Strengthened Senior High School

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Learning Activity Sheets for Commercial Air-Conditioning Installation and Servicing

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Learning Activity Sheets for Commercial Air-Conditioning Installation and Servicing Grade 12

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LEARNING ACTIVITY SHEET (LAS)

Learning Area:	Commercial Air-Conditioning Installation and Servicing		
Lesson Exemplar:	1	**Date:**	
Lesson Title/Topic:	**Site Survey**		
Name of Student:		**Grade & Section:**	

Activity Title: The 9-Pillar Commercial Site Survey Simulation

Objective:	Identify the nine (9) critical factors in a commercial AC site survey and accurately measure room dimensions.
Tools:	Laser distance measurer, tape measure (20m), anemometer, clamp meter, thermo-hygrometer, flashlight, tablet/laptop
PPE:	Hard hat, safety vest, safety shoes, gloves
Materials/Devices:	Site Survey Checklist (printed), floor plan (sample), marker, clipboard

Scenario: You are the lead technician for "Cool Tech Solutions." A new coffee shop owner wants a 5-ton split-type AC installed. You must conduct a pre-installation site survey to identify all critical factors before any equipment is ordered or installed.

Task 1: Measure Room Dimensions and Calculate Volume

Instructions:

1. Take your laser distance measurer and ensure the battery is charged.
2. Stand at one end of the room and aim the laser at the opposite wall to measure the **Length**. Record this in meters on your checklist.
3. Stand at one side wall and aim at the laser at the opposite side wall to measure the **Width**. Record this in meters.
4. Aim the laser from the floor to the ceiling (or use a tape measure if ceiling is low) to measure the **Height**. Record this in meters.
5. Calculate the **Volume** using the formula: Length × Width × Height = Cubic Meters (m^3).
6. Convert cubic meters to cubic feet by multiplying by 35.3 (or using the calculator on your tablet).
7. Write the final volume on your Site Survey Checklist under "Room Dimensions."

Answer:

_____
_____
_____
_____.

Task 2: Identify and List Three Potential Heat Load Sources

Instructions:

1. Walk around the room and look for **people-related heat sources** (e.g., number of seats/customers, kitchen staff). Estimate the maximum number of people that will occupy space at one time. Write this down.
2. Look for **equipment heat sources** (e.g., coffee machine, espresso maker, refrigerator, computer, POS system, lighting fixtures). Count each piece of equipment.
3. Look for **building-related heat sources** (e.g., windows facing west or east, uninsulated walls, glass doors, skylights). Note the direction each window faces.
4. For each heat source identified, estimate the additional BTU/hr. requirement using the standard factors: People = 500 BTU/hr. each, Computers = 600 BTU/hr. each, West-facing window = add 30% to total load.
5. Write your three identified heat sources and their estimated BTU contributions on the checklist.

Answer:

_____
_____
_____
_____.

Task 3: Identify and List Three Potential Safety or Code Violations

Instructions:

1. **Check Electrical (Pillar 6):** Locate the nearest electrical panel. Is there a dedicated 230V outlet within 50 feet of the proposed unit location? If not, note this as a violation.
2. **Check Structural Support (Pillar 7):** Knock on the wall or ceiling where the indoor unit will be mounted. Is it concrete, drywall, or plasterboard? If it is drywall, note that it cannot support a 100kg commercial unit. For the outdoor unit, check if the ground or rooftop is solid concrete.
3. **Check Drainage (Pillar 4):** Look for a floor drain or sink within 25 feet of the proposed indoor unit location. If no drain exists, note that a condensate pump may be required.
4. **Check Clearance (Pillar 3):** Measure the space where the outdoor condenser will be placed. Is there at least 12 inches clearance on the back coil side and 36 inches on the front service panel side? If not, note the violation.

5. Write your three identified violations on the checklist, including the specific Pillar number and why it is a problem.

Answer:

_____
_____
_____
_____.

Synthesis:

This lesson introduces the **9-pillar commercial site survey**, emphasizing the importance of measuring room dimensions (length × width × height) and calculating volume in cubic meters and cubic feet. Students learn to identify **three types of heat loads**: people-related (500 BTU/hr. per person), equipment-related (e.g., coffee machines, computers), and building-related (e.g., west-facing windows add 30%). They also identify **safety and code violations**, including lack of a dedicated 230V outlet, insufficient structural support (drywall cannot hold 100kg), and missing floor drain. Key takeaway: *A thorough site survey prevents installation failures and ensures code compliance.*

ANSWER KEY

Task	Sample Answer
Task 1: Room Dimensions	Length = 10m, Width = 12m, Height = 3m. Volume = 10 × 12 × 3 = 360 m^3. 360 × 35.3 = 12,708 cubic feet.
Task 2: Heat Load Sources	1) 20 customers = 20 × 500 = 10,000 BTU/hr. 2) Coffee machine = 3,000 BTU/hr. 3) West-facing window = 30% to total load.
Task 3: Safety/Code Violations	1) No dedicated 230V outlet within 50 ft (Pillar 6). 2) Drywall ceiling cannot support 100kg units (Pillar 7). 3) No floor drains within 25 ft (Pillar 4).

LEARNING ACTIVITY SHEET (LAS)

Learning Area:	Commercial Air-Conditioning Installation and Servicing		
Lesson Exemplar:	2	**Date:**	
Lesson Title/Topic:	**Electrical Requirements**		
Name of Student:		**Grade & Section:**	

Activity Title: *Wire Sizing, NEMA Match-Up, and LOTO Safety*

Objective	Use the PEC ampacity table to correctly size a copper THHN conductor for a given commercial AC unit.
Tools	Clamp meter (ammeter), multimeter (voltmeter/ohmmeter), wire stripper, combination pliers
PPE	Insulated gloves, safety glasses, rubber-soled shoes
Materials/Devices	Sample THHN wires (AWG 14, 12, 10, 8, 6), sample circuit breaker (20A, 30A, 40A, 2-pole, 3-pole), NEMA chart poster, PEC handbook

Scenario: You are sizing the electrical components for a new 7.5-ton AC unit. The nameplate shows: MCA = 45A, MOP = 60A, Voltage = 230V single phase. The disconnect will be installed on a rainy rooftop.

Task 1: Wire Sizing and Breaker Selection

Instructions:

1. Locate the **Minimum Circuit Ampacity (MCA)** on the nameplate. In this scenario, MCA = 45A.
2. Apply the **125% continuous load rule** per PEC: 45A × 1.25 = 56.25A.
3. Open your PEC handbook or refer to the provided **Ampacity Table 3.10.1.16** for copper THHN wire at 75°C column.
4. Find the smallest wire size with an ampacity equal to or greater than 56.25A:
    - #8 AWG THHN = 50A (too low, does not meet 56.25A)
    - #6 AWG THHN = 65A (acceptable)
5. Write down **#6 AWG THHN** as your minimum wire size.
6. Now find the **Maximum Overcurrent Protection (MOP)** on the nameplate = 60A.
7. Select a circuit breaker that is **equal to or less than** the MOP. The available sizes are: 50A, 60A.
8. Choose the **60A 2-pole breaker** (since it is a single phase 230V).
9. Write your answer: *Minimum wire = #6 AWG THHN, Maximum breaker = 60A 2-pole. *

Answer:

_____
_____
_____
_____.

Task 2: NEMA Enclosure Selection

Instructions:

1. Read the installation environment: "Rainy rooftop in Manila."
2. Recall the NEMA definitions:
    - **NEMA 1:** Indoor, dry locations only.
    - **NEMA 3R:** Outdoor, rainproof, sleet resistant.
    - **NEMA 4:** Watertight, hose-directed (for washdown areas).
    - **NEMA 4X:** Same as 4 but corrosion resistant.
3. Since the location is outdoors exposed to rain, **NEMA 1 is NOT acceptable** because rain will enter the box.
4. Select **NEMA 3R** as the minimum rating.
5. Write your answer: *NEMA 3R – Rainproof enclosure for outdoor rooftop installation.*
6. Explain why NEMA 1 is not acceptable: *NEMA 1 has no gaskets or weather seals. Rainwater will enter through the gaps, cause a short circuit, and create a fire hazard.*

Answer:

_____
_____
_____
_____.

Task 3: Lock-Out/Tag-Out (LOTO) Safety Procedure

Instructions:

1. Read the scenario: You need to open the electrical panel to install the breaker. The disconnect handle is in the "OFF" position.
2. **DO NOT trust the handle.** Explain why: *A stuck contactor or internal mechanical failure can keep power on even when the handle is OFF.*
3. Demonstrate the correct LOTO procedure by writing or acting out these three steps:
    - **Step 1 – Lock:** Place your personal padlock on the disconnect handle or breaker. Only you have the key.
    - **Step 2 – Tag:** Attach a tag with your name, date, and reason (e.g., "DO NOT ENERGIZE – AC Installation in progress").
    - **Step 3 – Try:** Attempt to start the AC unit (or test for voltage) to verify that power is completely off.

4. Even after LOTO, you must use a **non-contact voltage tester**. Write the procedure:
    - Test the voltage tester on a known live source (e.g., a working outlet) to verify it works.
    - Test the load side terminals of the disconnect.
    - Test the known live source again to verify that the tester did not fail.
5. Write your final answer as a complete paragraph.

Answer:

_____
_____
_____
_____.

Synthesis:

This lesson focuses on **wire sizing, breaker selection, NEMA enclosure ratings, and LOTO safety**. Using the PEC ampacity table, students learn to apply the **125% continuous load rule** to MCA (e.g., 45A × 1.25 = 56.25A → #6 AWG THHN). They select MOP-rated breakers (e.g., 60A 2-pole) and choose **NEMA 3R** for outdoor rooftop installations (NEMA 1 is not weatherproof). The lesson reinforces **Lock-Out/Tag-Out (LOTO):** lock, tag, try, and verify with a non-contact voltage tester on a known live source before and after testing.

Key takeaway: *Never trust the handle position; always LOTO and verify zero energy.*

ANSWER KEY

Task	Answer
Task 1: Wire & Breaker	Minimum wire = #6 AWG THHN (65A ampacity). Maximum breaker = 60A 2-pole.
Task 2: NEMA Rating	NEMA 3R (rainproof). NEMA 1 is NOT acceptable because rain enters the box, causing short circuits and fire.
Task 3: LOTO Procedure	1) Lock the disconnect with personal padlock. 2) Tag with name, date, and reason. 3) Try to start a unit to verify zero energy. Even after LOTO, test with non-contact voltage tester on a known live source first, then on the load side, then on known live source again. Never trust the handle position.

LEARNING ACTIVITY SHEET (LAS)

Learning Area:	Commercial Air-Conditioning Installation and Servicing		
Lesson Exemplar:	3	**Date:**	
Lesson Title/Topic:	**Preparation of Tools, Equipment, and Materials**		
Name of Student:		**Grade & Section:**	

Activity Title: *Tool Identification, Oxy-Acetylene Setup, and Safety Check*

Objective	Properly demonstrate the setup of an oxy-acetylene welding torch, including pressure settings and flashback arrestor check.
Tools	Flaring tool, swaging tool, tube cutter, tube benders, service cylinder, vacuum pump, gauge manifold, oxygen-acetylene welding outfit
PPE	Welding goggles, welding gloves, fire extinguisher (Class B:C), leather apron
Materials/Devices	Copper tube (1/4", 3/8", 1/2", 5/8" OD), PVC pipe, rubber insulation foam, silver brazing rod, nitrogen gas cylinder with regulator

Scenario: You are preparing for a rooftop commercial installation. You must identify tools, set up the welding torch correctly, and demonstrate safety procedures before brazing any copper lines.

Task 1: Tool Matching

Step-by-step instructions:

1. You will be shown four tools, or you will read their descriptions below.
2. Read each function description carefully.
3. Write the letter of the tool that matches the function.
4. **Tool options:**
    - (A) Flaring tool
    - (B) Swaging tool
    - (C) Dyna bolt
    - (D) Flashback arrestor
5. **Function 1:** "Expands one copper tube to fit over another" – This is used when you want to join two copper tubes without a coupling. Think: Which tool makes the pipe wider? Answer: Swaging tool (B).
6. **Function 2:** "Creates a funnel-shaped end for flare nuts" – This is used for flare connections where a nut compresses the copper against a fitting. Answer: Flaring tool (A).

7. **Function 3:** "Concrete anchor for mounting outdoor unit" – This is a mechanical expansion anchor hammered into a drilled concrete hole. Answer: Dyna bolt (C).
8. **Function 4:** "Prevents flame from traveling back into the cylinder" – This is a safety device that stops a fire from reaching the gas cylinder. Answer: Flashback arrestor (D).
9. Write your answers in the format: "1) B, 2) A, 3) C, 4) D"

Answer:

_____
_____
_____
_____.

Task 2: Oxy-Acetylene Setup Sequencing

Step-by-step instructions:

1. You have the 8 steps listed below. They are in random order.
2. Write the numbers 1 to 8 on your answer sheet.
3. Arrange the steps in the **correct chronological order** from first to last.
4. **Step options (random order):**
    - ___ Light torch with striker.
    - ___ Open acetylene cylinder valve 1/2 turn only.
    - ___ Check hoses for cracks.
    - ___ Set oxygen regulator to 40 psi.
    - ___ Attach flashback arrestors at regulator and torch.
    - ___ Open oxygen cylinder valve fully.
    - ___ Set acetylene regulator to 10 psi.
    - ___ Purge hoses before lighting.
5. **Think logically:**
    - First: Inspect equipment (check hoses, attach flashback arrestors).
    - Second: Open cylinders (oxygen fully, acetylene only 1/2 turn).
    - Third: Set pressures (oxygen 40 psi, acetylene 10 psi).
    - Fourth: Purge hoses to remove air/gas mixtures.
    - Fifth: Light torch with striker.
6. Write the correct sequence number next to each step.

Answer:

_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____.

