RQF LEVEL 5

TRADE FORESTRY

MODULE CODE: FORBP501

TEACHER'S GUIDE

Module name: Biochemical Properties of Wood Assessment

Acknowledgments

The publisher would like to thank the following for their assistance in the elaboration of this textbook:

Acronyms

MINEDUC: Ministry of Education

TVET: Technical and Vocational Education and Training

RP: Rwanda Polytechnic

RTB: Rwanda Technical Vocational Education and Training

RQF: Rwanda Qualification Framework.

CBT: Competence Based Training

CBC: Competence based curriculum

AGR: Agriculture

FOR: Forestry

BP: Biological properties of wood assessment

ASTM: American Society for Testing and Materials

IS: International standard

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Contents

Introduction

This training manual is to be used by trainers teaching the module entitled **"Biochemical Properties of Wood Assessment" in TVET Schools.** It identifies the learning units and learning outcomes of the module as well as assessment requirements. The trainer manual gives practical ideas about ways of training using this module: suggestions about what to teach, techniques for facilitating learning and teaching, how to assess and suggested assessment tasks. A variety of suggested learning and teaching activities provides trainers with ideas to motivate students to learn, and make learning relevant, interesting and enjoyable. Trainers should relate learning about **Biochemical Properties of Wood Assessment** to real world, issues and the local environment. Delivering session using clear examples to make learners participate in practical activities, facilitate students in acquiring knowledge, skills and right attitude reflecting agriculture sector. Trainers are encouraged to incorporate related modular activities in a way of branching out paths for the future development.

The module will allow the learner to prepare materials for wood samples collection and laboratory analysis, prepare the wood samples, Conduct biochemical wood analysis.

Module Code and Title: FORBP501 Biochemical properties of wood assessment

Learning Units:

1. Prepare tools, materials and equipment for wood sample collection and laboratory analysis.

2. Prepare wood samples

3. Conduct biochemical wood analysis.

4. Interpret the laboratory data

Learning Unit 1: Prepare tools, materials and equipment for wood sample collection and laboratory analysis.

Structure of learning unit 1

Learning outcomes:
 	
    1.1. Select tools, materials and equipment
    1.2. Adjust tools and equipment
    1.3. Maintain and keep materials, tools and equipment

Learning outcome 1.1: Select tools, materials and equipment.

🕐   **Duration: 3 hours**
🎯   **Objectives of Learning outcome 1.1** **By the end of the learning outcome, the trainees will be able to:** **1.** Describe correctly tools used for wood sample collection and laboratory analysis. **2.** Describe correctly materials used for wood sample collection and laboratory analysis. **3.** Describe correctly equipment used for wood sample collection and laboratory analysis.

Resources		
Equipment	**Tools**	**Materials**
1. Microscope 2. Electric furnace 3. Chainsaw 4. Thermometer 5. Hygrometer 6. Electronic balance 7. Computer 8. Projector 9. PPE	1. Knife 2. Axe 3. Panga 4. Handsaw 5. Tape measures	1. Wood samples 2. Pencils 3. Plastic bags 4. Papers 5. Notebooks 6. Water 7. Chalk 8. Wood sample containers 9. Wooden wedges

Advance preparation:

Before starting the session delivery,

- ✓ There should be availability of required resources as listed above depending on their necessity
- ✓ Learning place should be made ready,
- ✓ Facilitation techniques should be though about depending on the size of the class, the number of learners, the category of learners, and available learning resources

Ic   **Indicative content 1.1.1: Description of tools and materials**

1. Moisture-meter:

Moisturemeter is a tool used to measure the percentage of water in a given substance (wood for example). To know the moisture content in the wood is important to determine whether it is ready to be used unexpectedly wet or dry or otherwise need further inspection.

There two types of moisture meter one is pin type and other is pinless type moisture meter they differ in a way that pin type has pins that are pin-style meters use electrical resistance to measure the moisture content in wood by measuring the conductivity between the pins.

The pinless handheld moisturemeter incorporates the moisture sensor that monitor moisture in the wood and other building materials without causing damage on the surface damage. High frequency sensing technology allows the meter to take non-invasive moisture measurements.
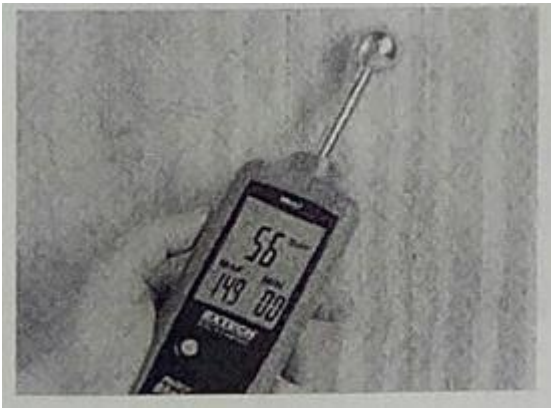
2. Thermometer

A **thermometer** is a device that measure the temperature or temperature gradients a thermometer has two important elements: (1) a temperature sensor, the bulb of mercury-in- glass thermometer in which some physical changes occur with temperature and (2) some means of converting this physical change into numerical value (e.g this visible scale that is marked on a mercury-in-glass thermometer).

There are various principles by which thermometers operate. They include the thermal expansion of solids or liquids with temperature and the change in pressure of a gas on heating or cooling. Radio-type thermometers measure the infrared energy emitted by an object, allowing measurement of temperature without contact.

Thermometer are widely used in industry to control and regulate the process, in the study of weather, in medicine and in scientific research.
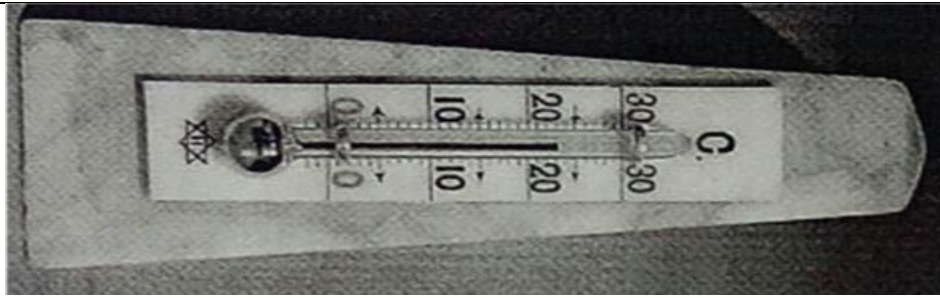
3. Electrical furnace:

Is a container that is heated to a very high temperature so that substances (such as wood) that are put inside are decomposed by heat.

4. Hygrometer:

It is an instrument that measure the humidity of air or other gases especially relative humidity and the moisture content of wood.

5. Personal Protective Equipment (PPEs)

Personal Protective Equipment (PPE) are specialized clothing or equipment worn by employees for protection against health and safety hazards. Personal protective equipment is designed to protect many parts of the body, i.e., eyes, head, face, hands, feet, and ears.

Need for PPE

Personal protective equipment, or PPE, is designed to provide protection from serious injuries or illnesses resulting from contact with chemical, radiological, physical, electrical, mechanical, or other hazards.

PPE	Protects	Hazards
Safety Glasses	eyes	chemical liquid splashes, dust
Hard Hat	head	falling material
Ear Protection	hearing	excessive noise
Gloves	hands	corrosives, toxic materials
Respirator	lungs	toxic gases, vapours, fumes or dust
Clothing	skin	toxic or corrosive materials
Footwear	feet	corrosive, toxic materials

6. Microscope:

Is a device that uses lenses to make very small objects look larger so that they can be scientifically examined and studied.

Theoretical learning Activity:

- Within groups of four members discuss about different tools and equipment used for wood sample collection.

- Within groups of four members discuss about different tools and equipment used for wood sample for laboratory analysis.

Practical learning Activity

- Each trainee performs selection of tools for wood sample collection.

- Each trainee performs selection of equipment for wood sample analysis.

Points to Remember

Selection of tools, materials and equipment:

1. Description of tools and materials used for wood sample collection

2. Description of materials used for wood samples collection

3. Description of equipment used for wood samples collection

4. Description of tools and equipment used for wood sample analysis.

Ic

Indicative content 1.1.2: Types of tools and materials

One can classify tools according to their basic function or users:

  ✓ Cutting and edging tools: knife, sickle, ideally the edge of the tools need to be harder than the materials being cut.

  ✓ Guiding, measuring and perception tools including the rulers, glasses, set square, theodolite, microscope, monitor, clock, phone and printer.

  ✓ Fastening tools such as welder, nails, adhesives/ glues gun

  ✓ Information and data manipulation tools,

Theoretical learning Activity:

- Within groups of four members discuss about different types of tools and equipment used for wood sample collection.
- Within groups of four members discuss about different types of tools and equipment used for wood sample for laboratory analysis.

Practical learning Activity

- Each trainee performs categorization of tools used for wood sample collection.
- Each trainee performs categorization of equipment for wood sample analysis.

Points to Remember

> **Selection of tools, materials and equipment:**
> 1. Tools used for wood sample collection
> 2. Tools used for wood sample analysis
> 3. Equipment used for wood sample collection
> 4. Equipment used for wood sample analysis

Learning outcome 1.1: Formative assessment about selection of tools, materials and equipment

Q1. List out at least five (5) tools and equipment used in collection of wood sample for laboratory analysis.

Answer:

- ✓ Hand saw
- ✓ Machete /panga
- ✓ Chain saw
- ✓ Pruning saw
- ✓ Knife

Q2. Tools and equipment can be classifying according to their basic function or users, give any four factors for classification.

Answer
- ✓ Cutting and edging tools
- ✓ Guiding, measuring and perception tools
- ✓ Fastening tools
- ✓ Information and data manipulation tools
- ✓ Analysis tools and equipment

Q4. Enumerate the criteria of selection of tools, material, and equipment for wood sample collection and analysis

Answer:

- ✓ Type of analysis to be carried out
- ✓ Sample size of wood
- ✓ Infrastructure on the work place
- ✓ Skills of operators
- ✓ Availability of tools and equipment

Learning outcome 1.1: Practical assessment about selection of tools, materials and equipment

Task: Select tools, materials and equipment for wood sample collection and analysis

Checklist	Score	
	Yes	No
Indicator 1: Materials, tools and equipment are well identified		
✓ Materials for wood sample collection are identified		
✓ Tool for wood sample collection are identified		
✓ Equipment for wood sample collection are identified		
Indicator 2: Criteria of selection of tools, material, and equipment are respected		
✓ Wood sample size is determined		
✓ Properties to analyze are identified		
✓ Type of wood is chosen		
✓ Tree species are selected		

Learning Outcome 1.2. Adjust tools and Equipment.

⏱	**Duration: 3 hours**

🎯 Objectives of Learning outcome 1.2

By the end of the learning outcome, the trainees will be able to:

1. Adjust correctly tools used for wood sample collection and laboratory analysis.

2. Adjust correctly equipment used for wood sample collection and laboratory analysis.

Resources

Equipment	Tools	Materials
1. Moisturemeter 2. Microscope 3. Electric furnace 4. Chainsaw 5. Thermometer 6. Hygrometer 7. Electronic balance 8. Computer 9. Projector 10. PPE	1. Knife 2. Axe 3. Panga 4. Handsaw 5. Tape measures	1. Wood samples 2. Pencils 3. Plastic bags 4. Papers 5. Notebooks 6. Water 7. Chalk 8. Wood sample containers 9. Wooden wedges

📋 Advance preparation:

Before starting the session delivery,

- ✓ There should be availability of required resources as listed above depending on their necessity
- ✓ Learning place should be made ready,
- ✓ Facilitation techniques should be though about depending on the size of the class, the number of learners, the category of learners, and available learning resources

Indicative content 1.2.1: Adjustment instructions

Adjustment instruction refers to the information from the manufacture of an item how it is operated, maintained and storage conditions. Adjustment can be done with the help of the following tools:

- ❖ Screw drivers
- ❖ Hammer
- ❖ Spanner
- ❖ Pinces /pliers
- ❖ Washers
- ❖ Files

Theoretical learning Activity:

- Within groups of four members discuss on how to adjust wood sample analysis equipment.
- Within groups of four members discuss on how to adjust wood sample collection tools and equipment.

