

Lesson Exemplars for Commercial Air-Conditioning Installation and Servicing

TECH-PRO ELECTIVE



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LESSON EXEMPLAR			
Learning Area	Commercial Air-Conditioning Installation and Servicing	Lesson Exemplar	1

I. OBJECTIVES	
A. Content Standard	The learner understands the concepts and principles of the Commercial Air-Conditioning unit
B. Performance Standard	The learner performs the installation of the Commercial Air-Conditioning unit with safety precautions.
C. Learning Competencies	1. Perform pre-installation procedure for the commercial air-conditioning units
II. REFERENCES and MATERIALS	<p>References:</p> <ol style="list-style-type: none"> 1. Althouse, A. D., Turnquist, C. H., & Bracciano, A. F. (2020). <i>Modern Refrigeration and Air Conditioning</i> (21st ed.). The Goodheart-Willcox Company, Inc. 2. Technical Education and Skills Development Authority (TESDA). (2021). <i>Training Regulation: Commercial Air-Conditioning Installation and Servicing NC III</i>. TESDA Philippines. <p>Materials & Integration:</p> <ul style="list-style-type: none"> • Tools: Laser distance measurer, tape measure (20m), anemometer, clamp meter, thermo-hygrometer, flashlight, tablet/laptop. • Software: Google Earth (for roof/access visualization), MS Teams/Google Classroom. • PPE: Hard hat, safety vest, safety shoes, gloves.
III. CONTENT	<p>Title: Pre-Installation Procedure: Site Survey for Commercial Air-Conditioning</p> <p>Sub-Topics:</p> <ol style="list-style-type: none"> 1. Assessing Room Size, Layout, and Heat Load. 2. Evaluating Airflow, Ventilation, and Drainage.

	3. Checking Power Supply, Structure, and Maintenance Access. 4. Identifying Codes, Permits, and Safety Hazards (OHS).	
IV. OBJECTIVES	<p>At the end of the lesson, the learners are expected to:</p> <ol style="list-style-type: none"> 1. Identify the nine (9) critical factors in a commercial AC site survey and explain their impact on system performance. 2. Accurately measure a room's dimensions, calculate estimated heat load (BTU/hr.), and document findings using a standard Site Survey Checklist. 3. Demonstrate safety awareness by wearing complete PPE and adhering to Occupational Health and Safety (OHS) protocols during a mock site inspection. 	
V. PROCEDURES		ANNOTATIONS
A. Activating Prior Knowledge	<ol style="list-style-type: none"> 1. Activating Prior Knowledge Teacher Script: "Good morning, class! Before we cool down big commercial spaces, let's remember what you learned in Domestic RAC. Raise your hand and complete this sentence: 'In installing a window-type aircon at home, the most important thing to check before drilling is the _____ because...'" <p>Expected Answers: "Electrical outlet," "wall thickness," "size of the room."</p> <p>Teacher: "Excellent! Today, we will scale that up to 100 times. A small mistake in a mall or office building means millions of losses. Let's begin."</p> 2. Establishing the Purpose of the Lesson Teacher Script: "Imagine you are hired by a new coffee shop owner. You install a 2.5 HP AC. But after installation, the AC keeps shutting down, water drips 	<p>This activity uses scaffolding by bridging prior knowledge (domestic AC) to the new, more complex context (commercial AC). It activates the learner's schema about "pre-installation checks."</p> <p>Uses a problem-posing approach to create a 'need to know.' Connects the lesson directly to professional accountability and financial</p>

	<p>on customers, and the circuit breaker trips every hour. Who is liable?”</p> <p>(Students respond: The installer.)</p> <p>Teacher: “Correct. A Site Survey prevents these disasters. Today, you will learn to be a detective. Your mission: find all the hidden problems BEFORE they happen. This is how you earn trust and avoid costly callbacks.”</p>	<p>consequences, increasing learner engagement.</p>
<p>B. Instituting New Knowledge</p>	<p>1. Presenting Examples Teacher Script: “Look at these two photos. Photo A: A split-type AC unit installed directly above a kitchen deep-fryer. Photo B: An outdoor condenser unit placed in a narrow alley with trash piled against it.”</p> <p>Teacher: “With your partner, discuss: ‘What will happen in 3 months to the units in Photo A and Photo B?’ Write down two predictions.”</p> <p>(Allow 3 minutes of pair work. Call for answers.)</p> <p>Teacher: “Great. Photo A will have oil-clogged filters. Photo B will overheat due to blocked airflow. These are real-world failures from poor site surveys.”</p> <p>2. Discussing New Concept Teacher Script: “Open your notebooks. We will cover the 9 Pillars of Commercial Site Survey. Listen carefully because you will use this checklist in our activity.”</p> <p>Detailed Lecture Guide (Teacher reads or projects):</p>	<p>The use of visual ‘fatal flaw’ analysis activates critical thinking. It allows students to see the <i>consequence</i> of a missing step before learning the step itself, making the theory immediately relevant.</p> <p>This section transforms the curriculum content into a direct, scripted lecture that a teacher can deliver verbatim. It uses real numbers, formulas, and code references (PEC, DENR) to ground the lesson in professional practice. The use of ““your” commands engages the learner directly.</p>

	<p>Pillar 1: Room Size & Layout</p> <p>“Get your laser measure. Record Length x Width x Height. A 20ft x 30ft x 10ft room has 6,000 cubic feet. For commercials, we estimate 25 BTU per cubic foot. Compute: $6,000 \times 25 = 150,000$ BTU/hr. That’s a 12.5 Ton unit. Layout also matters – long, narrow rooms need ductwork, not just a single cassette.”</p> <p>Pillar 2: Heat Load</p> <p>“Not just the room size. Count people (each adds 500 BTU/hr.), computers (each adds 600 BTU/hr.), and windows facing west (adds 30% more). If a server room has 20 computers, that is 12,000 BTU/hr. just from equipment!”</p> <p>Pillar 3: Air Flow & Ventilation</p> <p>“The evaporator (indoor unit) needs 400 CFM per ton. The condenser (outdoor) needs 5 feet of clearance. Never install a condenser where exhaust air recirculates. Use your anemometer to check existing airflow.”</p> <p>Pillar 4: Drainage</p> <p>“A 5-ton AC produces 5 gallons of condensate per hour! Check for floor drains, gravity pitch (1/4” per foot), or a condensate pump. Without proper drainage, you will get ceiling collapse.”</p>	
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	<p>Pillar 5: Insulation</p> <p>“Look for uninsulated walls or single-pane glass. If poor, specify thicker insulation on refrigerant lines (3/4” instead of 1/2”).”</p> <p>Pillar 6: Power Supply</p> <p>“Voltage (208/230V or 460V)? Phase (1 or 3)? Amperage capacity? Use your clamp meter to measure existing loads on the panel. The new AC needs 125% of its rated amps. Violating the Philippine Electrical Code (PEC) is a crime.”</p> <p>Pillar 7: Structure</p> <p>“Is the roof rated for a 200kg condenser? Is the wall concrete or drywall? Use a stud finder or knock test. You cannot hang a 100kg unit on plasterboard.”</p> <p>Pillar 8: Maintenance Access</p> <p>“Can a technician reach the unit to change filters or clean coils? If the unit is above a drop ceiling, you need a removable panel and a ladder space. No access = no service.”</p> <p>Pillar 9: Codes & Permits</p> <p>“Check the local government. Some require a building permit for units above 3 Tons. Check DENR rules for refrigerant type (R-410A or R-32). Also, check the National Building Code for clearances from property lines.”</p>	
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	<p>3. Developing Mastery Teacher Script: “Get into 5 groups. Each group receives a Case Study Card with a floor plan and photos of a problem site (e.g., ‘Restaurant Kitchen,’ ‘School Computer Lab’). Your task: In 10 minutes, identify at least 3 violations of the 9 Pillars and write them on a whiteboard.”</p> <p>Teacher circulates, prompting: “Check Pillar 4 – where does the water go? Look at Pillar 6 – is that a standard outlet?”</p> <p>Group Presentation: Each group stands and says: “In [Site Name], we found violation of Pillar [X] because [Reason].”</p>	<p>Collaborative problem-solving in small groups allows for peer learning and lowers the affective filter. The “case study” approach simulates real-world consulting. The teacher acts as a facilitator, not a lecturer.</p>
<p>C. Demonstrating Knowledge and Skills</p>	<p>1. Finding Practical Application</p> <p>Teacher Script: “Now, you are the expert. Using the Classroom Site Survey Checklist (printed handout), you will survey our very own classroom. Measure the length, width, and height. Estimate the number of computers and lights. Check the nearest wall outlet voltage (using multimeter – teacher supervised). Draw the location of the proposed outdoor unit on the floor plan.”</p> <p><i>Students move around the room with tape measures and checklists. The teacher supervises the use of electrical tools.</i></p> <p>2. Making Generalization</p> <p>Teacher Script: “Three-word summary. On a sticky note, complete this sentence: ‘A good site survey is _____, _____, and _____.’”</p>	<p>This is an authentic assessment. Moving from abstract case studies to the physical learning environment makes the skill tangible. It also reveals hidden challenges (e.g., measuring a high ceiling).</p> <p>This synthesis activity forces students to distill a complex topic into core principles. The sticky note method provides a quick, visual, and formative check.</p>

	<p>(Students post notes on the board. Teacher reads aloud: “Safe, detailed, accurate.” “Legal, logical, accessible.”)</p> <p>Teacher: “Remember: Measure twice, install once. The best service call is the one you never have to make because you surveyed correctly.”</p> <p>3. Evaluating Learning</p> <p>Teacher: “Clear your desks. Get a 1/4 sheet of paper. Number 1 to 5.”</p> <p>Quiz:</p> <ol style="list-style-type: none"> 1. What is the minimum recommended clearance (in feet) around a commercial outdoor condenser unit? 2. A 5-ton commercial AC produces, how many gallons of condensate per hour? 3. If a room has a high heat load from kitchen equipment, which pillar addresses this? 4. Why is it a violation of OHS to install an outdoor unit on an unverified roof? 5. A computer lab has 30 computers (600 BTU/hr. each) and 30 people (500 BTU/hr. each). What is the TOTAL internal heat load from people and equipment? <p>Answer Key:</p> <ol style="list-style-type: none"> 1. 5 feet 2. 5 gallons 3. Heat Load (Pillar 2) 4. Risk of structural collapse / falling hazard. 5. $(30 \times 600 = 18,000) + (30 \times 500 = 15,000) = 33,000$ BTU/hr. 	<p>This is a low-stake formative quiz with a mix of recall (Q1, Q2) and application (Q5). It directly checks the Knowledge objective.</p>
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	<p>4. Additional Activities</p> <p>For Remediation: - Watch a YouTube video titled “Commercial AC Site Survey Gone Wrong” and write a 3-sentence reflection on what the technician missed.</p> <p>For Enrichment: - Using Google Maps, find a commercial building (e.g., Jollibee, 7-Eleven) and identify three potential site survey challenges based on its roof or alleyway. Submit a screenshot with annotations.</p>	<p>Provides differentiated instructions to meet learners where they are. Remediation uses video; enrichment uses real-world digital tools.</p>
VI. ASSESSMENT	<p>Performance Task: <i>The Commercial Site Survey Report</i></p> <p>Scenario: You are a technician from “CoolTech Solutions.” A client (the teacher) wants to install a 5-ton split-type air conditioner in the school’s multi-Purpose Hall. You must conduct a pre-installation site survey.</p> <p>Task: Using the official Site Survey Checklist, complete a one-page Site Survey Report that includes:</p> <ol style="list-style-type: none"> 1. Measured dimensions (LxWxH). 2. Estimated heat load (BTU/hr.) including people, lights, and equipment. 3. Diagram showing proposed indoor unit location (drainage & airflow) and outdoor unit location (clearances & structure). 4. List of three (3) identified risks or code concerns (e.g., “No dedicated 230V outlet,” “Wall is drywall only”). 5. Signature of the technician (student) and the client (teacher). 	

	Rubric for Assessment:					
	Criteria	Excellent (4)	Satisfactory (3)	Developing (2)	Unsatisfactory (1)	Score
	Accuracy of Measurements	All dimensions are precise ($\pm$ 2 inches) and correctly recorded.	Most dimensions are correct with minor errors.	Several measurement errors that would affect unit sizing.	Measurements are missing or completely wrong.	
	Heat Load Calculation	Correctly calculates BTU/hr., including all load factors (people, equipment, sun).	Calculates BTU/hr. but misses 1-2 minor factors.	Major calculation errors or omits a key factor (e.g., people).	No calculations are attempted.	
	Identification of Site Constraints	Identifies 3+ valid risks (drainage, power, structural, code) with specific solutions.	Identifies 2 valid risks.	Identifies 1 risk or risks that are irrelevant.	No risks are identified.	

	OHS & Professionalism	Wear full PPE, use tools safely, and report professionally and signed.	Minor PPE missing; report is legible.	No PPE; the report is messy.	Unsafe behavior, no report.	
	Total (20 pts)					
VII. REFLECTION	<p><i>To be completed by the teacher after the lesson:</i></p> <p>Highlights: Did students actively participate in case study group activity? Which site survey pillar (room size, heat load, airflow, drainage, insulation, power supply, structure, access, codes) was easiest for students to understand?</p> <p>Challenges: Did students struggle with calculating heat load (BTU/hr.) from people and equipment? Were students able to effectively use the laser distance measurer? Did any student forget to check for permits and codes?</p> <p>Adjustments: Should I provide a pre-calculated example before the group activity? Should I create a simplified heat load formula card? Should I invite a building inspector to speak about permits?</p>					
VIII. USE OF GENERATIVE AI	<p>In preparing this Learning Exemplar (LE), the author used Generative AI to assist in structuring and drafting instructional content and assessment items. The author reviewed, edited, and finalized the writing of the content to ensure alignment with curriculum standards and contextual relevance. The author takes full responsibility for the final content of this LE.</p>					

LESSON EXEMPLAR			
Learning Area	Commercial Air-Conditioning Installation and Servicing	Lesson Exemplar	2

I. OBJECTIVES	
A. Content Standard	The learner understands the concepts and principles of the Commercial Air-Conditioning unit.
B. Performance Standard	The learner performs the installation of the Commercial Air-Conditioning unit with safety precautions.
C. Learning Competencies	1. Perform pre-installation procedure for the commercial air-conditioning units
II. REFERENCES and MATERIALS	<p>References:</p> <ol style="list-style-type: none"> 1. Institute of Integrated Electrical Engineers of the Philippines (IIEE). (2017). <i>Philippine Electrical Code (PEC) Part 1, 2017 Edition</i>. IIEE. 2. Althouse, A. D., Turnquist, C. H., & Bracciano, A. F. (2020). <i>Modern Refrigeration and Air Conditioning</i> (21st ed.). The Goodheart-Willcox Company, Inc. <p>Materials & Integration:</p> <ul style="list-style-type: none"> • Tools: Clamp meter (ammeter), multimeter (voltmeter/ohmmeter), wire stripper, combination pliers. • Materials: Sample THHN wires (AWG 14, 12, 10), sample circuit breaker (20A, 30A, 2-pole), NEMA chart poster. • PPE: Insulated gloves, safety glasses, rubber-soled shoes.
III. CONTENT	<p>Title: Electrical Requirements for Commercial Air-Conditioning</p> <p>Sub-Topics:</p> <ol style="list-style-type: none"> 1. Reading Electrical Plans and Layouts (Single Line Diagrams, Legend).

	2. NEMA Enclosure Types and Applications. 3. Selecting Proper Conductors (THHN, THWN) and Sizing per PEC. 4. Overcurrent Protection (Circuit Breakers) and Disconnecting Means.
IV. OBJECTIVES	<p>At the end of the lesson, the learners are expected to:</p> <ol style="list-style-type: none"> 1. Identify the correct NEMA enclosure type for different installation environments (indoor, outdoor, wet/dry). 2. Use the PEC ampacity table, correctly size a copper THHN conductor for a given commercial AC unit (e.g., 30A load). 3. Demonstrate lock-out/tag-out (LOTO) safety discipline when inspecting electrical panels.
V. PROCEDURES	
A. Activating Prior Knowledge	<div> <div> 1. Activating Prior Knowledge Teacher Script: "Quick review." In your Domestic RAC class, what color is the ground wire? What color is neutral? What color is the hot line?" Expected Answers: "Green or bare for ground, white for neutral, black or red for hot." Teacher: "Perfect. Now in commercial AC, we have three-phase power (black, red, blue). And we follow the PEC strictly. Let's go deeper." </div> <div> 2. Establishing the Purpose of the Lesson Teacher Script: "Show of hands: Have you ever plugged too many appliances into one extension cord, and it melted or tripped the breaker?" (Hands go up.) "Now imagine that happening in a bank's server room. A small #14 wire connected to a 5-ton AC unit. The wire becomes a heating element inside the wall. What happens?" </div> </div>
ANNOTATIONS	
<p>This rapid recall activates foundational electrical safety knowledge. It primes students for the more complex three-phase and high-voltage concepts to come.</p> <p>Use an analogy (overloaded extension cord) to explain the deadly consequence of undersized wires. Creates urgency for learning proper sizing.</p>	

	<p>Expected Answer: "Fire."</p> <p>Teacher: "Fire. Loss of life. Jail time for the unlicensed electrician. Today, you will learn to prevent electrical fires."</p>	
<p>B. Instituting New Knowledge</p>	<p>1. Presenting Examples</p> <p>Teacher Script: "I will project three electrical plan symbols." With your elbow partner, guess what they represent.</p> <p>Symbol 1: A circle with a diagonal line (Disconnect switch)</p> <p>Symbol 2: A breaker with "20" inside (20A branch circuit)</p> <p>Symbol 3: A rectangle labeled "MCC" (Motor Control Center)</p> <p>Teacher: "These symbols save space on plans." You must read them fluently.</p> <p>2. Discussing New Concept</p> <p>Teacher Script: "Open your PEC book or handout to Table 3.10.1.16 (Ampacity of Copper Wire)."</p> <p>Detailed Lecture Guide:</p> <p>Topic 1: Plans and Layout</p> <p>"Every commercial job starts with a Single Line Diagram. It shows: (1) Main panel, (2) Feeder wires, (3) Branch circuit breaker, (4) Disconnect near the AC unit, (5) The</p>	<p>Visual recognition of industry-standard symbols (ANSI/IEEE) is a fundamental skill for any HVAC technician reading blueprints.</p> <p>This is a scripted lecture with direct references to the Philippine Electrical Code, which is the legal standard. Students learn to navigate the code book, a critical job skill.</p>

	<p>AC unit itself. The legend tells you what each symbol means. Never guess."</p> <p>Topic 2: NEMA Enclosures</p> <p>"NEMA stands for the National Electrical Manufacturers Association. It tells you where a box can be installed."</p> <ul style="list-style-type: none"> - NEMA 1: Indoor, clean, dry (e.g., junction box inside a closet). - NEMA 3R: Outdoor, rainproof, sleet-resistant (e.g., disconnect box outside a building). - NEMA 4: Watertight, hose-directed (e.g., food processing plant washdown area). - NEMA 4X: Same as 4 but corrosion-resistant (e.g., chemical plant, coastal area). - NEMA 12: Industrial, dust-tight, oil-tight (e.g., factory floor). <p>"If you install a NEMA 1 box outside, rain gets in. Short circuit. Fire. Liability. Match the enclosure to the environment."</p> <p>Topic 3: Conductors</p> <p>"For commercial AC, we use THHN (Thermoplastic High Heat-resistant Nylon) or THWN (same but Wet-rated). THHN is for dry locations. THWN is for wet (conduit outside). Some wires are dual-rated THHN/THWN."</p> <p>"Wire sizing per PEC: For a 30A continuous load (AC compressor), you need 125% of the load. $30A \times 1.25 = 37.5A$. Looking at Table 3.10.1.16, #8 AWG copper THHN at 60°C is rated 40A. So, #8 is the minimum. Never use #10 (30A) for a 30A continuous load – it will overheat."</p>	
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	<p>Topic 4: Devices (Circuit Breakers)</p> <p>"The breaker protects the wire, not the AC unit. The breaker rating must be less than or equal to the wire ampacity. For the #8 wire (40A), you can use a 40A breaker. Some AC units allow a larger breaker to handle in rush current (starting surge) – check the manufacturer's nameplate. It says: 'Max Fuse or Breaker: 45A.' Follow that, not your guess."</p> <p>"Disconnecting means: A visible disconnect switch within sight (50 feet) of the AC unit. You must be able to lock it in the OFF position with a padlock (Lock-out/Tag-out)."</p> <p>3. Developing Mastery</p> <p>Teacher's Script: "Worksheet time." I will give you five (5) commercial AC scenarios. For each, you will specify: (a) Minimum wire size (AWG), (b) Breaker rating, (c) NEMA enclosure type for the disconnect."</p> <p>Example Scenario: "5-ton AC, nameplate: Minimum Circuit Ampacity = 28A, Max Fuse = 45A, installed on a wet rooftop in Manila."</p> <p>Answer: #10 THWN ($28A \times 1.25 = 35A$, #10=35A), 35A or 40A breaker (check local code), NEMA 3R disconnect. The teacher circulates, checking answers.</p>	
C. Demonstrating Knowledge and Skills	<p>1. Finding Practical Application</p> <p>Teacher Script: "We will now go to the shop's electrical panel (de-energized, LOTO applied)."</p>	<p>Guided practice with a structured worksheet allows students to apply code rules in a low-stakes setting before the performance task.</p> <p>Hands-on application in a real (de-energized) environment builds muscle memory. Teacher models Lock-out/Tag-out procedure first – this is non-negotiable for safety.</p>

	<p>Each group will:</p> <ol style="list-style-type: none"> 1. Locate a 2-pole 30A breaker. 2. Trace the conduit to a disconnect box. 3. Identify the wire gauge stamped on the cable jacket. 4. Note the NEMA rating on the box cover." <p>Students complete an "Electrical Field Survey" form with their findings.</p> <p>2. Making Generalization</p> <p>Teacher's Script: "Complete this sentence on your exit ticket: 'If I forget to check the NEMA rating of a disconnect box, the worst thing that could happen is _____.'"</p> <p>Expected Answers: "Water gets in and causes a short circuit," "Someone gets shocked," "The equipment fails."</p> <p>3. Evaluating Learning</p> <p>Teacher: "Get a 1/4 sheet of paper. Numbers 1-5."</p> <p>Quiz:</p> <ol style="list-style-type: none"> 1. What NEMA enclosure rating is required for an outdoor disconnect in a rainy area? 2. For a continuous load (AC compressor), what percentage of the full load current must the wire be sized to (per PEC)? 3. A commercial AC unit has a nameplate Minimum Circuit Ampacity of 45A. What is the MINIMUM AWG copper THHN wire size you can use? (Use PEC: #8=50A, #6=65A) 	<p>Reflective synthesis forces students to internalize the consequence of error, not just the rule.</p> <p>Formative quiz checks recall and application of code requirements.</p>
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	<p>4. True or False: The circuit breaker protects the AC compressor from damage.</p> <p>5. What is the maximum distance (in feet) allowed between an AC unit and its visible disconnect switch?</p> <p>Answer Key:</p> <ol style="list-style-type: none"> 1. NEMA 3R (or 4, 4X) 2. 125% 3. #8 AWG ($45A \times 1.25 = 56.25A$, #6 is 65A, but #8 at 75°C is 50A – some codes allow rounding. Safest: #6. Accept #8 with explanation or #6. 4. False (The breaker protects the WIRE). 5. 50 feet <p>4. Additional Activities</p> <p>Remediation: Watch "Electrical Code Basics for HVAC" on YouTube and list 3 new facts.</p> <p>Enrichment: Research the difference between a "Magnetic" vs "Thermal" circuit breaker and write a one-paragraph explanation of which is better for compressor motors.</p>	<p>Differentiation – video for visual learners, practical research for advanced students.</p>
VI. ASSESSMENT	<p>Performance Task: <i>Electrical Plan Mark-Up</i></p> <p>Scenario: You are given a partial electrical plan (floor plan) for a small commercial office. A 3-ton AC unit will be added. The existing panel has a spare 2-pole 30A breaker.</p> <p>Task: On the plan, draw, and label:</p> <ol style="list-style-type: none"> 1. The new dedicated branch circuit from the panel to the AC location. 2. The type of conduit (EMT or PVC). 3. Wire size and type (e.g., "#10 THHN/THWN"). 	