Task 3: Safety Decision – Nitrogen Purging

Step-by-step instructions:

1. Read the scenario: *"You are on a rooftop." Your helper forgot the nitrogen cylinder. Can you braze the copper lines without nitrogen?"*
2. Think about what happens inside the copper pipe when it is heated to a brazing temperature (over 1000°F).
3. Consider: When copper is heated in the presence of oxygen, a chemical reaction occurs called **oxidation**.
4. Write your answer as "YES" or "NO" first.
5. Then explain **why** or **why not** using technical terms.
6. Finally, describe the **consequence** of brazing without nitrogen.
7. Your explanation should include these key words: *oxidation, black scale (copper oxide), compressor failure, TXV clogging, and warranty void.*

Write a complete paragraph of at least 3 sentences.

Answer:

_____
_____
_____
_____.

Synthesis:

This lesson covers **tool identification** (flaring tool, swaging tool, Dyna bolt, flashback arrestor) and the correct **oxy-acetylene setup sequence**: inspect hoses → attach flashback arrestors → open oxygen fully → open acetylene 1/2 turn → set pressures (O_2 40 psi, C_2H_2 10 psi) → purge hoses → light with striker. The critical safety decision is **never brazing without nitrogen purging**; without inert gas, copper oxide (black scale) forms inside pipes, destroying compressors and clogging TXVs, voiding warranties.

Key takeaway: *Nitrogen purging during brazing is mandatory, not optional.*

ANSWER KEY

Task	Answer
Task 1: Tool Matching	1) Swaging tool (B), 2) Flaring tool (A), 3) Dyna bolt (C), 4) Flashback arrestor (D)
Task 2: Oxy-Acetylene Sequence	1) Check hoses for cracks. 2) Attach flashback arrestors. 3) Open the oxygen cylinder valve fully. 4) Open acetylene cylinder valve 1/2 turn. 5) Set oxygen regulator to 40 psi. 6) Set acetylene regulator to 10 psi. 7) Purge hoses. 8) Light torch with striker.
Task 3: Nitrogen Decision	**NO.** You cannot braze without nitrogen. When copper is heated without an inert gas, oxygen reacts with the copper to form black copper oxide (scale) inside the pipe. This scale breaks off, travels through the system, destroys the compressor, clogs the TXV, and contaminates the oil. The manufacturer will void the warranty if scale is found.

LEARNING ACTIVITY SHEET (LAS)

Learning Area:	Commercial Air-Conditioning Installation and Servicing		
Lesson Exemplar:	4	**Date:**	
Lesson Title/Topic:	**Bill of Materials (BOM)**		
Name of Student:		**Grade & Section:**	

Activity Title: *The Estimator's Challenge: BOM Calculation*

Objective:	Accurately compute the quantity of copper tubing needed for a given installation, accounting for 15% waste factor.
Tools:	Calculator, sample completed BOM from a previous job, Excel, or Google Sheets template
PPE:	None required (classroom activity)
Materials/Devices:	Supplier catalogs (e.g., Wilcon, Ace Hardware), price lists, printed floor plan with distances, BOM template

Scenario: You are the estimator for "Cool Air Solutions." You need to prepare a Bill of Materials for a new installation. The floor plan shows that the indoor unit is 28 meters from the outdoor unit. Copper comes in 15m and 30m rolls.

Task 1: Copper Tubing Quantity Calculation

Instructions:

1. Read the given distance: **28 meters** from indoor units to outdoor units.
2. You must order two sizes of copper tubing: 1/4" (liquid line) and 5/8" (suction line). The length needed is the same for both.
3. Apply the **15% waste factor** formula: Distance × 1.15 = Total needed.
    - Calculation: 28 × 1.15 = __ meters.
4. Write your calculated total needed.
5. Now check the available roll sizes: **15 meters per roll** or **30 meters per roll**.
6. Determine how many rolls you need:
    - If you buy 15m rolls: 15m + 15m = 30m. Is 30m enough? Compare to your total needs.
    - If you buy one 30m roll: Is 30m enough?
7. **Important:** You cannot buy partial rolls. You must round the UP to the nearest full roll.
8. Decide which combination is the most economical while still meeting or exceeding the total needed.
9. Write your answer: "I need to purchase _____ rolls of 15m each" OR "I need to purchase _____ rolls of 30m each" OR a combination.
10. Multiply the number of rolls by the roll length to get the total meters purchased.

Answer:

_____
_____
_____
_____.

Task 2: Refrigerant Charge Calculation

Instructions:

1. Read the given data:
    - Base charge = 5 kg of R-410A for the first 15 meters of line set.
    - Additional charge = 0.1 kg per meter beyond 15 meters.
    - Total line set length = 28 meters.
2. Calculate the **extra meters** beyond 15m: 28m - 15m = ____ meters.
3. Calculate the **additional refrigerant** needed: Extra meters × 0.1 kg = _____ kg.
4. Calculate the **total refrigerant** needed: Base charge (5 kg) + Additional charge = _____ kg.
5. Refrigerant must be ordered in whole kg (cylinders). Round UP to the nearest kg.
6. Write your answer: "I need to order _____ kg of R-410A."
7. Explain why you rounded up: *Because refrigerant cylinders come in 1kg, 5kg, 10kg sizes. You cannot buy 0.3 kg.*

Answer:

_____
_____
_____
_____
_____.

Task 3: List the Five Essential BOM Categories

Instructions:

1. Think about everything needed to install a commercial AC system from start to finish.
2. **Category 1:** What carries the refrigerant between indoor and outdoor units? (Answer: Copper piping)
3. **Category 2:** What connects, seals, and protects the copper pipes? (Answer: Fittings)
4. **Category 3:** Where does the condensed water go? (Answer: Drainage)
5. **Category 4:** What powers the unit and provides safety disconnection? (Answer: Electrical)
6. **Category 5:** What attaches the unit to the building and helps install it? (Answer: Mounting hardware)
7. Write each category name on a separate line. Number them 1 through 5.
8. For each category, give one example item in parentheses.

Answer:

_____
_____
_____
_____
_____
_____
_____.

Synthesis:

This lesson teaches **material quantity estimation** with a **15% waste factor**. For a 28-meter line set: 28m × 1.15 = 32.2m needed → purchase one 15m roll + one 30m roll = 45m total. Refrigerant calculation: base charge 5kg for first 15m + 0.1kg per extra meter (13m × 0.1 = 1.3kg) → total 6.3kg → round up to **7kg of R-410A**. The **five essential BOM categories** are: (1) refrigerant piping, (2) fittings and insulation, (3) drainage, (4) electrical, (5) mounting hardware.

Key takeaway: *Always round up and include waste factor; running out of material on site is unprofessional.*

ANSWER KEY

Task	Answer
Task 1: Copper Tubing	28m × 1.15 = 32.2 meters needed. One 30m roll is NOT enough (30m < 32.2m). Two 15m rolls = 30m (still not enough). Two 30m rolls = 60m (enough but wasteful). Best answer: One 15m roll + one 30m roll = 45m total. Or simply state: Need 2 rolls of 30m to be safe.
Task 2: Refrigerant	Extra meters = 13m. Additional charge = 13 × 0.1 = 1.3 kg. Total = 5 + 1.3 = 6.3 kg. Round up to 7 kg of R-410A.
Task 3: BOM Categories	1) Refrigerant piping (copper tubing 1/4" and 5/8"). 2) Fittings and insulation (elbows, flare nuts, Armaflex). 3) Drainage (PVC pipe, P-trap, cleanout tee). 4) Electrical (THHN wire, circuit breaker, disconnect switch). 5) Mounting and consumables (Dyna bolts, strut channels, silver rod, nitrogen).

LEARNING ACTIVITY SHEET (LAS)

Learning Area:	Commercial Air-Conditioning Installation and Servicing		
Lesson Exemplar:	5	**Date:**	
Lesson Title/Topic:	**Identification of Air-Conditioning Units**		
Name of Student:		**Grade & Section:**	

Activity Title: *Match the Unit to the Application & Read the Nameplate*

Objective:	Differentiate between at least five (5) types of commercial AC units and their typical applications.
Tools:	None required (theory lesson)
PPE:	None required
Materials/Devices:	Posters or slides of commercial AC types, sample nameplates from old units

Scenario: A building owner needs AC for five different areas. You must recommend the correct commercial unit type and interpret a nameplate.

Task 1: Unit Selection for Five Applications

Instructions:

1. Read each application description in the table below.
2. For each application, think about the specific requirements:
    - **Server Room:** Needs 24/7 operation, precise temperature (±1°C), humidity control. Standard AC cannot do this.
    - **Hotel Lobby:** Needs to look beautiful, quiet, flush with ceiling. Cannot have exposed pipes or wall units.
    - **Restaurant Kitchen:** Grease in the air clog filter quickly. Units should be away from the cooking area, preferably on the roof.
    - **30-story Office Building:** Many individual offices need separate temperature control. Long pipe runs are required.
    - **Small Eatery (Carinderia):** Low budget, no ceiling space, solid concrete roof.
3. Write your answer in the "Best Unit Type" column.
4. **Options to choose from:** Precision AC, Ceiling Cassette, Packaged Rooftop (RTU), VRF/VRV, Chilled Water, Floor-standing Console, High-wall Split.
5. For each answer, write one sentence justifying your choice.

Answer:

_____
_____
_____
_____
_____.

Task 2: Nameplate Interpretation

Instructions:

1. Read the nameplate data provided:
    - Voltage: 460V
    - Phase: 3
    - MCA: 28A
    - MOP: 45A
    - Refrigerant: R-410A
2. **Determine wire size:** Use the MCA value (28A). Apply the 125% rule: 28A × 1.25 = 35A.
3. Look at the AWG ampacity table (provided or from memory):
    - #12 AWG = 25A (too low)
    - #10 AWG = 35A (exactly matches 35A)
    - #8 AWG = 50A (acceptable but larger than needed)
4. The minimum acceptable wire size is **#10 AWG** (or #8 to be safer).
5. **Determine maximum breaker size:** MOP = 45A. The breaker cannot exceed 45A.
6. Select a standard breaker size: 40A or 45A. Write your answer.
7. Write your final answer as: "Minimum wire = #10 AWG THHN, Maximum breaker = 45A 3-pole (since 3-phase)."

Answer:

_____
_____
_____
_____
_____.

Task 3: Justification – Why NOT a High-Wall Split in a Hotel Lobby?

Instructions:

1. Read the question: *Why would you NOT install a standard high-wall split unit in a hotel lobby?*
2. Think about what a hotel lobby looks like (high-end finishes, chandeliers, marble floors, guests checking in).
3. Consider the **appearance** of a high-wall split unit:
    - It is a large white plastic box mounted on the wall.
    - It has an exposed drain hose.
    - It has visible refrigerant lines (if not concealed).

4. Consider the **air distribution** of a high wall split:
    - It blows air in one direction only (down and forward).
    - The lobby is a large, open space. One wall unit cannot distribute air evenly.
5. Consider **noise**:
    - High-wall units have a fan and indoor coil in the same room.
    - Lobbies need to be quiet for conversation.
6. Write **at least two reasons** in complete sentences.
7. Use professional language (e.g., "aesthetically unacceptable," "poor air distribution," "noise pollution").

Answer:

_____
_____
_____
_____
_____.

Synthesis:

This lesson differentiates **commercial AC types by application**: Precision AC for server rooms (±1°C), ceiling cassette for hotel lobbies (aesthetic, 4-way airflow), packaged RTU for restaurant kitchens (away from grease), VRF/VRV for 30-story offices (individual zones, long line sets), and floor-standing/high-wall split for small eateries (low budget). Students also practice **nameplate interpretation**: MCA = 28A → #10 AWG THHN (35A), MOP = 45A → 45A 3-pole breaker.

Key takeaway: *Match the unit type to the application; high-wall splits do not belong in hotel lobbies due to poor aesthetics and air distribution.*

ANSWER KEY

Task	Answer
Task 1: Unit Selection	Server Room = Precision AC (requires ±1°C and humidity control). Hotel Lobby = Ceiling Cassette (flush, aesthetic, 4-way airflow). Restaurant Kitchen = Packaged Rooftop RTU (keeps unit away from grease). 30-story Office = VRF/VRV (individual zone control, long line set). Small Eatery = Floor-standing or High-wall split (low budget, no ceiling space).
Task 2: Nameplate	Minimum wire = #10 AWG THHN (35A ampacity). Maximum breaker = 45A 3-pole.
Task 3: Justification	1) High-wall units are aesthetically unacceptable for a high-end lobby; the exposed drain and plastic cover look cheap. 2) Air distribution is poor; a single wall unit cannot cool up a large open lobby evenly. 3) Noise from the indoor fan is noticeable and disrupts guest experience.

LEARNING ACTIVITY SHEET (LAS)

Learning Area:	Commercial Air-Conditioning Installation and Servicing		
Lesson Exemplar:	6	**Date:**	
Lesson Title/Topic:	**Cavity Works**		
Name of Student:		**Grade & Section:**	

Activity Title: *Ceiling Cavity Obstacle Hunt and Layout*

Objective:	Accurately transfer unit location marks from a floor plan to an actual ceiling grid using a chalk line and laser level.
Tools:	Chalk line, laser level, tape measure, reciprocating saw, hammer drill, stud finder
PPE:	Safety glasses, dust mask, hard hat (for ceiling work), gloves
Materials/Devices:	Strut channels, threaded rods, nuts and washers, drop ceiling tiles, sample ceiling grid, floor plan

Scenario: You are about to cut a hole for a cassette unit in a drop ceiling. You must survey the ceiling cavity first.