Practical learning Activity

- In a group of two perform adjustment of tools and equipment used for wood sample collection.
- In a group of two perform adjustment of tools and equipment used for wood sample analysis.

Points to Remember

Selection of tools, materials and equipment:

1. Adjustment of tools and equipment used for wood sample collection
2. Adjustment of tools and equipment used for wood sample analysis.

Indicative content 1.2.2: Adjustment standards

A standard is something set up by authority or by general consent as a rule for measuring or as a model.

Tool and equipment are adjusted according to manufacturer's guidelines or instructions.

Theoretical learning Activity:

- Discuss about adjustment standards of tools and equipment of wood sample analysis.

Practical learning Activity

- You are called to measure wood sample for microscopic analysis; before measuring adjust the balance on required standards

Points to Remember

Selection of tools, materials and equipment:

1. Adjustment standards of tools and equipment used for wood sample collection
2. Adjustment standards of tools and equipment used for wood sample analysis.

 Indicative content 1.2.3: Adjusting tools and equipment

Adjustment of tools and equipment must follow information from the manufacture

Theoretical learning Activity:

- Discuss about adjustment of tools and equipment of wood sample analysis.

 Practical learning Activity

- You are called to measure wood sample for microscopic analysis; before measuring adjust the balance on required standards

- Adjust and manipulate tools and equipment based on laboratory standards and manufacture instructions

 Points to Remember

Selection of tools, materials and equipment:

1. Adjustment of tools and equipment used for wood sample collection
2. Adjustment of tools and equipment used for wood sample analysis.

 Learning Outcome 1.2. Formative assessment about adjustment tools and equipment

Q1. With an example at each side, give the difference between adjustment and maintenance of tools and Equipment.

Answer:

> **Preventive maintenance** is the systematic care and protection of tools, equipment, machines, and vehicles in order to keep them in a safe, usable condition, that limits downtime and extends productivity.

> **Corrective maintenance**

This is a reactive activity in nature. It is executed, when any defect or fault occurs in an asset, machine or equipment. Corrective maintenance restores the equipment depending on the fault.

> **Adjustment**

can be defined as the process of altering an equipment's performance to match a specific accuracy limit. Before adjustments are made, it is normal for equipment calibration to be carried out first.

Learning outcome 1.2: Practical assessment on adjustment of tools and equipment

Task: Maintain and keep tools, materials and equipment based on laboratory standards

Checklist	Score	
	Yes	**No**
Indicator 1: Adjustment and manipulation of tools and equipment based on laboratory standards and manufacture instructions		
✓ Adjustment of tools and equipment is made		
✓ Manipulation of tools and equipment is made		

Learning Outcome 1.3. Maintain and keep tools and materials.

 Duration: 3 hours

 Objectives of Learning outcome 1.3

By the end of the learning outcome, the trainees will be able to:

1. Maintain correctly tools used for wood sample collection and laboratory analysis.

2. Maintain correctly equipment used for wood sample collection and laboratory analysis.

3. Keep appropriately tools and equipment used for wood sample collection and laboratory analysis.

	Resources	

Equipment	Tools	Materials
1. Moisturemeter 2. Microscope 3. Electric furnace 4. Chainsaw 5. Thermometer 6. Hygrometer 7. Electronic balance 8. Computer 9. Projector 10. PPE	1. Knife 2. Axe 3. Panga 4. Handsaw 5. Tape measures	1. Wood samples 2. Pencils 3. Plastic bags 4. Papers 5. Notebooks 6. Water 7. Chalk 8. Wood sample containers 9. Wooden wedges

Advance preparation:

Before starting the session delivery,

- ✓ There should be availability of required resources as listed above depending on their necessity
- ✓ Learning place should be made ready,
- ✓ Facilitation techniques should be though about depending on the size of the class, the number of learners, the category of learners, and available learning resources

Indicative content 1.3.1: Maintenance instructions

Maintenance is an operation of keeping a tool or equipment in a good working condition of working or functioning. It involves the following:

- ✓ Cleaning
- ✓ Oiling
- ✓ And storing in good condition.

Theoretical learning Activity:

- Within groups of four members discuss on four types of maintenance of tools and equipment used for wood sample analysis.

 Practical learning Activity

- In a group of four, perform four maintenance techniques of tools and equipment used for wood sample collection.

 Points to Remember

Maintenance instructions:

1. Types of maintenance of tools and equipment used for wood sample collection

2. Types of maintenance of tools and equipment used for wood sample analysis.

3. following instructions about maintenance of tools and equipment.

 Indicative content 1.3.2: Keeping instructions

The following general principles of care, keeping and serving should be applied as routine matter for all sampling and laboratory tools, equipment and materials.

   ✓ All equipment and tools should be kept as clean and dry as practicable, particular.

   ✓ Wooden surface should be wiped clean

   ✓ Meta surface should be cleaned and wiped as dry as possible.

Theoretical learning Activity:

- Discuss about operating instructions of tools and equipment of wood sample analysis.

 Practical learning Activity

- By following instructions of tools and equipment, operate wood sample collection for laboratory analysis.

Points to Remember

> **Keeping instructions:**
>
> Following instructions during the use of tools and equipment.

Ic **Indicative content 1.3.3: Safety precautions**

> Safety precautions:
> - ✓ laboratory rules
> - ✓ Ventilation
> - ✓ Hazardous substances
> - ✓ First aid

Theoretical learning Activity:

- Discuss about general laboratory rules and regulations

Practical learning Activity

- Maintain tools and equipment for wood samples analysis as well as taking into account safety precautions.
- Maintain and keep tools, materials and equipment based on laboratory standards

Points to Remember

> **Safety precautions:**
> - ✓ Personal Protective equipment
> - ✓ Laboratory safety rules
> - ✓ Laboratory ventilation
> - ✓ Sources of laboratory hazards

Learning outcome 1.3. Formative assessment about maintenance and keep tools and materials.

Q1. Explain any four tools and equipment used for maintenance of tools

Answer:

- ✓ Screw
- ✓ Pliers/pinces   for fixing tools
- ✓ Clamping tool
- ✓ Washers

Learning outcome 1.3. Practical assessment about maintenance and keep tools and materials.

Task: Maintain tools and equipment for wood samples analysis as well as taking into account safety precautions.

Checklist	Score	
	Yes	**No**
Indicator 1: Maintenance and keeping of tools, materials and equipment based on laboratory		
✓ Tools		
✓ Materials		
✓ Equipment		
Indicator 2: Safety precautions are described		
✓ Laboratory rules		
✓ Ventilation		
✓ Hazardous substances		
✓ First aid		

Learning Unit 2: Prepare the wood samples.

Structure of learning unit 2

Learning outcomes:
2.1. Collect wood samples **2.2.** Handle and transport wood samples **2.3.** Store wood samples

Learning outcome 2.1: Collect wood sample.

⏱ **Duration: 3 hours**
🎯 **Objectives of Learning outcome 1.1** **By the end of the learning outcome, the trainees will be able to:** **1.** Identify correctly 5 tree species for sample collection and laboratory analysis. **2.** Locate appropriately 3 parts of the tree for sample collection and laboratory analysis. **3.** Explain 4 types of wood cuts used for sample collection and laboratory analysis.
🧰**Resources**

Equipment	Tools	Materials
1. Moisturemeter 2. Microscope	1. Knife 2. Axe	1. Wood samples 2. Pencils

3. Electric furnace 4. Chainsaw 5. Thermometer 6. Hygrometer 7. Electronic balance 8. Audi visual equipment 9. Oven 10. Relascope 11. Computer 12. Projector 13. PPE	3. Panga 4. Handsaw 5. Tape measures 6. Thermal conductivity meter.	3. Plastic bags 4. Papers 5. Notebooks 6. Water 7. Chalk 8. Wood sample containers 9. Wooden wedges 10. Forest stand 11. Bath or volumetric tank

Advance preparation:

Before starting the session delivery,

- ✓ There should be availability of required resources as listed above depending on their necessity
- ✓ Learning place should be made ready,
- ✓ Facilitation techniques should be though about depending on the size of the class, the number of learners, the category of learners, and available learning resources

Ic **Indicative content 2.1.1: Species Identification:**

Identification of species for wood sample collection and laboratory analysis

- ➢ **Hard wood:**
- ➢ **Definition:** Comes from angiosperm trees that are not monocots; trees are usually broad-leaved. Has vessel elements that transport water throughout the wood; under a microscope, these elements appear as pores.
- ➢ **Use:** hardwoods are more likely to be found in high-quality furniture, decks, flooring, and construction that needs to last
- ➢ **Examples:** Examples of hardwood trees include alder, balsa, beech, hickory, mahogany, maple, oak, teak, and walnut.
- ➢ **Density**: Most hardwoods have a higher density than most softwoods.
- ➢ **Cost**: Hardwood is typically more expensive than softwood.
- ➢ **Growth**: Hardwood has a slower growth rate.
- ➢ **Fire Resistance:** More

2. Soft wood:

> ➢ **Definition:** Comes from gymnosperm trees which usually have needles and cones. Medullary rays and tracheids transport water and produce sap. When viewed under a microscope, softwoods have no visible pores because of tracheids.
>
> ➢ **Use:** About 80% of all timber comes from softwood. Softwoods have a wide range of applications and are found in building components (e.g., windows, doors), furniture, medium-density fiberboard (MDF), paper, Christmas trees, and much more.
>
> ➢ **Examples:** Examples of softwood trees are cedar, Douglas fir, juniper, pine, redwood, spruce, and yew.
>
> ➢ **Density:** Most softwoods have a lower density than most hardwoods.
>
> ➢ **Cost:** Softwood is typically less expensive compared to hardwood.
>
> ➢ **Growth:** Softwood has a faster rate of growth
>
> ➢ **Fire Resistance:** Poor
>
> **3. Age:** affect wood properties like hardness, level of moisture content

Theoretical learning Activity:

- Discuss about the properties of softwood and hardwood for analysis

Practical learning Activity

- Identify the difference between softwood and hardwood.

- **Identify wood species with regard to the properties to be analyzed**

- **Select part to pick up wood sample with regard to the properties to be analyzed**

Points to Remember

> **Identification of tree species for sample collection and laboratory analysis:**
>
> ✓ Features of softwood
>
> ✓ Features of hardwood
>
> ✓ Tree age determination

Indicative content 2.1.2: Location of a part to pick up a sample

Location of a part to pick up a sample:

Bark:

Bark is the outermost layers of stems and roots of woody plants. Plants with bark include trees, woody vines, and shrubs. Bark refers to all the tissues outside the vascular cambium and is a nontechnical term.

❖ **Cambium**:

The cambium cell layer is the growing part of the trunk. It annually produces new bark and new wood in response to hormones that pass down through the phloem with food from the leaves.