4. The NEMA-rated disconnect box location.
5. A note specifying the lock-out/tag-out requirement.

Rubric for Assessment:

Criteria	Excellent (4)	Satisfactory (3)	Developing (2)	Unsatisfactory (1)	Score
Conductor Sizing	Correctly sized wire per PEC for a given load.	Minor error (one size off).	Major error (two+ sizes off).	No wire size specified.	
NEMA Selection	Correct NEMA rating for environment.	Acceptable alternative ratings.	Wrong ratings for the environment.	No NEMA specified.	
Disconnect Placement	Within 50 ft, visible, correctly labeled.	Within 50 ft but not clearly visible.	Beyond 50 ft.	No disconnect is shown.	
Code Compliance	All elements follow PEC 2017.	One minor violation.	Two or more violations.	No evidence of code use.	
Total (16 pts)					

VII. REFLECTION	<p><i>To be completed by the teacher after the lesson:</i></p> <p>Highlights: Did the NEMA enclosure matching game effectively help students remember enclosure types? Were students able to correctly identify NEMA 3R vs. NEMA 1 applications?</p> <p>Challenges: Did students struggle with navigating the PEC ampacity table? Were students confused about the difference between MCA and MOP? Did any student forget the 125% continuous load rule?</p> <p>Adjustments: Should I create a simplified one-page "Quick Wire Sizing Chart"? Should I add a color-coded PEC navigation guide? Should I use a mnemonic for MCA/MOP (e.g., "MCA = Minimum wire, MOP = Maximum breaker")?</p>
VIII. USE OF GENERATIVE AI	<p>In preparing this Learning Exemplar (LE), the author used Generative AI to assist in structuring and drafting instructional content and assessment items. The author reviewed, edited, and finalized the writing of the content to ensure alignment with curriculum standards and contextual relevance. The author takes full responsibility for the final content of this LE.</p>

LESSON EXEMPLAR			
Learning Area	Commercial Air-Conditioning Installation and Servicing	Lesson Exemplar	3

I. OBJECTIVES	
A. Content Standard	The learner understands the concepts and principles of the Commercial Air-Conditioning unit
B. Performance Standard	The learner performs the installation of the Commercial Air-Conditioning unit with safety precautions.
C. Learning Competencies	1. Perform pre-installation procedure for the commercial air-conditioning units
II. REFERENCES and MATERIALS	<p>References:</p> <ol style="list-style-type: none"> TESDA. (2021). <i>Training Regulation: Commercial Air-Conditioning Installation and Servicing NC III – List of Tools and Equipment</i>. TESDA Philippines. Whitney, L. (2018). <i>HVACR Troubleshooting Fundamentals</i>. Pearson. <p>Materials & Integration:</p> <ul style="list-style-type: none"> Tools (Physical): Flaring tool, swaging tool, tube cutter, tube benders (lever and spring), service cylinder, vacuum pump, gauge manifold, oxygen-acetylene welding outfit. Materials: Copper tube (1/4", 3/8", 1/2", 5/8" OD), PVC pipe (1/2", 3/4"), rubber insulation foam, silver rod, nitrogen gas cylinder. PPE: Welding goggles, gloves, fire extinguisher (Class B:C).
III. CONTENT	<p>Title: Preparation of Tools, Equipment, and Materials</p> <p>Sub-Topics:</p> <ol style="list-style-type: none"> Fasteners (Dyna bolts, anchors, screws) and their load ratings. Hand tools vs. Power tools for commercial installation. Welding equipment setup (Oxy-Acetylene) and safety. Sealants, insulation types (Armaflex), and PVC drainpipe fittings.

IV. OBJECTIVES	<p>At the end of the lesson, the learners are expected to:</p> <ol style="list-style-type: none"> 1. Identify and describe the function of 10 specialized HVAC tools used in commercial installation. 2. Properly demonstrate the setup of an oxy-acetylene welding torch, including pressure settings and flashback arrestor check. 3. Consistently wear appropriate PPE and maintain a fire watch when using welding equipment.
V. PROCEDURES	ANNOTATIONS
A. Activating Prior Knowledge	<ol style="list-style-type: none"> 1. Activating Prior Knowledge <p>Teacher Script: "Name one tool you used in your Domestic RAC class to connect two copper tubes."</p> <p>Expected Answers: "Flaring tool," "Tube cutter," "Torch."</p> <p>Teacher: "Good. Today, we added 10 more tools to your arsenal. Commercial units are bigger, heavier, and have higher pressure. Your tools must be commercial grades too."</p> 2. Establishing the Purpose of the Lesson <p>Teacher Script: "Imagine you are on a rooftop." It is 2 PM, 35°C. You need to weld a 5/8" copper line. Your flaring tool is only for 1/4" Your torch has no flashback arrestor. Your helper forgot the nitrogen. What happens?</p> <p>Expected Answer: "You can't finish the job," "The pipe oxidizes inside," "Fire."</p> <p>Teacher: "Correct. Preparation is 80% of the job. Today, we prepared."</p> <p>Bridge from prior learning – students already know basic tools (tube cutter, flaring tool). Now they will learn commercial-grade versions.</p> <p>Problem-posing – shows that the wrong tool or missing material stops the job and creates danger.</p>

<p>B. Instituting New Knowledge</p>	<p>1. Presenting Examples</p> <p>Teacher Script: "I will pass around three tools." Pass them around your group. Discuss: What is this tool called? What is it used for?"</p> <p>Tool 1: Swaging tool Tool 2: Service cylinder with two valves (vapor and liquid) Tool 3: Electronic leak detector</p> <p>The teacher collects answers on the board.</p> <p>2. Discussing New Concept</p> <p>Teacher Script: "Open your notebook to the Tools and Materials section." We will cover five categories."</p> <p>Detailed Lecture Guide:</p> <p>Category 1: Fasteners</p> <p>"For commercials, we use Dyna bolts (expansion anchors) for concrete. Size #6, #8, #10 based on weight. A 100kg condenser needs at least four #8 Dyna bolts embedded 1.5 inches into solid concrete. Never use plastic anchors for outdoor units – they crack. For metal frames, use self-tapping screws with neoprene washers to prevent vibration loosening."</p> <p>Category 2: Hand Tools and Power Tools</p> <p>"Hand tools: Tube cutter (use the heavy-duty model, not the small one), lever-type tube bender (for 1/4" to 5/8" – no kinks), service wrench (for valve cores), Allen wrenches (metric AND English – commercial units use both!)."</p> <p>"Power tools: Electric hammer drill (for Dyna bolts), impact driver (for screws), portable band saw (for cutting</p>	<p>Hands-on exploration – tactile learning engages kinesthetic learners and builds curiosity before formal instruction.</p> <p>Structured categorization helps students organize information logically.</p>
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	<p>strut channels), vacuum pump (two-stage, 1/2 HP minimum, 220V). Never use a single-stage pump for commercials – it won't pull below 500 microns."</p> <p>Category 3: Welding Equipment</p> <p>"Oxy-Acetylene setup – memorize this sequence:"</p> <ol style="list-style-type: none"> 1. Check hoses for cracks. 2. Attach flashback arrestors at both regulator and torch. 3. Open oxygen cylinder valve fully. 4. Open acetylene cylinder valve 1/2 turn only. 5. Set oxygen regulator to 40 psi. 6. Set acetylene regulator to 10 psi. 7. Purge hoses. 8. Light torch with striker (never lighter!). 9. Adjust to neutral flame (small white cone)." <p>"The neutral flame prevents soot and oxidation. A carburizing flame (too much acetylene) adds carbon to the copper – weak joint. An oxidizing flame (too much oxygen) burns the copper."</p> <p>Category 4: Sealant and Insulation</p> <p>"For refrigerant line insulation: Closed-cell rubber foam (Armaflex). Thickness: 1/2" for indoor, 3/4" for outdoor, 1" for rooftop exposed to sun. For drain lines: PVC primer and solvent cement. For electrical conduit: Liquid-tight sealant at fittings."</p>	
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	<p>Category 5: PVC Drainpipes and Fittings</p> <p>"Schedule 40 PVC for condensing drains. Sizes: 1/2" for up to 2 tons, 3/4" for 2-5 tons, 1" for 5+ tons. Fittings: Elbows (45° and 90°), tees, couplings, cleanout plugs. Always install a P-trap on the evaporator drain to prevent air suction."</p> <p>3. Developing Mastery</p> <p>Teacher Script: "Tool Matching Game." I will project 15 tool names on the left and 15 descriptions on the right. Your group has 5 minutes to match them. The fastest group with the most correct answers wins a prize." Students race to match (e.g., "Dyna bolt" to "Concrete anchor for outdoor unit").</p>	<p>Gamification increases engagement and reinforces recall of tool names and functions.</p>
<p>C. Demonstrating Knowledge and Skills</p>	<p>1. Finding Practical Application</p> <p>Teacher Script: "Station rotation! You will spend 4 minutes at each of the 4 stations."</p> <p>Station 1 (Cutting & Bending): Cut a 12" piece of 3/8" copper tube, then bend a 90° angle without kinking.</p> <p>Station 2 (Welding Prep): Properly set up the oxy-acetylene torch (no ignition – just setup and pressure check). Instructor checks settings.</p> <p>Station 3 (Fasteners): Drill one hole in a concrete block and install a Dyna bolt.</p> <p>Station 4 (PVC): Cut a 6" piece of 3/4" PVC pipe and glue a 90° elbow. Teachers and assistants circulate to assess and correct.</p>	<p>Station-based learning maximizes hands-on time with limited equipment and ensures every student touches every tool.</p>

	<p>2. Making Generalization</p> <p>Teacher's Script: "One-sentence summary." Complete this: 'I know I am ready for an installation job when all my tools are _____, _____, and _____.'"</p> <p>3. Evaluating Learning</p> <p>Teacher: "Get a 1/4 sheet of paper. Numbers 1-5."</p> <p>Quiz:</p> <ol style="list-style-type: none"> 1. What is the minimum thickness of rubber insulation for an outdoor refrigerant line in direct sunlight? 2. What safety device MUST be installed on both the oxygen and acetylene regulator to prevent flashback? 3. A 5-ton commercial AC requires minimum size PVC drainpipe? 4. What type of flame (neutral, carburizing, or oxidizing) is correct for brazing copper? 5. A Dyna bolt is used for anchoring into what material? <p>Answer Key:</p> <ol style="list-style-type: none"> 1. 3/4 inch 2. Flashback arrestor 3. 3/4 inch (or 1 inch – both acceptable) 4. Neutral flame 5. Concrete <p>4. Additional Activities</p> <p>Remediation: Create flashcards for 15 tools with name on front and function/photo on back.</p> <p>Enrichment: Research the cost of a complete commercial HVAC tool set (catalog or online) and create a budget spreadsheet.</p>	<p>Forced summarization – students articulate their own standard of readiness.</p>
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VI. ASSESSMENT	Performance Task: <i>Tool & Material Pre-Installation Checklist</i>					
	Scenario: You are the lead technician for a commercial installation tomorrow. The site is a 4th-floor rooftop, 40 meters from the service elevator.					
	Task: Complete the official Tool & Material Checklist by:					
	<div><div>1. Listing all tools needed (categorized: hand, power, welding, measuring, safety).</div><div>2. Listing all consumable materials (copper sizes, insulation, PVC, fasteners, refrigerant, nitrogen).</div><div>3. Noting any special considerations (e.g., "Need extension cord for power tools – 50m").</div></div>					
	Rubric for Assessment:					
	Criteria	Excellent (4)	Satisfactory (3)	Developing (2)	Unsatisfactory (1)	Score
	Tool Completeness	All necessary tools listed, correctly categorized.	Missing 1-2 tools.	Missing 5+ tools.	No list or completely wrong.	
	Material Sizing	Correct sizes and quantities specified.	Minor size error.	Major size error.	No materials are listed.	

	Safety Equipment	Includes full PPE, fire extinguisher , and first aid kit.	Missing 1 safety item.	Missing 2+ safety items.	No safety items are listed.	
	Practicality	List considers job constraints (rooftop, distance, power).	Some consideration .	Little consideration.	No consideration.	
	Total (16 pts)					
VII. REFLECTION	<p><i>To be completed by the teacher after the lesson:</i></p> <p>Highlights: Did the station rotation (cutting, welding prep, fasteners, PVC) allow all students in adequate hands-on time? Which station was most popular?</p> <p>Challenges: Did any student skip the flashback arrestor check on the oxy-acetylene setup? Were students able to correctly size Dyna bolts for given weights? Did students struggle with identifying tool names?</p> <p>Adjustments: Should I add a "safety stop" checklist before allowing torch setup? Should I create tool flashcards for remediation? Should I demonstrate the consequence of a missing flashback arrestor (video)?</p>					
VIII. USE OF GENERATIVE AI	<p>In preparing this Learning Exemplar (LE), the author used Generative AI to assist in structuring and drafting instructional content and assessment items. The author reviewed, edited, and finalized the writing of the content to ensure alignment with curriculum standards and contextual relevance. The author takes full responsibility for the final content of this LE.</p>					

LESSON EXEMPLAR			
Learning Area	Commercial Air-Conditioning Installation and Servicing	Lesson Exemplar	4

I. OBJECTIVES	
A. Content Standard	The learner understands the concepts and principles of the Commercial Air-Conditioning unit
B. Performance Standard	The learner performs the installation of the Commercial Air-Conditioning unit with safety precautions.
C. Learning Competencies	1. Perform pre-installation procedure for the commercial air-conditioning units
II. REFERENCES and MATERIALS	<p>References:</p> <ol style="list-style-type: none"> TESDA. (2021). <i>Training Regulation: Commercial Air-Conditioning Installation and Servicing NC III – Unit of Competency: Prepare Bill of Materials</i>. TESDA Philippines. Sullivan, M. (2019). <i>HVACR Business Management and Estimating</i>. Cengage. <p>Materials & Integration:</p> <ul style="list-style-type: none"> Samples: Supplier catalogs (e.g., Wilcon, Ace Hardware, HVAC supply), price lists. Software: Microsoft Excel (or Google Sheets) template for BOM. Tools: Calculator, sample completed BOM from a previous job.
III. CONTENT	<p>Title: Bill of Materials (BOM) Preparation</p> <p>Sub-Topics:</p> <ol style="list-style-type: none"> Identify all required materials from plans and specifications. Quantifying materials (length, count, volume). Sourcing and pricing from suppliers. Formatting a professional BOM (quantity, unit, description, unit cost, total cost).

IV. OBJECTIVES	<p>At the end of the lesson, the learners are expected to:</p> <ol style="list-style-type: none"> 1. Identify the five essential sections of a professional Bill of Materials. 2. Accurately compute the quantity of copper tubing needed for a given installation, accounting for 15% waste factor. 3. Demonstrate accuracy and honesty when estimating material costs for a client quotation. 	
V. PROCEDURES	ANNOTATIONS	
A. Activating Prior Knowledge	<ol style="list-style-type: none"> 1. Activating Prior Knowledge <p>Teacher Script: "When your parents ask you to buy groceries for a birthday party, what do you write down before going to the supermarket?"</p> <p>Expected Answers: "A list," "Items and quantities," "Prices."</p> <p>Teacher: "Exactly. That is a Bill of Materials. Today, we make the professional version – for a commercial AC installation worth PHP 500,000."</p> 2. Establishing the Purpose of the Lesson <p>Teacher Script: "You are bidding for a contract to install 10 split-type AC units in a small hotel." If your BOM is missing 20 meters of 5/8" copper, you must buy it at retail price (double the cost) and pay for rush delivery. Who loses money?</p> <p>Expected Answer: "You do. The installer."</p> <p>Teacher: "Correct. A good BOM protects your profit. A bad BOM destroys it."</p> 	

<p>B. Instituting New Knowledge</p>	<p>1. Presenting Examples</p> <p>Teacher Script: "I will show you two BOMs." BOM A is handwritten on a napkin: 'Copper, insulation, wire, etc.' BOM B is a printed Excel sheet with columns: Qty, Unit, Description, Unit Cost, Total Cost, and a waste factor column."</p> <p>Teacher: "Which one would you give to a bank manager? Which one would you use to buy materials?"</p> <p>2. Discussing New Concept</p> <p>Teacher Script: "Open your BOM template. We will complete it step by step."</p> <p>Detailed Lecture Guide:</p> <p>Step 1: Read the Plans and Specs</p> <p>"Every material starts with the floor plan and the single line diagram. The plan tells you: distance from indoor to outdoor unit (copper length), number of units (quantity), drain line route (PVC length), electrical conduit path (EMT/PVC length). The specification sheet tells you: refrigerant type (R-410A or R-32), insulation thickness, wire gauge."</p> <p>Step 2: List All Categories</p> <p>"A complete BOM has these categories: (1) Refrigerant piping (copper sizes), (2) Fittings (elbows, couplings, flare nuts), (3) Insulation, (4) Drainage (PVC pipes and fittings), (5) Electrical (wires, breakers, disconnects, conduits, boxes), (6) Mounting (brackets, Dyna bolts, vibration isolators), (7) Consumables (silver rod, nitrogen, flux, tape), (8) Refrigerant (kg of R-410A or R-32), (9) Safety and PPE."</p>	<p>Contrasting examples – students immediately see which is professional and which is unacceptable.</p> <p>Step-by-step guided instruction ensures all students follow the same logical process.</p>
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	<p>Step 3: Calculate Quantities</p> <p>"Measure the distance. For copper: straight line distance + 10% for bends + 5% waste = 15% total waste factor. Example: Plan shows 20 meters from condenser to evaporator. $20 \times 1.15 = 23$ meters. Round up to the nearest full roll (rolls are 15m, 30m, 50m). 23m means buying one 30m roll."</p> <p>"For fittings: Count every bend. A 90° bend uses one elbow or one bent tube. For 10 bends, specify 10 elbows OR note '10 field bends. For flare nuts: Each connection needs two nuts (one on each tube)."</p> <p>"For refrigerant: A 5-ton R-410A unit holds approximately 5 kg for a line set up to 15m. Add 0.1 kg per additional meter. Calculation: $5 \text{ kg} + (8 \text{ extra meters} \times 0.1) = 5.8 \text{ kg}$. Round 6 kg."</p> <p>Step 4: Source and Price</p> <p>"Call or check online from three suppliers. Record the lowest price for each item. Do not assume prices – they change weekly. Always ask: 'Do you have a contractor discount?'"</p> <p>Step 5: Format Professionally</p> <p>"Columns: Item No., Description, Brand/Model (if specific), Unit (pcs, meter, roll, kg), Quantity, Unit Cost, Total Cost. Footer: Subtotal, Tax (12% VAT), Grand Total. Header: Project Name, Date, Prepared By."</p> <p>3. Developing Mastery</p> <p>Teacher Script: "Here is a case study: A small restaurant needs one 3-ton split-type AC. Distance from indoor to outdoor: 12 meters. Using the supplier price list, I gave</p>	<p>Application task – students apply the 5 steps to a realistic, scaled-down scenario.</p>
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	<p>you a complete BOM in 15 minutes. Include copper (1/4" and 5/8"), insulation, drainpipe (3/4"), electrical wire (#12 THHN, 15 meters), and refrigerant (R-410A)."</p> <p>Students work individually or in pairs. The teacher circulates.</p>	
<p>3. Demonstrating Knowledge and Skills</p>	<p>1. Finding Practical Application</p> <p>Teacher Script: "Now, you will use the actual floor plan of our school's covered court. I will give you a real supplier price list (from local hardware). Your group will create a BOM for installing TWO 5-ton cassette-type AC units. The distance from each indoor unit to the outdoor unit is 25 meters. You have 20 minutes."</p> <p>Groups present their BOMs to the class for critique.</p> <p>2. Making Generalization</p> <p>Teacher Script: "Complete this statement: 'A Bill of Materials is not just a list; it is a promise of _____, _____, and _____ to the client.'"</p> <p>Expected Answers: "Quality, accuracy, honesty," "Cost, timeline, professionalism."</p> <p>3. Evaluating Learning</p> <p>Teacher: "Get a 1/4 sheet of paper. Numbers 1-5."</p> <p>Quiz:</p> <ol style="list-style-type: none"> 1. What is the standard waste factor percentage added to copper tubing length? 2. List the three main categories of items in a BOM (any three from: piping, fittings, insulation, drainage, electrical, mounting, consumables, refrigerant). 	<p>Authentic assessment – using real floor plan and real prices from local suppliers. This is as close to industry as possible in a classroom.</p> <p>Values integration – BOM is a legal and ethical document, not just a shopping list.</p>

	<p>3. A 4-ton AC unit requires 18 meters of line set. How many kg of R-410A should you estimate if the base charge is 4 kg for 15m plus 0.1 kg per additional meter?</p> <p>4. True or False: You should use last year's price list to estimate costs to save time.</p> <p>5. What column comes after "Quantity" in a standard BOM?</p> <p>Answer Key:</p> <ol style="list-style-type: none"> 1. 15% (10% bends + 5% waste, or just 15%) 2. Any three: Refrigerant piping, Fittings, Insulation, Drainage, Electrical, Mounting, Consumables, Refrigerant 3. 4 kg + (3 x 0.1) = 4.3 kg (round to 4.5 or 5 kg) 4. False 5. Unit (or Unit Cost – either acceptable) <p>4. Additional Activities</p> <p>Remediation: Complete a partially filled BOM by adding the missing 5line items.</p> <p>Enrichment: Create a BOM for a hypothetical 10-unit apartment building using online supplier prices.</p>	
VI. ASSESSMENT	<p>Performance Task: <i>Complete BOM for a Commercial Installation</i></p> <p>Scenario: You are the estimator for "Cool Air Solutions." A client wants a quotation for installing a 10-ton packaged unit (rooftop) at a supermarket. Distance from electrical panel to unit: 30 meters.</p> <p>Task: Using the provided floor plan and spec sheet, create a complete, professional BOM in Excel or Google Sheets. Include all categories. Compute the total cost (including 12% VAT). Submit as a PDF.</p>	

	Rubric for Assessment:					
	Criteria	Excellent (4)	Satisfactory (3)	Developing (2)	Unsatisfactory (1)	Score
	Completeness	All 9 categories included, no missing items.	Missing 1 category or 2-3 items.	Missing 2+ categories.	Skeleton list only.	
	Quantity Accuracy	All quantities are correct with waste factor applied.	Minor errors (10% off).	Major errors (25%+ off).	Random quantities.	
	Cost Accuracy	Correct unit costs, correct extensions, and correct VAT.	Minor math errors.	Major math errors.	No costs or completely wrong.	

		Professional Format	Clean layout, headers, footer, prepared by line.	Acceptable but missing one element.	Messy or missing multiple elements.	Unreadable.	
		Total (16 pts)					
VII. REFLECTION	<p><i>To be completed by the teacher after the lesson:</i></p> <p>Highlights: Did the grocery list analogy help students understand the BOM concept? Were students able to complete the restaurant BOM exercise successfully?</p> <p>Challenges: Did students forget to add the 15% waste factor for copper tubing? Are calculations for refrigerant quantity (base charge + additional per meter) accurate? Did students struggle with Excel or spreadsheet formatting?</p> <p>Adjustments: Should I provide a BOM template with pre-set formulas? Should I add a "waste factor reminder" stamp on all worksheets? Should I demonstrate a real supplier price lookup online?</p>						
VIII. USE OF GENERATIVE AI	<p>In preparing this Learning Exemplar (LE), the author used Generative AI to assist in structuring and drafting instructional content and assessment items. The author reviewed, edited, and finalized the writing of the content to ensure alignment with curriculum standards and contextual relevance. The author takes full responsibility for the final content of this LE.</p>						

LESSON EXEMPLAR			
Learning Area	Commercial Air-Conditioning Installation and Servicing	Lesson Exemplar	5

I. OBJECTIVES	
A. Content Standard	The learner understands the concepts and principles of the Commercial Air-Conditioning unit
B. Performance Standard	The learner performs the installation of the Commercial Air-Conditioning unit with safety precautions.
C. Learning Competencies	2. Perform Installation of Commercial Air-Conditioning Units
II. REFERENCES and MATERIALS	<p>References:</p> <ol style="list-style-type: none"> 1. ASHRAE. (2020). <i>ASHRAE Handbook – HVAC Systems and Equipment</i>. American Society of Heating, Refrigerating and Air-Conditioning Engineers. 2. Carrier Corporation. (2019). <i>Commercial HVAC Product Catalog</i>. Carrier. <p>Materials & Integration:</p> <ul style="list-style-type: none"> • Visuals: Posters or slides of different commercial AC types (packaged, split, VRF, rooftop, cassette, ducted, floor-standing). • Samples: Actual nameplates from old units (cover the serial numbers). • Tools: None required for this theory-heavy lesson.
III. CONTENT	<p>Title: Identification of Commercial Air-Conditioning Units</p> <p>Sub-Topics:</p> <ol style="list-style-type: none"> 1. Types of commercial AC systems (Packaged, Split, VRF/VRV, Rooftop, Cassette, Ducted, Floor-standing). 2. Reading manufacturer specifications (nameplate data: voltage, phase, MCA, MOP, refrigerant type, charge). 3. Matching unit type to application (restaurant, office, server room, hotel, mall).