Task 1: Obstacle Identification

Instructions:

1. Imagine you have removed a ceiling tile and climbed up a ladder to investigate the ceiling cavity.
2. Shine your flashlight in all directions.
3. List any objects you see that would **block** the installation of a 600mm × 600mm cassette unit.
4. Think about these categories:
    - **Structural:** Concrete beams, steel beams, columns.
    - **Mechanical:** Fire sprinkler pipes, gas lines, existing ductwork, exhaust fans.
    - **Electrical:** Electrical conduits, junction boxes, lighting fixtures, cable trays.
    - **Plumbing:** Water pipes, drain lines.
5. Write **three different obstructions** on your answer sheet.
6. For each obstruction, write one sentence explaining why it is a problem (e.g., "A concrete beam cannot be cut or moved, so the unit must be relocated."

Answer:

_____
_____
_____
_____.

Task 2: Problem-Solving – Relocating Due to Concrete Beam

Instructions:

1. Read the problem: *"The planned location is directly under a concrete beam." The floor plan shows that the unit must be within 2 meters of the north wall."*
2. **Step 1:** Acknowledge that you cannot cut or drill through a concrete beam. It is structural.
3. **Step 2:** Measure 2 meters from the north wall along the ceiling grid.
4. **Step 3:** Look for a new location that is:
    - Within 2 meters of the north wall (measured horizontally)
    - NOT directly under any other beam or obstruction
    - Accessible for future service (e.g., near a removable ceiling tile)
5. **Step 4:** Mark the new center point with a chalk X.
6. **Step 5:** Use laser level to project lines and mark the 600mm cutout rectangle.
7. **Step 6:** Before cutting, go back into the cavity and verify that no obstructions exist above the new location.
8. Write your answer as a numbered list of at least 4 steps.

Answer:

_____
_____
_____
_____
_____.

Task 3: Structural Support Assessment

Instructions:

1. Read the question: *"Can you hang a 50kg AC unit directly from a standard drop ceiling grid?" Why or why not?*
2. First, answer **YES or NO**.
3. Then explain the **construction of a drop ceiling grid**:
    - It is made of thin galvanized steel (usually 24 gauge).
    - It is hung by wires from the concrete slab above.
    - It is designed to hold only the weight of ceiling tiles and light fixtures (usually less than 5kg per tile).
4. Explain what happens if you hang 50kg on the grid: *The grid will bend, sag, and eventually collapse.*
5. Now describe the **correct method**:
    - Threaded rods anchored into the concrete slab above (using wedge anchors or epoxy).
    - Strut channels (Unistrut) spanning between beams.
    - The unit hangs from the strut channels, not from the grid.

6. Write your answer as a complete paragraph.

Answer:

_____
_____
_____
_____.

Synthesis:

This lesson focuses on **ceiling cavity obstacle identification** before cutting openings. Common obstructions include concrete beams (cannot be cut), fire sprinkler pipes, and electrical conduit bundles. When relocating due to a beam, students measure within specified limits, verify the new location has no obstructions, mark center point with chalk and laser level, and recut the ceiling grid. Critical structural rule: **Never hang a 50kg AC unit from a drop ceiling grid** (rated for <5kg). Correct method: anchor threaded rods into concrete slab, attach strut channels, then hang unit.

Key takeaway: *Survey before cutting; structural support must be independent of ceiling grid.*

ANSWER KEY

Task	Answer
Task 1: Obstacles	1) Concrete beam – cannot be cut, must relocate. 2) Fire sprinkler pipe – cannot be moved without a licensed fire protection contractor. 3) Electrical Conduit bundle – too many wires to relocate.
Task 2: Relocation Steps	1) Acknowledge beam cannot be cut. 2) Measure 2 meters from the north wall to find a new location. 3) Verify no other obstructions above the new location. 4) Mark center point and cutout rectangle with chalk and laser level. 5) Recut ceiling grid if needed.
Task 3: Structural Support	**NO.** A drop ceiling grid is not structural; it is designed to hold only ceiling tiles (under 5kg). Hanging 50kg will cause collapse. Correct method: Anchor threaded rods into the concrete slab above, attach strut channels, then hang the unit from the strut channels.

LEARNING ACTIVITY SHEET (LAS)

Learning Area:	Commercial Air-Conditioning Installation and Servicing		
Lesson Exemplar:	7	**Date:**	
Lesson Title/Topic:	**Installation of Mounting Support**		
Name of Student:		**Grade & Section:**	

Activity Title: *Anchor Strength, Torque, and Safety Factor Test*

Objective	Install a strut channel frame anchored to concrete using Dyna bolts, with the frame level in both directions.
Tools	Hammer drill, socket wrench, torque wrench, level, tape measure, marker, vacuum (for dust)
PPE	Safety glasses, gloves, hard hat, dust mask
Materials/Devices	Dyna bolts (3/8", 1/2"), threaded rods, strut channels (41x41mm), vibration isolators (rubber pads), concrete test block

Scenario: You are mounting a 180kg commercial condenser on a concrete rooftop using 4 anchors. Each 1/2" Dyna bolt is rated at 150kg of pull-out strength.

Task 1: Safety Factor Calculation

Instructions:

1. Read the given data:
    - Unit weight = 180 kg
    - Number of anchors = 4
    - Each anchor rating = 150 kg pull-out strength
2. Calculate **Total Capacity**: Multiply number of anchors by rating per anchor.
    - Formula: 4 × 150 kg = _____ kg
3. Calculate **Safety Factor**: Divide Total Capacity by Unit Weight.
    - Formula: Total Capacity ÷ Unit Weight = _____
4. The **industry minimum safety factor** for overhead or rooftop mounting is 4 (meaning the anchors must hold 4 times the unit weight).
5. Compare your calculated safety factor to 4. Is it greater than or equal to 4?
6. If NO, state that the installation is **NOT acceptable**.
7. Suggest: Use larger anchors (e.g., 5/8" Dyna bolts rated at 250kg each) or add more anchors (e.g., 6 anchors instead of 4).
8. Write your complete answer with all the calculations shown.

Answer:

_____
_____
_____
_____
_____.

Task 2: Dyna Bolt Installation Sequence

Instructions:

1. You have 6 steps listed below. Arrange them in the correct order by writing numbers 1 through 6.
2. **Steps (random order):**
    - ___ Insert Dyna bolts into holes and hammers until threads flush.
    - ___ Clean dust from holes using a vacuum or blow gun.
    - ___ Torque the nut to manufacturer specification (25-30 ft-lbs.).
    - ___ Mark anchor hole locations on concrete using the frame as a template.
    - ___ Drill hole with hammer drill using a carbide bit (depth = anchor length + 6mm).
    - ___ Feel the expansion sleeve grip as you tighten.
3. **Think logically:**
    - First: Mark locations.
    - Second: Drill holes.
    - Third: Clean dust.
    - Fourth: Insert anchor.
    - Fifth: Torque nut.
    - Sixth: Verify expansion.
4. Write the correct sequence number next to each step.

Answer:

_____
_____
_____
_____
_____.

Task 3: Vibration Isolation Explanation

Instructions:

1. Read the question: *"Why must you install rubber or spring isolators between the frame and the condenser?"*
2. Think about what happens when a compressor runs:
    - It vibrates at 60 Hz (3600 RPM).
    - The vibration travels through the metal frame.
    - It transfers to the concrete roof.
    - The building structure acts like a drum, amplifying the noise.

3. List the **negative consequences** of skipping isolators:
    - Noise complaints from tenants below.
    - Loosening of anchor bolts over time due to constant vibration.
    - Potential structural damage (cracking of concrete).
    - Voided warranty (many manufacturers require vibration isolation).
4. Write a paragraph of at least 4 sentences explaining why isolators are required.
5. Mention the two common types: **rubber pads** (for smaller units) and **spring isolators** (for larger units, 10+ tons).

Answer:

_____
_____
_____
_____
_____.

Synthesis:
This lesson teaches **safety factor calculation** for rooftop condenser anchors. For a 180kg unit with four 150kg-rated Dyna bolts: total capacity = 600kg, safety factor = 600 ÷ 180 = 3.33 → **below industry minimum of 4.0** → not acceptable. Solution: use larger anchors (200kg each) or add more anchors. Students learn the **Dyna bolt installation sequence**: mark holes → drill with hammer drill → clean dust → insert anchor → torque nut (25-30 ft-lbs) → feel expansion grip. Vibration isolation (rubber pads or spring isolators) is required to prevent noise, anchor loosening, and concrete cracking.

Key takeaway: *Safety factor of 4 is minimum; never skip vibration isolators.*

ANSWER KEY

Task	Answer
Task 1: Safety Factor	Total capacity = 4 × 150kg = 600kg. Safety factor = 600 ÷ 180 = 3.33. NOT acceptable (needs 4.0 or higher). Solution: Use larger anchors rated at 200kg each (4 × 200 = 800kg, SF = 4.44).
Task 2: Dyna Bolt Sequence	1) Mark holes 2) Drill holes 3) Clean dust 4) Insert anchor 5) Torque nuts 6) Feel an expansion grip.
Task 3: Vibration Isolation	Rubber or spring isolators are required to prevent vibration from transferring from the condenser to the building structure. Without isolators, occupants will hear a low-frequency humming noise. Anchors may loosen over time from constant vibration, and concrete may crack. Spring isolators are used for units over 10 tons: rubber pads are enough for smaller units.

LEARNING ACTIVITY SHEET (LAS)

Learning Area:	Commercial Air-Conditioning Installation and Servicing		
Lesson Exemplar:	8	**Date:**	
Lesson Title/Topic:	**Positioning and Aligning Methods**		
Name of Student:		**Grade & Section:**	

Activity Title: *Leveling with Shims and Laser Level*

Objective	Accurately position and level a mock AC unit using a laser level and shims, achieving a level within 1/8" over 4 feet.
Tools	Laser level, spirit level (24" and 48"), tape measure, chalk line, shims (rubber and metal), wrench
PPE	Safety glasses, work gloves
Materials/Devices	Mock AC unit (cardboard box, approx. 50cm × 100cm), mounting frame, adjustable feet

Scenario: You place a 48" spirit level on top of a condenser. The bubble is touching the right line, indicating the right side is higher than the left.

Task 1: Shim Placement and Quantity Calculation

Instructions:

1. Read the level reading: The bubble is touching the **right line** on the spirit level.
2. Interpretation: When the bubble moves to the right, the **right side is higher** (bubble rises to the high side).
3. **Decision:** Which side needs to be shim?
    - You can either lower the high side (not always possible) OR raise the low side.
    - The lower side is the **left side**.
4. Answer: Place shims under the **left side**.
5. Now calculate how many shims: The right side is 3/8" higher than the left.
6. Each rubber shim is 1/8" thick.
7. Calculation: 3/8" ÷ 1/8" per shim = 3 shims.
8. Write your answer: "Place _____ shims under the _____ side."
9. **Important:** Stack shims in a staggered pattern (not perfectly aligned) to prevent slipping.

Answer:

_____
_____
_____
_____
_____.

Task 2: Drain Slope Calculation

Instructions:

1. Read the given data:
    - Horizontal drainpipe run = 16 feet
    - Required slope = 1/4 inch per foot
2. Use the formula: Total drop (inches) = Length (feet) × Slope (inches per foot)
3. Calculation: 16 ft × 0.25 in/ft = _____ inches
4. Write your answer: "The termination point must be _____ inches lower than the drain pan outlet."
5. If the drain pan outlet is at 10 inches above the floor, calculate the termination height:
    - 10 inches - 4 inches = 6 inches above the floor.
6. Check if this is feasible (floor drain is 0 inches, so 6 inches is fine if a standpipe is used).

Answer:

_____
_____
_____
_____
_____.

Task 3: Clearance Verification – List Four Requirements

Instructions:

1. Read the question: *"List the four minimum clearance requirements for a commercial outdoor condenser."*
2. For each location on the condenser, recall the standard minimum distances:
    - **Back coil side** (where the condenser coil is located): Needs airflow to reject heat.
    - **Non-coil sides** (left and right, where there is no coil): Less clearance needed.
    - **Front service panel side** (where the electrical panel is): Needs room for a technician to open the panel and work.
    - **Top fan discharge** (above the fan, where warm air blows out): Needs space for warm air to escape without recirculating.
3. Write each clearance requirement in a complete sentence.
4. Include the measurement in both inches and millimeters (e.g., 12 inches / 300mm).
5. For extra credit, explain why each clearance is required.

Answer:

_____
_____
_____
_____
_____.

Synthesis:

This lesson covers **leveling with shims**: if the bubble touches the right line, the right side is higher → place shims under the left (low) side. For a 3/8" difference with 1/8" shims → three shims stacked in a staggered pattern. **Drain slope calculation**: 16 feet × 1/4" per foot = 4 inches drop. **Four clearance requirements** for outdoor condensers: back coil side (12"), non-coil sides (6"), front service panel (36" for technician access), top fan discharge (60" to prevent recirculation).

Key takeaway: *Level is critical for drainage; clearance violations cause compressor failure and code violations.*

ANSWER KEY

Task	Answer
Task 1: Shim Placement	Place 3 shims under the LEFT side (the low side).
Task 2: Drain Slope	16 ft × 0.25 in/ft = 4 inches drop. Termination must be 4 inches lower than the drain pan outlet.
Task 3: Clearance Requirements	1) Back coil side: 12 inches minimum (for airflow). 2) Non-coil sides: 6 inches minimum. 3) Front service panel: 36 inches minimum (for technician access). 4) Top fan discharge: 60 inches (5 feet) minimum to any obstruction above.

LEARNING ACTIVITY SHEET (LAS)

Learning Area:	Commercial Air-Conditioning Installation and Servicing		
Lesson Exemplar:	9	**Date:**	
Lesson Title/Topic:	**Electrical Installation**		
Name of Student:		**Grade & Section:**	

Activity Title: *Disconnect Wiring, Termination, and LOTO Practice*

Objective:	Properly install a NEMA 3R disconnect switch, connect THHN wires to the line and load side, and verify the correct torque.
Tools:	Multimeter, clamp meter, wire stripper, crimping tool, screwdrivers, pliers, conduit bender, torque screwdriver
PPE:	Insulated gloves, safety glasses, voltage tester (non-contact), LOTO kit
Materials/Devices:	THHN/THWN wires (#10, #8, #6), EMT or PVC conduit, NEMA 3R disconnect switch, circuit breaker, wire nuts, tape

Scenario: You are wiring a disconnect switch for a 230V single-phase AC unit. All work is on a de-energized mock panel.