❖ **Sapwood:**

The younger softer living or physiologically active outer portion of wood that lies between the cambium and the heartwood and is more permeable, less durable, and usually lighter in color than the heartwood.

❖ **Heartwood,**

The older harder non-living central wood of trees that is usually darker, denser, less permeable, and more durable than the surrounding sapwood.

❖ **Root**

The usually underground part of a seed plant body that originates usually from the hypocotyl, functions as an organ of absorption, aeration, and food storage or as a means of anchorage and support, and differs from a stem especially in lacking nodes, buds, and leaves.

Theoretical learning Activity:

- Discuss about the different part of wood for taking samples.

- Identify the section of wood for taking samples.
- Handle and transport of wood samples to the laboratory according to the laboratory protocol

Points to Remember

Part of wood for pick up samples:

✓ Bark,

✓ Cambium,

✓ Sapwood,

✓ Heartwood,

✓ Root

Ic **Indicative content 2.1.3: Types of cuts**

Types of cuts (Section/Surface):

Wood shows three main section: tangential, transversal and radial section.

a) Tangential.

Tangential sections: are made perpendicular to the rays and tangential to the annual rings and face of the log. This plane is also called slab-cut or plane-sawed lumber. The annual rings appear in irregular, wavy patterns.

b) Radial,

It is section observed when timber is cut from bark to the central/pith. The radial plane, or the view from the center of the tree out to the bark may also be helpful. The ray tissue is apparent on this plane. Ray tissue is responsible for moving water, nutrients and other substances laterally in the tree (as opposed to xylem and phloem tissue that moves materials up and down the tree).

c) Transversal

Transversal section /cross section is explaining as the surface observed when the log/trunk is cut against fiber orientation where you can observe rays and growth in that section.

d) Longitudinal

This cut/section look like tangential section/cut except that it doesn't consider starting sawing from tangent (slabbing).

Theoretical learning Activity:

- Explain four types of wood cuts for sample collection and laboratory analysis.

Practical learning Activity

- Describe four types of wood cuts for sample collection and laboratory analysis.

Points to Remember

Types of cuts for wood sample collection and laboratory analysis:
- ✓ Tangential,
- ✓ Radial,
- ✓ Transversal
- ✓ Longitudinal

Indicative content 2.1.4: Wood sample cut

Wood sample cut

a) Wood sample cutting out procedures

Sample preparation

Depending on the hardness of the wood, cut little blocks of 25-100 mm^2 (shape depends on the purpose) and of at least 1 cm but max. 2 cm high (otherwise it will not

fit in the microtome). You can do this with a handsaw or if the samples are already small you can also use a single-side-razor blade. Use a marble or glass plate as cutting board. For liquid preserved samples, take them out of the solution only one by one to be cut, to limit the time they are out of liquid. We don't want them to become hard.

Tv   Tg   Rd
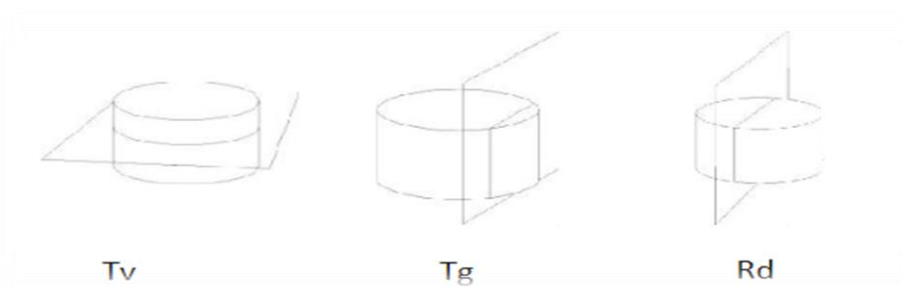
The orientation of the wood block when cutting is of high importance to be able to make sections that show exactly the anatomy as seen in *transverse*, *tangential* or *radial* plane.

b) Dimensions/size

The size of wood sample will depend much on the test to be done for example samples for density, moisture content, pests resistance, elasticity and microscopic analysis are differing in size or dimension; the most important is to reduce the size to the workable minimum possible.

In sample we can have different forms like cylindrical, cubic, parallelogram for various analysis.

Theoretical learning Activity:

- Discuss about the wood sample size and shape for analysis.

Practical learning Activity

- Describe the samples size and laboratory analysis.
- Store of wood samples according to their properties and laboratory protocol

Points to Remember

Wood sample cut
✓ Wood sample cutting out procedures
✓ Dimensions/size

Learning outcome 2.1 formative assessment about collect wood sample.

Q1. Explain four types of wood cuts for sample collection and laboratory analysis.

Answer:

a) Tangential.

Tangential sections: are made perpendicular to the rays and tangential to the annual rings and face of the log.

b) Radial,

It is section observed when timber is cut from bark to the central/pith. The radial plane, or the view from the center of the tree out to the bark may also be helpful.

c) Transversal

Transversal section /cross section is explaining as the surface observed when the log/trunk is cut against fiber orientation where you can observe rays and growth in that section.

d) Longitudinal

This cut/section look like tangential section/cut except that it doesn't consider starting sawing from tangent (slabbing).

Learning outcome 2.1 Practical assessment about ccollection of wood sample.

Task1: Identify wood species with regard to the properties to be analysed

Task2: Select part to pick up wood sample with regard to the properties to be analysed

Task 3: Performance of wood sample cut with regard to the properties to be analyzed

Checklist	Score	
	Yes	No
Indicator 1: Wood species with regard to the properties to be analyzed are well identified		

✓ Softwood is identified		
✓ Hardwood is identified		
Indicator 2: Part to pick up of wood sample with regard to the properties to be analyzed is well selected.		
✓ Bark is selected		
✓ Cambium is selected		
✓ Sap wood is selected		
✓ Heart wood is selected		
Indicator 3: Wood sample cut with regard to the properties to be analyzed is well performed		
✓ Tangential cut		
✓ Radial cut		
✓ Transversal cut		
✓ Size		

Learning outcome 2.2: Handle and transport wood sample.

Duration: 4 hours
Objectives of Learning outcome 2.2   **By the end of the learning outcome, the trainees will be able to:**   **1.** Packing correctly wood sample for laboratory analysis.   **2.** Transport appropriately collected wood sample.
Resources

Equipment	Tools	Materials
1. Moisturemeter 2. Microscope 3. Electric furnace 4. Chainsaw 5. Thermometer 6. Hygrometer 7. Electronic balance 8. Audi visual equipment 9. Oven 10. Relascope	1. Knife 2. Axe 3. Panga 4. Handsaw 5. Tape measures 6. Thermal conductivity meter.	1. Wood samples 2. Pencils 3. Plastic bags 4. Papers 5. Notebooks 6. Water 7. Chalk 8. Wood sample containers 9. Wooden wedges

11. Computer 12. Projector 13. PPE		10. Forest stand 11. Bath or volumetric tank

Advance preparation:

Before starting the session delivery,

- ✓ Avail transport means of wood sample
- ✓ There should be availability of required resources as listed above depending on their necessity
- ✓ Learning place should be made ready,
- ✓ Facilitation techniques should be though about depending on the size of the class, the number of learners, the category of learners, and available learning resources

Indicative content 2.2.1: Handling wood sample

Handling wood sample

Wood to be used as samples must be protected from external factors of humidity and heavy sunshine for not affecting its morphological properties.

During transport these wood samples must be in the containers

Theoretical learning Activity:

- Discuss about the packaging and transport of wood sample for laboratory analysis

Practical learning Activity

- Identify different packaging materials for collected wood sample for laboratory analysis.

 Points to Remember

Handling wood samples:

> ➢ Packaging wood sample (glass containers)
>
> ➢ Softening (water)

 Indicative content 2.2.2: Transporting wood sample

Transport of wood sample

Wood sample for laboratory analysis should be arranged in the longitudinal direction of the truck, vertically or in triangles and pyramids. In addition, vehicles suitable for wood transportation must undergo a safety inspection to obtain the CRV (Certificate of Vehicle Registration) and CRVL (Certificate of Vehicle Registration and License).

 Theoretical learning Activity:

- During a wood sample taking, different wood cuts can be created, name these three cuts of wood.
- on these three cuts of wood.
- Discuss about transport precautions of wood sample for laboratory analysis

 Practical learning Activity

- Describe equipment used for wood sample for laboratory analysis.

 Points to Remember

Transporting wood sample:

> ➢ Time
> ➢ Secure/pallets

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Learning outcome 2.2 Formative assessment about Handle and transport wood sample

Q1. Identify different packaging materials for collected wood sample for laboratory analysis.

Answer:

- ✓ Envelops
- ✓ Plastic bottles
- ✓ Wooden envelops
- ✓ Glass bottles

Q2. Wood sample for laboratory analysis are taken on different parts of tree, precisely tell the location of part on which wood sample should be picked up?

Answer:

- ✓ Bark,
- ✓ Cambium,
- ✓ Sapwood,
- ✓ Heartwood,
- ✓ Root

Learning outcome 2.2 Practical assessment about Handle and transport wood sample

Task: Handle and transport of wood samples to the laboratory according to the laboratory protocol

Checklist	Score	
	Yes	**No**
Indicator 1: Handle and transport of wood samples to the laboratory according to the laboratory protocol		
✓ Glass containers sealing		
✓ Wood sample containers indications		
✓ Softening		
✓ Time respect		

Learning outcome 2.3: Store wood sample

⏱	**Duration: 3 hours**

🎯 **Objectives of Learning outcome 2.3**

By the end of the learning outcome, the trainees will be able to:

1. Store correctly wood samples for laboratory analysis according to the required conditions.

2. Apply correctly 3 methods of wood sample storage for laboratory analysis.

🧰 **Resources**

Equipment	Tools	Materials
1. Moisturemeter	**1.** Knife	**1.** Wood samples
2. Microscope	**2.** Axe	**2.** Pencils
3. Electric furnace	**3.** Panga	**3.** Plastic bags
4. Chainsaw	**4.** Handsaw	**4.** Papers
5. Thermometer	**5.** Tape measures	**5.** Notebooks
6. Hygrometer	**6.** Thermal conductivity meter.	**6.** Water
7. Electronic balance		**7.** Chalk
8. Audi visual equipment		**8.** Wood sample containers
9. Oven		**9.** Wooden wedges
10. Relascope		**10.** Forest stand
11. Computer		**11.** Bath or volumetric tank
12. Projector		
13. PPE		

📋**Advance preparation:**

Before starting the session delivery,

 ✓ Avail warehouse for wood sample storage

 ✓ There should be availability of required resources as listed above depending on their necessity

 ✓ Learning place should be made ready,

 ✓ Facilitation techniques should be though about depending on the size of the class, the number of learners, the category of learners, and available learning resources

Indicative content 2.3.1: Storing conditions

Storing conditions:

- ✓ **Temperature:** it must be a bit higher to allow timber to continue drying.

- ✓ **Aeration:** store house must allow air circulation inside for continuous drying

- ✓ **Free from pests:** house used for storing wood sample disinfected with pesticide for not damaging wood sample.

 Theoretical learning Activity:

- Discuss about wood sample for laboratory analysis storing conditions

 Practical learning Activity

- In a group of four; perform wood sample storage by respecting storing conditions.

 Points to Remember

Storing conditions:

- ✓ Temperature
- ✓ Aeration
- ✓ Free from pests

Indicative content 2.3.2: Storing methods

Storing methods:

- ✓ **Cold room:** helps to keep freshness of wood sample and prevent some species of wood pests to develop and damage those sample.