IV. OBJECTIVES	<p>At the end of the lesson, the learners are expected to:</p> <ol style="list-style-type: none"> 1. Differentiate between at least five (5) types of commercial AC units and their typical applications. 2. Correctly interpret a manufacturer's nameplate to extract voltage, phase, MCA, MOP, and refrigerant type. 3. Value the importance of reading the nameplate before any installation or service work.
V. PROCEDURES	ANNOTATIONS
A. Activating Prior Knowledge	<ol style="list-style-type: none"> 1. Activating Prior Knowledge <p>Teacher Script: "In Domestic RAC, you learned about window type and split type. Raise your hand: What is the main difference?"</p> <p>Expected Answer: "Window type is one piece; split type is indoor and outdoor."</p> <p>Teacher: "Correct. Commercial takes the split concept and adds many variations. Let's explore."</p> 2. Establishing the Purpose of the Lesson <p>Teacher Script: "A hospital operating room needs AC. A restaurant kitchen needs AC. A hotel lobby needs AC. Would you install the SAME type of unit in all three places?"</p> <p>Expected Answer: "No."</p>

	<p>Teacher: "Exactly. If you install a noisy cassette unit in a recording studio, you will fail. Today, you learn to match the right unit to the right space."</p>	
<p>B. Instituting New Knowledge</p>	<p>1. Presenting Examples</p> <p>Teacher Script: "I will project photos of 7 different commercial AC units." On your whiteboard, write: 'Where would you install this?' for each photo."</p> <p>Photo 1: Rooftop packaged unit (RTU) Photo 2: Ceiling cassette (4-way blow) Photo 3: Floor-standing console Photo 4: Ducted concealed unit Photo 5: VRF outdoor unit with multiple indoor units Photo 6: High wall split (but commercial size) Photo 7: Precision AC (server room)</p> <p>The teacher collects and discusses answers.</p> <p>2. Discussing New Concept</p> <p>Teacher Script: "Open your notebook, we will classify commercial AC units by application and configuration."</p> <p>Detailed Lecture Guide:</p> <p>Type 1: Packaged Rooftop Unit (RTU)</p> <p>"All components (compressor, condenser, evaporator, blower) are in one box on the roof. Ductwork distributes air. Pros: No indoor space used, easy service access. Cons: Ductwork cost, heat loss in ducts. Application: Supermarkets, big box stores, schools, and one-story commercial buildings."</p>	<p>Visual classification – students begin pattern recognition before formal definitions.</p> <p>Systematic classification provides a mental framework for remembering unit types.</p>

	<p>Type 2: Split System – Ducted</p> <p>"Condenser outside, evaporator in ceiling plenum, ducts to multiple rooms. Pros: Hidden, quiet indoors. Cons: Ductwork, ceiling space required. Application: Offices, hotels (concealed in corridor ceiling), apartments."</p> <p>Type 3: Split System – Cassette (4-way or 2-way)</p> <p>"Indoor unit mounts flush in ceiling, blows air in 2 or 4 directions. Pros: Good for large open areas, modern look. Cons: Requires drop ceiling, condensate pump often needed. Application: Restaurants, bank lobbies, conference rooms, retail stores."</p> <p>Type 4: Split System – Floor Standing / Console</p> <p>"Indoor unit stands on floor, often against a wall or in a corner. Pros: No ceiling access needed, easy to clean filter. Cons: Takes floor space, can be bumped. Application: Server rooms, older buildings with solid ceilings, hotels (in-room units)."</p> <p>Type 5: Split System – High Wall (Commercial)</p> <p>"Looks like a residential split but larger (2-5 tons). Pros: Inexpensive, easy to install. Cons: Not aesthetic for high-end spaces, drain exposed. Application: Small offices, guard houses, break rooms, IT closets."</p> <p>Type 6: VRF/VRV (Variable Refrigerant Flow/Volume)</p> <p>"One outdoor unit connected to multiple (up to 40+) indoor units of various types (cassette, ducted, wall). Refrigerant flow adjusts to each zone. Pros: Energy efficient, individual zone control, long line set length (up to 150m). Cons: Expensive, complex, requires specialized</p>	
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	<p>training. Application: Hotels (each room in its own zone), office buildings, hospitals, condominiums."</p> <p>Type 7: Precision / Close Control AC</p> <p>"Also called 'Computer Room AC' or 'Server Room AC.' Maintains exact temperature ($\pm 1^{\circ}\text{C}$) and humidity. Run 24/7/365. Pros: Reliable, filters exceptionally fine dust. Cons: Extremely expensive. Application: Data centers, server rooms, telecom shelters, clean rooms."</p> <p>Type 8: Chilled Water System</p> <p>"A chiller (large refrigeration unit) cools water. Water pumps through pipes to fan coil units (FCUs) in each room. Pros: Very efficient for large buildings, long pipe runs. Cons: High initial cost requires mechanical room. Application: Large malls, hospitals, airports, high-rise office buildings (over 10 stories)."</p> <p>Reading the Nameplate</p> <p>"Every unit has a nameplate (metal sticker). You MUST read it before anything else. Key information:"</p> <ol style="list-style-type: none"> 1. Model Number: Tells you size, voltage, and refrigerant. 2. Voltage / Phase / Hz: e.g., 230V / 1 / 60 or 460V / 3 / 60. 3. Minimum Circuit Ampacity (MCA): Minimum wire size. 4. Maximum Overcurrent Protection (MOP): Max breaker or fuse size. 5. Refrigerant Type: R-410A, R-32, R-134a. 6. Charge: Factory charge (kg) and required charge per meter of line set. 7. Design Pressure: High and low side (e.g., 650 psi high side for R-410A). 	
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	<p>8. Manufacturing Date: Warranty and lifespan tracking. "Never guess. If the nameplate is missing or unreadable, contact the manufacturer or reject the job.</p> <p>3. Developing Mastery</p> <p>Teacher Script: "I will give each group a different commercial AC scenario card. Your group will: (1) Identify the BEST unit type for that application, (2) Explain why the other types are NOT suitable."</p> <p>Scenario Examples:</p> <ol style="list-style-type: none"> 1. A 30-story office building with 500 individual offices. (Answer: Chilled water or VRF) 2. A small carinderia (eatery) with no ceiling space. (Answer: Floor standing or high wall split) 3. A bank server room requiring 24/7 cooling with humidity control. (Answer: Precision AC) 4. A school gymnasium with a high ceiling. (Answer: Cassette or ducted) 5. A fast-food restaurant kitchen with grease-laden air. (Answer: Packaged rooftop – ducted away from grease) 	<p>Justification-based learning – students must defend their choice, which deepens understanding.</p>
<p>C. Demonstrating Knowledge and Skills</p>	<p>1. Finding Practical Application</p> <p>Teacher Script: "Nameplate Scavenger Hunt." I have posted 5 fake (but realistic) nameplates around the room. Your task: For each nameplate, write down: Voltage, Phase, MCA, MOP, Refrigerant Type, and one application where this unit could be used."</p>	<p>Simulated real-world task – reading nameplates is a daily task for HVAC technicians.</p>

	<p>Students move around the room, recording data.</p> <p>2. Making Generalization</p> <p>Teacher Script: "Complete this sentence: 'Before I plug in or connect any AC unit, I will always _____ first, because _____.'"</p> <p>Expected Answer: "Read the nameplate," "Because it tells me the electrical and refrigerant requirements."</p> <p>3. Evaluating Learning</p> <p>Teacher: "Get a 1/4 sheet of paper. Numbers 1-5."</p> <p>Quiz:</p> <ol style="list-style-type: none"> 1. What type of commercial AC system is best for a hotel with 100 rooms, each needing individual temperature control? 2. On a nameplate, what does "MCA" stand for, and what does it tell you? 3. A restaurant with no ceiling space and a solid concrete roof needs AC. What two-unit types could work? 4. What is the main difference between a standard split system and a VRF system? 5. A server room requires $\pm 1^{\circ}\text{C}$ temperature control and humidity regulation. What SPECIFIC type of AC is required? 	<p>Safety and professionalism integration – emphasizes the nameplate as the first and most important document.</p>
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	<p>Answer Key:</p> <ol style="list-style-type: none"> 1. VRF/VRV (or chilled water – both acceptable) 2. Minimum Circuit Ampacity – the minimum wire size/ampacity required. 3. Floor-standing console OR high-wall split (or packaged rooftop if roof accessible) 4. VRF can connect multiple indoor units (up to 40+) to one outdoor unit; standard split is one-to-one. 5. Precision / Close Control AC (or Computer Room AC) <p>4. Additional Activities</p> <p>Remediation: Match 10-unit type names to 10 application photos using a drag-and-drop digital activity.</p> <p>Enrichment: Research a real commercial building near your school, identify the AC system type used, and take a photo (with permission) to share in class.</p>	
VI. ASSESSMENT	<p>Performance Task: <i>Unit Selection and Nameplate Interpretation</i></p> <p>Scenario: You are the HVAC consultant for a new 3-story office building. The ground floor is a bank lobby (high ceiling, aesthetic required). The second floor is an open-plan office (50 workstations). The third floor is a server room (24/7 cooling) and a small break room.</p> <p>Task:</p> <ol style="list-style-type: none"> 1. Recommend a specific AC unit type for each floor, justifying your choice. 2. For the server room unit, interpret a provided nameplate and answer: voltage, phase, MCA, MOP, refrigerant type, and factory charge. 	

	Rubric for Assessment:					
	Criteria	Excellent (4)	Satisfactory (3)	Developing (2)	Unsatisfactory (1)	Score
	Unit Selection	Correct type for each application with strong justification.	Correct type but weak justification.	One incorrect type.	Multiple incorrect types.	
	Nameplate Reading	All 6 data points are correctly extracted.	4-5 is correct.	2-3 correct.	0-1 correct.	
	Application Knowledge	Demonstrates clear understanding of the pros/cons of each type.	Some understanding.	Limited understanding.	No understanding.	
	Professional Terminology	Use correct industry terms (VRF, RTU, MCA, MOP, etc.) fluently.	Uses some terms.	A few terms.	No technical terms.	

	Total (16 pts)						
VII. REFLECTION	<p><i>To be completed by the teacher after the lesson:</i></p> <p>Highlights: Did the nameplate scavenger hunt engage students? Were students able to correctly match unit types to applications (restaurant, server room, hotel, etc.)?</p> <p>Challenges: Was the lecture on unit types (VRF, RTU, cassette, ducted, etc.) too long and passive? Did students confuse VRF with standard split systems? Were students able to read all nameplate data correctly?</p> <p>Adjustments: Should I replace the lecture with a "Unit Type Card Sort" activity? Should I invite a VRF manufacturer representative for a guest lecture? Should I create a nameplate reading cheat sheet?</p>						
VIII. USE OF GENERATIVE AI	<p>In preparing this Learning Exemplar (LE), the author used Generative AI to assist in structuring and drafting instructional content and assessment items. The author reviewed, edited, and finalized the writing of the content to ensure alignment with curriculum standards and contextual relevance. The author takes full responsibility for the final content of this LE.</p>						

LESSON EXEMPLAR			
Learning Area	Commercial Air-Conditioning Installation and Servicing	Lesson Exemplar	6

I. OBJECTIVES	
A. Content Standard	The learner understands the concepts and principles of the Commercial Air-Conditioning unit
B. Performance Standard	The learner performs the installation of the Commercial Air-Conditioning unit with safety precautions.
C. Learning Competencies	2. Perform Installation of Commercial Air-Conditioning Units
II. REFERENCES and MATERIALS	<p>References:</p> <ol style="list-style-type: none"> 1. ASHRAE. (2019). <i>ASHRAE Handbook – HVAC Applications</i>. ASHRAE. 2. SMACNA. (2018). <i>HVAC Duct Construction Standards – Metal and Flexible</i>. Sheet Metal and Air Conditioning Contractors National Association. <p>Materials & Integration:</p> <ul style="list-style-type: none"> • Tools: Chalk line, laser level, tape measure, reciprocating saw, hammer drill. • Materials: Strut channels (metal framing), threaded rods, nuts and washers, drop ceiling tiles, sample ceiling grid. • PPE: Safety glasses, dust mask, hard hat (for ceiling work).
III. CONTENT	<p>Title: Cavity Works for Commercial Air-Conditioning</p> <p>Sub-Topics:</p> <ol style="list-style-type: none"> 1. Understanding ceiling cavities (plenum spaces) and their use for HVAC. 2. Layout of unit locations (transferring plans to actual ceiling). 3. Execution of cavity preparation (cutting, reinforcing, access panels).

IV. OBJECTIVES	<p>At the end of the lesson, the learners are expected to:</p> <ol style="list-style-type: none"> 1. Explain what a ceiling plenum is and why it is used for commercial HVAC installation. 2. Accurately transfer unit location marks from a floor plan to an actual ceiling grid using a chalk line and laser level. 3. Work safely at height using ladders or scaffolding and wear appropriate PPE. 	
V. PROCEDURES	ANNOTATIONS	
A. Activating Prior Knowledge	<ol style="list-style-type: none"> 1. Activating Prior Knowledge <i>Teacher Script:</i> "In your home, where is the air conditioner usually mounted? On the wall or window?" <i>Expected Answer:</i> "Yes." <i>Teacher:</i> "In commercial buildings, you often don't see the AC unit at all." It is hidden inside the ceiling. Today, we learned to work in the 'cavity' – the space above the ceiling." 2. Establishing the Purpose of the Lesson <i>Teacher Script:</i> "Imagine you install a beautiful new cassette AC in a bank lobby. But you forgot to check the ceiling cavity. When you cut the hole, you hit a concrete beam. Now what will happen?" <i>Expected Answer:</i> "You can't install it there," "You have to move the unit." <i>Teacher:</i> "Expensive mistakes. Today, you learn to survey and prepare the cavity BEFORE you cut." 	

<p>B. Instituting New Knowledge</p>	<p>1. Presenting Examples</p> <p>Teacher Script: "I will show you a photo of a drop ceiling (exposed grid with tiles). Then a photo of the space ABOVE the tiles – pipes, wires, ductwork, concrete beams."</p> <p>Teacher: "This is the cavity. It is a shared space. You must coordinate with electricians, plumbers, and structural engineers."</p> <p>2. Discussing New Concept</p> <p>Teacher Script: "Open your notebook, cavity work has three phases: Survey, Layout, Execution."</p> <p>Detailed Lecture Guide:</p> <p>Phase 1: Survey the Cavity</p> <p>"Before you even bring a tool to the site, you must access the ceiling cavity. Use a ladder or lift. Remove one ceiling tile. Shine a flashlight. Look for:"</p> <ol style="list-style-type: none"> 1. Obstructions: Concrete beams, fire sprinkler pipes, electrical conduits, existing ductwork, gas lines. You cannot cut through a beam. You must move the unit location." 2. Structural Support: Is there a place to hang the unit? You need threaded rods anchored to the concrete slab above, or strut channels spanning between beams. You cannot hang a 50kg unit from a ceiling tile grid – it will collapse." 3. Drainage Path: Where will the condensate drain go? Does it need a pump? Is there a gravity slope to drain? 4. Access for Service: After installation, can a technician reach the unit to change filters or clean 	<p>Visualization – many students have never seen above a drop ceiling. This reveals the hidden complexity.</p>
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	<p>the coil? You may need a removable ceiling panel or a dedicated access door."</p> <p>Phase 2: Layout</p> <p>"Transfer the plan to the actual ceiling. You will need:"</p> <ol style="list-style-type: none"> Floor plan showing the exact location of each indoor unit (dimensions from walls)." Chalk line or laser level to mark the center point of the unit." Template (some units come with a cardboard cutout)." <p><i>"Steps:</i></p> <ol style="list-style-type: none"> Measure from two reference walls to find the center point. Mark with chalk. Use the unit's mounting dimensions to mark the four corners of the cutout. Snap chalk lines to create a rectangle. Double-check clearance to obstructions above." <p>Phase 3: Execution (Cutting and Preparation)</p> <p>"Only after layout is confirmed do you cut."</p> <ol style="list-style-type: none"> Remove ceiling tiles within the marked rectangle. Set them aside carefully (they are expensive)." Using a reciprocating saw or drywall saw, cut the ceiling grid if needed (some grids are removable without cutting)." Install reinforcement: Strut channels or Unistrut spanning from beam to beam. Secure with threaded rods to the concrete slab using wedge anchors." Install access panels if the unit is above a solid ceiling (drywall). The access panel must be at least the size of the unit's service panel." 	
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	<p>5. Vacuum or clean all debris. Construction dust will clog the new AC filter immediately."</p> <p>Safety Note: "Never work alone in a ceiling cavity." I always have a spotter. Use a hard hat because you will hit your head on the beams. Use a dust mask. Lock out any electrical panels before cutting near wires."</p> <p>3. Developing Mastery</p> <p>Teacher Script: "We will now go to the shop's mock ceiling grid (or use a marked floor area). Your group will:</p> <ol style="list-style-type: none"> Be given a floor plan showing a cassette unit 2 meters from the north wall and 3 meters from the east wall. Using chalk lines, mark the center point and the 600mm x 600mm cutout rectangle. Identify where you would install Strut Channels for hanging." <p>Teacher circulates, checking measurements.</p>	<p>Hands-on simulation – practicing layout on a mock grid builds muscle memory without risking an actual ceiling.</p>
<p>d. Demonstrating Knowledge and Skills</p>	<p>1. Finding Practical Application</p> <p>Teacher Script: "Cavity Obstacle Course." I have set up a mock ceiling cavity with simulated obstructions (ropes for pipes, cardboard boxes for beams, etc.). Your group will:</p> <ol style="list-style-type: none"> Enter the cavity (safely). Identify all obstructions. Propose a new unit location that avoids them. Mark the new location on the floor plan." <p>2. Making Generalization</p> <p>Teacher Script: "Complete this sentence: 'The difference between a good installer and a bad installer is that a good installer checks the _____ before _____.'"</p>	<p>Problem-solving under constraints – simulates real-world conditions where the ideal plan is impossible, and you must adapt.</p> <p>Principle extraction – emphasizes the importance of pre-work inspection.</p>

	<p>Expected Answer: "cavity, cutting."</p> <p>3. Evaluating Learning</p> <p>Teacher: "Get a 1/4 sheet of paper. Numbers 1-5."</p> <p>Quiz:</p> <ol style="list-style-type: none"> 1. What is the first thing you must do before any layout or cutting in a ceiling cavity? 2. Can you hang a 50kg AC unit directly from a standard drop ceiling grid? Why or why not? 3. List three types of obstructions you might find in a ceiling cavity. 4. What tool is used to transfer a straight line across a ceiling for layout? 5. Why is a hard hat required for cavity work? <p>Answer Key:</p> <ol style="list-style-type: none"> 1. Survey the cavity (check for obstructions and structural support). 2. No – the grid is not structural; it will collapse. You must hang from the concrete slab above. 3. Concrete beams, fire sprinkler pipes, electrical conduits, ductwork, gas lines (any three). 4. Chalk line (or laser level). 5. To protect your head from hitting concrete beams or other protruding objects. <p>4. Additional Activities</p> <p>Remediation: Draw a simple cross-section of a ceiling cavity, labeling the slab, beam, grid, tile, and AC unit mounting.</p>	
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	<p>Enrichment: Research the weight limits of different ceiling grid systems (standard vs. heavy-duty) and write a one-page report.</p>													
VI. ASSESSMENT	<p>Performance Task: <i>Cavity Survey and Layout Report</i></p> <p>Scenario: You are the lead installer for a new cassette AC in a classroom with a drop ceiling. The floor plan shows the unit at a specific location.</p> <p>Task:</p> <ol style="list-style-type: none">1. Survey the actual classroom ceiling cavity (teacher will provide a photo or mock setup if actual cavity is inaccessible).2. Complete a Cavity Survey Form listing all obstructions and structural findings.3. Mark the proposed unit location on a printed floor plan.4. List the materials needed for hanging (strut channels, threaded rods, anchors).													
	<p>Rubric for Assessment:</p> <table><tr><th>Criteria</th><th>Excellent (4)</th><th>Satisfactory (3)</th><th>Developing (2)</th><th>Unsatisfactory (1)</th><th>Score</th></tr><tr><td>Obstruction Identification</td><td>All obstructions are correctly identified and noted.</td><td>Most identified.</td><td>Some identified.</td><td>None identified.</td><td></td></tr></table>		Criteria	Excellent (4)	Satisfactory (3)	Developing (2)	Unsatisfactory (1)	Score	Obstruction Identification	All obstructions are correctly identified and noted.	Most identified.	Some identified.	None identified.	
	Criteria	Excellent (4)	Satisfactory (3)	Developing (2)	Unsatisfactory (1)	Score								
Obstruction Identification	All obstructions are correctly identified and noted.	Most identified.	Some identified.	None identified.										

	Layout Accuracy	Marks are precise (± 2 cm).	Minor errors.	Major errors.	No marks or wrong location.	
	Structural Plan	Correct hanging method specified with proper materials.	Acceptable method but minor material error.	Wrong hanging method.	No hanging plans.	
	Safety Awareness	Notes all safety hazards (heights, dust, electrical).	Notes most hazards.	Notes a few hazards.	No safety notes.	
	Total (16 pts)					
VII. REFLECTION	<p><i>To be completed by the teacher after the lesson:</i></p> <p>Highlights: Did the mock ceiling obstacle course effectively simulate real-world constraints? Did students understand why you cannot hang a unit from a drop ceiling grid?</p> <p>Challenges: Did students forget to check for structural support before marking cut outs? Were students able to correctly transfer floor plan dimensions to the ceiling? Did any student fail to identify obstructions (beams, pipes, conduits)?</p> <p>Adjustments: Should I add "Find the beam" as a mandatory first step? Should I provide a cavity survey checklist? Should I use a real ceiling space (if available) instead of a mock-up?</p>					

VIII. USE OF GENERATIVE AI	<p>In preparing this Learning Exemplar (LE), the author used Generative AI to assist in structuring and drafting instructional content and assessment items. The author reviewed, edited, and finalized the writing of the content to ensure alignment with curriculum standards and contextual relevance. The author takes full responsibility for the final content of this LE.</p>
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LESSON EXEMPLAR			
Learning Area	Commercial Air-Conditioning Installation and Servicing	Lesson Exemplar	7

I. OBJECTIVES	
A. Content Standard	The learner understands the concepts and principles of the Commercial Air-Conditioning unit
B. Performance Standard	The learner performs the installation of the Commercial Air-Conditioning unit with safety precautions.
C. Learning Competencies	2. Perform Installation of Commercial Air-Conditioning Units
II. REFERENCES and MATERIALS	<p>References:</p> <ol style="list-style-type: none"> 1. International Code Council (ICC). (2018). <i>International Mechanical Code (IMC)</i>. ICC. 2. TESDA. (2021). <i>Training Regulation: Commercial Air-Conditioning Installation and Servicing NC III</i>. TESDA Philippines. <p>Materials & Integration:</p> <ul style="list-style-type: none"> • Tools: Hammer drill, socket wrench, torque wrench, level, tape measure. • Materials: Dyna bolts (various sizes), threaded rods (3/8" or 1/2"), strut channels (41x41mm), vibration isolators (rubber pads or spring mounts), mounting brackets (L-brackets, wall brackets). • PPE: Safety glasses, gloves, hard hats.
III. CONTENT	<p>Title: Installation of Mounting Support</p> <p>Sub-Topics:</p> <ol style="list-style-type: none"> 1. Frames (strut channel frames, Unistrut systems). 2. Brackets (wall-mounted L-brackets, roof curb adapters). 3. Vibration isolation and leveling. 4. Anchoring concrete, steel, and wood.