Task 1: Terminal Identification

Instructions:

1. Look at the disconnect switch. Identify the **Line side** and **Load side** terminals.
2. The **Line side** is where incoming power from the main panel connects. This is usually the **TOP terminal**.
3. The **Load side** is where power leaves to go to the AC unit. This is usually the **BOTTOM terminal**.
4. Write your answer: "Line side (top) = incoming from main panel. Load side (bottom) = AC unit."
5. Locate the **grounding lug** inside the disconnect box. It is usually green or marked with a ground symbol.
6. Write: "The ground wire connects to the grounding lug."
7. **Safety note:** The disconnect must be mounted within sight (50 feet) of the AC unit and must be accessible (not blocked by the unit itself).

Answer:

_____
_____
_____
_____
_____.

Task 2: Wire Termination Practice

Instructions:

1. Take a piece of #10 THHN wire (black, red, or green).
2. Use a wire stripper to remove approximately **5/8 inches (15mm)** of insulation from the end.
3. **Check your work:** Look at the exposed copper. There should be no nicks or cuts on the copper strands.
4. Twist the strands together tightly with your fingers.
5. Insert the stripped wire into the terminal lug. No copper strands should be visible outside the lug.
6. **Why is this important?** Write a sentence: *Strands left outside can touch other terminals or the box, causing a short circuit or fire.*
7. Tighten the terminal screw. If using a torque screwdriver, set it to 20-30 in-lbs. for #10 wire.
8. **Consequence of over-torquing:** Write: *Over-torquing strips the threads or breaks the terminal lug. The wire will be loose, or the lug will need replacement.*
9. **Consequence of under-torquing:** Write: *Under-torquing creates a loose connection, causing arcing, heat buildup, and eventually fire.*

Answer:

_____
_____
_____
_____
_____.

Task 3: LOTO Safety Scenario – Never Trust the Handle

Instructions:

1. Read the scenario: *The disconnect handle is in the "OFF" position. Do you trust it and start working?*
2. Answer **NO** immediately. Write: "Never trust the handle position."
3. Explain why: *A stuck contactor or welded contact can keep power on the load side even when the handle is OFF.*
4. Demonstrate the correct safety procedure by writing these steps in order:
    - **Step A:** Apply your personal padlock to the disconnect handle (LOTO).
    - **Step B:** Attach a tag with your name, date, and reason.

    - **Step C:** Test your non-contact voltage tester on a **known live source** (e.g., a working outlet) to verify it works.
    - **Step D:** Test the **load side terminals** of the disconnect. The tester should remain silent (no voltage).
    - **Step E:** Test the known live source again to verify the tester did not fail during testing.
5. Write: "Only after all five steps are completed, can you consider the circuit de-energized."

Answer:

_____
_____
_____
_____
_____.

Synthesis:

This lesson focuses on **disconnect switch wiring**: line side (top) receives incoming power from main panel; load side (bottom) goes to AC unit; ground connects to grounding lug. **Proper wire termination** requires stripping 5/8" (15mm), twisting strands, inserting fully (no copper visible), and torquing to 20-30 in-lbs (for #10 wire). Over-torquing strips threads; under-torquing causes arcing and fire. **LOTO procedure** is reinforced: lock, tag, test tester on live source, test load side, re-test on live source.

Key takeaway: *Never trust the handle position; a stuck contactor can keep power on even when OFF.*

ANSWER KEY

Task	Answer
Task 1: Terminal ID	Line side (top) = incoming from main panel. Load side (bottom) = AC unit. Ground connects to grounding lugs.
Task 2: Wire Termination	Strip 5/8" (15mm). Exposed strands outside lug can cause short circuits or fires. Over-torquing strips threads; under-torquing causes arcing.
Task 3: LOTO Safety	NEVER trust the handle. Steps: 1) Lock, 2) Tag, 3) Test tester on live source, 4) Test load side, 5) Re-test on live source. A stuck contactor can keep power on even with a handle OFF.

LEARNING ACTIVITY SHEET (LAS)

Learning Area:	Commercial Air-Conditioning Installation and Servicing		
Lesson Exemplar:	10	**Date:**	
Lesson Title/Topic:	**Application of Insulation Material**		
Name of Student:		**Grade & Section:**	

Activity Title: *Slit Down, Tape Smooth, and UV Protection*

Objective:	Finely cut, fit, and seal a piece of closed-cell insulation on a 5/8" copper tube, with seams facing down and taped.
Tools:	Utility knife, straight edge, tape measure, marker, roller (for adhesive), scissors
PPE:	Safety glasses, gloves
Materials/Devices:	Closed-cell rubber insulation (Armaflex) in 5/8" ID, PVC tape, insulation adhesive, copper pipe sample (5/8")

Scenario: You are insulating a cold suction line (5/8" copper) in a high-humidity outdoor environment.

Task 1: Orientation and Sealing

Instructions:

1. Take a piece of closed-cell rubber insulation (Armaflex) with a pre-cut slit or cut your own slit along the length.
2. Wrap it around the 5/8" copper pipe.
3. **Decision:** Which direction should the slit face?
    - Imagine water condensation running down the copper pipe (from the evaporator down to the condenser).
    - If the slit faces UP, water will run into the slit, soak the insulation, and drip out.
    - If the slit faces DOWN, water will run over the sealed surface, not into the slit.
4. Answer: The slit must face **DOWN** (or to the side, but never UP).
5. Apply a thin bead of **insulation adhesive** (not general-purpose glue) inside the slit.
6. Press the slit closed firmly.
7. Now seal the seam with **manufacturer-approved PVC tape** (not duct tape). Duct tape dries out and falls off.

8. Wrap the tape with **50% overlap**, stretch it slightly as you wrap.
9. Write your answer: "Slit faces DOWN. Use insulation adhesive, then PVC tape with 50% overlap."

Answer:

_____
_____
_____
_____.

Task 2: Material Selection – Why Not Fiberglass?

Instructions:

1. Read the question: *"Why can you NOT use fiberglass pipe wrap insulation on a refrigerant suction line?"*
2. Think about the properties of fiberglass:
    - It is **an open cell** (air and water can pass through).
    - It absorbs water like a sponge.
    - It requires an external vapor barrier (jacket) to block moisture.
3. Think about the suction line temperature (40-50°F / 4-10°C).
4. In a humid environment (Philippines, 80-90% humidity), moisture will condense on the cold pipe.
5. If fiberglass absorbs this moisture, it becomes **wet, heavy, and loses all insulating value**.
6. Write **two specific reasons** in complete sentences.
7. Reason 1: *Fiberglass is open-cell and absorbs water.*
8. Reason 2: *Wet fiberglass has almost no insulating R-value and will cause condensation of drips.*

Answer:

_____
_____
_____
_____.

Task 3: Outdoor UV Protection

Instructions:

1. Read the scenario: *The insulation will be exposed to direct sunlight on a rooftop in Manila.*
2. Standard black rubber insulation (Armaflex) is **not UV-resistant**. Sunlight will:
    - Dry out the rubber.
    - Cause cracking and crumbling.
    - Turn the insulation into powder within 1-2 years.
3. List **two methods** to protect outdoor insulation:
    - **Method 1:** Wrap the insulation with **aluminum foil tape** (also called UV tape or metal tape).

- **Method 2:** Install a **PVC jacket** (a white plastic cover that snaps over the insulation).
- **Method 3: Buy UV-protected insulation (some Armaflex products have a UV-resistant coating, usually gray or white).**

4. Write your answer in two sentences.
5. For each method, describe how it protects the insulation.

Answer:

_____
_____
_____
_____.

Synthesis:

This lesson teaches **proper closed-cell insulation installation** on suction lines. The slit must face **DOWN** (never up) to prevent water from running into the seam. Use insulation adhesive inside the slit, then seal with **PVC tape at 50% overlap** (duct tape is not acceptable). **Why not fiberglass?** Fiberglass is open-cell and absorbs water, losing all insulating value in humid environments. **Outdoor UV protection** requires aluminum foil tape, PVC jacket, or UV-protected insulation (gray/white Armaflex); standard black rubber crumbles in 1-2 years under sunlight.

Key takeaway: *Slit down, tape with 50% overlap, and protect from UV.*

ANSWER KEY

Task	Answer
Task 1: Orientation	Slit must face DOWN (never up). Use insulation adhesive inside the slit, then seal with PVC tape at 50% overlap. Duct tape is NOT acceptable.
Task 2: Why Not Fiberglass	1) Fiberglass is open-cell and absorbs water like a sponge. 2) Wet fiberglass loses all insulating value and will cause condensation to drip from the pipe.
Task 3: UV Protection	1) Wrap the insulation with aluminum foil tape (UV-resistant metal tape). 2) Install a PVC jacket over the insulation. 3) Use UV-protected insulation (gray or white Armaflex).

LEARNING ACTIVITY SHEET (LAS)

Learning Area:	Commercial Air-Conditioning Installation and Servicing		
Lesson Exemplar:	11	**Date:**	
Lesson Title/Topic:	**Installation of Condensate Drain**		
Name of Student:		**Grade & Section:**	

Activity Title: *P-Trap, Slope Calculation, and Water Flow Test*

Objective	Properly assemble a PVC condensate drain line with a P-trap, cleanout tee, and proper slope to a termination point.
Tools	PVC pipe cutter or hacksaw, deburring tool, PVC primer and cement, tape measure, level, marker, funnel
PPE	Safety glasses, gloves, respirator (for primer fumes)
Materials/Devices	PVC pipe (3/4", 1"), PVC fittings (90° elbows, tees, cleanout tee with cap), mock drain pan, bucket

Scenario: You are installing a drain for a 7.5-ton AC. The drain pan outlet is 8 inches above the floor. The floor drain is 20 feet away at floor level (0 inches).

Task 1: Slope Calculation – Is Gravity Possible?

Instructions:

1. Read the given data:
    - Horizontal distance = 20 feet
    - Required slope = 1/4 inch per foot
    - Drain pan outlet height = 8 inches above floor
    - Floor drain height = 0 inches (at floor level)
2. Calculate the **required drop** over 20 feet:
    - Formula: 20 ft × 0.25 in/ft = _____ inches
3. Calculate the **available drop**:
    - Available drop = Outlet height - Termination height
    - 8 inches - 0 inches = _____ inches
4. Compare: Is the available drop greater than or equal to the required drop?
    - If YES → Gravity drainage is possible.
    - If NO → A condensate pump is required.
5. Write your answer: "Required drop = _____ inches." Available drop = _____ inches. Therefore, gravity drainage is _____ (possible / not possible)."
6. If possible, state that you can proceed with the PVC pipe.
7. If not possible, state that you need a condensate pump.

Answer:

_____
_____
_____
_____.

Task 2: P-Trap Purpose and Installation Location

Instructions:

1. Read the question: *"What is the purpose of a P-trap on an evaporator condensate drain?"*
2. Think about the **evaporator fan**:
    - The fan is inside the indoor unit, pulling air across the coil.
    - This creates **negative pressure** (suction) inside the drain pan.
3. Without a P-trap, the fan will suck air **up** the drainpipe.
    - This prevents water from flowing **down** the pipe.
    - Water backs up in the pan and overflows.
4. The P-trap holds a small amount of water in the U-bend. This water acts as a **seal** (like a toilet trap), blocking air but allowing water to pass.
5. Write your answer in 2-3 sentences.
6. Second part: *"Where should it be installed?"*
    - Answer: As close to the evaporator drain pan outlet as possible.
7. Third part: *"What happens if you omit the P-trap?"*
    - Answer: Water will not drain. The pan will overflow, causing ceiling damage.

Answer:

_____
_____
_____
_____.

Task 3: Cleanout Tee and Water Test Procedure

Instructions:

1. Read the question: *"Where is the cleanout tee installed?"*
    - Look at a drain diagram: Drain pan → P-trap → Cleanout Tee → Termination.
    - Answer: **After the P-trap** (between the trap and the termination point).
2. Why? The cleanout allows you to insert a brush or blow nitrogen to clear clogs that form after the trap.
3. Now describe the **water test procedure** step by step:
    - **Step 1:** Ensure all PVC glue is fully cured (follow manufacturer cure time, typically 15-30 minutes for initial set, 24 hours for full cure).
    - **Step 2:** Pour 1 liter of clean water into the drain pan (use a funnel if needed).

- **Step 3:** Observe the termination point (where the pipe ends at the floor drain or outside).
- **Step 4:** Water should begin flowing out within **10 seconds**.
- **Step 5:** Check all glued joints for moisture or drips (dry joints indicate a glue failure).

4. **What indicates a failed test?**
   - No water appears at the termination point after 30 seconds.
   - Gurgling sounds (indicates a venting problem or sag).
   - Water leaks from a joint.
5. Write your answer as a numbered list.

Answer:

_____
_____
_____
_____.

Synthesis:

This lesson covers **drain slope calculation**: 20 feet × 1/4" per foot = 5 inches required drop; available drop = 8" (outlet) - 0" (floor drain) = 8" → gravity drainage is possible. **P-trap purpose** blocks negative pressure from the evaporator fan, allowing water to drain; install as close to the drain pan as possible; omitting it causes water backup and ceiling overflow. **Cleanout tee** goes after the P-trap for clearing clogs. **Water test procedure**: cure glue → pour 1 liter of water → water should flow within 10 seconds → check joints for leaks.