> ✓ **Room temperature:** the temperature in the room for storing wood sample must be optimum for them to continue drying, for these avoid storing wood samples in conditions of low temperature
>
> ✓ **Containers arrangement:** Contain of wood samples must be arranged in a way that they are not overstacked

Theoretical learning Activity:

- Storage conditions should ensure that the wood sample is not altered, in any way that might affect the parameters to be analyzed. What are the key factors to consider when storing wood sample?

- Discuss about storing methods of wood samples for laboratory analysis.

Practical learning Activity

- Apply three methods of storage of wood samples for laboratory analysis.

- Store of wood samples according to their properties and laboratory protocol

Points to Remember

Storing methods:

- ✓ Cold room
- ✓ Room temperature
- ✓ Containers arrangement

Learning outcome 2.3 formative assessment about storing wood sample

Q1. Storage conditions should ensure that the wood sample is not altered, list four (4) required wood storage conditions for the storage being successful.

Answer:

- ✓ Cold room should be availed
- ✓ The room temperature should be optimum
- ✓ Wood sample containers should be arranged in good manner to avoid confusion

Learning outcome 2.3 Practical assessment about storing wood sample

Task: Storing of the wood samples according to the properties and laboratory protocol

Checklist	Score	
	Yes	No
Indicator 1: Storing of the wood samples according to the properties and laboratory protocol		
✓ Temperature		
✓ Aeration		
✓ Free from pests		

Learning Unit 3: Conduct biochemical properties of wood analysis

Structure of learning unit 3

Learning outcomes:

    3.1: Arrange the laboratory tools, materials, and wood sample
    3.2: Carry out the laboratory analysis
    3.3: Record the analysis result

Learning outcome 3.1: Arrange the laboratory tools, materials, and wood sample

---

    Duration: 3 hours

    Objectives of Learning outcome 3.1

By the end of the learning outcome, the trainees will be able to:

1. Arrange appropriately laboratory tools and materials for wood sample analysis.

2. Carry out correctly two laboratory analysis of wood sample.

3. Record correctly an analysis results of wood sample.

Resources

Equipment	Tools	Materials
1. Moisturemeter 2. Microscope 3. Electric furnace 4. Chainsaw 5. Thermometer 6. Hygrometer 7. Electronic balance 8. Audio visual equipment 9. Oven 10. Relascope 11. Computer 12. Projector 13. PPE	1. Knife 2. Axe 3. Panga 4. Handsaw 5. Tape measures 6. Thermal conductivity meter.	1. Wood samples 2. Pencils 3. Plastic bags 4. Papers 5. Notebooks 6. Water 7. Chalk 8. Wood sample containers 9. Wooden wedges 10. Forest stand 11. Bath or volumetric tank

Advance preparation:

Before starting the session delivery,

- ✓ Avail wood laboratory
- ✓ There should be availability of required resources as listed above depending on their necessity
- ✓ Learning place should be made ready,
- ✓ Facilitation techniques should be though about depending on the size of the class, the number of learners, the category of learners, and available learning resources

Ic Indicative content 3.1.1: Wood sample arrangement instructions

Instructions to wood sample arrangement: ➢ **Species:** during wood sample collection it is important to mention specie to be analyzed to avoid confusion with other wood sample. ➢ **Collection date:** the date also must also be noted for distinguishing different samples to be analyzed. ➢ **Properties to analyze:** sample are collected and cut reflecting types of analysis to be done for example: density, moisture content, extractives, lignin content etc.

Theoretical learning Activity:

- Discuss about wood sample arrangement instructions

Practical learning Activity

- In groups of two arrange wood sample at your school workshop.

Points to Remember

Instructions about wood sample arrangement that considers:

- The species of wood,
- Collection date and
- Properties to be analysed of wood samples.

Indicative content 3.1.2: Materials categorization

Categorization of materials:

- ➤ **Metal:** made from metal
- ➤ **Ceramic:** made from clay
- ➤ **Plastic:** are also types of contain for keeping wood samples.
- ➤ **Wood:** are collected as samples to be analyzed
- ➤ **Paper:** Paper are used as an envelope for taking wood samples
- ➤ **Glass:** bottle-like container are also used to keep wood sample in desired conditions

Theoretical learning Activity:

- Discuss about category of different materials used keeping wood samples.

Practical learning Activity

- Identify category of different materials used for keeping wood samples.

Points to Remember

Category of different materials used for keeping wood samples

✓ Metal

✓ Ceramic

✓ Plastic

✓ Wood

✓ Paper

✓ Glass

Indicative content 3.1.3: Emergency tools

Tools used for emergency:

➤ **First aid kit:** a small box containing items such as bandages, plasters, and antiseptic wipes for use in giving help to a sick or injured person until full medical treatment is available.

➤ **Fire extinguisher:** a portable device that discharges a jet of water, foam, gas, or other material to extinguish a fire.

➤ **Water:** standard water fire extinguishers only work on fires involving flammable solids, but can be a good choice for some premises, such as warehouses and storage facilities.

Theoretical learning Activity:

- Explain commonly used tools for emergency during laboratory analysis.

Practical learning Activity

- Identify three tools used for emergency during laboratory analysis.

Points to Remember

Tools used for emergency during laboratory analysis
- ✓ First aid kit
- ✓ Fire extinguisher
- ✓ Water

Indicative content 3.1.4: Working place safety

Working safety during laboratory analysis

General lab safety rules

The following are rules that relate to almost every laboratory and should be included in most safety policies. They cover what you should know in the event of an emergency, proper signage, safety equipment, safely using laboratory equipment, and basic common-sense rules.

1. Be sure to read all fire alarm and safety signs and follow the instructions in the event of an accident or emergency.
2. Ensure you are fully aware of your facility's/building's evacuation procedures.
3. Make sure you know where your lab's safety equipment including first aid kit(s), fire extinguishers, eye wash stations, and safety showers is located and how to properly use it.
4. Know emergency phone numbers to use to call for help in case of an emergency.
5. Lab areas containing carcinogens, radioisotopes, biohazards, and lasers should be properly marked with the appropriate warning signs.

6. Open flames should never be used in the laboratory unless you have permission from a qualified supervisor.

7. Make sure you are aware of where your lab's exits and fire alarms are located.

8. An area of 36" diameter must be kept clear at all times around all fire sprinkler heads.

9. If there is a fire drill, be sure to turn off all electrical equipment and close all containers.

10. Always work in properly-ventilated areas.

11. Do not chew gum, drink, or eat while working in the lab.

12. Laboratory glassware should never be utilized as food or beverage containers.

13. Each time you use glassware, be sure to check it for chips and cracks. Notify your lab supervisor of any damaged glassware so it can be properly disposed of.

14. Never use lab equipment that you are not approved or trained by your supervisor to operate.

15. If an instrument or piece of equipment fails during use, or isn't operating properly, report the issue to a technician right away. Never try to repair an equipment problem on your own.

16. If you are the last person to leave the lab, make sure to lock all the doors and turn off all ignition sources.

17. Do not work alone in the lab.

18. Never leave an ongoing experiment unattended.

19. Never lift any glassware, solutions, or other types of apparatus above eye level.

20. Never smell or taste chemicals.

21. Do not pipette by mouth.

22. Make sure you always follow the proper procedures for disposing lab waste.

23. Report all injuries, accidents, and broken equipment or glass right away, even if the incident seems small or unimportant.

24. If you have been injured, yell out immediately and as loud as you can to ensure you get help.

25. In the event of a chemical splashing into your eye(s) or on your skin, immediately flush the affected area(s) with running water for at least 20 minutes.

26. If you notice any unsafe conditions in the lab, let your supervisor know as soon

as possible.

Theoretical learning Activity:

- Discuss about general rules to consider during laboratory analysis of wood samples.
- Suggest the arrangement layout of laboratory tools and materials based on laboratory guidelines
- Let 's assume that you are performing wood analysis within a laboratory, and you fall in a corrosive accident due to chemicals, justify how are you going to behave in such situation?

Practical learning Activity

- Apply safety rules during tissues of wood sample analysis.
- Arrange the wood sample based on laboratory instructions
- Arrange the laboratory tools and materials based on laboratory guidelines
- Arrange the emergency tool based on laboratory safety rules instructions

Points to Remember

General laboratory rules about:
  ➢ Emergency,
  ➢ Personal protection equipment and
  ➢ Safety of tools and equipment.

Learning outcome 3.1: Formative assessment about Arrange the laboratory tools, materials, and wood sample.

Q1. List any five safety rules when working in wood laboratory.

Answer:

1. Be sure to read all fire alarm and safety signs and follow the instructions in the event of an accident or emergency.

2. Ensure you are fully aware of your facility's/building's evacuation procedures.

3. Make sure you know where your lab's safety equipment including first aid kit(s),

fire extinguishers, eye wash stations, and safety showers is located and how to properly use it.

4. Know emergency phone numbers to use to call for help in case of an emergency.
5. Lab areas containing carcinogens, radioisotopes, biohazards, and lasers should be properly marked with the appropriate warning signs.

Learning outcome 3.1: Practical assessment about arranging the laboratory tools, materials, and wood sample.

Task: Arrange the wood sample based on laboratory instructions

Task: Arrange the laboratory tools and materials based on laboratory guidelines

Task: Arrange the emergency tool based on laboratory safety rules instructions

Checklist	Score	
	Yes	No
Indicator 1: Arrangement of the wood sample based on laboratory instructions is done		
✓ Temperature		
✓ Aeration		
✓ Free from pests		
Indicator 2: Arrangement of the laboratory tools and materials based on laboratory guidelines is well done		
✓ Metal is arranged		
✓ Ceramic is arranged		
✓ Plastic is arranged		
✓ Wood is arranged		
✓ Glass is arranged		
✓ Paper is arranged		
Indicator 3: Arrangement of the emergency tool based on laboratory safety rules instructions is done		
✓ First aid kit arranged		
✓ Fire extinguisher arranged		
✓ Water availed		

Learning outcome 3.2: Carry out the laboratory analysis

⏰ **Duration: 4 hours**

🎯 **Objectives of Learning outcome 3.2**

By the end of the learning outcome, the trainees will be able to:

1. Respect correctly wood sample analysis protocol
2. Identify appropriately solvents for laboratory analysis of wood sample.
3. Identify at least three tissues of trees.
4. Classify correctly 5 tree tissues according to their functions
5. Determine correctly 4 chemical content of wood.
6. Describe correctly physical and chemical properties of wood.

🧰**Resources**

Equipment	Tools	Materials
1. Moisturemeter 2. Microscope 3. Electric furnace 4. Chainsaw 5. Thermometer 6. Hygrometer 7. Electronic balance 8. Audi visual equipment 9. Oven 10. Relascope 11. Computer 12. Projector 13. PPE	1. Knife 2. Axe 3. Panga 4. Handsaw 5. Tape measures 6. Thermal conductivity meter.	1. Wood samples 2. Pencils 3. Plastic bags 4. Papers 5. Notebooks 6. Water 7. Chalk 8. Wood sample containers 9. Wooden wedges 10. Forest stand 11. Bath or volumetric tank

📋**Advance preparation:**

Before starting the session delivery,

✓ Avail laboratory for wood sample

✓ There should be availability of required resources as listed above depending on their necessity

✓ Learning place should be made ready,

Indicative content 3.2.1: Laboratory rules and regulations

Laboratory rules regulations

1. Follow the instructions

Whether it's listening to your instructor or lab supervisor or following a procedure in a book, it's critical to listen, pay attention, and be familiar with all the steps, from start to finish, *before* you begin.

