total power; Go to step 6.

5 Switch on the supply and read the wattmeters W_1 and W_2. Record the values in the Table. Record the readings of the wattmeter with the changed potential coil as negative quantity.

6 Measure the 3-phase power for different load conditions specified below:

a) L_1 = 400 W bulb

L_2 = 400 W bulb parallel 4 MFD capacitor

L_3 = 200 W bulb

b) Water load to take a current maximum of 3 amps.

c) Induction motor 3 HP on no load

d) Induction motor 3 HP with load

The instructor may connect the three-phase motor to ensure it is running properly.

7 Calculate the power factor in all the above cases and enter them in Table 2.

8 Get it checked by the instructor.

Table 2

Type of Load	Wattmeter W_1	Wattmeter W_2	Total $W_1 + W_2$	Calculated Power factor Cos θ $\text{Tan} \bullet = \sqrt{3}\frac{W_1 - W_2}{W_1 + W_2}$ Determine Cos θ
1				
2				
3				
4				
5				

Conclusion : _____

Measure current and voltage of two phases in case of one phase is short-circuited in three phase four wire system and compare with healthy system

Objectives: At the end of this exercise, you shall be able to
- **connect and test the circuit**
- **measure the current and voltage in healthy conditions**
- **check the condition of the two phase, when one phase is overloaded/short-circuited**
- **record the current and voltage in both conditions.**

Requirements

Tools/Instruments

• M.I Ammeter 0-10A	- 2 Nos.
• M.I Ammeter 0-20A	- 1No.
• M.I Voltmeter 0-300V	- 3 Nos.
• Load 1500W/ 240V	- 4 Nos.
• 3 Phase supply board 3φ, 4 wire	- 1 No.

Materials

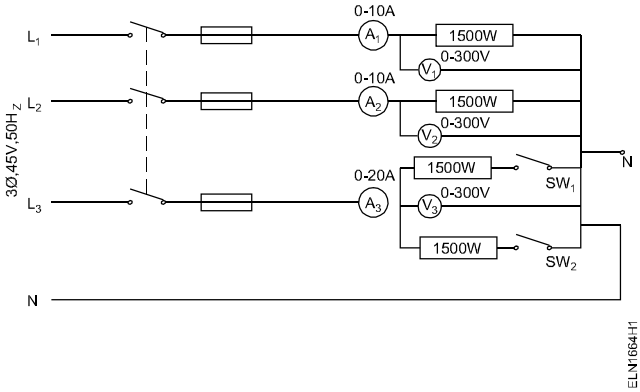
• S.P. switch 240V/16A	- 2 Nos.
• Connecting wires	- as reqd.
• TPIC - 415V/16A	- 1 No.

PROCEDURE

We cannot manually make a short circuit in the phase line as it is dangerous and it may trip the circuit. In order to make a short circuit condition load current is doubled in one phase.

1 Connect the circuit as per the diagram shown in Fig 1.

Fig 1



2 Switch 'ON' the 3 Phase supply and ON the switch SW_1. Record the current and voltage the tabular column.

3 Switch 'OFF' the 3 Phase in supply and SW_2 switch 'ON'.

4 Switch 'ON' the 3 Phase supply and record the readings of the current and voltage in the tabular column.

5 Switch 'OFF' all the supply lines, and disconnect the wiring and return all the materials and equipment.

6 Get it checked by the instructor.

Conclusion : _____

Table 1

Sl.No.	SW_1 - ON				SW_1 - ON & SW_2 ON			
1	A_1		V_1		A_1		V_1	
2	A_2		V_2		A_2		V_2	
3	A_3		V_3		A_3		V_3	

Project Works

Objectives: The Trainees/Participants shall be able to
- **select a project work of their choice**
- **prepare the list of materials required and collect them**
- **list out the tools required**
- **prepare a brief note on the project**
- **complete the project and submit the project report with all the details.**

Note: Instructor has to explain in detail regarding the project works to the carried out in the section. The trainees may be divided in groups according to the strength available in section and give all details how to prepare and finish the work with complete workmanship and accuracy.

- Step to start and follow the project work
- Motivate the group by emphasising the technical work involved and its future influences.
- Divide the work equally and make sure inyoke participating with full interest.
- Start the project work, test of stage by stage and complete it.
- Test the completed project job for its functional and its utility.
- Prepare a project report containing its technical parameters, specification, material requirement and its cost, operational procedure, maintenance, utility and marketting etc.
- Indicate his scope of future expansion, easy conversion to other project for advanced version in the report.
- Get it checked with your instructor.
- The project him to complete with all operational instructions and carry necessary procedure with switches, controls, labels, symbols etc.
- Safety devices has to be placed according to the project and its functions.
- Maintenance and repair instructions has to be indicated clearly.

Note : Instructor has to evaluate the project work with all records and reports. Marks to be awarded for the Project working, Accuracy, Workmanship, Safety features and its work performance related to the viva question.

Project work

1 Prepare and assemble a test board with switches plug socket, lamp holder etc.

2 Temperature controlled system for switchning 'ON 'and 'OFF' of any circuit using bi-metallic strip.

3 Series/Parallel combinational circuits.