Key takeaway: *P-trap is mandatory for draw-through evaporators; always water-test drains.*

ANSWER KEY

Task	Answer
Task 1: Slope Calculation	Required drop = 20 ft × 0.25 = 5 inches. Available drop = 8 inches - 0 inches = 8 inches. 8 ≥ 5, so gravity drainage IS possible.
Task 2: P-Trap	Purpose: The P-trap holds water to block negative pressure (suction) from the evaporator fan, allowing water to drain by gravity. Install as close to the drain pan outlet as possible. Omitting it causes water backup and ceiling overflow.
Task 3: Cleanout & Water Test	Cleanout tee goes AFTER the P-trap. Water test: 1) Cure glue. 2) Pour 1 liter of water into the pan. 3) Water should flow within 10 seconds. 4) Check joints for leaks. Failure = no flow, gurgling, or leaks.

LEARNING ACTIVITY SHEET (LAS)

Learning Area:	Commercial Air-Conditioning Installation and Servicing		
Lesson Exemplar:	12	**Date:**	
Lesson Title/Topic:	**Performance Test of AC Unit**		
Name of Student:		**Grade & Section:**	

Activity Title: *Subcooling, Superheat, and System Diagnosis*

Objective:	Perform a complete performance test on a running AC unit, measuring voltage, amperage, pressures, temperatures, and air velocity.
Tools:	Gauge manifold (R-410A compatible), digital clamp meter, digital thermometer, anemometer, micron gauge, leak detector, megohmmeter
PPE:	Safety glasses, gloves, refrigerant-rated gloves, face shield
Materials/Devices:	Running AC unit or HVAC trainer, P-T chart, Performance Test Report form

Scenario: You connect your gauges to an R-410A system. You must calculate subcooling, superheat, and airflow, then diagnose system issues.

Task 1: Subcooling Calculation (Scenario A)

Instructions:

1. Read the given data for Scenario A:
    - High Side Pressure = 380 psi
    - Saturation temperature at 380 psi (from P-T chart) = 105°F
    - Liquid Line Temperature (measured with thermocouple) = 95°F
2. Use the formula: **Subcooling = Saturation Temperature - Liquid Line Temperature**
    - Calculation: 105°F - 95°F = _____ °F
3. Target subcooling for a TXV system using R-410A = **8-12°F**.
4. Compare your calculated value to the target range.
    - If below 8°F = Too low (undercharged or restriction)
    - If within 8-12°F = Correct
    - If above 12°F = Too high (overcharged)
5. Write your answer: "Subcooling = _____ °F. This is _____ (too low / correct / too high)."
6. If it is outside the range, state the problem.

Answer:

_____
_____
_____
_____.

Task 2: Superheat Calculation (Scenario B)

Instructions:

1. Read the given data for Scenario B:
    - Low Side Pressure = 130 psi
    - Saturation temperature at 130 psi (from P-T chart) = 40°F
    - Suction Line Temperature (measured with thermocouple) = 62°F
2. Use the formula: **Superheat = Suction Line Temperature - Saturation Temperature**
    - Calculation: 62°F - 40°F = _____ °F
3. Target superheat for a TXV system using R-410A = **10-15°F**.
4. Compare your calculated value to the target range.
    - If below 10°F = Too low (overcharged or TXV stuck open)
    - If within 10-15°F = Correct
    - If above 15°F = Too high (undercharged or low airflow)
5. Write your answer: "Superheat = _____ °F. This indicates the system is likely _____ (undercharged / overcharged / correct)."
6. Explain why: *High superheat means not enough liquid refrigerant is entering the evaporator, so the gas is getting too hot.*

Answer:

_____
_____
_____
_____.

Task 3: Airflow Calculation (Scenario C)

Instructions:

1. Read the given data for Scenario C:
    - Unit size = 5 tons
    - Target airflow = 400 CFM per ton
    - Measured average air velocity at supply grille = 400 feet per minute (ft/min)
    - Grille dimensions = 2 feet × 2 feet = 4 square feet (sq ft)
2. Calculate the **target CFM**: 5 tons × 400 CFM/ton = _____ CFM
3. Calculate the **actual CFM** using the formula: **CFM = Velocity (ft/min) × Area (sq ft)**
    - Calculation: 400 ft/min × 4 sq ft = _____ CFM
4. Calculate the **percentage difference** from target:
    - (Actual - Target) ÷ Target × 100% = _____ %

    - Example: If actual = 1600, target = 2000, then (1600-2000)/2000 × 100% = -20%
5. The acceptable range is **±10%** of targets.
6. Write your answer: "Actual CFM = _____. Target CFM = _____. This is _____% below/above target. This is ___ (acceptable / not acceptable)."
7. List **one possible cause** if airflow is too low:
    - Dirty air filter
    - Undersized ductwork
    - Fan speed set too low
    - Closed or blocked dampers

Answer:

_____
_____
_____
_____.

Synthesis:

This lesson teaches **subcooling calculation**: saturation temperature (105°F) minus liquid line temperature (95°F) = 10°F → correct (target 8-12°F). **Superheat calculation**: suction line temperature (62°F) minus saturation temperature (40°F) = 22°F → too high → indicates **undercharged system**. **Airflow calculation**: 5-ton units need 2000 CFM (400 CFM/ton). Actual: 400 ft/min × 4 sq ft = 1600 CFM → 20% below target → not acceptable (must be within ±10%).

Key takeaway: *Subcooling, superheat, and airflow are the three pillars of performance testing; never diagnose without all three.*

ANSWER KEY

Task	Answer
Task 1: Subcooling	105°F - 95°F = 10°F. Correct (within 8-12°F target).
Task 2: Superheat	62°F - 40°F = 22°F. Too high. Indicates UNDERCHARGED system (not enough refrigerant in evaporator).
Task 3: Airflow	Target = 2000 CFM. Actual = 400 × 4 = 1600 CFM. 20% below target. Not acceptable. Possible cause: dirty filter or undersized duct.

LEARNING ACTIVITY SHEET (LAS)

Learning Area:	Commercial Air-Conditioning Installation and Servicing		
Lesson Exemplar:	13	**Date:**	
Lesson Title/Topic:	**Service Costing and Documentation**		
Name of Student:		**Grade & Section:**	

Activity Title: *The Professional Invoice: Costing, VAT, and Documentation*

Objective:	Prepare a complete, professional invoice for a commercial AC installation, including itemized materials, labor hours, tax, and payment terms.
Tools:	Calculator, computer with Excel/Google Sheets, printer
PPE:	None required
Materials/Devices:	Blank invoice forms, service report forms, price lists

Scenario: You have completed a commercial AC installation. You must calculate the total cost and prepare a professional invoice.

Task 1: Complete Cost Calculation (Materials, Labor, Overhead, Profit, VAT)
Instructions:

1. Read the given data:
    - Materials = PHP 85,000
    - Labor = 2 technicians × 8 hours × PHP 600/hour per technician
    - Travel = PHP 2,500
    - Overhead = 20% of (Materials + Labor + Travel)
    - Profit = 15% of (Subtotal before tax)
    - VAT = 12%

2. **Step A: Calculate Labor Cost**
    - Formula: Number of technicians × Hours × Rate per hour

3. **Step B: Calculate Direct Costs Subtotal (before overhead)**
    - Formula: Materials + Labor + Travel

4. **Step C: Calculate Overhead**
    - Formula: Direct Costs Subtotal × 0.20

5. **Step D: Calculate Subtotal after Overhead**
    - Formula: Direct Costs Subtotal + Overhead

6. **Step E: Calculate Profit**
    - Formula: Subtotal after Overhead × 0.15

7. **Step F: Calculate Total Before Tax**
    - Formula: Subtotal after Overhead + Profit

8. **Step G: Calculate VAT**
    - Formula: Total Before Tax × 0.12

9. **Step H: Calculate Grand Total**
    - Formula: Total Before Tax + VAT
    - Round to the nearest whole peso.

10. Write your final answer as: "Grand Total = PHP _____"

Answer:

_____
_____
_____
_____
_____.

Task 2: Document Matching

Instructions:

1. Read the four document types and definitions below.
2. Match each document to its correct purpose by writing the letter (A, B, C, or D) in the blank.
3. **Document options:**
    - (A) Quotation
    - (B) Service Report
    - (C) Invoice
    - (D) Official Receipt
4. **Purposes to match:**
    - _____: Issued BEFORE work begins, specifying estimated cost. Valid for a specific period (e.g., 30 days). Client signs to approve.
    - _____: Completed DURING or AFTER work. Records of what was done, hours worked, materials used, and measurements taken (subcooling, pressures). Signed by a client.
    - _____: Issued AFTER work is complete. Request payment. Must match the quotation unless change orders are approved.
    - _____: Issued WHEN payment is received. Proof of payment. Required for BIR compliance.
5. Write your answers in the blanks.

Answer:

_____
_____
_____
_____
_____.

Task 3: Discount Decision Scenario

Instructions:

1. Read the scenario: *"A client asks for a discount after you have completed the installation." You have already submitted the invoice.*
2. Before agreeing to any discount, you must check **three things**.
3. **Check #1 – Profitability:** Will the discount still leave you with a net profit? Calculate your profit margin after the discount. If the discount eliminates your profit, refuse.
4. **Check #2 – Hard Costs:** Materials, travel, and subcontractor costs are **hard costs** that you have already paid. These cannot be discounted. Only discount your labor and profit margin.
5. **Check #3 – Documentation:** Has the client already signed a quotation? Does the discount require a change of order or a credit memo? Will you issue a revised invoice?
6. **Check #4 – Future Relationship:** Will this discount set a bad precedent? Will the client expect discounts on every future job?
7. Write your answer as a numbered list of **three checks** with a brief explanation for each.
8. Conclude a recommendation: "I would offer a discount only on labor, never on materials, and only if the client signs a revised invoice."

Answer:

_____
_____
_____
_____
_____.

Synthesis:

This lesson covers **complete invoice calculation** including materials (₱85,000), labor (2 techs × 8hrs × ₱600 = ₱9,600), travel (₱2,500), overhead (20%), profit (15%), and VAT (12%) → grand total = **₱150,078**. Students learn **four document types**: Quotation (before work), Service Report (during/after, signed by client), Invoice (after work, requests payment), Official Receipt (proof of payment, BIR requirement). For discount requests: check profit remains, never discount hard costs (materials/travel), and require revised documentation.

Key takeaway: *Proper documentation protects payment, warranty, and legal compliance; never discount hard costs.*

ANSWER KEY Commissioning of Commercial Air Conditioning Units

Task	Answer
Task 1: Cost Calculation	Labor = 2 × 8 × 600 = PHP 9,600. Direct Subtotal = 85,000 + 9,600 + 2,500 = PHP 97,100. Overhead = 97,100 × 0.20 = PHP 19,420. Subtotal after OH = 116,520. Profit = 116,520 × 0.15 = PHP 17,478. Total before tax = 133,998. VAT = 133,998 × 0.12 = PHP 16,079.76. GRAND TOTAL = PHP 150,078 (rounded).
Task 2: Document Matching	(A) Quotation, (B) Service Report, (C) Invoice, (D) Official Receipt
Task 3: Discount Decision	1) Check if profit remains after a discount. 2) Never discount hard costs (materials, travel). 3) Ensure proper documentation (revised invoice, credit memo). Recommendation: Discount labor only, not materials.

LEARNING ACTIVITY SHEET (LAS)

Learning Area:	Commercial Air-Conditioning Installation and Servicing		
Lesson Exemplar:	14	**Date:**	
Lesson Title/Topic:	**Cleaning Procedure of the Air Filter**		
Name of Student:		**Grade & Section:**	

Activity Title: Filter First: Commercial Air Filter Maintenance

Objective:	Properly remove, clean (if washable), and reinstall a commercial AC filter while noting airflow direction and filter specifications.
Tools:	Vacuum cleaner with brush attachment, soft-bristle brush, water hose (for washable filters), screwdrivers
PPE:	Dust mask (N95), safety glasses, nitrile gloves
Materials/Devices:	Practice AC unit or trainer, replacement filters (various types), maintenance log sheet, pen, clipboard

Scenario: You are the maintenance technician for a small commercial building with five air-conditioning (AC) units. The building manager reports that one unit is not cooling effectively and that the airflow seems weak. You suspect that the air filter may be dirty. Your task is to inspect the filter, clean or replace it as needed, and document its condition.

Task 1: Identify Filter Types and MERV Rating
Instructions:

1. Read each question carefully.
2. Write your answer to the space provided.
3. Use complete sentences for short answer questions.

Questions:

1. What does MERV stand for?

   Answer: _____

2. List three effects of a clogged air filter on a commercial AC system.

   Answer: _____

   _____

   _____

3. Can a disposable fiberglass filter be washed? Why or why not?

   Answer: _____

4. What direction should the airflow arrow on a filter point?

   Answer: _____

5. A restaurant kitchen AC filter should be replaced how often?

   Answer: _____

Task 2: Remove, Clean, and Reinstall Filter
Instructions:

1. Put on your PPE (dust mask, safety glasses, gloves).
2. Turn off the AC unit at the thermostat or disconnect.
3. Remove the filter access panel using a screwdriver.
4. Slide out the filter. Note the airflow arrow direction.
5. Inspect the filter condition (clean, dirty, clogged).
6. If disposable, replace a new filter of the same size and MERV.
7. If washable, vacuum both sides, then rinse with gentle water. Let dry completely (24 hours).
8. Reinstall filter with arrow pointing toward the fan/blower.
9. Close access panel and restore power.
10. Complete the maintenance log below.

Maintenance Log:

Item	**Recorded Value**
1. Filter size (L x W x H)	
2. MERV rating	
3. Filter type (disposable/washable)	
4. Condition before service	
5. Action taken (cleaned/replaced)	
6. Airflow arrow direction (toward)	

Date of service:
Technician’s Name:

Task 3: Professional Commitment to Proper Maintenance
Instructions:

1. Read the scenario below carefully.
2. Write your response to the question.
3. Use at least 3-5 complete sentences.
4. Explain both what you would say and why it is the right professional choice.

Scenario: A restaurant manager says, "Just flip the filter over. It looks fine. We don't want to pay for a new one today. Can you just reinstall it the other way?"

Question: What do you say to the manager? Write your response.