2. Keep snacks out of the lab

Food and drinks should *never* be consumed in a lab. There is a chance that they could become contaminated by the chemicals used in the lab. There is also a chance that the food and drinks could spill and contaminate an experiment. If you need to eat or drink, make sure you do it before you enter a lab or wait until you leave.

3. Don't sniff the chemicals

Not only should you not bring in food or drinks, but you shouldn't taste or smell chemicals or biological cultures already in the lab. Tasting or smelling some chemicals can be dangerous or even deadly. The best way to know what's in a container is to label it, so get in the habit of making a label for glassware before adding the chemical.

4. Dispose of waste properly

Much of the waste created in a lab needs to be disposed of in something other than just the regular waste bin.

5. Identify safety equipment

If something goes wrong while you're in the lab, you need to know where the safety equipment is located so that you can start using it right away.

6. Think safety first

If a chemical were to spill in the lab, what would you do? Or if you were injured while doing an experiment, what would be your next move? It's impossible to eliminate all

accidents from a lab, but you can take the right steps to prepare yourself for one. It could prevent a small problem from turning into a larger one.

7. Dress for the lab

From the moment you walk into a lab, you need to be dressed properly from head to toe. This means wearing long pants, a lab coat, safety goggles, covered shoes, and any other protective gear required by the lab.

8. Leave Experiments at the Lab

It's important, for your safety and the safety of others, to leave your experiment in the lab. Don't take it home with you. You could have a spill or lose a specimen or have an accident.

Theoretical learning Activity:

- Discuss about rules and regulations for analysis laboratory

Practical learning Activity

- Identify different rules of analysis laboratory.

Points to Remember

Rules and laboratory:

- ➢ PPE for operator
- ➢ Emergency equipment
- ➢ Laboratory protocol

Indicative content 3.2.2: Preparation of laboratory reagent

Preparation of reagents

The standard practice is to use either distilled water or deionized water to prepare most reagent solutions.

Theoretical learning Activity:

- Discuss about preparation of reagent for laboratory analysis.

 Practical learning Activity

- Describe reagents for laboratory analysis of wood sample.

 Points to Remember

Preparation of reagents for laboratory analysis

Indicative content 3.2.3: Respect of analysis protocol

Analysis protocol for wood sample

A lab protocol, also known as a standard operating procedure, is a list of instructions to perform an experiment. It is a plan used to duplicate favourable results from a previous test. In a research laboratory, many protocols are needed for safety, to operate analytical equipment and to make solutions with minimal mistakes.

Theoretical learning Activity:

- Discuss about laboratory protocol for wood sample analysis.

Practical learning Activity

- Describe the protocol for laboratory analysis of wood sample.

Points to Remember

Preparation of protocol for wood sample analysis.

Ic

Indicative content 3.2.4: Identification of solvents

Solvents for wood sample analysis

➢ **Organic:** Organic solvents are carbon-based substances capable of dissolving or dispersing one or more other substances.

Properties of Organic Solvents

Organic solvents do exhibit various physical and chemical properties as given below-

- **Organic solvents are volatile in nature**– Volatile solvents are those which have the ability to vaporize. Organic solvents possess these properties. Due to nature of volatility, organic solvents release smell when released into air.

- **Organic solvents exhibit low boiling point-** Organic solvents are said to have very low boiling points. Due to this low boiling point, they are highly volatile.

- **Organic solvents are colorless liquids-** These are clear liquids and have lower molecular weights.

Examples: toluene, alcohols, methanol, acetone

➢ **Inorganic solvents:** An inorganic compound is any compound that lacks a carbon atom, for lack of a more in-depth definition. Those compounds with a carbon atom are called organic compounds, due to their root base in an atom that is vital for life.

Examples of inorganic solvent:

Fe_2O_3 - Iron (III) oxide, NO_2 - Nitrogen dioxide, Hcl – Hydrochloride, H_2O - Water

Theoretical learning Activity:

- Discuss about solvents for laboratory analysis of wood sample.

Practical learning Activity

- Identify reagents for laboratory analysis of wood sample.

Points to Remember

Solvent for laboratory analysis of wood sample:

- ✓ Organic solvent
- ✓ Inorganic solvent

Ic **Indicative content 3.2.5: Identification of tree tissues group**

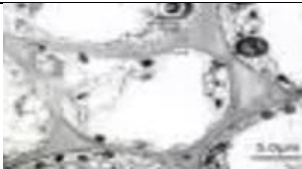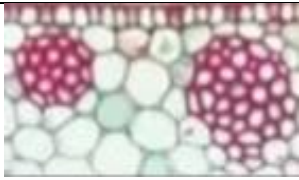**Identification of tree tissues group:**

1) Dermal tissues:

Dermal tissue is found covering the younger primary parts of a plant. These include leaves, roots, stems, flowers, fruits, and seeds. Plant parts that become woody no longer have dermal tissue as their outer layer because it is replaced by periderm, or cork. Just as our own skin serves to protect our bodies, the dermal layer of a plant has the same function.

Function: Like our own skin, the dermal layer of a plant is its first line of defense. It protects against damage to the plant itself. In addition, the epidermal cells of a plant are closely packed together to create an effective barrier against potentially harmful intruders, like fungi.

On leaves, we find a waxy coating secreted by epidermal cells. This coating is called the cuticle. The cuticle helps water from constantly evaporating from the leaves.

2) Ground tissues:

Is made up of three components: parenchyma, collenchyma and sclerenchyma

	Parenchyma	Collenchyma	Sclerenchyma
Characteristics	1. Spherical 2. Thin walled 3. Living tissues	1. Elongated cells with unevenly thickened cell wall. 2. Alive at maturity	1. Have primary and secondary wall 2. Dead at maturity
Location	1. Throughout the plant	1. Under epidermis and veins of leaves	1. Fiber in wood, bark, leaves and stem. 2. Fruits and seeds
Function	1. Photosynthesis and respiration 2. Storage and regeneration	1. Flexible supporting the system	1. Structural support
Appearance			

3) Vascular tissues:

Types of Vascular Tissue

A. Xylem

Xylem is a specialized type of vascular tissue created in vascular plants to transport water and nutrients from the roots of a plant to the tips of the leaves. The xylem is created from hollow, dead cells. Water is absorbed into the roots, which creates a positive pressure on the water inside the column. As water evaporates out of the leaves, the process of transpiration pulls water into the leaves. In this way, the xylem serves as a straw, allowing water to carry minerals upwards through the plant.

B. Phloem

At the same time, the plant is producing sugars via photosynthesis, which must be transported downwards, to the stem and root cells. Another vascular tissue, the phloem, accounts for this process. Unlike the xylem, this vascular tissue is made up of living cells. The so-called sieve cells are connected via a thin membrane called the sieve plate. Through this channel of phloem cells sugar is transported throughout the plant. Unlike water, sugar is thick and sappy. The phloem requires inputs of water from the xylem and specialized proteins to help quickly pass the sugars through the plant.

Theoretical learning Activity:

- Discuss about tree tissues.
- Differentiate conducting tissues to supporting tissues

Practical learning Activity

- Identify 3 types of wood tissues for laboratory analysis.
- **Carry out the laboratory experiment based on laboratory guidelines**

Points to Remember

Types of tree tissues used for laboratory analysis

- ✓ Ground tissues which give origin to other tissues.
- ✓ Vascular tissues for transport of nutrients
- ✓ Dermal tissues for protection

Classification of tree tissues according to their functions:

1) **Conducting tissues**

There are two conducting tissues such as xylem and phloem for conducting water and sap (for more read the above information).

2) **Protective tissues:**

The **protective tissue** is that **tissue**, which is present in the outermost layer of the **plant** such as roots, stem, and leaves. **Protective tissue** prevents desiccation, mechanical injury, and infection in **plants**. They form a **protective** barrier which does not allow the entry of the pathogen into the **plant** and from water loss and pest attach.

3) **Reserve tissues**

They lack of chloroplasts and has the function of store food substances to be used later by the plant, for example, starches, lipids, sugars and other active ingredients. This parenchyma has large intercellular spaces and is abundant in the rhizomes, tubers, bulbs and aerial stems.

4) **Growth tissues**

Growth tissues also known as meristematic tissues may be defined as a group or collection of living cells which have specific locations and divide continuously to add new cells to the plant body.

1. Apical meristem:

This meristem is located at the growing apices of main and lateral shoots and roots. These cells are responsible for linear growth of an organ. Example root apical meristem and shoot apical meristem.

2. Lateral meristem:

This meristem consists of initials which divide mainly in one plane and cause the organ to increase in diameter and girth. The lateral meristem usually occurs on the sides both in stem and root. Lateral meristem is of two types, i.e., in the form of cork cambium and in vascular bundles of dicots in the form of vascular cambium. The activity of this cambium results in the formation of secondary growth.

3. Intercalary meristem:

This meristem is located in between the regions of permanent tissues. The intercalary meristem is usually present at the base of node, base of internode or at the base of the leaf. They are responsible for growth of leaves and internodes.
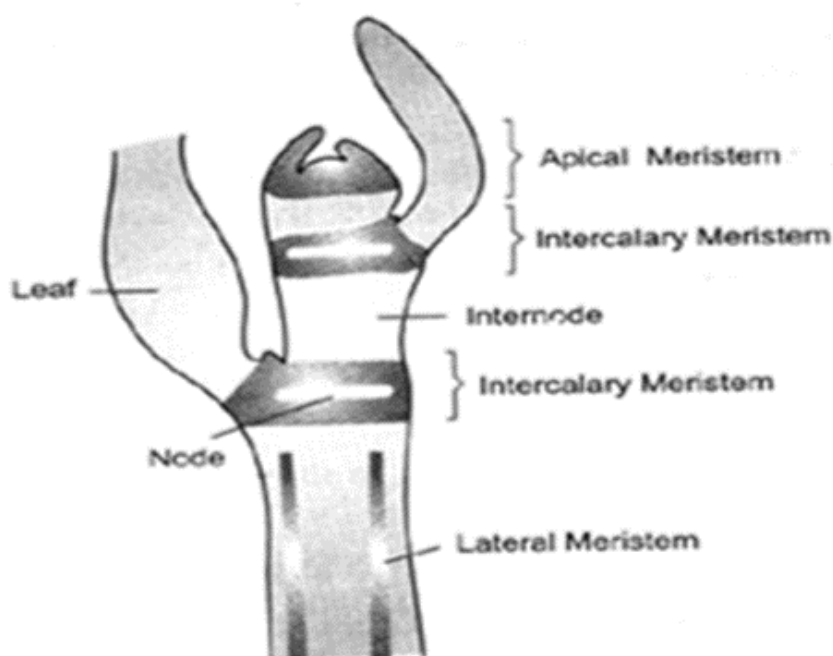
5) Supporting tissues

They are rigid, contain thick and lignified secondary walls. Their main function is to provide strength and support to parts of the plant.

Supporting tissues are of three categories:

1. The collenchyma, a tissue of living cells,
2. the sclerenchyma, a tissue of nearly always dead cells, and
3. The vascular tissue consisting of both living and dead cells. It is responsible for the transport and dispersal of water, nutriments and assimilates.

Theoretical learning Activity:

- Discuss about tree tissues based on their function.

Practical learning Activity

- Identify 5 types of wood tissues based on their function.

Types of tree tissues used for laboratory analysis

- ✓ Conducting tissues
- ✓ Protective tissues
- ✓ Reserve tissues
- ✓ Growth tissues
- ✓ Supporting tissues

Indicative content 3.2.7: Classification of tree tissues according to their functions:

Determination of wood chemical content:

1) **Cellulose**: It is an organic material – a natural composite of cellulose fibers that are strong in tension and embedded in a matrix of lignin that resists compression as wood fibers in softwoods contains 40-45% cellulose and hardwoods contains 40-50% cellulose.