IV. OBJECTIVES	<p>At the end of the lesson, the learners are expected to:</p> <ol style="list-style-type: none"> 1. Identify the correct mounting support system for different surfaces (concrete roof, steel beam, exterior wall). 2. Properly install a strut channel frame anchored to concrete using Dyna bolts, with the frame level in both directions. 3. Double-check all anchor torque and stability before releasing the unit onto the support.
V. PROCEDURES	ANNOTATIONS
A. Activating Prior Knowledge	<ol style="list-style-type: none"> 1. Activating Prior Knowledge <p>Teacher Script: In Domestic RAC, how do you mount the outdoor condenser? What holds it to the wall?</p> <p>Expected Answer: "L-shaped metal brackets, screwed into the wall."</p> <p>Teacher: Correct. Now imagine a 200kg commercial condenser on a rooftop. Your little L-brackets will not work. Today, we built industrial strength support.</p> 2. Establishing the Purpose of the Lesson <p>Teacher Script: News headline: 'Air conditioning unit falls from 5th floor, crushes car below.' What caused this?</p> <p>Expected Answer: "Weak mounting," "Wrong anchors," "Rust."</p> <p>Teacher: A falling AC unit can kill. Your mounting support is a life-safety system. We treat it with the seriousness it deserves.</p> <p>Bridge from prior learning – wall brackets for domestic units are the simplest form of mounting support.</p> <p>Dramatic consequence – a real (or plausible) disaster scenario creates immediate engagement.</p>

<p>B. Instituting New Knowledge</p>	<p>1. Presenting Examples</p> <p>Teacher Script: I will show you three mounting systems, tell me which one is for a concrete roof, which is for a steel beam, and which is for a masonry wall.</p> <p>a. System 1: Unistrut frame with spring isolators (rooftop concrete)</p> <p>b. System 2: C-clamps around an I-beam (steel beam)</p> <p>c. System 3: Heavy-duty L-brackets with epoxy anchors (masonry wall)</p> <p>2. Discussing New Concept</p> <p>Teacher Script: Open your notebook; we will cover mounting support by surface type.</p> <p>Detailed Lecture Guide:</p> <p>Surface Type 1: Concrete (Rooftop Slab)</p> <p>"This is the most common commercial installation. The condenser sits on a concrete pad or directly on the roof slab."</p> <p>"Step-by-step concrete mounting:"</p> <p>"1. Position the frame: Place the strut channel frame at the marked location. Frame must be larger than the unit's feet by at least 50mm on each side."</p> <p>"2. Mark anchor holes: Through the frame holes, mark the concrete with a marker or center punch."</p>	<p>Visual discrimination – students must match the system to the substrate.</p>
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	<p>"3. Drill: Use a hammer drill with a carbide bit. Drill depth = anchor length + 6mm. For a 1/2" Dyna bolt (2 inches long), drill 2-1/4 inches deep."</p> <p>"4. Clean the hole: Use a blow gun or vacuum. Dust prevents full expansion."</p> <p>"5. Insert anchor: Drive the Dyna bolt into the hole with a hammer until the threads are flushed with the surface."</p> <p>"6. Set the anchor: Use a torque wrench to tighten the nut to manufacturer's specification (typically 25-30 ft-lbs. for 1/2" anchor). You will feel the expansion sleeve grip."</p> <p>"7. Install vibration isolators: Place rubber pads (neoprene) or spring isolators between the frame and the unit. This prevents noise transmission to the building."</p> <p>"8. Level: Use a level to check the frame in both X and Y axes. Use shims (metal or rubber) under the frame if the concrete is not perfectly flat."</p> <p><i>"Critical rule:</i> Never mount a condenser directly on the concrete without a frame. The unit needs airflow underneath to prevent corrosion and allow drain holes to work."</p> <p>Surface Type 2: Steel Beams (Structural I-Beams)</p> <p>"For rooftop units on steel-framed buildings. You cannot weld without permission (and certification). Use mechanical clamps."</p> <p>"1. Beam clamps: Clamp around the flange of the I-beam. They have a threaded hole for a rod or bolt."</p>	
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	<p>"2. Unistrut clamps: Attach strut channels perpendicular to the beams."</p> <p>"3. Spring isolators: Essential for steel structures because steel transmits vibration very efficiently."</p> <p>Surface Type 3: Masonry Wall (Exterior Wall, Brick or Block)</p> <p>"For wall-mounted condensers when a roof is not available (e.g., ground floor of a building)."</p> <p>"1. Use epoxy anchors or sleeve anchors. Standard Dyna bolts can crack hollow block."</p> <p>"2. L-brackets must be rated for the unit's weight x 4 (safety factor of 4). A 100kg unit needs brackets rated for 400kg."</p> <p>"3. The wall must be inspected for cracks or spalling before mounting."</p> <p>Surface Type 4: Wood (Rare in Commercial – mostly residential)</p> <p>"If you encounter wood (e.g., roof sheathing), use lag screws with washers, not nails. Pre-drill to prevent splitting. Minimum 3/8" diameter lag screw, 3 inches into solid wood (not just plywood)."</p> <p>Frame Types:</p> <p>"1. Strut channel (Unistrut): Versatile, galvanized steel. Can be cut to length. Use spring nuts and bolts."</p>	
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	<p>"2. Square tube steel: Welded frame. Strong but requires fabrication."</p> <p>"3. Prefabricated condenser stand: Adjustable legs, comes as a kit. Expensive but fast."</p> <p>3. Developing Mastery</p> <p>Teacher Script: Mounting Math Challenge. A 5-ton condenser weighs 120kg. The installation is on a concrete rooftop. You have 1/2" Dyna bolts rated at 200kg each in pull-out. The frame has 4 mounting holes. What is the safety factor? Is it acceptable?</p>	<p>Calculation-based mastery – students compute safety factor ($4 \times 200\text{kg} = 800\text{kg}$ capacity / 120kg weight = 6.7 safety factor – acceptable, exceeds the 4x minimum).</p>
C. Demonstrating Knowledge and Skills	<p>1. Finding Practical Application</p> <p>Teacher Script: Shop activity! We have a concrete test block or simulated concrete base. Your group will:</p> <ol style="list-style-type: none"> Position the strut channel frame. Mark and drill TWO holes (not all four for time's sake). Install two Dyna bolts. Torque specs. Verify the level. The instructor will test stability by trying to rock the frame. <p>The teacher demonstrates drilling technique first. Students work in pairs. One drills; one holds vacuum for dust.</p> <p>2. Making Generalization</p> <p>Teacher Script: Complete this sentence: 'A mounting support is only as strong as its _____.'</p>	<p>Authentic hands-on skill – every step of concrete anchoring is practiced. Instructor tests for quality.</p>

	<p>Expected Answer: "Anchor," "Connection to the building," "Base."</p> <p>Teacher: The anchor. If the anchor fails, nothing else matters. Always use the correct anchor for the substrate.</p> <p>3. Evaluating Learning</p> <p>Teacher: "Get a 1/4 sheet of paper. Numbers 1-5."</p> <p>Quiz:</p> <ol style="list-style-type: none"> 1. What tool is used to drill holes in concrete for anchors? 2. Why must you clean the dust out of a drilled anchor hole? 3. What is the purpose of vibration isolators (rubber pads) between the frame and the condenser? 4. A 150kg condenser is mounted on a concrete roof using four anchors each rated at 100kg. What is the safety factor? Is it acceptable? 5. Can you mount a condenser directly on a concrete roof without a frame? Why or why not? <p>Answer Key:</p> <ol style="list-style-type: none"> 1. Hammer drill (with carbide bit). 2. Dust prevents the anchor from expanding fully and gripping the concrete. 3. To prevent vibration and noise from transmitting to the building structure. 	
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	<p>4. Total capacity = $4 \times 100\text{kg} = 400\text{kg}$. Safety factor = $400/150 = 2.67$. Not acceptable (needs 4x or higher). Need stronger anchors.</p> <p>5. No – needs a frame for airflow underneath, drainage, and leveling.</p> <p>4. Additional Activities</p> <p>Remediation: Draw and label a concrete anchor installation showing drill hole, cleaned hole, anchor inserted, nut tightened, expansion sleeve.</p> <p>Enrichment: Research the pull-out strength of anchor types (wedge, sleeve, epoxy) in 2000 psi concrete and make a comparison chart.</p>	
VI. ASSESSMENT	<p>Performance Task: <i>Condenser Mounting Installation</i></p> <p>Scenario: You are installing a 7.5-ton commercial condenser on a concrete rooftop. The unit weighs 180kg. You must provide a stable, level, vibration-isolated mounting.</p> <p>Task:</p> <ol style="list-style-type: none"> 1. Select the correct frame and anchor type. 2. Install the frame on a test concrete block (or mock-up) with four anchors. 3. Torque all anchors to specifications. 4. Verify level in both directions. 5. Submit a Mounting Inspection Report with photos (or sketches) and torque values. 	

	Rubric for Assessment:					
	Criteria	Excellent (4)	Satisfactory (3)	Developing (2)	Unsatisfactory (1)	Score
	Anchor Installation	Holes correctly drilled, cleaned, anchors fully seated and torqued.	Minor issues (e.g., the hole is not fully cleaned).	Major issues (e.g., anchor loose).	Anchors are incorrectly installed or missing.	
	Leveling	Frame level within 1/16" per foot.	Level within 1/8" per foot.	Noticeably unlevel (>1/4").	Not leveled at all.	
	Vibration Isolation	Isolators are placed correctly under all mounting points.	Isolators present but one missing or misaligned.	Isolators present but incorrectly placed.	No isolators.	
	Safety	Uses PPE, follows LOTO, maintains a safe work zone.	Minor PPE lapse.	Multiple safety lapses.	Unsafe behavior.	

	Total (16 pts)						
VII. REFLECTION	<p><i>To be completed by the teacher after the lesson:</i></p> <p>Highlights: Did the hands-on concrete drilling and Dyna bolt installation build student confidence? Did students understand the safety factor requirement (4x weight)?</p> <p>Challenges: Did any student over-torque and strip an anchor? Were students able to select the correct anchor type for different substrates (concrete, steel, masonry, wood)? Did students forget to install vibration isolators?</p> <p>Adjustments: Should I demonstrate torque wrench feel using a "click-type" torque wrench? Should I create a substrate-anchor matching chart? Should I add a "vibration isolator check" to the mounting checklist?</p>						
VIII. USE OF GENERATIVE AI	<p>In preparing this Learning Exemplar (LE), the author used Generative AI to assist in structuring and drafting instructional content and assessment items. The author reviewed, edited, and finalized the writing of the content to ensure alignment with curriculum standards and contextual relevance. The author takes full responsibility for the final content of this LE.</p>						

LESSON EXEMPLAR			
Learning Area	Commercial Air-Conditioning Installation and Servicing	Lesson Exemplar	8

I. OBJECTIVES	
A. Content Standard	The learner understands the concepts and principles of the Commercial Air-Conditioning unit
B. Performance Standard	The learner performs the installation of the Commercial Air-Conditioning unit with safety precautions.
C. Learning Competencies	2. Perform Installation of Commercial Air-Conditioning Units
II. REFERENCES and MATERIALS	<p>References:</p> <ol style="list-style-type: none"> 1. Carrier Corporation. (2019). <i>Installation Instructions – Commercial Split Systems</i>. Carrier. 2. TESDA. (2021). <i>Training Regulation: Commercial Air-Conditioning Installation and Servicing NC III</i>. TESDA Philippines. <p>Materials & Integration:</p> <ul style="list-style-type: none"> • Tools: Laser level, spirit level (24" and 48"), tape measure, chalk line, shims (rubber and metal). • Equipment: Mock AC unit (or cardboard box of similar size), mounting frame. • PPE: Safety glasses, work gloves.
III. CONTENT	<p>Title: Positioning and Aligning Methods</p> <p>Sub-Topics:</p> <ol style="list-style-type: none"> 1. Position indoor and outdoor units per manufacturer for specifications. 2. Aligning units for proper condensate drainage. 3. Leveling techniques (using shims, adjustable feet). 4. Clearance requirements for airflow and service access.

IV. OBJECTIVES	<p>At the end of the lesson, the learners are expected to:</p> <ol style="list-style-type: none"> 1. State the minimum clearance requirements for a commercial condenser (sides, back, top). 2. Accurately position and level a mock AC unit using a laser level and shims, achieving a level within 1/8" over 4 feet. 3. Verify alignment multiple times before final tightening (measure twice, set once). 	
V. PROCEDURES	ANNOTATIONS	
A. Activating Prior Knowledge	<ol style="list-style-type: none"> 1. Activating Prior Knowledge <i>Teacher's Script:</i> "Why does a window AC need to tilt slightly downward toward the outside?" <i>Expected Answer:</i> "So condensate drains out, not inside." <i>Teacher:</i> "Correct. Commercial units also need precise leveling – but for more reasons than just drainage. Let's explore." 2. Establishing the Purpose of the Lesson <i>Teacher Script:</i> "You install a 10-ton split system." You level the indoor unit perfectly. But six months later, the owner complained about water stains on the ceiling. You go back. The unit is now sagging 1/2 inch on one side because the ceiling structure is settled. What happened? <i>Expected Answer:</i> "The building settled," "The mounts loosened." <i>Teacher:</i> "You should have used adjustable hanger rods and re-checked level after 30 days. Today, we learned about precision positioning." 	

<p>B. Instituting New Knowledge</p>	<p>1. Presenting Examples</p> <p>Teacher's Script: "I will show you two photos.</p> <p><i>Photo A:</i> A condenser placed 2 inches from a wall. <i>Photo B:</i> A condenser with 36 inches clearance on all sides.</p> <p>Which one will have high head pressure and short compressor life?"</p> <p>Expected Answer: "Photo A."</p> <p>Teacher: "Why? Airflow is blocked. The condenser cannot reject heat. Today, you learned the clearance rules."</p> <p>2. Discussing New Concept</p> <p>Teacher's Script: "Open your notebook." Positioning is about clearances. Alignment is about leveling."</p> <p>Detailed Lecture Guide:</p> <p>A. Positioning – Outdoor Condenser</p> <p>"Every manufacturer provides clearance requirements. These are MINIMUM distances. More clearance is always better."</p> <p>"Standard clearances for commercial condensers (typical):"</p> <p>"1. Back (coil side): 12 inches (300mm) minimum. 18-24 inches preferred."</p> <p>"2. Sides (non-coil): 6 inches (150mm) minimum. 12 inches preferred."</p>	<p>Visual comparison – students see the consequence of poor positioning.</p>
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	<p>"3. Front (service panel): 36 inches (900mm) minimum for technician access. You must be able to open the panel fully."</p> <p>"4. Top (above fan discharge): 60 inches (1500mm) minimum clearance to any obstruction (overhang, roof parapet)."</p> <p>"5. Between two condensers facing each other: 60 inches minimum. If side-by-side, 24 inches minimum between them."</p> <p><i>B. Positioning – Indoor Unit (Cassette/Ducted)"</i></p> <p>"1. From walls: Centered in the ceiling tile, minimum 12 inches from any wall to allow air return."</p> <p>"2. From light fixtures: 36 inches minimum to prevent heat interference with thermostat."</p> <p>"3. From sprinkler heads: 18 inches minimum (fire code requirement – AC cannot block sprinkler spray pattern)."</p> <p>"4. From supply diffusers: 48 inches minimum to avoid short cycling (supply air going directly into return)."</p> <p><i>"Positioning tools:</i> Laser measure, tape measure, floor plan. Mark the location with a chalk 'X' BEFORE drilling any holes."</p> <p><i>C. Alignment and Leveling</i></p> <p>"Why level matters:"</p> <p>"1. Condensate drainage: The drain pan must slope toward the drain outlet. For cassette units, the unit itself must be</p>	
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	<p>leveled; the drain pump handles the rest. For ducted units, the entire unit must slope 1/4" per foot toward the drain.</p> <p>"2. Compressor oil return: In the outdoor unit, the compressor has oil. If the unit is tilted more than 5 degrees, oil may not return to the compressor properly, leading to bearing failure."</p> <p>"3. Fan operation: The condenser fan blade must spin on a horizontal plane. A tilted unit causes blade wobble and noise."</p> <p>"Leveling methods:"</p> <p>"1. Adjustable feet: Many commercial units have threaded feet. Turn clockwise to raise, counterclockwise to lower. Use wrench or channel locks."</p> <p>"2. Shims: Plastic or rubber wedges. Slide under the low corners. Stack shims if needed. Never use wood (it compresses and rots)."</p> <p>"3. Spring isolators: Some have built-in leveling nuts on the threaded rod."</p> <p>"Leveling process:"</p> <p>"1. Place a 48" spirit level on top of the unit (front-to-back). Adjust until the bubble is centered."</p> <p>"2. Place the level side-to-side. Adjust."</p> <p>"3. Re-check front-to-back (adjusting side-to-side can affect front-to-back)."</p> <p>"4. For precision, use a laser level. Set the laser to project a horizontal line across the unit. Measure from the line to</p>	
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	<p>the top of the unit at each corner. All measurements should be within 1/8"</p> <p>"5. After leveling, tighten all lock nuts to prevent movement."</p> <p>"6. For ceiling-hung units, use a water level (clear tube with water) or laser to ensure all four hanging rods are at the same height."</p> <p>3. Developing Mastery</p> <p>Teacher Script: "Clearance Calculation Exercise." I will give you a floor plan for a rooftop. The plan shows a condenser location. Your task: Measure the distances to the nearest wall, another condenser, and the roof edge. Identify at least two clearance violations."</p>	<p>Applied measurement – students practice reading plans and identifying violations before field work.</p>
<p>D. Demonstrating Knowledge and Skills</p>	<p>1. Finding Practical Application</p> <p>Teacher's Script: "Hands-on: Your group has a mock condenser (cardboard box) and a mounting frame. Using a laser level and shims, position, and level of the unit. Your target: Level within 1/8" over 4 feet in both directions. You have 15 minutes." Students work. The teacher checks each group's level with a master's level.</p> <p>2. Making Generalization</p> <p>Teacher's Script: "Complete this sentence: 'An AC unit that is not level will cause problems with _____, _____, and _____.'"</p> <p>Expected Answers: "Drainage, oil return, fan operation."</p>	<p>Authentic skill practice – leveling is a physical skill that requires repetition. The mock unit allows safe practice.</p> <p>Synthesis – students recall the three main consequences of poor leveling.</p>

	<p>3. Evaluating Learning</p> <p>Teacher: "Get a 1/4 sheet of paper. Numbers 1-5."</p> <p>Quiz:</p> <ol style="list-style-type: none"> 1. What is the minimum clearance required for the service panel on the side of a commercial condenser? 2. What is the maximum allowable tilt angle for a compressor for proper oil return? 3. Why should you never use wooden shims under an outdoor condenser? 4. A cassette indoor unit must be centered in a ceiling tile. What is the minimum distance from a wall? 5. What tool is most precise for leveling a unit across a large distance (e.g., 20 feet)? <p>Answer Key:</p> <ol style="list-style-type: none"> 1. 36 inches (900mm) 2. 5 degrees 3. Wood compresses over time and can rot. 4. 12 inches (300mm) 5. Laser level <p>4. Additional Activities</p> <p>Remediation: Practice leveling a small box on a table using only shims and a bubble level.</p> <p>Enrichment: Research the clearance requirements for a specific real-world commercial condenser model (e.g., Daikin, Mitsubishi, Trane) and create a clearance diagram.</p>	
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VI. ASSESSMENT

Performance Task: *Positioning and Leveling Check*

Scenario: You have installed a 10-ton condenser on a rooftop frame. The manufacturer requires a level within 1/8" over the width (36") and 1/4" over the length (48").

Task:

1. Using a 48" spirit level and a laser level, measure the actual level of the provided mock unit.
2. Record your measurements (front-left, front-right, back-left, back-right relative to a reference line).
3. Add shims as needed to achieve specifications.
4. Submit a **Leveling Report** with before and after measurements.

Rubric for Assessment:

Criteria	Excellent (4)	Satisfactory (3)	Developing (2)	Unsatisfactory (1)	Score
Measurement Accuracy	All 4 corner measurements recorded correctly.	3 corners are correct.	The 2 corners are correct.	No measurements or wrong.	
Leveling Achievement	Achieves spec (<1/8" over 36") in both axes.	Achieves spec in one axis only.	Improves but does not meet specs.	No improvement or worse.	

	Shim Placement	Shims correctly placed and stacked, no wood.	Shims are placed but not optimal.	Wrong shim material.	No shims used.	
	Tool Use	Use laser and spirit levels correctly and safely.	Use tools with minor errors.	Struggles with tool use.	Cannot use tools.	
	Total (16 pts)					
VII. REFLECTION	<p><i>To be completed by the teacher after the lesson:</i></p> <p>Highlights: Did the laser level activity impress students with the precision required? Were students able to achieve a level within 1/8" over 4 feet?</p> <p>Challenges: Did any student think "eyeballing it" was acceptable? Were students confused about clearance requirements (36 inches for service access, 12 inches for coil side)? Did students forget to check drain slopes?</p> <p>Adjustments: Should I implement a "zero tolerance" policy for leveling? Should I create a clearance requirement for a quick reference card? Should I add a drain slope check to the alignment procedure?</p>					
VIII. USE OF GENERATIVE AI	<p>In preparing this Learning Exemplar (LE), the author used Generative AI to assist in structuring and drafting instructional content and assessment items. The author reviewed, edited, and finalized the writing of the content to ensure alignment with curriculum standards and contextual relevance. The author takes full responsibility for the final content of this LE.</p>					

LESSON EXEMPLAR			
Learning Area	Commercial Air-Conditioning Installation and Servicing	Lesson Exemplar	9

I. OBJECTIVES	
A. Content Standard	The learner understands the concepts and principles of the Commercial Air-Conditioning unit
B. Performance Standard	The learner performs the installation of the Commercial Air-Conditioning unit with safety precautions.
C. Learning Competencies	2. Perform Installation of Commercial Air-Conditioning Units
II. REFERENCES and MATERIALS	<p>References:</p> <ol style="list-style-type: none"> 1. Institute of Integrated Electrical Engineers of the Philippines (IIEE). (2017). <i>Philippine Electrical Code (PEC) Part 1, 2017 Edition</i>. IIEE. 2. TESDA. (2021). <i>Training Regulation: Commercial Air-Conditioning Installation and Servicing NC III</i>. TESDA Philippines. <p>Materials & Integration:</p> <ul style="list-style-type: none"> • Tools: Multimeter, clamp meter, wire stripper, crimping tool, screwdrivers (flat and Philips), pliers, conduit bender. • Materials: THHN/THWN wires (various gauges), EMT or PVC conduit, junction boxes, disconnect switch, circuit breaker, wire nuts, electrical tape, cable ties. • PPE: Insulated gloves, safety glasses, voltage tester (non-contact), LOTO kit.
III. CONTENT	<p>Title: Electrical Installation for Commercial Air-Conditioning</p> <p>Sub-Topics:</p> <ol style="list-style-type: none"> 1. Running conduit and pulling wires. 2. Installing disconnect switch and circuit breaker. 3. Making proper connections (wire nuts, crimp terminals, terminal blocks).