Answer: _____

_____

_____

_____

_____

Synthesis:
This lesson focuses on the **importance of air filter maintenance** in commercial AC systems. Students learn to identify **MERV ratings**, recognize signs of a clogged filter, and determine whether a filter is washable or disposable. The proper procedure includes turning off the unit, removing the filter, noting airflow direction, cleaning or replacing it correctly, and documenting the work. The lesson emphasizes **professional integrity**, especially when clients suggest shortcuts like reusing a dirty filter.

Key takeaway: *A clean filter protects the system, improves efficiency, and prevents costly compressor failures.*

ANSWERS KEY

Task	Possible Answer
Task 1 – Q1	Minimum Efficiency Reporting Value
Task 1 – Q2	(1) Reduced airflow below 400 CFM/ton; (2) Evaporator coil freezing; (3) Compressor failure due to floodback; (4) High energy consumption; (5) Poor indoor air quality. (Any three)
Task 1 – Q3	No. Washing will disintegrate the media because disposable filters are made of paper or fiberglass that fall apart when wet.
Task 1 – Q4	Toward the fan or blower (into the unit, away from the return grille).
Task 1 – Q5	Every month (or every 2 weeks for heavy grease environments).
Task 2 – Log	Filter size: 20x25x2; MERV: 8; Type: Disposable; Condition: Dirty; Action: Replaced; Arrow toward: Fan; Date: [current date]; Name: [student name]
Task 3	"I understand you want to save money, but flipping a dirty filter does not clean it. It still blocks airflow, which will freeze the coil and could destroy the compressor. Replacing the filter now costs much less than a compressor replacement later. I recommend replacing it today. This is the right professional choice because it protects your equipment, saves you money in the long run, and follows manufacturer recommendations."

LEARNING ACTIVITY SHEET (LAS)

Learning Area:	Commercial Air-Conditioning Installation and Servicing		
Lesson Exemplar:	15	**Date:**	
Lesson Title/Topic:	**Cleaning Methods of the Mechanical System**		
Name of Student:		**Grade & Section:**	

Activity Title: Coil Care: Evaporator and Condenser Coil Cleaning

Objective:	Distinguish between alkaline and acidic coil cleaners and safely clean an evaporator coil using a no-rinse foam cleaner.
Tools:	Soft brush, fin comb, vacuum cleaner with HEPA filter, water sprayer, screwdrivers
PPE:	Rubber gloves, safety glasses, respirator (for chemical cleaners), waterproof apron
Materials/Devices:	AC trainer or mock coil, coil cleaning spray (alkaline, no-rinse), plastic sheeting, drop cloths, condensate pan treatment tablets

Scenario: A 10-ton commercial AC has reduced cooling capacity. Inspection shows a dirty evaporator coil covered with dust and light grease. The condenser coil also has a dirt buildup. You must clean both coils properly using the correct chemicals and procedures.

Task 1: Coil Cleaner Chemistry

Instructions:

1. Read each scenario carefully.
2. Write your answer to the space provided.

Questions:

1. What type of chemical cleaner (alkaline or acidic) should be used on an aluminum evaporator coil?

   Answer: _____

   _____

2. Why should you never use a pressure washer on a condenser coil?

   Answer: _____

3. What tool is used to straighten bent coil fins?

   Answer: _____

4. What must you protect before spraying any liquid cleaner on an evaporator coil?

   Answer: _____

5. A kinked liquid line causes what problem?

   Answer: _____

Task 2: Evaporator Coil Cleaning Procedure
Instructions:

1. Put on full PPE (rubber gloves, safety glasses, respirator, apron).
2. Disconnect power from the unit. Use LOTO (Lock-Out/Tag-Out).
3. Remove access panels to expose the evaporator coil.
4. Cover electrical components (control board, motor, contactor) with plastic sheeting.
5. Vacuum loose dust from the coil face using a soft brush attachment.
6. Apply no-rinse alkaline foam cleaner generously across the entire coil face.
7. Wait 5-10 minutes for the foam to lift dirt. Do not let it dry completely.
8. Vacuum or wipe away loosened dirt. Or turn fan ON (blower only) to pull dirt into the drain pan.
9. Clean the drain pan with a brush and mild detergent. Add a condensate pan tablet.
10. Remove plastic sheeting. Replace access panels.
11. Restore power and test the unit.
12. Complete the Coil Cleaning Report below.

Coil Cleaning Report:

Item	Recorded Value
1. Unit identification	
2. Coil type cleaned	
3. Cleaner used (brand and type)	
4. Dwell time (minutes)	
5. Electrical components protected? (Yes/No)	
6. Drain pan cleaned? (Yes/No)	
7. Pan tablet added? (Yes/No)	

Item	Recorded Value
8. Before cleaning condition	
9. After cleaning condition	
Technician's Name:	
Date:	

Task 3: Chemical Safety and Environmental Responsibility

Instructions:

1. Read the scenario below carefully.
2. Write your response to the question.
3. Use at least 3-5 complete sentences.

Scenario: You are out of alkaline coil cleaner. A senior technician says, "Just use dish soap and water. It's basically the same. The client won't know the difference."

Question: Do you follow the instructions? Why or why not? Write your response.

Answer: _____

_____

_____

_____

_____

_____

Synthesis: This lesson teaches the **correct chemical and mechanical procedures** for cleaning evaporators and condenser coils. Students distinguish between **alkaline and acidic cleaners**, learning that alkaline is safe for aluminum coils while acidic can destroy them. The step-by-step process includes protecting electrical components, applying no-rinse foam, using a fin comb, and cleaning the drain pan. The lesson stresses **chemical safety and environmental responsibility**, rejecting shortcuts like using dish soap.

Key takeaway: *Proper coil cleaning restores efficiency and prevents system damage, but only when done with the right tools and chemicals.*

ANSWERS KEY

Task	Possible Answer
Task 1 – Q1	Alkaline (or neutral/universal). Never use an acidic cleaner on an aluminum evaporator coil because it will corrode and destroy the coil.
Task 1 – Q2	High pressure bends fins and can puncture the coil tubes, causing refrigerant leaks.
Task 1 – Q3	Fin comb
Task 1 – Q4	Electrical components (control board, motor, contactor, wiring)
Task 1 – Q5	Restricted refrigerant flow (pressure drop, starves the expansion valve, reduces cooling capacity)
Task 2 – Report	Unit: AHU-101; Coil: Evaporator; Cleaner: Nu-Calgon Evap Foam (alkaline no-rinse); Dwell time: 7 minutes; Electrical protected: Yes; Drain pan cleaned: Yes; Pan tablet: Yes; Before: Dusty/greasy; After: Clean; Name: [student]; Date: [current]
Task 3	"No. Dish soap leaves residue that attracts dirt and can foam inside the drain pan, causing clogs and algae growth. I will get the correct alkaline cleaner or wait until it is available. Using the wrong chemical can damage the coil, void the warranty, and harm the system. The right professional choice is to use the correct product for the job, even if it takes more time."

LEARNING ACTIVITY SHEET (LAS)

Learning Area:	Commercial Air-Conditioning Installation and Servicing		
Lesson Exemplar:	17	**Date:**	
Lesson Title/Topic:	**Maintenance Methods of the Fan Motor**		
Name of Student:		**Grade & Section:**	

Activity Title: Motor Care: Fan Motor Lubrication and Capacitor Testing

Objective:	Differentiate between PSC and ECM motors, properly lubricate a fan motor with oil ports, and test a capacitor using a multimeter.
Tools:	Multimeter (capacitance testing), megger (insulation resistance), oil can with SAE 20 oil, hex keys, socket set, puller (for fan blade), soft brush
PPE:	Safety glasses, gloves, hearing protection (for noisy fan testing)
Materials/Devices:	Practice fan motor (PSC type with oil ports), replacement fan motor (sample), fan blade, capacitor (run and start), lubricating oil, wire connectors

Scenario: You are performing annual preventive maintenance on a 20-ton commercial AC unit. The condenser fan motor has been in service for 3 years. You notice the motor sounds dry, and the bearings feel rough when you spin the shaft by hand.

Task 1: Motor Types and Capacitor Testing
Instructions:

1. Read each question carefully.
2. Write your answer to the space provided.

Questions:

1. What type of motor (PSC or ECM) requires a run capacitor?

   Answer: _____

2. What is the acceptable tolerance range for a capacitor's microfarad rating?

   Answer: _____

3. What type of oil is used for electric motor lubrication?

   Answer: _____

4. True or False: You can hammer a fan blade off a motor shaft. Explain your answer.

   Answer: _____

5. What happens to the amperage if the voltage is too low?

   Answer: _____

Task 2: Fan Motor Preventive Maintenance
Instructions:

1. Put on PPE (safety glasses, gloves).
2. Disconnect power from the unit. Use LOTO.
3. Identify the motor type (PSC, ECM, or three-phase). Record it.
4. Locate oil ports (small holes or fittings on the motor housing).
5. Clean the area around each oil port with a soft brush.
6. Add 3-5 drops of SAE 20 non-detergent electric motor oil per port. Do not over-oil.
7. If the motor has sealed bearings, do not oil. Note this in the report.
8. Test the run capacitor (if PSC motor):
   - Discharge the capacitor (short across terminals with an insulated screwdriver).
   - Remove wires from the capacitor.
   - Set multimeter to capacitance (μF).
   - Place probes on terminals. Read the value.
   - Compare to nameplate rating. Acceptable range: ±10%.
9. Inspect the fan blade for dents, cracks, or imbalance.
10. Check mounting bolts for tightness. Tighten if loose.
11. Complete the Fan Motor Maintenance Report below.

Fan Motor Maintenance Report:

Item	Recorded Value
1. Motor type	
2. Motor voltage rating	
3. Motor FLA (nameplate)	
4. Oil ports present? (Yes/No)	
5. Number of oil ports	

Item	Recorded Value
6. Amount of oil added (drops)	
7. Capacitor rated µF	
8. Capacitor measured µF	
9. Capacitor pass/fail (±10%)	
10. Fan blade condition	
11. Mounting bolts condition	
12. Recommended action	
Technician’s Name:	
Date:	

Task 3: Lubricate Correctly, Don't Destroy

Instructions:

1. Read the scenario below carefully.
2. Write your response to the question.
3. Use at least 3-5 complete sentences.

Scenario: A technician adds 20 drops of oil to a motor with oil ports because "more is better." The motor fails three months later. The technician blames the motor manufacturer.

Question: What went wrong? What should the technician do instead? Write your response.

Answer: _____

_____

_____

Synthesis: This lesson covers **PSC vs. ECM motors**, proper lubrication techniques, and capacitor testing. Students learn to locate oil ports, apply **only 3–5 drops of SAE 20 oil**, and avoid over-oiling (which damages windings). They also practice testing to run capacitors with a multimeter, accepting only values within **±10%** of the rating. The lesson warns against hammering fan blades and emphasizes using a puller.

Key takeaway: *Correct lubrication and capacitor testing extend motor life; guessing or over-oiling leads to premature failure.*

ANSWERS KEY

Task	Possible Answer
Task 1 – Q1	PSC (Permanent Split Capacitor) motor
Task 1 – Q2	±10% of the rated microfarad value
Task 1 – Q3	SAE 20 non-detergent electric motor oil
Task 1 – Q4	False. Hammering will damage the bearings and shafts. Always use a puller to remove a fan blade.
Task 1 – Q5	Amperage increases (motor draws more current to compensate for low voltage, causing overheating).
Task 2 – Report	Motor type: PSC; Voltage: 230V; FLA: 5.2A; Oil ports: Yes (2 ports); Oil added: 4 drops per port; Capacitor rated: 7.5 µF; Measured: 7.4 µF; Pass; Fan blade: Good; Mounting bolts: Tight; Action: Lubricated, capacitor good, no further action; Name: [student]; Date: [current]
Task 3	"Over-oiling causes excess oil to leak into motor windings, attracting dust and causing insulation failure. The technician should have added only 3-5 drops per port. More oil is not better. The technician should have checked the capacitor and amperage. Blaming the manufacturer without investigating the real cause is unprofessional. The correct approach is to follow manufacturer specifications for lubrication."

LEARNING ACTIVITY SHEET (LAS)

Learning Area:	Commercial Air-Conditioning Installation and Servicing		
Lesson Exemplar:	18	**Date:**	
Lesson Title/Topic:	**Maintenance of Service Power**		
Name of Student:		**Grade & Section:**	

Activity Title: Power Check: Electrical Component Maintenance

Objective:	Explain the function of a contactor, perform an insulation resistance test (megger), and interpret the results.
Tools:	Multimeter (voltage, continuity), clamp meter, megohmmeter, non-contact voltage tester, screwdrivers, wire brush
PPE:	Insulated gloves, safety glasses, LOTO kit
Materials/Devices:	De-energized trainer or mock panel, replacement contactor, relay, overload protector, wire connectors, electrical tape, corrosion inhibitor spray

Scenario: You are performing annual preventive maintenance on a 10-year-old 15-ton commercial AC unit. The maintenance schedule requires inspection of all electrical components, including the contactor, terminals, and motor insulation.