2) **Lignin**: Lignin is an important organic polymer which is abundant in cell walls of some specific cells. It has many biological functions such as water transport, mechanical support and resistance to various stresses. In a wood sample lignin represent 25%

3) **Hemicelluloses**: Hemicelluloses can be defined as cell wall polysaccharides that have the capacity to bind strongly to cellulose micro fibrils by hydrogen bonds. Hemicellulose is known as the second most abundant carbohydrate material and consists of 25%–35% dry weight wood material.

4) **Extractives**: Wood extractives are the non-structural components of wood. They are typically concentrated in the heartwood and are often produced by the standing tree as defensive compounds to environmental stresses. Represent 3.5% in a sample of wood.

Theoretical learning Activity:

- Discuss about wood chemical content observed during laboratory analysis.

Practical learning Activity

- Describe 4 chemical content of wood for laboratory analysis.

Points to Remember

Chemical content of wood:

> Cellulose, lignin, hemicellulose and extractives that are structural component of wood and mechanical support of wood and wood protection.

Indicative content 3.2.8: Description of properties of wood chemical content:

Description of properties of wood chemical content:

A. Physical properties

- ➢ **Color:** feature that is assessed by one's eyes
- ➢ **Taste:** due to different chemical composition wood taste differently on our tongue
- ➢ **Odor:** by using one's noise we can assess different wood odors
- ➢ **Structure:** of wood is define as physical feature that are obvious by any one fiber orientation, sections or cuts etc.

B. Chemical properties

- ➢ **Solubility:** The components extracted from wood with a specified solvent represent the solubility of wood in that solvent at the condition described.
- ➢ **Viscosity:** it is an ability of wood to withstand breaking as results of applied force onto it.
- ➢ **Carbon chain:** wood is an organic material into which Carbon shows high content from 40 up to 49% and it is the root for other chemical components.

> ➢ **Reactivity:** some chemical component of wood reacts with some other chemical like sodium hydroxide for separating lignin from fibers.

Theoretical learning Activity:

- Discuss about physical properties of wood for laboratory analysis.
- Discuss about chemical properties of wood for laboratory analysis.

Practical learning Activity

- Identify physical and chemical properties of wood for laboratory analysis.

Points to Remember

Physical and chemical properties of wood for laboratory analysis

> ➢ Physical properties of wood maintain hardness of wood and resistance damage by pests (Color, Taste, Odour, Structure).
> ➢ Chemical properties of wood maintain mechanical support and resistance to stress like break by wind and pests and diseases (Solubility, Viscosity, Carbon chain, Reactivity)

Learning outcome 3.2 Formative assessment about carrying out laboratory analysis

Q1. Identify any 5 wood tissues based on their function

Answer:

- ✓ Conducting tissues
- ✓ Protective tissues
- ✓ Reserve tissues

- ✓ Growth tissues
- ✓ Supporting tissues

Q2. Complete the following statement with missing terms for having proper meaning

1. The tissues specialised to transport food throughout the plant, are called…………………**(Phloem)……**
2. They uptake water and mineral from the soil to the leaves for photosynthesis, they are called, ……………………………**(Xylem)……**

Learning outcome 3.2 Practical assessment about carrying out laboratory analysis.
Task: Carry out the laboratory experiment based on laboratory guidelines

Checklist	Score	
	Yes	No
Indicator 1: Preparation of reagent and solvent is well done		
✓ Organic		
✓ Inorganic		
Indicator 2: Classification of tree tissues according to their functions is done		
✓ Conducting tissues are classified		
✓ Protective tissues are classified		
✓ Reserve tissues are classified		
✓ Growth tissues are classified		
✓ Supporting tissues are classified		
Indicator 3: Determination of wood chemical content is done		
✓ Cellulose is determined		
✓ Lignin is determined		
✓ Hemicellulose is determined		
✓ Extractives are determined		
Indicator 4: Description of Physical properties of wood chemical content is done		
✓ Color is described		
✓ Taste is described		
✓ Odor is described		
✓ Structure is described		
Indicator 5: Description of Physical properties of wood chemical content is done		
✓ Solubility is described		
✓ Viscosity is described		

✓ Carbon chain is described		
✓ Reactivity is described		
✓ Solubility is described		

Learning outcome 3.3: Record the analysis results

Duration: 3 hours
Objectives of Learning outcome 3.3 **By the end of the learning outcome, the trainees will be able to:** 1. Record correctly the time of analysed data of wood sample. 2. Characterize the data of wood sample to be analysed in laboratory. 3. Fill appropriately laboratory format sheet during laboratory analysis of wood sample.
Resources

Equipment	Tools	Materials
1. Moisturemeter 2. Microscope 3. Electric furnace 4. Chainsaw 5. Thermometer 6. Hygrometer 7. Electronic balance 8. Audi visual equipment 9. Oven 10. Relascope 11. Computer 12. Projector 13. PPE	1. Knife 2. Axe 3. Panga 4. Handsaw 5. Tape measures 6. Thermal conductivity meter.	1. Wood samples 2. Pencils 3. Plastic bags 4. Papers 5. Notebooks 6. Water 7. Chalk 8. Wood sample containers 9. Wooden wedges 10. Forest stand 11. Bath or volumetric tank

Advance preparation:

Before starting the session delivery,

✓ Avail laboratory for wood sample

✓ There should be availability of required resources as listed above depending on their necessity

Ic **Indicative content 3.3.1: Recording time**

Recording time: Any sample to be analyzed must show date and time of analysis to avoid any confusion with other ongoing wood sample being analysed.

Instructions for Recording Data in the Laboratory Notebook

1. All entries should be made in a legible and orderly manner using permanent ink, preferably black. Make entries clear and complete so that someone else could repeat the experiment if necessary.

2. Avoid erasures. If an error is made, cross it out and make the correction immediately thereafter. Cancellations or insertions should be initialed, dated and explained (in the margin, if possible), by an appropriate notation.

3. Make sure the control page information is filled out prior to usage.

4. Each day's work should, whenever possible, be started on a separate page with lines drawn diagonally across the unused portion of the previous page. (This gives legal evidence that additions were not made at a later date.)

5. Each page must be signed and dated by the individual who makes the entry and does the work. In addition, each page should be witnessed (signed and dated), using the notation "Read and Understood", preferably on the same day, but at least within one week.

6. For copying purposes, graphs, charts, analytical data, etc. should be attached to the notebook pages with a permanent adhesive and should, when unfolded, be kept within the confines of the opened notebook.

Theoretical learning Activity:

- Discuss about recording time about results from analysis.

Practical learning Activity

- Identify different rules of recording time of results of laboratory analysis.

Points to Remember

Timing of recording of results of laboratory analysis
➢ Hours ➢ Day ➢ Month

Indicative content 3.3.2: Data characteristics

Characterisation of data
➢ **Weight:** is define as the quantity of wood sample to be analyzed which is measure in kg or grams ➢ **Volume**: is also quantity of wood sample to be analyzed and it is measured in m^3 or cm^3 ➢ **Form**: is about wood quality by observing its physical characteristics. ➢ **Percentage**: quantity of wood used during analysis and it is expressed in percentage compared to wood used initially.

Theoretical learning Activity:

- Discuss about different wood sample data for analysis.

- Describe any 4 wood sample data for laboratory analysis.

Points to Remember

Characteristics of wood samples for laboratory analysis.

➢ Weight
➢ Volume
➢ Form
➢ Percentage

Indicative content 3.3.3: Filling laboratory format sheet

Filling laboratory format sheet

A **laboratory format sheet** report is broken down into eight sections: title, abstract, introduction, methods and materials, results, discussion, conclusion, and references. The title of the lab report should be descriptive of the experiment and reflect what the experiment analyzed.

1. Title

The title of the lab report should be descriptive of the experiment and reflect what the experiment analyzed.

Ex: "Determining water content in a wood sample"

2. Introduction

➢ The introduction of a lab report discusses the problem being studied and other theory that is relevant to understanding the findings.

➢ Write the introduction in your own words. Try not to copy from a lab manual or other guidelines. Instead, show comprehension of the experiment by briefly explaining the problem.

3. Methods and Materials

> ➤ The methods and materials section provides an overview of any equipment, apparatus, or other substances used in the experiment, as well as the steps taken during the experiment. If using any specific amounts of materials, make sure the amount is listed.

Ex: pipette, graduated cylinder, 1.13mg of Na, 0.67mg Ag

> ➤ List the steps taken as they actually happened during the experiment, not as they were supposed to happen.
> ➤ If written correctly, another researcher should be able to duplicate the experiment and get the same or very similar results.

4. Results

> ➤ The results show the data that was collected or found during the experiment.
> ➤ Explain in words the data that was collected.
> ➤ If using graphs, charts, or other figures, present them in the results section of the lab report.
>> o Tables should be labeled numerically, as "Table 1", "Table 2", etc. Other figures should be labeled numerically as "Figure 1", "Figure 2", etc.
> ➤ Calculations to understand the data can also be presented in the results.

5. Discussion

> ➤ The discussion section is one of the most important parts of the lab report. It analyzes the results of the experiment and is a discussion of the data.
> ➤ If any results are unexpected, explain why they are unexpected and how they did or did not affect the data obtained.
> ➤ Explain your results and discuss them using relevant terms and theories.
> ➤ When writing a discussion, try to answer these questions:
>> ▪ What do the results indicate?
>> ▪ What is the significance of the results?
>> ▪ Are there any gaps in knowledge?
>> ▪ Are there any new questions that have been raised?

6. Conclusion

> ➤ The conclusion is a summation of the experiment. It should clearly and concisely state what was learned and its importance.
> ➤ If there is future work that needs to be done, it can be explained in the conclusion.

7. References

> If using any outside sources to support a claim or explain background information, those sources must be cited in the references section of the lab report.

> In the event that no outside sources are used, the references section may be left out.

Theoretical learning Activity:

- Discuss about how to fill laboratory format sheet.

Practical learning Activity

- Describe the way of filling laboratory format sheet.
- Record the laboratory data based on laboratory format sheet

Points to Remember

Fill laboratory format sheet reflect the following points:
   ✓ Title
   ✓ Introduction
   ✓ Methods and Materials
   ✓ Results
   ✓ Discussion
   ✓ Conclusion
   ✓ References

N/S	Parts of format sheet	Description
1	Title	
2	Introduction	
3	Methods and Materials	
4	Results	
5	Discussion	
6	Conclusion	
7	References	

Learning outcome 3.3 formative assessment about recording the analysis results.

**Q1.** Enumerate any 7 elements of a laboratory format sheet.

Answer:

- ✓ Title
- ✓ Introduction
- ✓ Methods and Materials
- ✓ Results
- ✓ Discussion
- ✓ Conclusion
- ✓ References

Learning outcome 3.3 practical assessment about recording the analysis results.