	4. Grounding and bonding. 5. Lock-out/Tag-out (LOTO) safety.	
IV. OBJECTIVES	<p>At the end of the lesson, the learners are expected to:</p> <ol style="list-style-type: none"> 1. Explain the purpose of a disconnect switch within the AC unit. 2. Properly install a NEMA 3R disconnect switch, connect THHN wires to the line and load side, and verify the correct torque. 3. Always verify that power is OFF using a non-contact voltage tester before touching any electrical connection. 	
V. PROCEDURES		ANNOTATIONS
A. Activating Prior Knowledge	<ol style="list-style-type: none"> 1. Activating Prior Knowledge <i>Teacher Script:</i> "What is the first thing you do before working on any electrical circuit?" <i>Expected Answer:</i> "Turn off the power," "Lock out/tag out," "Test for voltage." <i>Teacher:</i> "Correct. Today, we applied that rule to commercial AC electrical installation. But now we have 480 volts and three phases. One mistake is fatal." 2. Establishing the Purpose of the Lesson <i>Teacher Script:</i> "You are on a rooftop." The AC is not working. You open the disconnect box. The handle says 'OFF.' Do you trust it?" <i>Expected Answer:</i> "No, test it first." <i>Teacher:</i> "Exactly. A stuck contactor can keep power on even with the handle in OFF. Today, you learn to never trust – always test." 	<p>Safety recall – reinforces the most critical electrical safety habit.</p> <p>Critical thinking – teaches that mechanical indicators can fail.</p>

<p>B. Instituting New Knowledge</p>	<p>1. Presenting Examples</p> <p>Teacher Script: "I will show you three electrical installation photos." Identify the code violation in each."</p> <p><i>Photo 1:</i> Disconnect switch mounted upside down. (Violation: handle should be vertical for ON, horizontal for OFF.)</p> <p><i>Photo 2:</i> Wires entering a box without a bushing. (Violation: sharp edges can cut insulation.)</p> <p><i>Photo 3:</i> A junction box with no cover. (Violation: exposed live parts.)</p> <p>2. Discussing New Concept</p> <p>Teacher's Script: "Open your notebook." We will cover the complete electrical installation sequence."</p> <p>Detailed Lecture Guide:</p> <p>Step 1: Plan the Circuit "From the panel to the disconnect to the AC unit. Follow the single line diagram. Determine:" "a. Wire size (from MCA on nameplate)." "b. Conduit size (40% fill rule – PEC). For three #8 wires, use 3/4" conduit minimum." "c. Breaker size (from MOP on nameplate – never exceed)."</p> <p>Step 2: Install Conduit "a. EMT (Electrical Metallic Tubing): For indoor or protected outdoor. Use a conduit bender for bends. No more than 360 degrees of bend between pull points."</p>	<p>Error identification – students learn by spotting common mistakes.</p>
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	<p>"b. PVC (Rigid Non-Metallic): For underground or corrosive areas. Use PVC cement for joints. Allow to cure before pulling wire."</p> <p>"c. Liquid-tight flexible conduit: For the last 6 feet to the AC unit (vibration isolation)."</p> <p>Step 3: Pull Wires</p> <p>"a. Use fish tape or a vacuum and pull string."</p> <p>"b. Lubricate the wires with wire pulling lubricant (never soap – soap dries and becomes sticky)."</p> <p>"c. Pull all wires at once (line, neutral, ground)."</p> <p>"d. Leave at least 12 inches of extra wire at each box for connections."</p> <p>Step 4: Install Disconnect Switch</p> <p>"a. Mount the disconnect within sight (50 feet) of the AC unit and accessible (not behind the unit)."</p> <p>"b. NEMA 3R for outdoor, NEMA 1 for indoor."</p> <p>"c. Connect line side (incoming power from panel) to the top lugs. Connect load side (to AC unit) to the bottom lugs."</p> <p>"d. Torque all lugs to manufacturer specification (typically 20-30 in-lbs for #10 wire). Overtightening strips threads; undertightening causes arcing and fire."</p> <p>"e. Install the correct fuses if it is a fused disconnect (check MOP rating)."</p> <p>Step 5: Install Circuit Breaker</p> <p>"a. At the main panel, turn off the main breaker (LOTO applied)."</p> <p>"b. Install the correct breaker (2-pole for 230V single phase, 3-pole for 460V three phase)."</p> <p>"c. Connect the wires to the breaker terminals. Torque to spec."</p>	
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	<p>"d. Label the breaker clearly: 'AC UNIT – 5 TON – DISCONNECT AT ROOF.'"</p> <p>Step 6: Make Final Connections at AC Unit</p> <p>"a. Open the AC unit's electrical panel (with power OFF and verified)."</p> <p>"b. Route the conduit into the unit's knock-out using a listed connector (Romex connector or liquid-tight fitting)."</p> <p>"c. Connect line wires to the contactor terminals (L1, L2, L3 if three-phase)."</p> <p>"d. Connect ground wire to the grounding lug."</p> <p>"e. Check all factory connections inside the unit (sometimes they vibrate loose in shipping)."</p> <p>"f. Close and secure the panel."</p> <p>Step 7: Grounding and Bonding</p> <p>"a. The AC unit must be grounded to the building's grounding electrode system."</p> <p>"b. The disconnect box must be bonded to the ground wire."</p> <p>"c. Conduit must be bonded at both ends (using grounding bushings if specified)."</p> <p>"Never: Use the conduit as the ground path. Always pull a separate green or bare ground wire."</p> <p>Step 8: Safety Check Before Power On</p> <p>"a. Visually inspect all connections."</p> <p>"b. Check for loose wires or exposed copper."</p> <p>"c. Use a multimeter to check continuity between ground and line (should be open – no short)."</p> <p>"d. Check resistance between phases (should be balanced)."</p> <p>"e. Apply LOTO tags. Only the authorized person removes them."</p>	
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	<p>3. Developing Mastery</p> <p>Teacher's Script: "Electrical installation sequencing game. I will give each group a set of 10 steps (shuffled). Your task: Arrange them in the correct order from start to finish."</p> <p>Groups race to complete. Teacher reviews the correct sequence.</p>	<p>Sequencing activity – ensures students understand the logical flow of installation, which is critical for safety.</p>
<p>C. Demonstrating Knowledge and Skills</p>	<p>1. Finding Practical Application</p> <p>Teacher's Script: "Shop activity – but with a critical safety rule: No live power. We will use a de-energized mock panel and disconnect. Your group will:"</p> <p>"1. Pull three wires (black, red, green) through a 3-foot piece of conduit." "2. Install the conduit into a disconnect box." "3. Connect the line side (top) and load side (bottom) with proper torque." "4. Install a breaker in a mock panel (de-energized)." "5. Test your connections with a multimeter (continuity)."</p> <p>Teacher inspects each group's work before allowing them to proceed.</p> <p>2. Making Generalization</p> <p>Teacher's Script: "Complete this sentence: 'The most important tool in electrical installation is not a screwdriver – it is a _____.'"</p> <p>Expected Answer: "Voltage tester," "LOTO lock," "Multimeter."</p>	<p>Safe simulation – students practice all skills without risk of electrocution. The muscle memory transfers to real jobs.</p> <p>Values reinforcement – emphasizes that safety tools (tester, LOTO) are more important than installation tools.</p>

	<p>3. Evaluating Learning</p> <p>Teacher: "Get a 1/4 sheet of paper. Numbers 1-5."</p> <p>Quiz:</p> <ol style="list-style-type: none"> 1. What is the maximum distance allowed between an AC unit and its visible disconnect switch? 2. Why should you never use soap as a wire pulling lubricant? 3. What color wire is used for grounding in the Philippine Electrical Code? 4. True or False: You can use the metal conduit as the equipment grounding conductor. 5. What tool do you use to verify that power is OFF before touching any terminal? <p>Answer Key:</p> <ol style="list-style-type: none"> 1. 50 feet 2. Soap dries and becomes sticky, making future pulls difficult or impossible. 3. Green (or bare copper) 4. False – always pull a separate ground wire. 5. Non-contact voltage tester (or multimeter set to voltage) <p>4. Additional Activities</p> <p>Remediation: Practice stripping and terminating THHN wire into a terminal block repeatedly until smooth.</p> <p>Enrichment: Research the difference between a fused and non-fused disconnect switch and write a paragraph explaining when each is required.</p>	
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VI. ASSESSMENT	<p>Performance Task: <i>Complete Electrical Installation (De-energized)</i></p> <p>Scenario: You are installing a 5-ton commercial split system. The disconnect switch must be installed within sight of the unit. The main panel is 40 feet away.</p> <p>Task:</p> <ol style="list-style-type: none">1. Install EMT conduit from the mock panel to the disconnect.2. Pull #10 THHN wires (black, red, green).3. Terminate at the disconnect (line side).4. Install a 30A 2-pole breaker in the mock panel.5. Terminate the wires at the breaker.6. Test for continuity and correct torque.7. Complete an Electrical Installation Checklist signed by the instructor.																
	<p>Rubric for Assessment:</p>																
	<table><tr><th>Criteria</th><th>Excellent (4)</th><th>Satisfactory (3)</th><th>Developing (2)</th><th>Unsatisfactory (1)</th><th>Score</th></tr><tr><td>Conduit Installation</td><td>Conduit properly secured, bends smooth, no kinks, connectors tight.</td><td>Minor issues (one loose strap).</td><td>Multiple issues.</td><td>Conduit not installed or unsafe.</td><td></td></tr></table>						Criteria	Excellent (4)	Satisfactory (3)	Developing (2)	Unsatisfactory (1)	Score	Conduit Installation	Conduit properly secured, bends smooth, no kinks, connectors tight.	Minor issues (one loose strap).	Multiple issues.	Conduit not installed or unsafe.
Criteria	Excellent (4)	Satisfactory (3)	Developing (2)	Unsatisfactory (1)	Score												
Conduit Installation	Conduit properly secured, bends smooth, no kinks, connectors tight.	Minor issues (one loose strap).	Multiple issues.	Conduit not installed or unsafe.													

	Wire Termination	Wires stripped correct length, terminals torqued, no stray strands.	Minor issue (one strand stray).	Multiple issues (loose, over-stripped).	Connections unsafe.	
	Grounding	Ground wire present and properly terminated at all points.	Ground present but one termination loose.	Ground missing at one point.	No ground wire.	
	Safety & LOTO	Demonstrates LOTO, uses voltage tester (simulated), wears PPE.	Missing one safety step.	Missing multiple steps.	No safety practices.	
	Total (16 pts)					
VII. REFLECTION	<p><i>To be completed by the teacher after the lesson:</i></p> <p>Highlights: Did the de-energized panel wiring exercise build confidence? Did students understand the importance of LOTO (Lock-Out/Tag-Out)?</p> <p>Challenges: Was wire stripping length inconsistent (too much or too little exposed copper)? Did students confuse line side and load side on the disconnect? Did any student forget to pull a separate ground wire (using conduit as ground instead)?</p>					

	<p>Adjustments: Should I use wire stripping guides (marked tape on the tool)? Should I color-code line side (red tape) and load side (black tape)? Should I demonstrate the danger of using conduit as ground with a continuity test?</p>
<p>VIII. USE OF GENERATIVE AI</p>	<p>In preparing this Learning Exemplar (LE), the author used Generative AI to assist in structuring and drafting instructional content and assessment items. The author reviewed, edited, and finalized the writing of the content to ensure alignment with curriculum standards and contextual relevance. The author takes full responsibility for the final content of this LE.</p>

LESSON EXEMPLAR			
Learning Area	Commercial Air-Conditioning Installation and Servicing	Lesson Exemplar	10

I. OBJECTIVES	
A. Content Standard	The learner understands the concepts and principles of the Commercial Air-Conditioning unit
B. Performance Standard	The learner performs the installation of the Commercial Air-Conditioning unit with safety precautions.
C. Learning Competencies	2. Perform Installation of Commercial Air-Conditioning Units
II. REFERENCES and MATERIALS	<p>References:</p> <ol style="list-style-type: none"> 1. ASHRAE. (2019). <i>ASHRAE Handbook – HVAC Applications (Insulation Systems)</i>. ASHRAE. 2. Armacell LLC. (2020). <i>Technical Manual – AP/Armaflex Insulation</i>. Armacell. <p>Materials & Integration:</p> <ul style="list-style-type: none"> • Tools: Utility knife, straight edge, tape measure, marker, roller (for adhesive). • Materials: Closed-cell rubber insulation (Armaflex or equivalent) in various sizes (1/2", 5/8", 3/4", 1"), insulation adhesive, PVC tape, zip ties. • Samples: Fiberglass insulation (for comparison – not used in refrigerant lines).
III. CONTENT	<p>Title: Application of Insulation Material</p> <p>Sub-Topics:</p> <ol style="list-style-type: none"> 1. Types of insulation (closed-cell rubber, fiberglass, polyethylene). 2. Specifications (thickness, temperature rating, and UV resistance). 3. Proper installation techniques (cutting, fitting, sealing, and taping). 4. Preventing condensation and energy loss.

IV. OBJECTIVES	<p>At the end of the lesson, the learners are expected to:</p> <ol style="list-style-type: none"> 1. Explain why closed-cell rubber insulation is preferred over fiberglass for refrigerant lines. 2. Properly cut, fit, and seal a piece of closed-cell insulation on a 5/8" copper tube, with all seams facing down and taped with manufacturer-approved tape. 3. Inspect insulation for gaps or damage before finalizing the installation. 	
V. PROCEDURES	ANNOTATIONS	
A. Activating Prior Knowledge	<ol style="list-style-type: none"> 1. Activating Prior Knowledge <i>Teacher's Script:</i> "In Domestic RAC, what is the black foam wrapped around the copper lines called?" <i>Expected Answer:</i> "Insulation," "Armaflex." <i>Teacher:</i> "Yes. But in commercial, insulation is not optional. It is a critical system. Without proper insulation, you get water damage, mold, and high energy bills." 2. Establishing the Purpose of the Lesson <i>Teacher Script:</i> "A restaurant owner calls you: 'Water is dripping from my ceiling onto the customers!' You go to the site. The cold copper line is bare for 2 meters. The hot, humid air hits the cold pipe. What happens?" <i>Expected Answer:</i> "Condensation forms," "Water drips." <i>Teacher:</i> "Exactly. Today, you learn to prevent that embarrassment." 	

<p>B. Instituting New Knowledge</p>	<p>1. Presenting Examples</p> <p>Teacher Script: "I will pass around three insulation samples." Feel them. Squeeze them."</p> <p>Sample 1: Closed-cell rubber (Armaflex) – flexible, dense, smooth skin.</p> <p>Sample 2: Fiberglass pipe wrap – fluffy, itchy, needs outer covering.</p> <p>Sample 3: Polyethylene foam – cheap, less durable, open-cell.</p> <p>Teacher: "Which one would you use outside, exposed to rain?"</p> <p>2. Discussing New Concept</p> <p>Teacher's Script: "Open your notebook." Insulation has one job: keep the pipe's temperature from reaching the surrounding air's dew point."</p> <p>Detailed Lecture Guide:</p> <p>Why Insulate?</p> <p>"The suction line (the large copper line) carries cold gas from the evaporator back to the compressor. Its temperature is typically 40°F to 50°F (4°C to 10°C). In the Philippines, ambient air is often 90°F (32°C) with 80% humidity. The dew point is around 85°F (29°C). When the 45°F pipe touches 85°F humid air, water condenses instantly – like a cold soda can on a hot day. This condensation drips, damages ceilings, grows mold, and rots structures."</p>	<p>Tactile learning – students physically compare materials to understand their properties.</p>
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	<p>"The liquid line (small copper line) is warm (90-110°F). Insulation here prevents heat gain before the refrigerant reaches the expansion valve."</p> <p><i>Types of Insulation for Refrigerant Lines</i></p> <p>"1. <i>Closed-cell rubber (Elastomeric) – BEST</i>"</p> <p>"- Example: Armaflex, K-Flex."</p> <p>"- Closed-cell means each bubble is sealed. The water vapor cannot pass through."</p> <p>"- Built-in vapor barrier (the smooth skin)."</p> <p>"- Temperature range: -40°F to 220°F."</p> <p>"- UV resistant? Only if UV-coated. Standard black Armaflex degrades in sunlight. For outdoor exposed lines, use UV-protected insulation or cover with aluminum or PVC jacket."</p> <p>"2. <i>Polyethylene foam – NOT for refrigerant</i>"</p> <p>"- Open-cell or mixed. Water vapor passes through."</p> <p>"- Becomes brittle in cold temperatures."</p> <p>"- Only for duct insulation or chilled water pipes with a vapor barrier jacket."</p> <p>"3. <i>Fiberglass – NOT for refrigerant</i>"</p> <p>"- Absorbs water when wet. Becomes heavy and useless."</p> <p>"- Requires an outer vapor barrier jacket (canvas or foil)."</p> <p>"- Used for hot pipes (heating) or ductwork, not cold suction lines."</p> <p><i>Thickness Specifications</i></p> <p>"Thickness depends on pipe size and environment:"</p> <p>"- Indoor, dry, air-conditioned space: 1/2" thickness."</p> <p>"- Indoor, unconditioned space (hot attic, garage): 3/4" thickness."</p>	
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	<p>"- Outdoor, exposed to sun and rain: 3/4" thickness + UV protection jacket."</p> <p>"- High humidity areas (pool, laundry, coastal): 1" thickness."</p> <p>"For pipe sizes: 1/4" to 5/8" OD use insulation with matching ID. For 3/4" and larger, insulation is sized by nominal pipe size."</p> <p><i>Proper Installation Technique</i></p> <p>"Step 1: Cut to length"</p> <p>"- Measure the pipe section."</p> <p>"- Use a sharp utility knife. Dull knife tears the foam."</p> <p>"- Cut on a flat surface using a straight edge for straight cuts."</p> <p>"Step 2: Slit the insulation"</p> <p>"- Most insulation comes pre-slit. Open the slit."</p> <p>"- If not pre-slit, cut a straight line along the length."</p> <p>"Step 3: Fit over the pipe"</p> <p>"- Open the slit and wrap around the pipe."</p> <p>"- The slit should face DOWN or to the side – never up. Water running down the pipe will enter an upward-facing slit."</p> <p>"Step 4: Seal the seam"</p> <p>"- Use manufacturer-approved insulation adhesive (not general-purpose glue)."</p> <p>"- Apply a thin bead inside the slit. Press together firmly."</p> <p>"- Then apply PVC tape over the seam, overlapping 50% of the tape width. Stretch the tape slightly as you wrap."</p>	
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	<p>"Step 5: Seal the ends"</p> <p>"- At fittings, valves, and unit connections, use pre-formed fittings or carefully miter-cut the insulation to fit tightly."</p> <p>"- Seal all end joints with tape. Any gap allows air to reach the cold pipe."</p> <p>"Step 6: Protect outdoor insulation"</p> <p>"- For outdoor exposed lines, wrap the insulation with aluminum foil tape or install a PVC jacket."</p> <p>"- Use UV-resistant zip ties every 24 inches to hold the insulation in place."</p> <p><i>"Common mistakes to avoid:"</i></p> <p>"- Using tape alone without adhesive – tape drives and falls off."</p> <p>"- Leaving gaps at elbows – miter-cut 45° angles for 90° bends."</p> <p>"- Insulating only the suction line – both lines need insulation in outdoor runs."</p> <p>"- Crushing the insulation with zip ties – snug, not tight."</p> <p>3. Developing Mastery</p> <p><i>Teacher's Script:</i> "Thickness selection exercise." I will describe 5 installation environments. You will write the minimum insulation thickness required for the suction line."</p> <p>Examples:</p> <p>"1. Basement mechanical room, dry, 70°F. (Answer: 1/2)"</p> <p>"2. Rooftop, Manila, direct sunlight. (Answer: 3/4" + UV jacket)"</p> <p>"3. Pool equipment room, 90% humidity. (Answer: 1)"</p>	<p>Application of specifications – students must match thickness to conditions.</p>
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	<p>"4. Chilled water pipe (not refrigerant) in a crawl space. (Answer: 1/2" to 3/4")"</p> <p>"5. Suction line inside a refrigerated warehouse (already cold). (Answer: None or minimal – but check code)"</p>	
<p>C. Demonstrating Knowledge and Skills</p>	<p>1. Finding Practical Application</p> <p>Teacher's Script: "Hands-on: Each student will receive a 12-inch piece of 5/8" copper pipe and a 12-inch piece of 3/4" insulation (ID 5/8"). Your task:"</p> <p>"1. Cut the insulation to fit exactly (if too long, trim)."</p> <p>"2. Slit it (if not pre-slit)."</p> <p>"3. Fit it onto the pipe with the slit facing down."</p> <p>"4. Apply adhesive to the slit and press closed."</p> <p>"5. Tape the seam with PVC tape (50% overlap)."</p> <p>"6. Tape both ends."</p> <p>"7. Present to instructor for inspection."</p> <p>The teacher inspects each piece. Criteria: slit down, no gaps, tape smooth, ends sealed.</p> <p>2. Making Generalization</p> <p>Teacher Script: "Complete this sentence: 'Insulation is not just for efficiency; it is for _____ prevention.'"</p> <p>Expected Answer: "Condensation," "Water damage," "Mold."</p> <p>3. Evaluating Learning</p> <p>Teacher: "Get a 1/4 sheet of paper. Numbers 1-5."</p>	<p>Skill-building repetition – each student practices the full insulation process.</p> <p>Reframing – insulation is a moisture control device, not just an energy saver.</p>

	<p>Quiz:</p> <ol style="list-style-type: none"> 1. What is the primary problem caused by uninsulated or poorly insulated suction lines in humid climates? 2. Why is closed-cell rubber insulation preferred over fiberglass for refrigerant suction lines? 3. Which way should the slit (seam) face when installing insulation on a horizontal pipe? 4. What minimum thickness is required for outdoor refrigerant lines in direct sunlight in the Philippines? 5. What must be added to standard black rubber insulation when used outdoors? <p>Answer Key:</p> <ol style="list-style-type: none"> 1. Condensation (water dripping, mold, ceiling damage). 2. Closed cells act as a vapor barrier; fiberglass absorbs water and loses insulating value. 3. Down (or to the side – never up). 4. 3/4 inch (with UV jacket). 5. UV protection (UV jacket, aluminum foil tape, or PVC covering). <p>4. Additional Activities</p> <p>Remediation: Practice cutting straight lines on scrap insulation using a sharp knife and straight edge.</p> <p>Enrichment: Research the R-value per inch of different insulation types (closed-cell rubber vs. fiberglass vs. polyiso) and create a comparison chart.</p>	
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VI. ASSESSMENT	Performance Task: <i>Insulation Installation on a Line set</i>					
	Scenario: You have installed a 25-meter line set (suction line 5/8", liquid line 1/4") on a rooftop. The lines are exposed to sun and rain. You must insulate both lines.					
	Task:					
	<div>1. On a mock line set (two pipes parallel), install insulation on both pipes.</div> <div>2. For the suction line (5/8"): 3/4" closed-cell rubber with UV jacket.</div> <div>3. For the liquid line (1/4"): 1/2" closed-cell rubber (less critical but still insulated).</div> <div>4. Seal all seams with adhesive and tape.</div> <div>5. Seal the ends where pipes enter the condenser and evaporator.</div> <div>6. Submit for inspection.</div>					
	Rubric for Assessment:					
	Criteria	Excellent (4)	Satisfactory (3)	Developing (2)	Unsatisfactory (1)	Score
	Material Selection	Correct thickness and type for each pipe and environment.	One pipe is corrected.	Wrong thickness.	Wrong material entirely.	
	Seam Orientation	All seams facing down or side, properly sealed.	Most seams are correct.	Some seams are facing up.	Seams randomly, unsealed.	