Task 1: Contactors, Meggers, and Safety
Instructions:

1. Read each question carefully.
2. Write your answer to the space provided.

Questions:

1. What device switches the high-voltage compressor and fan on/off based on a 24V signal from the thermostat?
   Answer: _____

2. What voltage (DC) should a megohmmeter be set for testing a 230V compressor?
   Answer: _____

3. A megger reading of 0.3 MΩ between a compressor terminal and ground indicates what?
   Answer: _____

4. What is one sign of a loose electrical terminal?

Answer: _____

5. True or False: You should megger a motor while it is still connected to the contactor. Explain your answer.
   Answer: _____

Task 2: Electrical Power Maintenance
Instructions:

1. Put on PPE (insulated gloves, safety glasses).
2. Disconnect power from the unit. Apply LOTO (Lock-Out/Tag-Out).
3. Verify power is OFF using a non-contact voltage tester.
4. Open the electrical panel and locate the contactor.
5. Inspect contactor contacts:
   - Clean and silver-colored = good
   - Black, pitted, or burned = replace
   - Welded (stuck closed) = replace immediately
6. Check all terminal screws for tightness. Use a screwdriver. If you can turn the screw, it was loose. Tighten to specifications.
7. Look for discoloration (brown/black) on wires – indicates overheating.
8. Look for corrosion (white/green powder) – clean with a wire brush or replace terminal.
9. Perform megger test on the compressor (instructor supervised):
   - Disconnect wires from compressor terminals (C, S, R).
   - Set megohmmeter to 500V DC (for 230V motor).
   - Measure between each terminal and ground (C to ground, S to ground, R to ground).
   - Also measure between terminals (C to S, C to R, S to R).
10. Interpret readings:
    - 10 MΩ = Pass (excellent)
    - 1-10 MΩ = Caution (monitor, retest in 6 months)
    - <1 MΩ = Fail (replace compressor soon)
11. Complete the Power Maintenance Report below.

Power Maintenance Report:

Item	Finding	Action Taken
1. Contactor contacts condition		
2. Contactor coil resistance (ohms)		
3. Terminal screws (tightness)		
4. Wire discoloration observed?		

Item	Finding	Action Taken
5. Corrosion observed?		
6. Megger reading – C to ground		Pass / Caution / Fail
7. Megger reading – S to ground		Pass / Caution / Fail
8. Megger reading – R to ground		Pass / Caution / Fail
9. Overall recommendation		
Technician's Name:		
Date:		

Task 3: Torque Matters: No Guesswork
Instructions:

1. Read the scenario below carefully.
2. Write your response to the question.
3. Use at least 3-5 complete sentences.

Scenario: A technician tightens electrical terminals "by feel" and does not own a torque screwdriver. He says, "I've been doing this for 10 years. I know when it's tight enough."

Question: Is this acceptable? Why or why not? What should the technician do instead? Write your response.

Answer: _____

_____

_____

_____

Synthesis: This lesson focuses on **electrical component maintenance**, including contactors, terminals, and insulation testing. Students learn to inspect contactor contacts for pitting or welding, check terminal tightness, and perform **megger tests** (insulation resistance) at 500V DC for 230V systems. Readings above 10 MΩ passes; below 1 MΩ indicate imminent failure. The lesson strongly emphasizes **torque specifications** over "feel" and compliance with the Philippine Electrical Code.

Key takeaway: *Loose or over-tightened terminals cause arcing and fire; proper torque and megger testing are non-negotiable for safety.*

ANSWERS KEY

Task	Possible Answer
Task 1 – Q1	Contactor
Task 1 – Q2	500V DC
Task 1 – Q3	Failed insulation (compressor winding is failing and will fail soon)
Task 1 – Q4	Discolored wire insulation, carbon deposits, arcing marks, or screw turns easily with a screwdriver
Task 1 – Q5	False. Disconnect the motor first to avoid damaging the contactor or control board with the high voltage from the megger.
Task 2 – Report	Contactor: Clean, good; Coil resistance: 18 ohms; Terminals: Tight; Discoloration: None; Corrosion: None; Megger C-ground: 25 MΩ (Pass); S-ground: 22 MΩ (Pass); R-ground: 24 MΩ (Pass); Recommendation: No action needed, schedule next maintenance in 6 months; Name: [student]; Date: [current]
Task 3	"No, this is not acceptable. Loose terminals cause arcing, heat, and fire. Over-tightened terminals strip threads or break wires. The Philippine Electrical Code requires proper torque specifications. 'Feel' is not accurate and varies from person to person. The technician should purchase a torque screwdriver and use the manufacturer's torque specifications for each terminal size. Professionalism means using the right tool for the job, not relying on guesswork."

LEARNING ACTIVITY SHEET (LAS)

Learning Area:	Commercial Air-Conditioning Installation and Servicing		
Lesson Exemplar:	18	**Date:**	
Lesson Title/Topic:	**Service Costing and Documentation**		
Name of Student:		**Grade & Section:**	

Activity Title: Cost It Right: Maintenance Pricing and Reports

Objective:	Explain the difference between time-and-materials of billing and fixed-price maintenance contracts and prepare a professional maintenance service report.
Tools:	Calculator
PPE:	None required
Materials/Devices:	Excel, Word, or Google Docs; blank maintenance contract template, service report form, invoice template, maintenance schedule spreadsheet

Scenario: A potential client with 5 commercial AC units (3 x 5-ton, 2 x 10-ton) requests a proposal for quarterly maintenance. You need to calculate pricing and prepare a professional maintenance contract proposal.

Task 1: Pricing Models and Documentation Requirements
Instructions:

1. Read each question carefully.
2. Write your answer to the space provided.

Questions:

1. What is the main difference between time-and-materials billing and a fixed-price maintenance contract?
   Answer: _____

2. List three items that must be included in a professional maintenance service report.
   Answer: _____
   _____
   _____

3. A 5-ton AC unit costs PHP 250,000. What is a typical annual maintenance contract price range (1-2% of equipment cost)?
   Answer: _____

4. True or False: A signed service report is legally valuable if a client disputes the work performed. Explain your answer.
   Answer: _____

5. Why should you never backdate a service report?
   Answer: _____

Task 2: Create a Maintenance Service Report
Instructions:

1. Read the scenario below.
2. Using the template provided, complete a Maintenance Service Report.
3. Include all required sections.
4. Submit the report to your teacher.

Scenario: You performed a quarterly maintenance visit on a 10-ton split AC at "ABC Office Building, 123 Main St." Unit model: ABC-123, serial number: 456. Tasks performed: replaced MERV 8 filter, cleaned evaporator coil, inspected electrical (contactor OK, terminals tight), measured pressures (125 psi low side, 410 psi high side), temperatures (suction line 55°F, liquid line 100°F), calculated subcooling 10°F, superheat 13°F. No issues found. Next maintenance is due in 3 months.

Maintenance Service Report Template:

Section	Content
1. Header	Client name: _____ Site address: _____ Date: _____ Technician name: _____
2. Unit information	Brand: _____ Model: _____ Serial: _____ Location: _____
3. Checklist of tasks performed	☐ Filter replaced (MERV: ___) ☐ Coils cleaned (evaporator/condenser) ☐ Drain checked/cleaned ☐ Electrical inspection ☐ Fan motor checked ☐ Refrigerant pressures checked ☐ Other: _____

Section	Content
4. Measurements	Voltage (L1-L2): _____ V Compressor amperage: _____ A Low side pressure: _____ psi High side pressure: _____ psi Suction line temp: _____ °F Liquid line temp: _____ °F Subcooling: _____ °F Superheat: _____°F
5. Findings	_____
6. Recommendations	_____
7. Parts used	Part name: _____ Part number: _____ Quantity: _____
Client signature	_____ (acknowledges work was performed)

Task 3: Documentation is Legal Protection
Instructions:

1. Read the scenario below carefully.
2. Write your response to the question.
3. Use at least 3-5 complete sentences.

Scenario: A client refuses to sign the service report, saying, "I trust you. You don't need my signature. It's just paperwork."

Question: What do you say to the client? Why is signature important? Write your response.

Answer: _____

_____

_____

_____

_____

_____

Synthesis: This lesson introduces **pricing models** (time-and-materials vs. fixed-price contracts) and the legal importance of **service documentation**. Students learn to calculate maintenance costs (typically 1–2% of equipment value) and prepare a professional service report containing header data, measurements, findings, recommendations, and a **client signature**. The lesson stresses that signed reports protect both technicians and clients in disputes.
Key takeaway: *Good documentation is legal protection; never skip or backdate signatures.*

ANSWERS KEY

Task	Possible Answer
Task 1 – Q1	Time-and-materials bills for actual hours worked plus materials used; fixed-price charges a set fee per visit or per year regardless of actual time.
Task 1 – Q2	(1) Header (client name, date, technician name); (2) Measurements (voltage, amperage, pressure); (3) Client signature. (Any three)
Task 1 – Q3	PHP 2,500 to PHP 5,000 per year (or PHP 200-400 per month)
Task 1 – Q4	True. A signed service report is proof that the work was performed and accepted by the client. It protects the technician in case of disputes or warranty claims.
Task 1 – Q5	Backdating a service report is fraud. It misrepresents when the work was done and can be used as evidence in legal proceedings.
Task 2 – Report	Header: ABC Office Building, 123 Main St, [current date], [student name]; Unit: ABC-123, serial 456, rooftop; Checklist: all checked; Measurements: 235V, 18.2A, 125 psi, 410 psi, 55°F, 100°F, 10°F, 13°F; Findings: No issues; Recommendations: Next maintenance in 3 months; Parts: MERV 8 filter, part# F808; Signature line present
Task 3	"I appreciate your trust, but I still need your signature. It protects both of us. It proves that the work was done on this date and that you accepted it. Without your signature, there is no proof of a warranty claim or a dispute later. Please sign here so I can complete your file. This is standard professional practice for all service companies."

LEARNING ACTIVITY SHEET (LAS)

Learning Area:	Commercial Air-Conditioning Installation and Servicing		
Lesson Exemplar:	19	**Date:**	
Lesson Title/Topic:	**Pre-Troubleshooting of Commercial Air Conditioning Units**		
Name of Student:		**Grade & Section:**	

Activity Title: Think First: Systematic Troubleshooting Approach

Objective:	List the five steps of systematic troubleshooting in order and correctly identify the first three pieces of information to gather from a client.
Tools:	None for theory; optional: sample service manuals, wiring diagrams
PPE:	Not applicable for discussion
Materials/Devices:	Troubleshooting flowcharts, decision trees, scenario cards

Scenario: You receive a service call from a hotel: "Our lobby AC is not cooling, and there is water on the floor." You need to gather information before arriving and follow a systematic troubleshooting process.

Task 1: The 5 Steps of Troubleshooting
Instructions:

1. Read each question carefully.
2. Write your answer to the space provided.

Questions:

1. List the five steps of systematic troubleshooting in order (use the mnemonic O-V-I-T-C).
   Answer: _____

2. What is the first thing you should do before removing any panels on a commercial AC unit?
   Answer: _____

3. True or False: Adding refrigerant 'just to see if it helps is an acceptable troubleshooting technique. Explain your answer.
   Answer: _____

4. A contactor pulls in (you hear a click), but the compressor does not run. What is the next thing you should check?
   Answer: _____

5. What safety procedure must be followed before touching electrical terminals?
   Answer: _____

Task 2: Pre-Call Questioning and Visual Inspection Plan
Instructions:

1. Read the scenario below.
2. Write a list of 8 questions you would ask the client BEFORE arriving on site.
3. Write a list of 5 things you will check visually as soon as you arrive (before any tools).

Scenario: A hotel manager calls: "Our lobby AC is not cooling, and there is water on the floor."

Part A: Pre-Call Questions (8 questions)

Questions

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____

Part B: Visual Inspection Plan (5 items to check upon arrival)

Item to Check

1. _____
2. _____
3. _____

Item to Check

4. _____

5. _____

Task 3: Never Guess, Never Replace Without Diagnosis
Instructions:

1. Read the scenario below carefully.
2. Write your response to the question.
3. Use at least 3-5 complete sentences.

Scenario: A technician says, "I think the compressor is bad. Let's replace it." He has not checked the contactor, capacitor, or overload protector.

Question: What is wrong with this approach? What should the technician do instead? Write your response.

Answer: _____

_____

_____

_____

_____

_____

Synthesis: This lesson teaches the **systematic troubleshooting process (O-V-I-T-C)**: Observe, Verify, Isolate, Test, Correct. Students learn to gather **critical information from clients before arriving** (e.g., when problems start, any ice, recent work) and perform a **visual inspection** (filter, ice, drain pan, contactor, breaker) before using tools. The lesson condemns guessing or replacing parts without diagnosis.

Key takeaway: *Troubleshooting is a logical process, not random parts changing.*

ANSWERS KEY

Task	Possible Answer
Task 1 – Q1	1. Observe, 2. Verify, 3. Isolate, 4. Test 5. Correct
Task 1 – Q2	Verify power is OFF (LOTO) and wear PPE. Also ask the client questions and visually inspect them.
Task 1 – Q3	False. Adding refrigerant without calculating subcooling and superheating can overcharge the system, damage the compressor, and waste money. Always diagnose before adding.
Task 1 – Q4	Voltage at the load side of the contactor (or check if the contactor's contacts are actually closing). Also check the overload protector and capacitor.
Task 1 – Q5	LOTO (Lock-Out/Tag-Out) and verify with a non-contact voltage tester.
Task 2 – Questions	(1) When did the problem start? (2) Does the unit run at all? (3) Is there ice on the unit? (4) Has anyone worked on it recently? (5) Is the thermostat set to cool? (6) Is the breaker tripped? (7) Is water coming from the unit or from somewhere else? (8) Has there been any recent construction or electrical work?
Task 2 – Visual	(1) Filter condition; (2) Evaporator coil for ice; (3) Drain pan for standing water; (4) Contactor condition; (5) Disconnect and breaker position
Task 3	"Guessing wastes the client's money and damages trust. The technician must follow O-V-I-T-C: first observe and ask questions, then verify basics (power, thermostat, filter), then isolate the control circuit, power circuit, and refrigerant circuit, then test components (contactor, capacitor, overload) before condemning the compressor. Replacing parts without testing is 'parts changing,' not professional troubleshooting."

LEARNING ACTIVITY SHEET (LAS)

Learning Area:	Commercial Air-Conditioning Installation and Servicing		
Lesson Exemplar:	7	**Date:**	
Lesson Title/Topic:	**Tools and Equipment for Troubleshooting**		
Name of Student:		**Grade & Section:**	

Activity Title: Tool Master: Matching Tools to Troubleshooting Tasks

Objective:	Match each troubleshooting tool to its specific function and correctly connect a gauge manifold to a service port.
Tools:	Multimeter (digital and analog), clamp meter, gauge manifold (R-410A and R-22), electronic leak detector, micron gauge, thermometer, psychrometer, anemometer, megohmmeter
PPE:	Safety glasses, gloves, refrigerant gloves
Materials/Devices:	Tool identification chart, service port trainer

Scenario: You are troubleshooting a 15-ton commercial AC with the following symptoms: "Compressor runs, but system has low cooling capacity. No obvious leaks." You need to select the correct tools and use them properly.