Task: Record the laboratory data based on laboratory format sheet

Checklist	Score	
	Yes	No
Indicator 1: Recording of the laboratory data based on laboratory format sheet is well done		
✓ Weight is recorded		
✓ Volume is recorded		
✓ Percentage is recorded		
✓ Form is recorded		

Learning Unit 4: Interpret the laboratory data

Proportion (%)
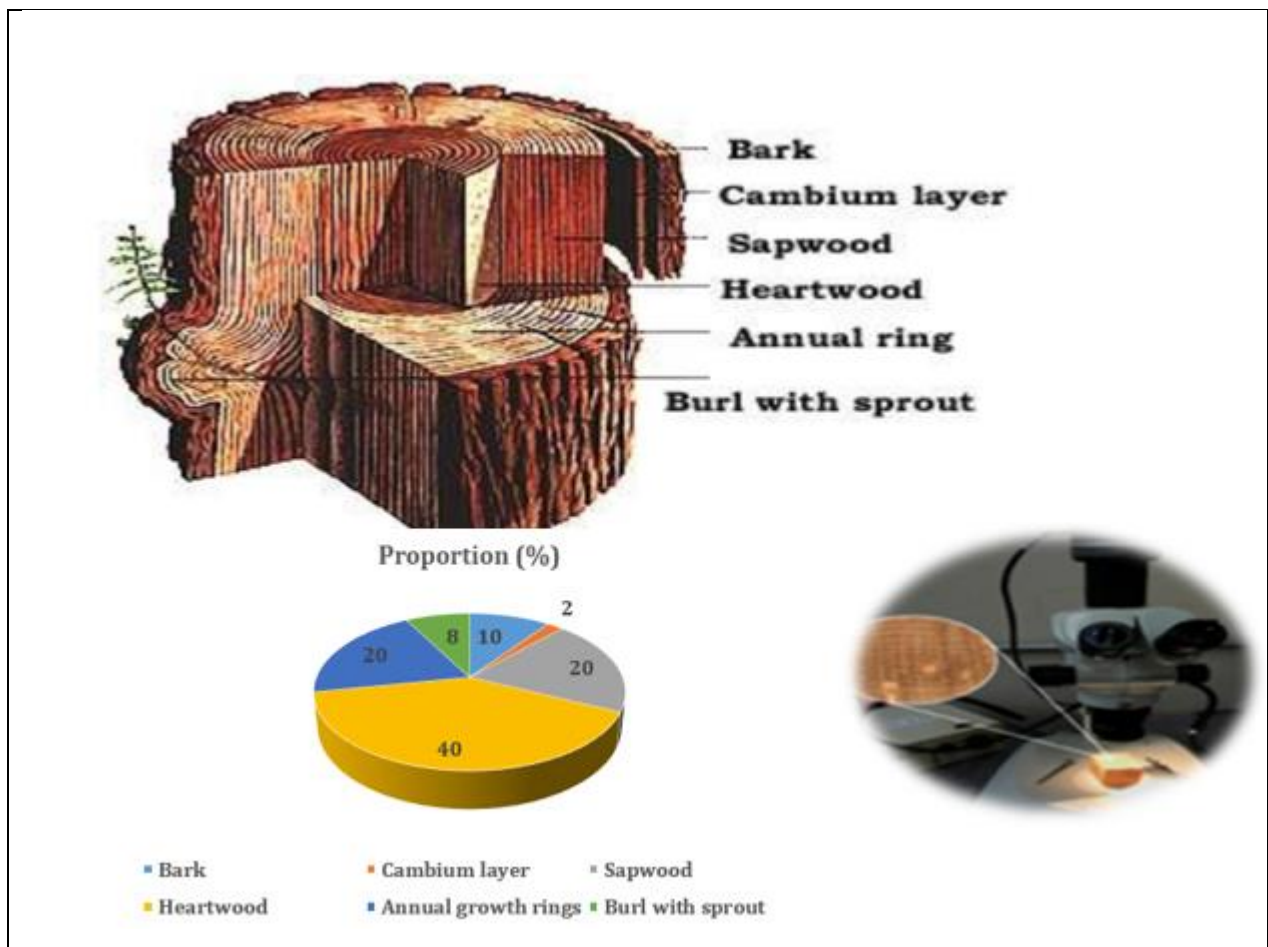
Structure of learning unit 4

> **Learning outcomes:**
>
> **4.1:** Consult standard norms
> **4.2:** Compare the laboratory result to the standard norms
> **4.3:** Conclude the test results

Learning outcome 4.1: Consult standard norms

> ⏱ **Duration: 3 hours**
>
> 🎯 **Objectives of Learning outcome 4.1**
>
> **By the end of the learning outcome, the trainees will be able to:**

1. Define correctly the standards norms used in laboratory analysis of wood.

2. Identify correctly different types of standards norms used in wood laboratory analysis.

3. Analyse correctly laboratory data using descriptive statistics.

Resources

Equipment	Tools	Materials
1. Moisturemeter 2. Microscope 3. Electric furnace 4. Chainsaw 5. Thermometer 6. Hygrometer 7. Electronic balance 8. Audio visual equipment 9. Oven 10. Relascope 11. Computer 12. Projector 13. PPE	1. Knife 2. Axe 3. Panga 4. Handsaw 5. Tape measures 6. Thermal conductivity meter.	1. Wood samples 2. Pencils 3. Plastic bags 4. Papers 5. Notebooks 6. Water 7. Chalk 8. Wood sample containers 9. Wooden wedges 10. Forest stand 11. Bath or volumetric tank

Advance preparation:

Before starting the session delivery,

- ✓ Avail wood laboratory
- ✓ There should be availability of required resources as listed above depending on their necessity
- ✓ Learning place should be made ready,
- ✓ Facilitation techniques should be though about depending on the size of the class, the number of learners, the category of learners, and available learning resources

Ic

Indicative content 4.1.1: Description of standards norms

Description of standard norms:

ASTM's wood standards are instrumental in the evaluation and testing of the physical and chemical properties of a wide range of wood and wood-based products. Wooden materials covered here include timber, lumber, wood-base fibers, commercial softwoods and hardwoods, wood preservatives, laminated timber, and composite

lumber to name a few. These materials are notably used in the fabrication of construction materials such as structural panels and members, construction poles, and log buildings. These wood standards are helpful in guiding wooden material and product manufacturers and end-users in their proper testing and fabrication procedures to ensure acceptable quality towards safe and satisfactory use.

Theoretical learning Activity:

- Discuss about standards norms referred to when carrying out laboratory analysis of wood sample.

 Practical learning Activity

- In groups of two analyse wood sample by referring to standard norms.

 Points to Remember

Standard norms to refer to when analysing wood sample in the laboratory.

 Indicative content 4.1.2: Types of standards norms

Different types of standard norms:

1. Modulus of rupture:

Modulus of rupture is the maximum load carrying capacity of a wood sample. It is generally used in tests of bending strength to quantify the stress required to cause breakage. (Test Method: IS: 1734 (P-11)1983, RA-2003, IS: 1708 (P-5) 1985)

2. Modulus of elasticity:

This test helps in determining the flexural stiffness and modulus of elasticity properties of wood-based materials by nondestructive testing using transverse vibration in the vertical direction. (Test Method: IS: 1734 (P-11)1983, RA-2003, IS: 1708 (P-5)1985)

3. Internal bond strength:

The purpose of this test is to design a compression shear device for easy and fast measurement of the bond shear strength of wood-based materials. (Test Method: IS: 1734 (P-1) 1983, RA-2003)

4. Moisture Content Test:

This test helps in determining the moisture content (MC) of solid wood, veneer, and other wood-based materials, including those that contain adhesives and chemical additives. (Test Method: IS: 1734 (P-1) 1983, RA-2003)

5. Density Test:

Analyzing tree density can serve great ecological and scientific function. These tools are easy to understand and eliminate the risk of damage done to tree specimens. (Test Method: 1708 (P-2)1986, RA-2008)

6. Bending Strength Test:

In bending, it is assumed that wood is linearly elastic for low values of stress, i.e., the stress and strain are proportional to each other and the output on stress-strain curve is either an elastic or straight-line plot. (Test Method: IS: 1734 (P-11) 1983)

7. Absorbability Test:

This test helps in determining the quantity of water absorbed in a specified time through the surface of an overlaid wood-based panel. The test method measures the rate of water weight gain within a controlled surface area of the overlaid panel surface when exposed to standing water. (Test Method: ASTM D 5795.)

8. Wood Quality Test:

This test helps in determining the quality of wood. The kind of wood that is used has a lot of bearing on the lifespan of any furniture. It may be made of hardwood, softwood, or engineered wood. (Test Method: IS: 4020 (P-4)1998)

Theoretical learning Activity:

- Discuss about types standards norms referred to when carrying out laboratory analysis of wood sample.

 Practical learning Activity

- In groups of two analyse wood sample by referring to different types of standard norms.

 Points to Remember

Types of standard norms.

    1.   Modulus of rupture:

    2.   Modulus of elasticity:

    3.   Internal bond strength:

    4.   Moisture Content Test:

    5.   Density Test:

    6.   Bending Strength Test:

    7.   Absorbability Test:
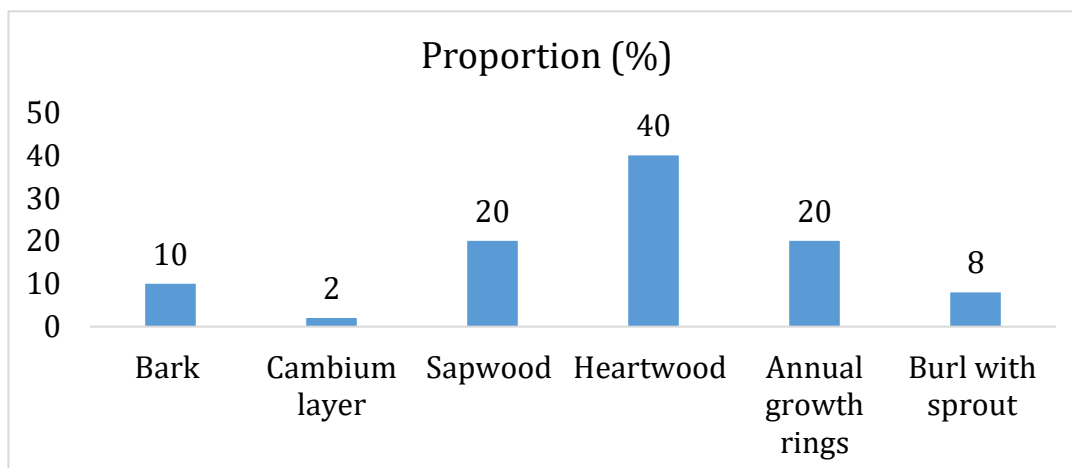
    8.   Wood Quality Test:

**Indicative content 4.1.3: Laboratory data analysis:**

Analysis of laboratory data:

Descriptive statistics:

➢ **Graphs:** Graphical Representation is a way of analysing numerical data. It exhibits the relation between data, ideas, information and concepts in a diagram. It is easy to understand and it is one of the most important learning strategies.

Proportion (%)

Category	Value
Bark	10
Cambium layer	2
Sapwood	20
Heartwood	40
Annual growth rings	20
Burl with sprout	8

➢ Pie-charts: Pie charts make sense to show a parts-to-whole relationship for categorical or nominal data. The slices in the pie typically represent percentages of the total. With categorical data, the sample is often divided into groups and the responses have a defined order.

Proportion (%)
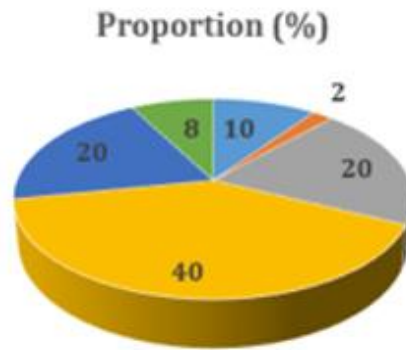
> **Tables:** In tabular representation of data, the given data set is presented in rows and columns. When a table is used to represent a large amount of data in an arranged, organised, engaging, coordinated and easy to read form it is called the tabular representation of data.