	Fit and Coverage	Insulation fits tightly, no gaps, ends sealed.	Minor gaps (<1/8").	Major gaps (>1/4").	Large gaps or missing sections.	
	Taping Quality	Tape 50% overlap, stretched, smooth, no wrinkles.	Acceptable but not perfect.	Poor taping (wrinkles, gaps).	No tape or tape falling off.	
	Total (16 pts)					
VII. REFLECTION	<p><i>To be completed by the teacher after the lesson:</i></p> <p>Highlights: Did the "slit facing down" rhyme help students remember correct orientation? Did students understand why closed-cell rubber is preferred over fiberglass?</p> <p>Challenges: Did students use regular duct tape instead of manufacturer-approved PVC tape? Were there gaps in elbows or fittings? Did students insulate only the suction line and forget the liquid line?</p> <p>Adjustments: Should I remove duct tape from the tool crib during this lesson? Should I demonstrate a miter cut for 90° elbows? Should I add a "both lines" reminder to the checklist?</p>					
VIII. USE OF GENERATIVE AI	<p>In preparing this Learning Exemplar (LE), the author used Generative AI to assist in structuring and drafting instructional content and assessment items. The author reviewed, edited, and finalized the writing of the content to ensure alignment with curriculum standards and contextual relevance. The author takes full responsibility for the final content of this LE.</p>					

LESSON EXEMPLAR			
Learning Area	Commercial Air-Conditioning Installation and Servicing	Lesson Exemplar	11

I. OBJECTIVES	
A. Content Standard	The learner understands the concepts and principles of the Commercial Air-Conditioning unit
B. Performance Standard	The learner performs the installation of the Commercial Air-Conditioning unit with safety precautions.
C. Learning Competencies	2. Perform Installation of Commercial Air-Conditioning Units
II. REFERENCES and MATERIALS	<p>References:</p> <ol style="list-style-type: none"> 1. International Code Council (ICC). (2018). <i>International Mechanical Code (IMC) – Chapter 13: Condensate Disposal</i>. ICC. 2. TESDA. (2021). <i>Training Regulation: Commercial Air-Conditioning Installation and Servicing NC III</i>. TESDA Philippines. <p>Materials & Integration:</p> <ul style="list-style-type: none"> • Tools: PVC pipe cutter or hacksaw, deburring tool, PVC primer and cement, tape measure, level, marker. • Materials: PVC pipe (1/2", 3/4", 1"), PVC fittings (elbows, tees, couplings, cleanout tee), condensate pump (sample), tubing (vinyl), hose clamps. • PPE: Safety glasses, gloves (for PVC cement), respirator (for primer fumes).
III. CONTENT	<p>Title: Installation of Condensate Drain</p> <p>Sub-Topics:</p> <ol style="list-style-type: none"> 1. Positioning the drain outlet and slope requirements. 2. Sizing the drainpipe per unit capacity.

	3. Installing P-traps and vents. 4. Condensate pumps when gravity drainage is impossible. 5. Testing the drain for leaks and flow.
IV. OBJECTIVES	<p>At the end of the lesson, the learners are expected to:</p> <ol style="list-style-type: none"> 1. State the required slope for a gravity condensate drain (1/4" per foot). 2. Properly assemble a PVC condensate drain line with a P-trap, cleanout tee, and proper slope to a termination point. 3. Test every drain with water before leaving the job site.
V. PROCEDURES	
A. Activating Prior Knowledge	<div> <div> 1. Activating Prior Knowledge <i>Teacher Script:</i> "In your home window AC, where does the water go?" How does it get out? <i>Expected Answer:</i> "Drips outside," "Drain hole at the back." <i>Teacher:</i> "Yes. But a commercial AC can produce 5-10 gallons per hour. You cannot just let it drip. You must pipe it to a drain. Today, we learned about condensate drainage." </div> <div> 2. Establishing the Purpose of the Lesson <i>Teacher's Script:</i> "News headline: 'Ceiling collapses at 5-star hotel due to AC drain leak.' The hotel loses millions in room revenue and pays a huge lawsuit. The cause? A missing P-trap that allowed air to suck water out of the drain pan." <i>Expected Answer:</i> (Shock, attention.) </div> </div>
ANNOTATIONS	
<p>Bridge from prior learning – students know that AC produces water; now they learn to manage it professionally.</p> <p>High-stakes consequence – shows that drainage is not trivial; it is a liability issue.</p>	

	<p>Teacher: "Today, you learn to build drains that never leak and never clog."</p>	
<p>B. Instituting New Knowledge</p>	<p>1. Presenting Examples</p> <p>Teacher Script: "I will show you two drain installations."" <i>Photo A:</i> A drainpipe that slopes upward (backwards). <i>Photo B:</i> A drainpipe with a P-trap and a cleanout tee. Which one works? Which one will clog?"</p> <p>Expected Answer: "Photo B works; Photo A will not drain."</p> <p>Teacher: "Why does Photo A fail? Water cannot flow uphill. Slope is everything."</p> <p>2. Discussing New Concept</p> <p>Teacher Script: "Open your notebook." Condensate drainage is simple physics: water flows downhill. But there are rules."</p> <p>Detailed Lecture Guide:</p> <p>How Much Water?</p> <p>"A commercial AC produces approximately 0.1 to 0.2 gallons per hour per ton of cooling. A 10-ton unit produces 1 to 2 gallons per hour. In high humidity (Philippines), it can be double that – up to 4 gallons per hour from a 10-ton unit."</p> <p>Sizing the Drain Pipe</p> <p>"- Up to 3 tons: 1/2" PVC or vinyl tube."</p>	<p>Visual error identification – students learn by seeing what NOT to do.</p>

	<p>"- 3 to 5 tons: 3/4" PVC."</p> <p>"- 5 to 10 tons: 1" PVC."</p> <p>"- Over 10 tons: 1-1/4" or larger (per manufacturer)."</p> <p>"Always use PVC for commercial. Vinyl tube is for small residential only – it kinks and collapses."</p> <p>Slope Requirements</p> <p>"Minimum slope: 1/4 inch per foot (2% grade)."</p> <p>"Example: If the drain outlet is 10 feet from the termination point, the termination point must be 2.5 inches LOWER than the outlet (10 ft x 0.25 in/ft = 2.5 in)."</p> <p>"Maximum slope: No maximum, but too steep can cause water to splash inside the pipe."</p> <p>"Horizontal runs: Must be supported every 4 feet to prevent sagging. Sagging creates low spots that trap water and grow algae."</p> <p>P-Trap Requirements</p> <p>"What is a P-trap? A U-shaped bend in the drain pipe that holds water. The water blocks air from being sucked back into the drain pan."</p> <p>"Why needed? The evaporator fan creates negative pressure (suction) inside the drain pan. Without a P-trap, the fan will suck air up the drain pipe, preventing water from flowing out. Water backs up and overflows the pan."</p> <p>"Installation: The P-trap must be installed as close to the evaporator drain outlet as possible. The trap depth (vertical</p>	
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	<p>height of the U) should be at least 2 inches. For high-static units (ductwork), trap depth may need to be 4 inches or more."</p> <p>"Exception: If the evaporator is on the positive pressure side of the fan (e.g., some package units), no trap is needed. Check the manual."</p> <p>Cleanout Tee</p> <p>"Install a tee with a removable cap (cleanout) after the P-trap. Algae and mold will grow in the drain over time. The cleanout allows you to insert a brush or blow compressed nitrogen into clear clogs."</p> <p>Termination Points</p> <p>"Where does the water go?"</p> <p>"- Floor drain: Best option. Terminate with an air gap (pipe ends 1 inch above the drain). Do not insert the pipe into the drain – it can siphon the trap."</p> <p>"- Outside grade: Terminate at least 12 inches from the building foundation. Do not let the water pool near the footing."</p> <p>"- Condensate pump: Used when no gravity drain is available (basement, interior room). The pump collects water and pumps it up to a drain."</p> <p>"Never terminate: Into a sink (cross-contamination), into a sewer without a trap (sewer gas), or onto a roof (standing water damages the membrane)."</p>	
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	<p>Condensate Pump Installation</p> <p>"If the AC is below the drain (basement) or far from any drain, install a condensate pump."</p> <p>"1. Mount the pump near the AC unit (check valve accessible)."</p> <p>"2. Connect the AC drain pan outlet to the pump inlet with vinyl tube."</p> <p>"3. Run the pump discharge tube (1/2" vinyl) up and over to a sink or floor drain."</p> <p>"4. The discharge tube must have a check valve (built into most pumps) to prevent backflow."</p> <p>"5. Connect the pump's safety switch (if equipped) to the AC control circuit. If the pump fails and water level rises, the switch shuts off the AC to prevent overflow."</p> <p>Testing the Drain</p> <p>"Before leaving the job:"</p> <p>"1. Pour 1 liter of water into the drain pan (use a funnel)."</p> <p>"2. Watch the termination point. Water should flow within 10 seconds."</p> <p>"3. Check all joints for leaks. Dry joints (no water) indicate a glue failure."</p> <p>"4. Listen for gurgling (indicates a venting problem – add a vent tee)."</p> <p>"5. For pumps: Pour water to trigger the pump. Verify the pump turns on and discharges."</p>	
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	<p>3. Developing Mastery</p> <p>Teacher Script: "Drain slope calculation." A 10-ton AC is installed in a basement. The floor drain is 25 feet away. The drain outlet is 12 inches above the floor. The floor drain is at the floor level. Can gravity drain work? If not, what do you need?"</p> <p>Answer: "Slope needed = 25 ft x 0.25 in/ft = 6.25 inches drop. Outlet is at 12 inches, termination at 0 inches = 12 inches drop. 12 > 6.25, so YES gravity works. (But need to ensure the pipe can run without obstructions.)"</p>	<p>Math application – students calculate slopes and determine if gravity is possible.</p>
<p>4. Demonstrating Knowledge and Skills</p>	<p>1. Finding Practical Application</p> <p>Teacher's Script: "Shop activity: Your group will build a working condensate drain mock-up. You have:"</p> <p>"- A mock drain pan outlet (a fitting at a set height)." "- A target termination point (bucket or floor drain mock-up) 10 feet away and 3 inches lower."</p> <p>"Your task: Assemble a 3/4" PVC drain line with a P-trap and cleanout tee. The line must have continuous slope (no sags). After assembly, pour water through and verify flow."</p> <p>The teacher inspects each assembly before the water test. Students observe flow.</p> <p>2. Making Generalization</p> <p>Teacher Script: "Complete this sentence: 'If you leave a job without testing the condensate drain, you are gambling with _____.'"</p>	<p>Authentic assembly – students cut, glue, and assemble a real drain line.</p> <p>Risk awareness – emphasizes that untested drains are a liability.</p>

	<p>Expected Answer: "Ceiling damage," "Mold," "Lawsuit," "The client's property."</p> <p>3. Evaluating Learning</p> <p>Teacher: "Get a 1/4 sheet of paper. Numbers 1-5."</p> <p>Quiz:</p> <ol style="list-style-type: none"> 1. What is the minimum slope required for a gravity condensate drain (in inches per foot)? 2. What is the purpose of a P-trap on an evaporator drain? 3. A 5-ton AC requires, what minimum PVC drainpipe size? 4. Where should the cleanout tee be installed? 5. When is a condensate pump required? <p>Answer Key:</p> <ol style="list-style-type: none"> 1. 1/4 inch per foot 2. To prevent air from being sucked back into the drain pan (blocks negative pressure). 3. 3/4 inch (1 inch is also acceptable) 4. After the P-trap (between trap and termination) 5. When gravity drainage is impossible (unit below drain, long horizontal runs without slope) <p>4. Additional Activities</p> <p>Remediation: Draw a labeled diagram of a condensate drain system showing drain pan, P-trap, cleanout, slope, termination.</p>	
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	Enrichment: Research the function of a condensate overflow safety switch and explain how to wire it into a 24V control circuit.												
VI. ASSESSMENT	Performance Task: <i>Condensate Drain Installation and Test</i>												
	Scenario: You are installing a 7.5-ton cassette AC in a restaurant ceiling. The drain pan outlet is 8 inches above the ceiling grid. The nearest floor drain is 20 feet away, at the floor level.												
	Task: <div><div>1. Design a gravity drain system (PVC) with the correct slope.</div><div>2. Assemble the system on a mock setup or draw a detailed isometric diagram.</div><div>3. Include a P-trap and cleanout tee.</div><div>4. Calculate the exact drop needed.</div><div>5. Test with water (on mock setup) and document flow.</div><div>6. Submit a Drain Installation Report with measurements and test results.</div></div>												
	Rubric for Assessment: <table><tr><th>Criteria</th><th>Excellent (4)</th><th>Satisfactory (3)</th><th>Developing (2)</th><th>Unsatisfactory (1)</th><th>Score</th></tr><tr><td>Slope Calculation</td><td>Correct drops calculated and implemented.</td><td>Minor math errors.</td><td>Major math errors.</td><td>No slope calculations.</td><td></td></tr></table>		Criteria	Excellent (4)	Satisfactory (3)	Developing (2)	Unsatisfactory (1)	Score	Slope Calculation	Correct drops calculated and implemented.	Minor math errors.	Major math errors.	No slope calculations.
Criteria	Excellent (4)	Satisfactory (3)	Developing (2)	Unsatisfactory (1)	Score								
Slope Calculation	Correct drops calculated and implemented.	Minor math errors.	Major math errors.	No slope calculations.									

	P-Trap Installation	Trap correctly installed near outlet, depth correct.	Trap present but depth off.	Trap missing components.	No trap.	
	Cleanout	Cleanout tee with removable cap installed.	Cleanout present but cap missing.	Cleanout in the wrong location.	No cleanout.	
	Water Test	Water flows freely, no leaks, and termination is correct.	Minor drip or slow flow.	Significant leak or blockage.	No test is performed or complete failure.	
	Total (16 pts)					
VII. REFLECTION	<p><i>To be completed by the teacher after the lesson:</i></p> <p>Highlights: Did the water flow test (pouring water into the drain pan) give students satisfaction in seeing their work function? Did students understand the purpose of the P-trap?</p> <p>Challenges: Was the P-trap depth requirement (2 inches minimum) frequently ignored? Did students forget to install a cleanout tee? Did any student terminate the drain improperly (e.g., directly into a sewer without an air gap)?</p> <p>Adjustments: Should I provide a P-trap template (pre-cut cardboard U-shape)? Should I add "cleanout tee" as a mandatory line item on the BOM? Should I show photos of proper vs. improper drain terminations?</p>					

VIII. USE OF GENERATIVE AI	<p>In preparing this Learning Exemplar (LE), the author used Generative AI to assist in structuring and drafting instructional content and assessment items. The author reviewed, edited, and finalized the writing of the content to ensure alignment with curriculum standards and contextual relevance. The author takes full responsibility for the final content of this LE.</p>
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LESSON EXEMPLAR			
Learning Area	Commercial Air-Conditioning Installation and Servicing	Lesson Exemplar	12

I. OBJECTIVES	
A. Content Standard	The learner understands the concepts and principles of the Commercial Air-Conditioning unit
B. Performance Standard	The learner performs the installation of the Commercial Air-Conditioning unit with safety precautions.
C. Learning Competencies	2. Perform Installation of Commercial Air-Conditioning Units
II. REFERENCES and MATERIALS	<p>References:</p> <ol style="list-style-type: none"> 1. ASHRAE. (2020). <i>ASHRAE Handbook – HVAC Systems and Equipment (Testing and Balancing)</i>. ASHRAE. 2. TESDA. (2021). <i>Training Regulation: Commercial Air-Conditioning Installation and Servicing NC III</i>. TESDA Philippines. <p>Materials & Integration:</p> <ul style="list-style-type: none"> • Tools: Gauge manifold (R-410A/R-32 compatible), digital clamp meter, digital thermometer (thermocouple type), anemometer, digital micron gauge, electronic leak detector, psychrometer (humidity meter). • Equipment: Nitrogen cylinder with regulator, vacuum pump. • PPE: Safety glasses, gloves, refrigerant-rated gloves (for cold burns).
III. CONTENT	<p>Title: Performance Test of Air Conditioning Unit</p> <p>Sub-Topics:</p> <ol style="list-style-type: none"> 1. Power source requirements and verification. 2. Insulation resistance test (megger). 3. Pressure and temperature measurements (saturation, subcooling, superheat).

	4. Amperage draws vs. nameplate. 5. Air velocity and airflow (CFM). 6. Sound and vibration measurement. 7. Leak test (nitrogen pressure test, vacuum test, electronic detection). 8. Calibration and adjustment of controls.	
IV. OBJECTIVES	At the end of the lesson, the learners are expected to: <ol style="list-style-type: none"> 1. Explain the target ranges for subcooling (8-12°F) and superheat (10-15°F) for R-410A systems. 2. Perform a complete performance test on a running AC unit, measuring voltage, amperage, pressures, temperatures, and air velocity, and record findings on a standardized checklist. 3. Never add refrigerant without first calculating subcooling or superheat. 	
V. PROCEDURES		ANNOTATIONS
A. Activating Prior Knowledge	<ol style="list-style-type: none"> 1. Activating Prior Knowledge <i>Teacher Script:</i> "In Domestic RAC, how do you know if an AC is cooling properly? What do you measure?" <i>Expected Answer:</i> "Temperature of the air coming out," "Is it cold?" <i>Teacher:</i> "That tells you SOMETHING, but not enough. A unit can blow cold air but is still overcharged, undercharged, or has poor airflow. Today, we measure EVERYTHING." 2. Establishing the Purpose of the Lesson <i>Teacher's Script:</i> "You install a new AC. It cools. The client pays you. Three months later, the compressor failed. The manufacturer denies warranty because 'improper refrigerant charge.' You have no proof of the 	<p>Bridge from prior learning – students know basic performance checks; now they learn the full commercial commissioning process.</p> <p>Real-world liability – shows that performance testing is not optional; it is your legal protection.</p>

	<p>correct charge. Who pays for a new PHP 50,000 compressor?</p> <p>Expected Answer: "You do."</p> <p>Teacher: "Correct. Your performance test report is your proof. Today, you learned to document everything."</p>	
<p>B. Instituting New Knowledge</p>	<p>1. Presenting Examples</p> <p>Teacher Script: "I will show you three performance test reports." <i>Report A:</i> Blank – 'Seems okay.' <i>Report B:</i> Has numbers but no target ranges. <i>Report C:</i> Complete with measured values, target ranges, and pass/fail for each test.</p> <p>Which one would you like in court?</p> <p>Expected Answer: "Report C."</p> <p>2. Discussing New Concept</p> <p>Teacher's Script: "Open your notebook." We will perform a complete performance test in 9 steps.</p> <p>Detailed Lecture Guide:</p> <p>Step 1: Safety First – LOTO and PPE</p> <p>"Before touching anything: LOTO the disconnect. Verify that power is OFF. Wear safety glasses and gloves. Refrigerants can cause frostbite."</p> <p>Step 2: Verify Power Source</p> <p>"At the disconnect (line side, with power ON – careful!), measure voltage between L1 and L2 (single phase) or L1-</p>	<p>Documentation quality comparison – teaches professional standards for record-keeping.</p>

	<p>L2, L2-L3, L3-L1 (three phases). Voltage should be within $\pm 10\%$ of the nameplate. For 230V unit: 207V to 253V acceptable. For 460V unit: 414V to 506V."</p> <p>"Also check for voltage imbalance on three-phase: (Max deviation from average / average) x 100% should be less than 2%."</p> <p>Step 3: Insulation Resistance Test (Megger)</p> <p>"With power OFF, disconnect the wires from the compressor terminals. Use a megohmmeter (megger) set to 500V DC. Measure resistance between each terminal and ground (C to ground, S to ground, R to ground). Resistance should be > 10 megohms. Lower than 1 megohm indicates moisture or damaged insulation – do not start the compressor."</p> <p>Step 4: Start the Unit and Measure Running Amperage</p> <p>"Restore power. Start the AC. Use a clamp meter on one of the line wires (L1). Measure compressor amperage (RLA – Rated Load Amps) and fan motor amperage (FLA). Compare to nameplate. Should be within $\pm 10\%$ of nameplate RLA. High amperage indicates overcharge, tight bearings, or low voltage. Low amperage indicates undercharge or poor compression."</p> <p>Step 5: Measure Pressures and Temperatures (Gauge Manifold)</p> <p>"Connect the gauge manifold to the service ports (high side and low side). Use hoses rated for R-410A (high pressure – 800 psi)."</p> <p>"Low side (suction) pressure: Typically, 110-140 psi for R-410A at 75°F indoors. Corresponds to saturation temperature of 35-45°F."</p>	
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	<p>"High side (discharge) pressure: Typically, 350-450 psi for R-410A at 95°F outdoors. Corresponds to saturation temperature of 100-120°F."</p> <p>"Measure line temperatures: Attach thermocouple probes to the suction line (near the service valve) and liquid line (near the service valve). Insulate the probes from ambient air."</p> <p>Step 6: Calculate Subcooling</p> <p>"Subcooling = Liquid saturation temperature (from high side pressure) – Liquid line temperature."</p> <p>"Example: High side pressure = 400 psi. For R-410A, 400 psi = saturation temp 110°F. Liquid line temperature = 100°F. Subcooling = 110 – 100 = 10°F."</p> <p>"Target subcooling: Typically, 8-12°F for TXV systems. Fixed orifice systems have lower subcooling (5-8°F). Always check the manufacturer manual."</p> <p>"If subcooling is too LOW: Undercharge. Add the refrigerant."</p> <p>"If subcooling is too HIGH: Overcharge or restriction (filter drier)."</p> <p>Step 7: Calculate Superheat</p> <p>"Superheat = Suction line temperature – Saturation temperature (from low side pressure)."</p> <p>"Example: Low side pressure = 130 psi. For R-410A, 130 psi = saturation temperature 40°F. Suction line temperature = 55°F. Superheat = 55 – 40 = 15°F."</p>	
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	<p>"Target superheat: Typically, 10-15°F for TXV systems. For fixed orifices, use a target superheat chart based on outdoor and indoor conditions."</p> <p>"If superheat is too LOW: Overcharge or TXV stuck open. Liquid may flood back to the compressor."</p> <p>"If superheat is too HIGH: Undercharge or TXV stuck closed / low airflow."</p> <p>Step 8: Measure Air Velocity and Airflow</p> <p>"At the supply air grille, use an anemometer. Take 5 measurements across the grille and average. Calculate CFM = Average velocity (ft/min) x Area of grille (sq ft)."</p> <p>"Target CFM: 400 CFM per ton. A 5-ton unit should move 2000 CFM ±10%."</p> <p>"Low CFM indicates dirty filter, undersized duct, or fan speed too low."</p> <p>Step 9: Leak Test</p> <p>"After all measurements, shut down the unit. With the unit still pressurized (or after recovering refrigerant), perform an electronic leak detection scan on all brazed joints, flare connections, and valve stems. If a leak is found, recover refrigerant, repair, evacuate, and recharge."</p> <p>"Also check for sound and vibration. Unusual noise indicates loose panels, misaligned fans, or bad compressors."</p>	
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	<p>Step 10: Calibration and Adjustment</p> <p>"Adjust the thermostat setpoint and verify that the unit cycles off at the setpoint. Calibrate the thermostat if needed (some have offset adjustment)."</p> <p>"For units with electronic expansion valves (EEV), check that the valve is modulating correctly."</p> <p>Complete the Performance Test Report</p> <p>"All measurements go into a report. If any measurement is out of range, note the corrective action taken (e.g., 'Added 0.5 kg R-410A – subcooling increased from 5°F to 10°F')."</p> <p>3. Developing Mastery</p> <p>Teacher's Script: "Subcooling and superheat calculation drill." I will give you 5 sets of pressure and temperature readings. Calculate subcooling or superheating and state if the system is undercharged, overcharged, or correct."</p> <p><i>Example:</i> "R-410A: High side 380 psi, liquid line temp 95°F. Subcooling =? (Saturation at 380 psi = 105°F; 105-95=10°F – correct)."</p>	<p>Math practice – students must master these calculations; they are the heart of AC diagnostics.</p>
<p>C. Demonstrating Knowledge and Skills</p>	<p>1. Finding Practical Application</p> <p>Teacher Script: "We will now go to the shop's running AC unit (or a simulated trainer). Your group will perform a complete performance test. You will:"</p> <p>"1. Verify power (with instructor supervision)."</p> <p>"2. Measure voltage and amperage."</p>	<p>Authentic commissioning – students perform the full test on real equipment.</p>

	<p>"3. Connect gauges and measure pressure."</p> <p>"4. Measure line temperatures."</p> <p>"5. Calculate subcooling and superheat."</p> <p>"6. Measure air velocity at the grille."</p> <p>"7. Complete the Performance Test Report."</p> <p>"8. Present findings to the instructor."</p> <p>Teacher supervises closely, especially gauge connection.</p> <p>2. Making Generalization</p> <p>Teacher Script: "Complete this sentence: 'The difference between guessing and knowing is a _____.'"</p> <p>Expected Answer: "Measurement," "Performance test," "Gauge reading."</p> <p>3. Evaluating Learning</p> <p>Teacher: "Get a 1/4 sheet of paper. Numbers 1-5."</p> <p>Quiz:</p> <p>1. For a TXV system using R-410A, what is the typical target subcooling range?</p> <p>2. What does low superheat (e.g., 2°F) indicate?</p> <p>3. A 5-ton AC should move approximately how many CFM of air?</p>	<p>Reinforces the value of measurement – performance testing replaces guesswork with data.</p>
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	<p>4. What is the acceptable voltage tolerance ($\pm\%$) from nameplate?</p> <p>5. What instrument is used to measure insulation resistance (megohms)?</p> <p>Answer Key:</p> <ol style="list-style-type: none"> 1. 8-12°F 2. Overcharge or TXV stuck open (liquid flooding back) 3. 2000 CFM (400 CFM/ton x 5) 4. $\pm 10\%$ 5. Megohmmeter (megger) <p>4. Additional Activities</p> <p>Remediation: Practice converting pressure to saturation temperature using a P-T chart for R-410A.</p> <p>Enrichment: Research the superheat and subcooling targets for a specific commercial AC model (e.g., Daikin, Mitsubishi) and explain why they differ from generic targets.</p>	
VI. ASSESSMENT	<p>Performance Task: <i>Complete Performance Test Report</i></p> <p>Scenario: You have just installed a new 10-ton commercial split system. The client needs a signed Performance Test Report before final payment.</p> <p>Task:</p> <ol style="list-style-type: none"> 1. On the provided running AC unit (or simulator), perform all 9 steps of the performance test. 2. Complete the Performance Test Report form, recording all measured values, target ranges, and pass/fail status. 3. If any measurement fails, note the corrective action taken. 4. Sign and date the report as the installing technician. 	