Task 1: Tool-Function Matching
Instructions:

1. Match each tool to its primary function.
2. Write the letter of the correct match on the space provided.

Tool	**Function**
_____ 1. Megger	A. Measures air velocity (CFM)
_____ 2. Clamp meter	B. Measures insulation resistance (megohms)
_____ 3. Micron gauge	C. Measures current without disconnecting wires
_____ 4. Anemometer	D. Measures deep vacuum (microns)
_____ 5. Electronic leak detector	E. Finds refrigerant leaks

Short Answer:

6. What is the main difference between a multimeter and a clamp meter?
   Answer: _____

7. True or False: You can use R-22-gauge manifold hoses on an R-410A system. Explain your answer.
   Answer: _____

8. What tool verifies that a vacuum pump has achieved a deep vacuum below 500 microns?
   Answer: _____

Task 2: Tool Station Rotation
Instructions:
Visit each station and perform the required tasks. Record your results.

Station 1: Multimeter
- Measure voltage of a battery (simulated).
- Measure continuity of a wire.
  Result: _____ volts, Continuity: ☐ Yes ☐ No

Station 2: Clamp Meter
- Clamp around a single wire (simulated) and read amperage.
  Result: _____ amps

Station 3: Gauge Manifold
- Connect hoses to a service port trainer without damaging the Schrader valve.
- Practice opening and closing valves.
  Instructor sign-off: _____

Station 4: Megger
- On a practice motor (safe), megger from terminal to ground (instructor supervised).
  Result: _____ MΩ (Pass / Caution / Fail)

Station 5: Leak Detector
- Find a simulated leak (pinprick hole with refrigerant or alcohol).
  Leak found at: _____

Task 3: Inspect Before You Connect
Instructions:

1. Read the scenario below carefully.
2. Write your response to the question.
3. Use at least 3-5 complete sentences.

Scenario: A gauge manifold hose has a small crack. The technician uses it anyway, saying, "It probably won't leak. We're just doing a quick check."

Question: What should you do? Why is tool inspection important? Write your response.

Answer: _____

_____

_____

_____

_____

_____

Synthesis: This lesson matches **specific tools to specific functions**: megger (insulation), clamp meter (current), micron gauge (vacuum), anemometer (air velocity), leak detector (refrigerant leaks). Students practice connecting gauge manifolds safely, using a multimeter, and inspecting tools for damage (e.g., cracked hoses). The lesson highlights the danger of using **R-22 hoses on R-410A systems** (burst risk).

Key takeaway: *Use the right tool correctly and inspect it before every use; damaged tools are a safety hazard.*

ANSWERS KEY

Task	Possible Answer
Task 1 – Matching	1-B, 2-C, 3-D, 4-A, 5-E
Task 1 – Q6	Clamp meter measures current (amps) without disconnecting wires by clamping around one wire. Multimeter measures voltage, resistance, capacitance, and often current (but requires disconnecting wires or using test leads in series).
Task 1 – Q7	False. R-410A operates at much higher pressure (up to 800 psi) than R-22 (up to 400 psi). R-22 hoses can burst under R-410A pressure, causing injury and refrigerant loss.
Task 1 – Q8	Micron gauge
Task 2 – Results	Battery: 9V (or 1.5V); Continuity: Yes; Amperage: 5.2A (sample); Megger: 25 MΩ (Pass); Leak found at: service port connection
Task 3	"Do not use it. A cracked hose can burst under pressure, causing refrigerant loss, environmental harm, and serious injury to your face or hands. Tool inspection before each use is mandatory. Replace the hose immediately. The cost of a new hose is nothing compared to the cost of an injury or a lawsuit. Professionalism means never using damaged tools."

LEARNING ACTIVITY SHEET (LAS)

Learning Area:	Commercial Air-Conditioning Installation and Servicing		
Lesson Exemplar:	21	**Date:**	
Lesson Title/Topic:	**Troubleshooting of Commercial AC Units**		
Name of Student:		**Grade & Section:**	

Activity Title: Fault Finder: Diagnosing Commercial AC Problems

Objective:	Read and interpret a basic schematic wiring diagram and diagnose a given fault using systematic troubleshooting.
Tools:	Multimeter, clamp meter, gauges, thermometer, megger, leak detector
PPE:	Full PPE, LOTO kit
Materials/Devices:	Schematic wiring diagrams, troubleshooting flowcharts, error code tables, AC trainer with fault switches

Scenario: You are called to troubleshoot a 15-ton commercial AC. The complaint: "Compressor runs but system has low cooling capacity. No obvious leaks."

Task 1: Fault Patterns and Diagnosis
Instructions:

1. Match the symptoms to the most likely cause.
2. Write the letter of the correct match on the space provided.

Symptom	**Cause**
_____ 1. Compressor hums, does not start, trips overload after 3 seconds	A. Undercharge or restriction
_____ 2. Compressor runs, low suction + low head pressure	B. Bad run capacitor
_____ 3. Compressor runs continuously, will not shut off	C. Welded contactor
_____ 4. Unit short cycles (runs 2-5 minutes, stops)	D. Dirty filter or low airflow

Short Answer:

5. A compressor runs, but the suction pressure is low, and the head pressure is low. What is the most likely cause?
   Answer: _____

6. What is the legal requirement under the Philippine Clean Air Act regarding refrigerant?
   Answer: _____

7. After repairing a unit, how long should you run it to stabilize before taking final measurements?
   Answer: _____

Task 2: Simulated Fault Diagnosis
Instructions:

1. Your instructor has set up a fault on the AC trainer (or simulated trainer).
2. Follow the O-V-I-T-C method.
3. Use appropriate tools (multimeter, clamp meter, gauges, thermometer).
4. Identify the failed component or condition.
5. Complete the Troubleshooting Report below.

Troubleshooting Report:

Steps	**Your Actions and Findings**
1. Observe (questions asked, visual inspection)	_____
2. Verify (basics checked: thermostat, power, filter)	_____
3. Isolate (control vs. power vs. refrigerant circuit)	_____
4. Test (measurements	_____

Steps	Your Actions and Findings
taken, tools used)	
5. Diagnosis (specific failed component)	_____
Recommended remedy	_____

Task 3: Recover, Never Vent
Instructions:

1. Read the scenario below carefully.
2. Write your response to the question.
3. Use at least 3-5 complete sentences.

Scenario: A technician says, "Venting a little refrigerant is fine. It saves time. The ozone layer is already damaged anyway."

Question: What do you say to this technician? What are the legal and environmental consequences of venting? Write your response.

Answer: _____

_____

_____

_____

_____

_____

Synthesis: This lesson applies **fault pattern recognition** to diagnose common symptoms:

- Low suction + low head pressure → undercharge or restriction
- Compressor hums and trips → bad run capacitor
- Continuous run → welded contactor
- Short cycling → dirty filter or low airflow

Students follow O-V-I-T-C to complete a structured troubleshooting report. The lesson also reinforces the **Philippine Clean Air Act**, which prohibits venting refrigerant and imposes fines up to PHP 500,000.

Key takeaway: *Diagnose before repairing; recover, never vent.*

ANSWERS KEY

Task	Possible Answer
Task 1 – Matching	1-B, 2-A, 3-C, 4-D
Task 1 – Q5	Undercharge or restriction in the liquid line (e.g., clogged filter drier)
Task 1 – Q6	The refrigerant must be recovered, not vented to the atmosphere. Venting is illegal and subject to fines up to PHP 500,000 and possible imprisonment under the Philippine Clean Air Act.
Task 1 – Q7	15-20 minutes (until the system stabilizes)
Task 2 – Report	Observe: Asked when problem started, checked for ice; Verify: Thermostat set to cool, filter dirty, power present; Isolate: Control circuit has 24V, power circuit has voltage; Test: Pressures low side 60 psi, high side 250 psi, subcooling 2°F; Diagnosis: Undercharge due to small leak; Remedy: Locate leak, repair, evacuate, recharge to correct subcooling
Task 3	"Venting refrigerants is illegal, unprofessional, and environmentally destructive. Under the Philippine Clean Air Act, venting carries fines up to PHP 500,000 and possible jail time. Refrigerants damage the ozone layer (CFCs, HCFCs) or contribute to climate change (HFCs). The correct procedure is to use a recovery machine and recovery cylinder. Never vent. Ever."

LEARNING ACTIVITY SHEET (LAS)

Learning Area:	Commercial Air-Conditioning Installation and Servicing		
Lesson Exemplar:	22	**Date:**	
Lesson Title/Topic:	**Commissioning of Commercial Air Conditioning Units**		
Name of Student:		**Grade & Section:**	

Activity Title: Start It Right: Full System Commissioning

Objective:	List the four phases of commissioning and complete a full commissioning checklist for a commercial AC unit.
Tools:	All performance test tools (gauges, multimeter, clamp meter, thermometer, anemometer, psychrometer, leak detector)
PPE:	Full PPE
Materials/Devices:	Commissioning checklist template, manufacturer's startup manual, service report form

Scenario: You have just installed a new 7.5-ton commercial split system. The client requires a signed commissioning report before final payment. You must perform a full commissioning following the manufacturer's specifications.

Task 1: The Four Phases of Commissioning

Instructions:

1. Read each question carefully.
2. Write your answer to the space provided.

Questions:

1. List the four phases of commissioning in order.
   Answer: _____

2. Before applying power, what test verifies that the refrigerant piping has no leaks?
   Answer: _____

3. After starting the unit, how long should you let it run before taking final measurements?
   Answer: _____

4. Why is a client signature on the commissioning checklist important?
   Answer: _____

5. True or False: You can skip reading the manufacturer's manual if you have commissioned similar units before. Explain your answer.
   Answer: _____

Task 2: Complete Commissioning Checklist
Instructions:

1. Using the AC trainer (or simulated data), perform mock commissioning.
2. Complete all sections of the Commissioning Checklist below.
3. Obtain a "client signature" (instructor).
4. Submit the completed report.

Commissioning Checklist:

Phase	Item	Status (Pass/Fail)	Measured Value	Target Value
Pre-Start	All electrical connections tight		N/A	N/A
Pre-Start	System evacuated to <500 microns		_____ microns	<500
Pre-Start	Nitrogen pressure test passed		_____ psi hold	No drop
Pre-Start	Filter installed		N/A	N/A
Pre-Start	Drain line slope verified		N/A	N/A
Start-Up	Contactor pulls in			Yes
Start-Up	Compressor starts			Yes
Start-Up	Condenser fan starts			Yes
Start-Up	Evaporator blower starts			Yes

Phase	Item	Status (Pass/Fail)	Measured Value	Target Value
Operational	Voltage (L1-L2)		_____ V	230V ±10%
Operational	Compressor amperage		_____ A	RLA: _____
Operational	Low side pressure		_____ psi	Per manual
Operational	High side pressure		_____ psi	Per manual
Operational	Subcooling		_____ °F	8-12°F
Operational	Superheat		_____ °F	10-15°F
Operational	Temperature drop (supply-return)		_____ °F	15-20°F
Operational	Drainage flow verified		N/A	Yes
Post-Start	Thermostat cycles unit OFF/ON		N/A	Yes
Post-Start	Client signature obtained		N/A	Yes

Overall Recommendation: _____

Technician's Name: _____ **Date:** _____

Client's Signature: _____

Task 3: Attitude – Commissioning is Not Optional
Instructions:

1. Read the scenario below carefully.
2. Write your response to the question.
3. Use at least 3-5 complete sentences.

Scenario: A building owner says, "Just turn it on. We don't need all that paperwork. I trust you. Commissioning is just a waste of time."

Question: What do you say to the building owner? Why is commissioning essential? Write your response.

Answer: _____

_____

_____

_____

_____

_____

Synthesis: This lesson covers the **four phases of commissioning**: Pre-Start, Start-Up, Operational, and Post-Start. Students complete a full checklist that includes evacuation below 500 microns, nitrogen pressure test, voltage (±10%), subcooling (8–12°F), superheat (10–15°F), temperature drop (15–20°F), and client signature. The lesson rejects skipping commissioning as "waste of time," explaining it protects warranty, verifies safety, and ensures efficiency.

Key takeaway: *Commissioning is not optional—it is the final legal and technical proof of a proper installation.*

ANSWERS KEY

Task	Possible Answer
Task 1 – Q1	1. Pre-Start, 2. Start-Up, 3. Operational, 4. Post-Start
Task 1 – Q2	Nitrogen pressure test (pressurize with nitrogen to 150-300 psi for 24 hours, no pressure drops)
Task 1 – Q3	15-20 minutes (until the system stabilizes)
Task 1 – Q4	Legal proof that commissioning was performed and accepted by the client. It protects the technician's warranty and payment.
Task 1 – Q5	False. Each model may have specific requirements for subcooling, superheat, charging method, and start-up sequence. Always read the manual.
Task 2 – Checklist	Pre-Start: Pass, 220 microns, 250 psi hold no drop; Start-Up: All Pass; Operational: 235V, 18.2A (RLA 18.0), 125 psi, 410 psi, 10°F subcooling, 13°F superheat, 18°F drop; Post-Start: Pass; Recommendation: System commissioned successfully, no issues found. Next maintenance is in 3 months.
Task 3	"Commissioning is not optional. It protects your warranty, ensures the unit operates efficiently, and documents that the installation is correct. Without a signed commissioning report, the manufacturer may deny future warranty claims. This paperwork protects you and me. It also verifies that the system is safe, efficient, and ready for long-term operation. I cannot skip this step. Please sign here after I complete the checks."