Parts of wood	Proportion (%)
Bark	10
Cambium layer	2
Sapwood	20
Heartwood	40
Annual growth rings	20
Burl with sprout	8
Total	100

Theoretical learning Activity:

- Discuss about types standards norms referred to when carrying out laboratory analysis of wood sample.

Practical learning Activity

- In groups of two analyse wood sample by referring to different types of standard norms.

Points to Remember

Laboratory analysis.

Data representation in the following three form: graphs, pie-chart and table form

Learning outcome 4.1: Formative assessment about consult standard norms.

Q1. Describe any two standards norm referred to during laboratory analysis.

Answer:

1. Modulus of rupture:

Modulus of rupture is the maximum load carrying capacity of a wood sample. It is generally used in tests of bending strength to quantify the stress required to cause breakage. (Test Method: IS: 1734 (P-11)1983, RA-2003, IS: 1708 (P-5) 1985)

2. Modulus of elasticity:

This test helps in determining the flexural stiffness and modulus of elasticity properties of wood-based materials by nondestructive testing using transverse vibration in the vertical direction. (Test Method: IS: 1734 (P-11)1983, RA-2003, IS: 1708 (P-5)1985)

Learning outcome 4.1: practical assessment about consult standard norms.

Task: Consult the standard norms and interpret results based on standards norms

Checklist	Score	
	Yes	No
Indicator 1: Recording of the laboratory data based on laboratory format sheet is well done		
✓ Types of standards norms are referred to		
✓ Graphs are used		
✓ Pie-charts are used		
✓ Tables are used		

✓ Description of standards norms are referred to		

Learning outcome 4.2: Compare the laboratory results to the standard norms

Duration: 4 hours
Objectives of Learning outcome 4.2   **By the end of the learning outcome, the trainees will be able to:**   **1.** Apply correctly four methods of data comparison in laboratory analysis of wood.   **2.** refer correctly standards norms in wood laboratory analysis.
Resources

Equipment	Tools	Materials
1. Moisturemeter 2. Microscope 3. Electric furnace 4. Chainsaw 5. Thermometer 6. Hygrometer 7. Electronic balance 8. Audio visual equipment 9. Oven 10. Relascope 11. Computer 12. Projector 13. PPE	1. Knife 2. Axe 3. Panga 4. Handsaw 5. Tape measures 6. Thermal conductivity meter.	1. Wood samples 2. Pencils 3. Plastic bags 4. Papers 5. Notebooks 6. Water 7. Chalk 8. Wood sample containers 9. Wooden wedges 10. Forest stand 11. Bath or volumetric tank

Advance preparation:

Before starting the session delivery,

✓ Avail wood laboratory

Ic

Indicative content 4.2.1: Data comparison methods:

Comparison methods of data analysis:

➢ **Data presentation mean:**

The mean (average) of a data set is found by adding all numbers in the data set and then dividing by the number of values in the set.

➢ **Data correlation:**

Correlation is a statistical measure that expresses the extent to which two variables are linearly related (meaning they change together at a constant rate). It's a common tool for describing simple relationships without making a statement about cause and effect. E.g: correlation between density and hardness of wood.

➢ **Data discussion:**

What is data discussion? The discussion section links the results of your research to the conclusions you are drawing, explaining how you use your data to explain your results. Before you present your data, you should explain again, very briefly, the purpose and scope of your research study.

➢ **Regression:**

Formulating a regression analysis helps you predict the effects of the independent variable on the dependent one. Example: we can say that age and height can be described using a linear regression model. Since a tree's height increases as age increases, they have a linear relationship.

Theoretical learning Activity:

- Discuss about different methods of data analysis.

Practical learning Activity

- In groups of two describe 4 method of data analysis of wood sample by referring to standard norms.

Points to Remember

> **Comparison methods applied during data analysis:**
>
> ➢ Data presentation mean or average
> ➢ Data correlation shows relationship between variables
> ➢ Data discussion before you draw a conclusion for presentation
> ➢ Regression show the relationship between dependent variable and independent variables.

Indicative content 4.2.2: Laboratory standard norms

> **Laboratory standards norms:**
> ✓ **Fixed location:** everything should have a dedicated location and not "wander".
> ✓ **Fixed item:** a place for everything, and everything in its place.
> ✓ **Fixed quantity:** only a pre-determined amount of items can be stored; no mound-hills are allowed.
> ✓ **Emergency equipment:** available and visible.
> ✓ **Personal protective equipment:** must be available in the laboratory.
> ✓ **Waste management:** availability of chemical waste disposal mechanism.

Theoretical learning Activity:

- Discuss about standards norms referred to during data analysis of wood sample.

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 Practical learning Activity

- In groups of two identify standard norms referred to when carrying laboratory analysis of wood samples.

 Points to Remember

Standard norms to refer to during data analysis of wood sample:

- ➢ Fixed location
- ➢ Fixed item
- ➢ Fixed quantity
- ➢ Emergency equipment
- ➢ Personal protective equipment
- ➢ Waste management

Learning outcome 4.2 formative assessment about Compare the laboratory results to the standard norms.

Q1. Describe any 4 laboratory standards norms referred during analysis of wood sample.

Answer:

- ✓ **Fixed location:** everything should have a dedicated location and not "wander".
- ✓ **Fixed item:** a place for everything, and everything in its place.
- ✓ **Fixed quantity:** only a pre-determined amount of items can be stored; no mound-hills are allowed.
- ✓ **Emergency equipment:** available and visible.

Learning outcome 4.2 Practial assessment about Compare the laboratory results to the standard norms.
Task: Comparethe laboratory result to the standard norms

Checklist	Score	
	Yes	**No**
Indicator 1: Laboratory result to the standard norms are compared and discussed		

✓ Data presentation mean is presented		
✓ Data correlation is presented		
✓ Data discussion is presented		
✓ Regression is presented		
✓ Data presentation mean is presented		
✓ Laboratory standard norms is presented		

Learning outcome 4.3: Conclude the test results

Duration: 3 hours

Objectives of Learning outcome 4.3

By the end of the learning outcome, the trainees will be able to:

1. Conclude appropriately wood laboratory analysis procedures.

2. Identify correctly two elements of conclusion in wood laboratory analysis.

3. Describe appropriately indication data of wood laboratory analysis.

Resources

Equipment	Tools	Materials
1. Moisturemeter 2. Microscope 3. Electric furnace 4. Chainsaw 5. Thermometer 6. Hygrometer 7. Electronic balance 8. Audio visual equipment 9. Oven 10. Relascope 11. Computer 12. Projector 13. PPE	1. Knife 2. Axe 3. Panga 4. Handsaw 5. Tape measures 6. Thermal conductivity meter.	1. Wood samples 2. Pencils 3. Plastic bags 4. Papers 5. Notebooks 6. Water 7. Chalk 8. Wood sample containers 9. Wooden wedges 10. Forest stand 11. Bath or volumetric tank

Advance preparation:

Before starting the session delivery,

✓ Avail wood laboratory

Indicative content 4.3.1: Concluding procedures

Procedure of conclusion

When writing a conclusion you should: briefly restate the purpose of the experiment (i.e. the question it was seeking to answer) identify the main findings (i.e. the answer to the research/analysis question) note the main limitations that are relevant to the interpretation of the results.

Theoretical learning Activity:

- Discuss about conclusion procedures of wood sample during laboratory analysis.

Practical learning Activity

- In groups of two describe conclusion procedures of data analysis of wood sample.

Points to Remember

Conclusion procedures of wood sample during laboratory analysis.

Indicative content 4.3.2: Elements of conclusion

Elements of conclusion:

A conclusion paragraph contains a description of the purpose of the experiment, a discussion of your major findings, an explanation of your findings, and recommendations for further study**.**

Theoretical learning Activity:

- Discuss about element of conclusion about wood sample during laboratory analysis.

 Practical learning Activity

- In groups of two identify element of conclusion about laboratory analysis of wood sample.

 Points to Remember

Elements of conclusion about wood sample during laboratory analysis.

- ➢ Purpose of experiment about wood sample
- ➢ Discussion about findings
- ➢ Explanation about findings
- ➢ Recommendation for further study

Indicative content 4.3.3: Indication of data:

Indication of data:

wood, Hard, fibrous material formed by the accumulation of secondary xylem produced by the vascular cambium. It is the principal strengthening tissue found in the stems and roots of trees and shrubs. Wood forms around a central core (pith) in a series of concentric layers called growth rings.

A cross section of wood shows the distinction between heartwood and sapwood. Heartwood, the central portion, is darker and composed of xylem cells that are no longer active in the life processes of the tree.
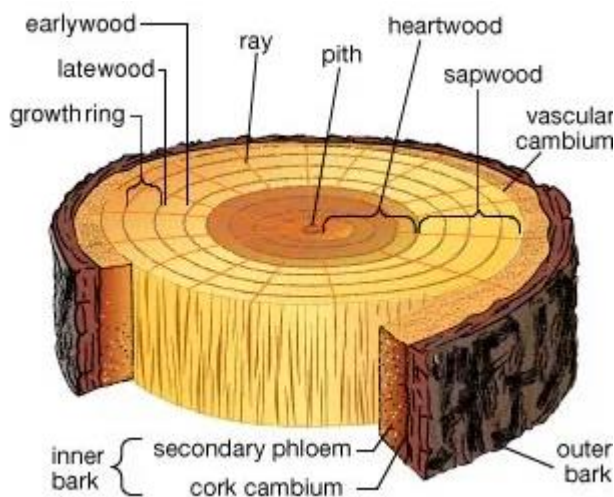
(**Picture:** cross section of wood)

➢ **Wood structure:** is arrangement of wood components that can be observed in cross section on a wood material as it is observed on the above picture.

➢ **wood texture:** The term texture describes the degree of uniformity of appearance of a wood surface, usually transverse. Grain is often used synonymously with texture, as in coarse, fine, or even texture or grain, and also to denote direction of wood elements, whether straight, spiral, or wavy, for example.

Theoretical learning Activity:

• Discuss about indication of data of wood sample during laboratory analysis.

Practical learning Activity

• In groups of two identify indication data of laboratory analysis of wood samples.

Points to Remember

Indication data of wood sample during laboratory analysis.

> ➢ Wood structure,
>
> ➢ wood texture

Learning outcome 4.3 formative assessment about concluding the test results

Q1. List out the major elements of a conclusion

Answer:

A conclusion paragraph contains a description of the purpose of the experiment, a discussion of your major findings, an explanation of your findings, and recommendations for further study**.**

Q2. Differentiate wood texture and wood structure

Answer:

Wood structure: is arrangement of wood components that can be observed in cross section on a wood material as it is observed on the above picture.

wood texture: The term texture describes the degree of uniformity of appearance of a wood surface, usually transverse.

Learning outcome 4.3 Practical assessment conclude the test results

Task: Task: Provide the relevant conclusion based on the intended use of tested wood

Checklist	Score	
	Yes	No
Indicator 1: Laboratory result to the standard norms are compared and discussed		
✓ Concluding procedures is respected		
✓ Elements of conclusion are used		
✓ Facts are shown		
✓ Recommendations are provide		

Reference books:

1. Brian Porter. 2002, Carpentry and Joinery, third edition, Elsevier.

2. George Mitchell, 1997, Carpentry and Joinery, second edition, Wellington House.

3. ShrivastavaMB, 1997, Wood Technology, Vikas Publishing House PVT Ltd.