Performance Test Report (Sample Format):

Test	Measured	Target	Pass/Fail	Action
Voltage (L1-L2)	235V	230V ±10%	Pass	None
Compressor Amps	18.2A	18.0A RLA	Pass	None
High Side Pressure	410 psi	350-450 psi	Pass	None
Low Side Pressure	125 psi	110-140 psi	Pass	None
Subcooling	9°F	8-12°F	Pass	None
Superheat	13°F	10-15°F	Pass	None
Airflow (CFM)	3850 CFM	4000 ±10%	Pass	None
Leak Test	No leak	No leak	Pass	None
Insulation Resistance	>20 MΩ	>10 MΩ	Pass	None

	Rubric for Assessment:					
	Criteria	Excellent (4)	Satisfactory (3)	Developing (2)	Unsatisfactory (1)	Score
	Measurement Accuracy	All measurements are correct and precise.	1-2 measurements off by <10%.	3+ measurements off.	Measurements are missing or wrong.	
	Calculation	Subcooling and superheating correctly calculated.	One calculation error.	Both calculations are wrong.	No calculations.	
	Report Completeness	All fields filled, targets noted; signatures present.	Missing 1-2 fields.	Missing 3+ fields.	Report mostly blank.	
	Safety	Follow all safety protocols (LOTO, PPE, gauge handling).	Minor safety lapse.	Major safety lapse.	Unsafe behavior.	
	Total (16 pts)					

VII. REFLECTION	<p><i>To be completed by the teacher after the lesson:</i></p> <p>Highlights: Did the subcooling and superheat calculations make students feel like "real technicians"? Did students correctly connect the gauge manifold without damaging Schrader valves?</p> <p>Challenges: Did students confuse saturation temperature (from P-T chart) with line temperature? Are calculations for subcooling and superheating accurate? Did any student skip the insulation resistance test (megger)?</p> <p>Adjustments: Should I create a two-column worksheet ("Saturation Temp" vs. "Line Temp")? Should I provide a P-T chart with a quick reference card? Should I make the megger test mandatory before unit startup?</p>
VIII. USE OF GENERATIVE AI	<p>In preparing this Learning Exemplar (LE), the author used Generative AI to assist in structuring and drafting instructional content and assessment items. The author reviewed, edited, and finalized the writing of the content to ensure alignment with curriculum standards and contextual relevance. The author takes full responsibility for the final content of this LE.</p>

LESSON EXEMPLAR			
Learning Area	Commercial Air-Conditioning Installation and Servicing	Lesson Exemplar	13

I. OBJECTIVES	
A. Content Standard	The learner understands the concepts and principles of the Commercial Air-Conditioning unit
B. Performance Standard	The learner performs the installation of the Commercial Air-Conditioning unit with safety precautions.
C. Learning Competencies	2. Perform pre-installation procedure for the commercial air-conditioning units
II. REFERENCES and MATERIALS	<p>References:</p> <ol style="list-style-type: none"> 1. TESDA. (2021). <i>Training Regulation: Commercial Air-Conditioning Installation and Servicing NC III – Unit of Competency: Cost Services</i>. TESDA Philippines. 2. Sullivan, M. (2019). <i>HVACR Business Management and Estimating</i>. Cengage. <p>Materials & Integration:</p> <ul style="list-style-type: none"> • Software: Microsoft Excel (invoice template), Google Sheets. • Samples: Blank invoice forms, purchase orders, service report forms, warranty certificates. • Tools: Calculator, printer.
III. CONTENT	<p>Title: Service Costing and Documentation</p> <p>Sub-Topics:</p> <ol style="list-style-type: none"> 1. Calculating service costs (labor, materials, travel, overhead, profit). 2. Preparing quotations and invoices. 3. Completing service reports and warranty documentation. 4. Filing and record keeping for compliance.

IV. OBJECTIVES	<p>At the end of the lesson, the learners are expected to:</p> <ol style="list-style-type: none"> 1. Identify the five components of a service cost (labor, materials, travel, overhead, profit). 2. Prepare a complete, professional invoice for a commercial AC installation, including itemized materials, labor hours, tax, and payment terms. 3. Recognize that accurate documentation is a legal and ethical obligation, not just a business formality.
V. PROCEDURES	ANNOTATIONS
A. Activating Prior Knowledge	<ol style="list-style-type: none"> 1. Activating Prior Knowledge <p>Teacher Script: "When you buy something at a store, what document do you receive that shows what you paid and how much tax?"</p> <p>Expected Answer: "Receipt," "Invoice," "Official receipt."</p> <p>Teacher: "Yes. In HVAC, we issue invoices and service reports. These are legal documents. Today, you learned to create them correctly."</p> 2. Establishing the Purpose of the Lesson <p>Teacher Script: "You finish a 3-day commercial installation. The client asks for an invoice. You write on a napkin: 'AC job – PHP 150,000.' The client says, 'What is this for?' Break it down. You have no breakdown. The client refuses to pay. What went wrong?"</p> <p>Expected Answer: "No breakdown," "Not professional."</p>

	<p>Teacher: "A professional invoice protects you and the client." Today, you learned to document everything."</p>	
<p>B. Instituting New Knowledge</p>	<p>1. Presenting Examples</p> <p>Teacher's Script: "I will show you two invoices.</p> <p><i>Invoice A:</i> 'AC installation – PHP 200,000.' No other details.</p> <p><i>Invoice B:</i> Itemized: 5-ton condenser – PHP 80,000, 5-ton evaporator – PHP 45,000, copper line set 20m – PHP 8,000, labor 24 hrs. @ PHP 500/hr. – PHP 12,000, travel – PHP 2,000, subtotal, VAT, total.</p> <p>Which one is professional?"</p> <p>Expected Answer: "Invoice B."</p> <p>2. Discussing New Concept</p> <p>Teacher's Script: "Open your notebook." Service costing has 5 components."</p> <p>Detailed Lecture Guide:</p> <p>Component 1: Direct Labor</p> <p>"Labor cost = Hours worked x Hourly rate. For commercial, typical rates: PHP 500-800 per hour for a technician, PHP 300-500 per hour for an assistant. For a 2-person team working 8 hours: (PHP 600 + PHP 400) x 8 = PHP 8,000 per day."</p> <p>"Include travel time to and from the site if it is beyond normal commute (e.g., >30 km)."</p>	<p>Contrasting examples – students see the difference between vague and professional.</p>

	<p>Component 2: Materials</p> <p>"All physical items installed: unit itself, copper tubing, insulation, wires, breaker, disconnect, PVC pipe, refrigerant, nitrogen, silver rod, etc."</p> <p>"Mark up materials by 20-30% to cover your procurement time, storage, and risk. If you bought a condenser for PHP 50,000, sell it for PHP 60,000-65,000."</p> <p>"Never charge the client for defective materials when you return to the supplier. That is your loss."</p> <p>Component 3: Travel and Transportation</p> <p>"Fuel, tolls, parking, vehicle depreciation. A common rate is PHP 50-100 per km or a flat travel fee of PHP 1,000-2,000 per day for local jobs."</p> <p>"For distant jobs (provincial), add accommodation and per diem (PHP 1,500-2,500 per day)."</p> <p>Component 4: Overhead</p> <p>"Your business costs that are not tied to one job: shop rent, office staff salaries, electricity, internet, tools depreciation, insurance, licenses, training."</p> <p>"Overhead is typically 15-25% of direct costs (labor + materials). Example: Direct costs = PHP 100,000. Overhead = PHP 20,000."</p> <p>Component 5: Profit</p> <p>"This is your income. Target 15-30% net profit. Total price = Direct costs + Overhead + Profit."</p> <p>"Example: Direct costs PHP 100,000 + Overhead PHP 20,000 = PHP 120,000. Add 20% profit = PHP 24,000. Total = PHP 144,000 + 12% VAT = PHP 161,280."</p>	
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	<p>Tax (VAT)</p> <p>"If your business is VAT-registered (annual sales > PHP 3M), add 12% VAT to the total. If non-VAT (percentage tax), add 3% percentage tax. For our exercises, use 12% VAT."</p> <p>Documentation Types</p> <p>"1. Quotation (Quote): Given BEFORE work starts. Valid for a specific period (e.g., 30 days). Includes all costs. Client signs to approve."</p> <p>"2. Service Report / Job Order: Completed DURING or AFTER work. Records of what was done, hours worked, materials used, measurements taken (subcooling, superheat, pressures). Signed by a client."</p> <p>"3. Invoice / Billing Statement: Given AFTER work is complete. Request payment. Must match the quotation unless change orders are approved."</p> <p>"4. Official Receipt (OR): Given WHEN payment is received. Proof of payment. Required for BIR compliance."</p> <p>"5. Warranty Certificate: States coverage period (e.g., 1 year on labor, 5 years on compressor). Specifies what is and is not covered."</p> <p>Sample Invoice Structure</p> <p>"Header: Your company name, address, TIN, contact."</p> <p>"Customer: Name, address, contact."</p> <p>"Invoice Details: Invoice number, date, PO number (if any), payment terms (e.g., 'Due upon receipt' or 'Net 30')."</p>	
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	<p>"Line Items: Qty, Description, Unit Price, Total."</p> <p>"Subtotal"</p> <p>"VAT (12%)"</p> <p>"Total Due"</p> <p>"Payment Instructions: Bank account, GCash, etc."</p> <p>"Footer: 'Thank you for your business. Please retain for warranty.'"</p> <p>3. Developing Mastery</p> <p>Teacher Script: "Costing exercise." A commercial job requires: 3-ton AC unit (PHP 45,000), 20m 1/4" and 5/8" copper (PHP 3,000), insulation (PHP 2,000), electrical (PHP 5,000), labor 16 hours @ PHP 600/hr., travel PHP 1,500. Overhead 20% of direct costs. Profit 25% off (direct + overhead). Compute the total price before VAT, then add 12% VAT."</p> <p>Answer:</p> <p>"Direct costs = $45,000 + 3,000 + 2,000 + 5,000 + (16 \times 600 = 9,600) + 1,500 = 66,100.$</p> <p>Overhead = $66,100 \times 0.20 = 13,220.$</p> <p>Subtotal = 79,320. Profit = $79,320 \times 0.25 = 19,830.$</p> <p>Total before VAT = 99,150. VAT = 11,898.</p> <p>Grand total = 111,048."</p>	<p>Math application – students must apply the costing formula.</p>
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<p>C. Demonstrating Knowledge and Skills</p>	<p>1. Finding Practical Application</p> <p>Teacher Script: "Using the Excel template on your computer (or paper form), create a complete invoice for the job in the exercise. Include:"</p> <p>"- Your company name (invent one)."</p> <p>"- Customer name (given)."</p> <p>"- Itemized line items."</p> <p>"- Subtotal, VAT, total."</p> <p>"- Payment terms."</p> <p>Students submit printed or digital invoices.</p> <p>2. Making Generalization</p> <p>Teacher Script: "Complete this sentence: 'A signed service report protects the technician because it proves _____.'"</p> <p>Expected Answer: "The work was done," "The client agreed to the work,"</p> <p>"The measurements were taken."</p> <p>3. Evaluating Learning</p> <p>Teacher: "Get a 1/4 sheet of paper. Numbers 1-5."</p> <p>Quiz:</p> <p>1. List the five components of service costing.</p>	<p>Authentic document creation – students produce a real invoice that could be used in business.</p> <p>Legal awareness – documentation is evidence of work performed.</p>
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	<p>2. What is the current VAT rate in the Philippines for VAT-registered businesses?</p> <p>3. A technician works 8 hours at PHP 700/hr. What is the labor cost?</p> <p>4. What document is issued BEFORE work begins, specifying the estimated cost?</p> <p>5. Why should materials be marked up (e.g., 20%) from their purchase price?</p> <p>Answer Key:</p> <ol style="list-style-type: none"> 1. Direct labor, materials, travel, overhead, profit. 2. 12% 3. PHP 5,600 4. Quotation 5. To cover procurement time, storage, and risk. <p>4. Additional Activities</p> <p>Remediation: Complete a partially filled invoice by adding the missing calculations.</p> <p>Enrichment: Research the BIR requirements for official receipts (e.g., authority to print, serial numbers) and write a one-page summary.</p>	
VI. ASSESSMENT	<p>Performance Task: <i>Complete Job Package (Quote + Service Report + Invoice)</i></p> <p>Scenario: A client requests a quotation for a 7.5-ton commercial split system installation. After you complete the work, you must provide a service report and final invoice.</p> <p>Task:</p> <ol style="list-style-type: none"> 1. Prepare a Quotation based on material costs and estimated labor (16 hours, 2 technicians). 	

2. After the job (simulated), complete a **Service Report** listing the work performed and performance test results (use data from Lesson 12).
3. Prepare the final **Invoice** based on the actual costs (may differ from quote if change orders occurred).
4. Submit all three documents as a package.

Rubric for Assessment:

Criteria	Excellent (4)	Satisfactory (3)	Developing (2)	Unsatisfactory (1)	Score
Quotation	Complete, clear, valid until date, client signature line.	Missing one element.	Missing multiple elements.	No quotation.	
Service Report	Detailed, includes measurements, hours, materials, and client signature.	Missing some measurements.	Vague, missing key data.	No service report.	
Invoice	Professional format, itemized, correct math, VAT, and	Minor math error or missing element.	Major errors.	No invoice.	

		payment terms.				
	Consistency	Quote, service report, and invoice match (prices, scope).	Minor discrepancy.	Major discrepancy.	No consistency.	
	Total (16 pts)					
VII. REFLECTION	<p><i>To be completed by the teacher after the lesson:</i></p> <p>Highlights: Did the "napkin invoice vs. professional invoice" comparison effectively show the importance of documentation? Did students understand the five components of service costing?</p> <p>Challenges: Did students struggle with sequential percentage calculations (overhead then profit, not combined)? Did students forget to add 12% VAT? Was the concept of "overhead" abstract and difficult to grasp?</p> <p>Adjustments: Should I provide a step-by-step calculator template? Should I use a tricycle driver for analogy overhead? Should I add a VAT-only practice worksheet before the full invoice activity?</p>					
VIII. USE OF GENERATIVE AI	<p>In preparing this Learning Exemplar (LE), the author used Generative AI to assist in structuring and drafting instructional content and assessment items. The author reviewed, edited, and finalized the writing of the content to ensure alignment with curriculum standards and contextual relevance. The author takes full responsibility for the final content of this LE.</p>					

LESSON EXEMPLAR			
Learning Area	Commercial Air-Conditioning Installation and Servicing	Lesson Exemplar	14

I. OBJECTIVES	
A. Content Standard	The learner understands the concepts and principles of the Commercial Air-Conditioning unit
B. Performance Standard	The learner performs maintenance, troubleshooting, and commissions Commercial Air- Conditioning units with safety precautions.
C. Learning Competencies	1. Perform service and maintenance of the commercial air- conditioning units
II. REFERENCES and MATERIALS	<p>References:</p> <ol style="list-style-type: none"> 1. ASHRAE. (2019). <i>ASHRAE Handbook – HVAC Applications (Filters and Air Cleaning)</i>. ASHRAE. 2. TESDA. (2021). <i>Training Regulation: Commercial Air-Conditioning Installation and Servicing NC III</i>. TESDA Philippines. <p>Materials & Integration:</p> <ul style="list-style-type: none"> • Tools: Vacuum cleaner with brush attachment, soft-bristle brush, water hose (for washable filters), screwdrivers. • Materials: Replacement filters (various types: panel, pleated, bag, HEPA), filter spray (tackifier for greasy filters). • PPE: Dust mask, safety glasses, gloves.
III. CONTENT	<p>Title: Cleaning Procedure of the Air Filter</p> <p>Sub-Topics:</p> <ol style="list-style-type: none"> 1. Types of commercial AC filters (disposable, washable, bag, HEPA). 2. Filter specifications (MERV rating, size, thickness). 3. Effects of restricted airflow (high superheat, coil freezing, compressor damage). 4. Proper cleaning and replacement procedures.

IV. OBJECTIVES	<p>At the end of the lesson, the learners should be able to:</p> <ol style="list-style-type: none"> 1. Explain how a clogged filter causes evaporator coil freezing and compressor failure. 2. Properly remove, clean (if washable), and reinstall a commercial AC filter, noting the airflow direction arrow. 3. Never operate an AC without a filter in place, even temporarily. 	
V. PROCEDURES	ANNOTATIONS	
A. Activating Prior Knowledge	<ol style="list-style-type: none"> 1. Activating Prior Knowledge <p>Teacher's Script: "How often do you change the filter in your home AC? What happens if you never change it?"</p> <p>Expected Answer: "Once a month," "The AC gets weak," "Ice forms."</p> <p>Teacher: "In commercial, filters are larger, more expensive, and more critical. A clogged filter in a server room can shut down computers. Today, we will learn about commercial filter maintenance."</p> 2. Establishing the Purpose of the Lesson <p>Teacher's Script: "A restaurant calls: 'Our AC is blowing warm air.' You arrive. The evaporator coil is a block of ice. You check the filter. It is completely clogged with grease. What caused the ice?"</p> <p>Expected Answer: "Low airflow over the coil," "The coil got too cold."</p> <p>Teacher: "Correct. Low airflow = low heat load = coil temperature drops below freezing = ice. Ice blocks airflow</p> 	

Personal experience – students likely have seen dirty filters at home.

Diagnostic thinking – students must connect clogged filter to the freezing coil.

	<p>more = more ice = compressor runs continuously = burnout. One clogged filter can destroy a PHP 80,000 compressor."</p>	
<p>B. Instituting New Knowledge</p>	<p>1. Presenting Examples</p> <p>Teacher's Script: "I will show you three filters. Filter A: Clean, new. Filter B: Moderately dirty (gray). Filter C: Completely black, caked with debris. Which one is acceptable? Which one is an emergency?"</p> <p>Expected Answer: "A is acceptable, B needs cleaning soon, C is emergency."</p> <p>2. Discussing New Concept</p> <p>Teacher's Script: "Open your notebook. Filters are the first line of defense for your AC system."</p> <p>Detailed Lecture Guide:</p> <p>Filter Types</p> <p>"1. <i>Disposable panel filters:</i> Most common. Fiberglass or synthetic media. MERV 1-4. Cheap. Change every 1-3 months. Cannot be washed."</p> <p>"2. <i>Washable (permanent) filters:</i> Aluminum or plastic frame with washable foam or mesh. MERV 1-3. Can be washed and reused many times. Not for high-efficiency needs."</p> <p>"3. <i>Pleated filters:</i> Accordion-style media. MERV 6-13. Higher efficiency. Disposable. Change every 3-6 months."</p>	<p>Visual inspection training – students learn to assess filter conditions by sight.</p>

	<p>"4. <i>Bag filters: Deep bags.</i> MERV 14-16. For hospitals, clean rooms. Expensive. Change annually or when pressure drops increase."</p> <p>"5. <i>HEPA filters:</i> MERV 17-20. Captures 99.97% of particles 0.3 microns. For operating rooms, pharmaceutical manufacturing. Very expensive. Changed based on pressure drop readings."</p> <p>"6. <i>Carbon filters:</i> For odor removal. Often used with another filter."</p> <p>MERV Rating</p> <p>"MERV = Minimum Efficiency Reporting Value. Higher MERV = captures smaller particles but also RESTRICTS airflow. Do not install a MERV 13 filter in a system designed for MERV 8 without checking fan static pressure – you may reduce airflow below 400 CFM/ton."</p> <p>Effects of Restricted Airflow</p> <p>"A clogged filter causes:"</p> <p>"1. Reduced CFM: Airflow drops below 400 CFM/ton."</p> <p>"2. Low heat load on the evaporator: The coil becomes too cold."</p> <p>"3. Coil temperature below freezing: Condensate freezes into ice."</p> <p>"4. Ice blocks airflow further: Vicious cycle."</p> <p>"5. Liquid refrigerant returns to compressor (floodback): Superheat drops below 5°F. Liquid does not compress – it washes out oil and breaks valves."</p> <p>"6. Compressor failure: Expensive."</p>	
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	<p>"Also: High energy use (fan works harder), poor indoor air quality (dust recirculates), and potential motor burnout (fan motor over-amps)."</p> <p>Cleaning Procedure (Washable Filters)</p> <p>"1. Turn off the AC at the thermostat or disconnect. Do not run the fan without a filter."</p> <p>"2. Remove the filter access panel (may require screwdriver)."</p> <p>"3. Slide out the filter. Note the airflow arrow direction (arrow points toward the fan/blower)."</p> <p>"4. Vacuum the filter with a brush attachment to remove loose dust. Do this OUTSIDE the building."</p> <p>"5. Wash with water (if washable). Use a garden hose with gentle pressure. Do NOT use a pressure washer – it will tear the media."</p> <p>"6. Use mild detergent if greasy (restaurant kitchens). Rinse thoroughly. No soap residue."</p> <p>"7. Let the filter dry completely (24 hours). Installing a wet filter will grow mold and restrict airflow more (water blocks the pores)."</p> <p>"8. Reinstall with the airflow arrow pointing in the correct direction."</p> <p>"9. Close the access panel. Turn the AC back on."</p> <p>"For disposable filters: Do not wash. Replace with identical size and MERV rating."</p> <p>Replacement Schedule</p> <p>"1. Light commercial (office): Every 3 months."</p> <p>"2. Restaurant (grease): Every 1 month."</p> <p>"3. Medical facility: Every month or per policy."</p> <p>"4. Industrial (dusty): Every 2 weeks to 1 month."</p> <p>"Always check the filter at every service call, regardless of the original complaint."</p>	
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	<p>3. Developing Mastery</p> <p>Teacher's Script: "Scenario analysis. A technician replaces a MERV 8 filter with a MERV 13 filter because 'higher is better. Six months later, the compressor failed. What happened?"</p> <p>Expected Answer: "MERV 13 restricted airflow too much, causing low airflow, coil freezing, and floodback."</p>	<p>Critical thinking – students must understand that higher MERV is not always better.</p>
<p>C. Demonstrating Knowledge and Skills</p>	<p>1. Finding Practical Application</p> <p>Teacher's Script: "Hands-on: We have several commercial AC units (or filter mock-ups) in the shop. Your group will:"</p> <p>"1. Turn off the unit (simulated or real)."</p> <p>"2. Remove the filter access panel."</p> <p>"3. Remove the filter."</p> <p>"4. Inspect and classify the filter (disposable or washable, MERV if labeled)."</p> <p>"5. Clean or replace appropriately."</p> <p>"6. Reinstall with the correct airflow direction."</p> <p>"7. Document the filter size and MERV rating on a maintenance log."</p> <p>Teacher inspects each group's work.</p>	<p>Authentic maintenance – students perform the actual cleaning procedure.</p>

	<p>2. Making Generalization</p> <p>Teacher's Script: "Complete this sentence: 'A clogged filter does not just reduce cooling; it is a _____.'"</p> <p>Expected Answer: "Compressor killer," "System destroyer," "Fire hazard (for fan motor)."</p> <p>3. Evaluating Learning</p> <p>Teacher: "Clear your desks. Get a 1/4 sheet of paper. Number 1 to 5."</p> <p>Quiz:</p> <ol style="list-style-type: none"> 1. What does MERV stand for? 2. A clogged filter causes evaporator coil freezing. Explain why. 3. Can you wash a disposable fiberglass filter? 4. What direction should the airflow arrow on a filter point? 5. A restaurant kitchen AC filter should be checked and likely replaced. How often? <p>Answer Key:</p> <ol style="list-style-type: none"> 1. Minimum Efficiency Reporting Value 2. Low airflow reduces heat load on the coil; coil temperature drops below freezing; moisture freezes on the coil. 3. No – it will disintegrate. 4. Toward the fan/blower (into the unit). 5. Every month (or even every 2 weeks). 	<p>Reframing – a dirty filter is a system killer, not just an inconvenience.</p>
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	<p>4. Additional Activities</p> <p>Remediation: Draw a diagram showing airflow from return grille, through filter, across evaporator coil, to supply duct.</p> <p>Enrichment: Research the MERV rating requirements for different applications (hospital operating room vs. office vs. factory) and create a chart.</p>					
VI. ASSESSMENT	<p>Performance Task: <i>Filter Maintenance Log</i></p> <p>Scenario: You are the maintenance technician for a small commercial building with 5 AC units. You must inspect and service all filters.</p> <p>Task:</p> <ol style="list-style-type: none">1. Inspect the filters on the provided units (or mock-ups).2. For each unit, record: location, filter type, MERV rating (if visible), condition (clean, dirty, clogged), action taken (cleaned or replaced).3. If replaced, note the replacement filter part number or dimensions.4. Complete a Filter Maintenance Log form.5. Recommend a maintenance schedule for each unit based on its environment. <p>Rubric for Assessment:</p>					
	Criteria	Excellent (4)	Satisfactory (3)	Developing (2)	Unsatisfactory (1)	Score
	Inspection Accuracy	Correctly identifies filter type, condition, and MERV.	Minor error.	Major error.	No inspection.	

	Cleaning/ Replacement	Correct procedure for each filter type.	Minor error (e.g., washed disposable).	Major error.	Damaged filter.	
	Airflow Direction	Arrow correctly oriented in all units.	One unit wrong.	Multiple wrong.	No arrow checked.	
	Documentation	Log complete, legible, accurate.	Missing one field.	Missing multiple fields.	No log.	
	Total (16 pts)					
VII. REFLECTION	<p><i>To be completed by the teacher after the lesson:</i></p> <p>Highlights: Did the visual comparison of clean vs. clogged filters (including a restaurant grease filter) effectively gross out and educate students? Did students understand how a clogged filter causes coil freezing?</p> <p>Challenges: Did students want to wash disposable filters "just to save money"? Did students forget to note the airflow direction arrow before removing the filter? Did any student operate the unit without a filter?</p>					

	<p>Adjustments: Should I bring in a water-damaged disposable filter that fell apart after washing as a demonstration? Should I add "mark airflow direction" as the first step? Should I show a video of a coil freezing due to a dirty filter?</p>
<p>VIII. USE OF GENERATIVE AI</p>	<p>In preparing this Learning Exemplar (LE), the author used Generative AI to assist in structuring and drafting instructional content and assessment items. The author reviewed, edited, and finalized the writing of the content to ensure alignment with curriculum standards and contextual relevance. The author takes full responsibility for the final content of this LE.</p>

LESSON EXEMPLAR			
Learning Area	Commercial Air-Conditioning Installation and Servicing	Lesson Exemplar	15

I. OBJECTIVES	
A. Content Standard	The learner understands the concepts and principles of the Commercial Air-Conditioning unit
B. Performance Standard	The learner performs maintenance, troubleshooting, and commissioning of Commercial Air-Conditioning units while observing safety precautions.
C. Learning Competencies	1. Perform service and maintenance of the commercial air- conditioning units
II. REFERENCES and MATERIALS	<p>References:</p> <ol style="list-style-type: none"> 1. ASHRAE. (2020). <i>ASHRAE Handbook – HVAC Systems and Equipment (Coil Cleaning)</i>. ASHRAE. 2. TESDA. (2021). <i>Training Regulation: Commercial Air-Conditioning Installation and Servicing NC III</i>. TESDA Philippines. <p>Materials & Integration:</p> <ul style="list-style-type: none"> • Tools: Soft brush, coil cleaning spray, fin comb, vacuum cleaner with HEPA filter, water sprayer, drop cloths. • Materials: Coil cleaner (alkaline for evaporator, acidic for condenser), neutralizing agent, fin straightener (fin comb), condensate pan treatment tablets. • PPE: Rubber gloves, safety glasses, respirator (for chemical cleaners), waterproof apron.
III. CONTENT	<p>Title: Cleaning Methods of the Mechanical System</p> <p>Sub-Topics:</p> <ol style="list-style-type: none"> 1. Tools and equipment for cleaning (coil cleaner, fin comb, vacuum). 2. Assembling and disassembling access panels and blower assemblies. 3. Cleaning chemical agents (types, specifications, application). 4. Effects of kinks and dents (restricted airflow, reduced heat transfer).

IV. OBJECTIVES	<p>At the end of the lesson, the learners should be able to:</p> <ol style="list-style-type: none"> 1. Distinguish between alkaline coil cleaner (for evaporators) and acidic coil cleaner (for condensers). 2. Safely clean an evaporator coil using a no-rinse alkaline foam cleaner, including protecting electrical components. 3. Always neutralize chemical cleaners and rinse thoroughly to prevent coil corrosion.
V. PROCEDURES	ANNOTATIONS
A. Activating Prior Knowledge	<ol style="list-style-type: none"> 1. Activating Prior Knowledge <p>Teacher's Script: "In Domestic RAC, how do you clean a window AC? Do you just spray water on it?"</p> <p>Expected Answer: "Remove the cover, spray coil cleaner, rinse."</p> <p>Teacher: "Yes. But commercial coils are larger, harder to access, and more delicate. A wrong cleaner can destroy a PHP 50,000 coil."</p> 2. Establishing the Purpose of the Lesson <p>Teacher's Script: "A technician uses an acidic cleaner on an aluminum evaporator coil. He does not rinse it. Two months later, the coil is leaking refrigerant. What happened?"</p> <p>Expected Answer: "The acid ate through the aluminum."</p> <p>Teacher: "Correct. Today, you learn which cleaner for which coil is, and how to apply it safely."</p>

<p>B. Instituting New Knowledge</p>	<p>1. Presenting Examples</p> <p>Teacher's Script: "I will show you two coils. Coil A: Clean, shiny fins. Coil B: Matted with dust, grease, and mold. Which one transfers heat better? Which one is more efficient?"</p> <p>Expected Answer: "Coil A."</p> <p>2. Discussing New Concept</p> <p>Teacher's Script: "Open your notebook. Cleaning the mechanical system means cleaning the coils, blower wheel, and drain pan."</p> <p>Detailed Lecture Guide:</p> <p>Why Clean Coils?</p> <p>"A dirty evaporator coil has three problems:"</p> <p>"1. Reduced heat transfer: Dust acts as an insulator. The coil cannot absorb heat. Cooling capacity drops."</p> <p>"2. Restricted airflow: Dust fills the gaps between fins. Airflow (CFM) drops. Same problem as a dirty filter."</p> <p>"3. Mold and bacteria growth: Moisture + organic dust = biological growth. This causes 'dirty sock syndrome' (musty odor) and health issues."</p> <p>"A dirty condenser coil (outdoor) has similar problems: high head pressure, high compressor amperage, reduced efficiency, and eventual compressor failure."</p> <p>Tools and Equipment</p> <p>"1. Soft brush: For loose dust. Never use a wire brush – it will damage the fins."</p> <p>"2. Fin comb: Straightens bent fins. Use the correct tooth spacing (fins per inch – FPI)."</p>	<p>Visual comparison – students see the dramatic difference cleanliness makes.</p>
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	<p>"3. Vacuum with HEPA filter: Captures dust so it does not recirculate."</p> <p>"4. Coil cleaner sprayer: Garden sprayer or pump sprayer."</p> <p>"5. Water source: Garden hose with gentle pressure (no pressure washer – it bends fins)."</p> <p>"6. Drop cloths and plastic sheeting: To protect the surrounding area."</p> <p>"7. For disassembly: Screwdrivers, nut drivers, socket set. Some units require removing blower assemblies to access the coil."</p> <p>Cleaning Chemical Agents</p> <p>"1. Alkaline (basic) cleaners – for EVAPORATOR coils"</p> <p>"- pH 11-13."</p> <p>"- Dissolves organic matter (dust, pollen, mold, grease)."</p> <p>"- Safe for aluminum when used correctly."</p> <p>"- Available as 'no-rinse' foam (apply, let foam lift dirt, drains away with condensate) or 'rinse required' (must be rinsed with water)."</p> <p>"- Brands: Nu-Calgon Evap Foam, Viper, Frost King."</p> <p>"2. Acidic cleaners – for CONDENSER coils"</p> <p>"- pH 1-3."</p> <p>"- Dissolves inorganic deposits (calcium, lime, rust, oxidation)."</p> <p>"- Used on outdoor coils exposed to hard water (cooling towers) or coastal salt."</p> <p>"- DANGEROUS to aluminum evaporators. Do not use on indoor coils."</p> <p>"- Must be neutralized and rinsed thoroughly."</p> <p>"3. Universal cleaners (neutral pH ~7) – safe for both but less effective on heavy soils."</p>	
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	<p>"Never use: Bleach (corrodes aluminum), hydrochloric acid (muriatic acid – destroys coils instantly), dish soap (leaves residue, foams too much)."</p> <p>Cleaning Procedure – Evaporator Coil (No-Rinse Foam)</p> <p>"1. Turn off the AC at the disconnect. LOTO if needed."</p> <p>"2. Remove filter access panels to expose the coil."</p> <p>"3. Protect electrical components with plastic sheeting (control boards, motors, contactors)."</p> <p>"4. Vacuum loose dust from the coil face using a soft brush attachment."</p> <p>"5. Apply no-rinse foam cleaner generously across the entire coil face. The foam will expand and penetrate between the fins."</p> <p>"6. Wait 5-10 minutes for the foam to lift dirt (do not let it dry completely)."</p> <p>"7. Turn the AC fan ON (blower only, no cooling). The fan will pull the liquefied dirt into the drain pan. Or use a wet/dry vacuum with a brush attachment to remove loosened dirt."</p> <p>"8. Flush the drain pan with water to remove residue."</p> <p>"9. Replace panels and filters. Turn the AC back on."</p> <p>"For heavy grease (restaurant kitchens): Use a stronger alkaline cleaner that requires rinsing. You will need a catch pan and a water hose. Be prepared to collect and dispose of the rinse water properly (cannot go into storm drains)."</p> <p>Cleaning Procedure – Condenser Coil (Outdoor)</p> <p>"1. Turn off the AC at the disconnect. LOTO."</p> <p>"2. Remove the top grille (fan assembly) – some units require removing the fan motor. Label wires before disconnecting."</p>	
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	<p>"3. Brush loose debris (leaves, grass, cottonwood) from the outside of the coil."</p> <p>"4. Apply coil cleaner (acidic or universal as needed) from the inside out if possible. If not, spray from outside."</p> <p>"5. Wait 5-10 minutes."</p> <p>"6. Rinse from the inside out using a garden hose with a gentle spray nozzle. High pressure bends fins. Rinse until water runs clear."</p> <p>"7. Neutralize if required (follow product instructions – some require baking soda solution)."</p> <p>"8. Reassemble the fan and grille. Ensure the fan spins freely and does not rub."</p> <p>"9. Turn the AC back on."</p> <p>Fin Straightening</p> <p>"If fins are bent (from hail, pressure washer, or mishandling), use a fin comb. Choose the correct FPI (fins per inch – e.g., 12, 14, 16 FPI). Gently drag the comb vertically through the fins. Do not force it – you will tear the fins."</p> <p>Effects of Kinks and Dents</p> <p>"1. Kinked refrigerant lines: Restricts flow. Causes pressure drops. Starves the expansion valve. Results in low capacity and possible compressor damage."</p> <p>"2. Dented coil fins: Reduces surface area for heat transfer. Causes localized hot spots. Reduces efficiency by 5-30% depending on severity."</p> <p>"3. Dented fan blades: Causes imbalance, vibration, noise, and reduced airflow. Replace bent blades – do not try to straighten them (they will be unbalanced)."</p> <p>Drain Pan Cleaning</p> <p>"While the coil is accessible, clean the drain pan. Remove standing water (use a wet/dry vac). Scrub with a brush</p>	
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	<p>and mild detergent. Rinse. Add a condensate pan tablet (slow-release biocide) to prevent algae and mold growth between cleanings."</p> <p>3. Developing Mastery</p> <p>Teacher's Script: "Chemical selection quiz. For each scenario, write 'alkaline (evaporator)', 'acidic (condenser)', or 'neither'."</p> <p><i>Scenarios:</i></p> <p>"1. Restaurant evaporator coil with heavy grease. (Alkaline, rinse type)"</p> <p>"2. Outdoor condenser coil with calcium deposits from hard water. (Acidic)"</p> <p>"3. Aluminum evaporator coil with light dust. (Alkaline, no-rinse)"</p> <p>"4. Bleach was found under the sink. (Neither – never use bleach)"</p>	<p>Application of chemical knowledge – critical for preventing damage.</p>
<p>C. Demonstrating Knowledge and Skills</p>	<p>1. Finding Practical Application</p> <p>Teacher's Script: "Shop activity – Evaporator coil cleaning (simulated or on a trainer). Your group will:"</p> <p>"1. Disconnect power (LOTO)."</p> <p>"2. Remove the access panels."</p> <p>"3. Protect electrical components with plastic."</p> <p>"4. Apply a no-rinse foam cleaner (or water with a drop of soap as a safe simulant)."</p> <p>"5. Wait, then vacuum or wipe clean."</p> <p>"6. Clean the drain pan."</p>	<p>Authentic skill practice – students perform a full coil cleaning safely.</p>

	<p>"7. Reassemble."</p> <p>"8. Complete a Coil Cleaning Report."</p> <p>Teacher inspects for safety, chemical handling, and completeness.</p> <p>2. Making Generalization</p> <p>Teacher's Script: "Complete this sentence: 'The difference between a clean coil and a dirty coil is _____% efficiency and _____ years of equipment life.'"</p> <p>Expected Answers: "10-30%, 3-5 years."</p> <p>3. Evaluating Learning</p> <p>Teacher: "Clear your desks. Get a 1/4 sheet of paper. Number 1 to 5."</p> <p>Quiz:</p> <ol style="list-style-type: none"> 1. What type of chemical cleaner (alkaline or acidic) should be used on an aluminum evaporator coil? 2. Why should you never use a pressure washer on a condenser coil? 3. What tool is used to straighten bent coil fins? 4. What must you protect before spraying any liquid cleaner on an evaporator coil? 5. A kinked liquid line causes what problem? 	<p>Quantifying the benefit – emphasizes the business case for regular cleaning.</p>
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	<p>Answer Key:</p> <ol style="list-style-type: none"> 1. Alkaline (or neutral/universal – but never acidic) 2. High pressure bends fins and can puncture the coil tubes. 3. Fin comb 4. Electrical components (control board, motor, contactor) 5. Restricted refrigerant flow (pressure drop, starves TXV) <p>4. Additional Activities</p> <p>Remediation: Practice using a fin comb on a scrap coil or piece of cardboard with lines drawn to simulate fins.</p> <p>Enrichment: Research the environmental regulations for disposing of coil cleaning rinse water in your local area (can it go to a storm drain? Sanitary sewer?).</p>	
VI. ASSESSMENT	<p>Performance Task: <i>Mechanical System Cleaning and Report</i></p> <p>Scenario: A 10-ton commercial AC has reduced cooling capacity. Inspection shows a dirty evaporator coil and a dirty condenser coil.</p> <p>Task:</p> <ol style="list-style-type: none"> 1. Clean both coils using the correct chemicals and procedures. 2. Straighten any bent fins. 3. Clean the drain pan and add a pan tablet. 4. Complete a Mechanical System Cleaning Report with before/after photos (or sketches), chemicals used, and observations. 5. Note any kinks or dents found and recommend corrective action. 	

	Rubric for Assessment:					
	Criteria	Excellent (4)	Satisfactory (3)	Developing (2)	Unsatisfactory (1)	Score
	Chemical Selection	Correct chemical for each coil, proper mixing.	One coil wrong chemical.	Both coils wrong.	No chemical or dangerous chemical.	
	Procedure	Follows all steps: LOTO, protect electrics, apply, dwell, rinse, reassemble.	Missing one step.	Missing multiple steps.	Unsafe procedure.	
	Fin Condition	Fins straightened; no further damage.	Minor improvement.	No improvement or worse.	Damaged fins.	
	Documentation	Complete report with before/after, chemicals, notes.	Missing one element.	Missing multiple.	No report.	

	<table><tr><td>Total (16 pts)</td><td></td><td></td><td></td><td></td><td></td></tr></table>	Total (16 pts)					
Total (16 pts)							
VII. REFLECTION	<p><i>To be completed by the teacher after the lesson:</i></p> <p>Highlights: Did the chemical selection quiz (alkaline vs. acidic) prevent potential coil damage mistakes? Did students correctly protect electrical components before spraying?</p> <p>Challenges: Did students use too much water when rinsing, soaking electrical components? Did any student use a pressure washer on a coil (bending fins)? Were students able to correctly use a fin comb?</p> <p>Adjustments: Should I require plastic sheeting over the control box before any liquid is sprayed? Should I post a "NO PRESSURE WASHER" sign at the coil cleaning station? Should I provide scrap coils for fin comb practice?</p>						
VIII. USE OF GENERATIVE AI	<p>In preparing this Learning Exemplar (LE), the author used Generative AI to assist in structuring and drafting instructional content and assessment items. The author reviewed, edited, and finalized the writing of the content to ensure alignment with curriculum standards and contextual relevance. The author takes full responsibility for the final content of this LE.</p>						

LESSON EXEMPLAR			
Learning Area	Commercial Air-Conditioning Installation and Servicing	Lesson Exemplar	16

I. OBJECTIVES	
A. Content Standard	The learner understands the concepts and principles of the Commercial Air-Conditioning unit
B. Performance Standard	The learner performs maintenance, troubleshooting, and commissioning Commercial Air-Conditioning units while observing safety precautions.
C. Learning Competencies	1. Perform service and maintenance of the commercial air- conditioning units
II. REFERENCES and MATERIALS	<p>References:</p> <ol style="list-style-type: none"> Emerson Electric Co. (2019). <i>Motors & Drives – HVAC Motor Application Guide</i>. Emerson. TESDA. (2021). <i>Training Regulation: Commercial Air-Conditioning Installation and Servicing NC III</i>. TESDA Philippines. <p>Materials & Integration:</p> <ul style="list-style-type: none"> Tools: Multimeter (capacitance testing), megger (insulation resistance), oil can with SAE 20 oil, hex keys, socket set, puller (for fan blade), soft brush. Materials: Replacement fan motor (sample), fan blade, capacitor (run and start), lubricating oil, wire connectors. PPE: Safety glasses, gloves, hearing protection (for noisy fan testing).
III. CONTENT	<p>Title: Maintenance Methods of the Fan Motor</p> <p>Sub-Topics:</p> <ol style="list-style-type: none"> Types of fan motors (PSC, ECM, shaded pole, three-phase). Operation and voltage requirements. Fan blade/blower types and specifications. Mounting support inspection.

	<p>Teacher: "Today, you learn to catch these problems BEFORE failure."</p>	
<p>B. Instituting New Knowledge</p>	<p>1. Presenting Examples</p> <p>Teacher's Script: "I will pass around three fan motors. Motor A: PSC with a run capacitor. Motor B: ECM (has a control module). Motor C: Three-phase (no capacitor, six wires). Identify which is which."</p> <p>2. Discussing New Concept</p> <p>Teacher's Script: "Open your notebook. Fan motors are the most replaced component in HVAC after capacitors." Detailed Lecture Guide:</p> <p>Motor Types</p> <p>"1. PSC (Permanent Split Capacitor) – Most common in commercial"</p> <p>"a. Has a run capacitor (and sometimes a start capacitor for larger motors)."</p> <p>"b. Capacitor provides phase shift for starting and running."</p> <p>"c. Single-speed (or two-speed with two capacitors)."</p> <p>"d. Inexpensive, reliable, but less efficient than ECM."</p> <p>"e. Voltage: 208-230V single phase (common) or 460V (rare for fans)."</p> <p>"2. ECM (Electronically Commutated Motor) – High efficiency"</p> <p>"a. Also called 'variable speed motor.'"</p> <p>"b. Has a control module (black box) attached to the motor."</p>	<p>Hands-on identification – students learn to recognize motor types by sight.</p>

	<p>"c. No capacitor needed."</p> <p>"d. Programmable for constant torque or constant CFM."</p> <p>"e. More expensive, more efficient, but control module can fail."</p> <p>"f. Used in high-end commercial equipment and high-efficiency units."</p> <p>"3. Shaded Pole – <i>Small fans</i>"</p> <p>"a. Low torque, low efficiency."</p> <p>"b. No capacitor. Simple but weak."</p> <p>"c. Used in small exhaust fans, not main condenser fans."</p> <p>"4. Three-Phase Induction Motor – <i>Large commercial</i>"</p> <p>"a. No capacitor. Requires three-phase power (208, 230, 460V)."</p> <p>"b. Can be reversed by swapping any two phases."</p> <p>"c. Very efficient, high starting torque."</p> <p>"d. Used on large rooftop units, chillers, and industrial equipment."</p> <p>Voltage Requirements</p> <p>"Always check the nameplate voltage. Common voltages:"</p> <p>"a. 115V (small fans, residential)"</p> <p>"b. 208-230V (most commercial – can run on 208V or 230V)"</p> <p>"c. 460V (large commercial, three-phase)"</p> <p>"d. Voltage tolerance: ±10%."</p> <p>"Low voltage causes high amperage and overheating."</p> <p>"High voltage damages insulation and capacitors."</p> <p>Fan Blades and Blowers</p> <p>"1. Condenser fan blade (propeller type):"</p> <p>"a. Aluminum or plastic."</p>	
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	<p>"b. Must be matched to the motor's horsepower and RPM."</p> <p>"c. Blade pitch (angle) determines airflow. Too steep = motor overload. Too shallow = low airflow."</p> <p>"d. Must be mounted at the correct height in the orifice."</p> <p>"2. <i>Evaporator blower wheel (squirrel cage):</i>"</p> <p>"a. Cylindrical with many curved blades."</p> <p>"b. Spins inside a housing."</p> <p>"c. Must be balanced. A dented or bent blower wheel causes vibration and noise."</p> <p>"d. Direction matters – blower wheels are directional (marked 'rotation')."</p> <p>Mounting Support Inspection</p> <p>"Check:"</p> <p>"1. Motor base: Not cracked or rusted."</p> <p>"2. Mounting bolts: Tight. Loose bolts cause vibration and bearing wear."</p> <p>"3. Vibration isolators: Rubber grommets or springs. Replace if cracked or hardened."</p> <p>"4. Belt (if belt-drive): Tension, wear, alignment."</p> <p><i>"For belt-drive fans (larger units):"</i></p> <p>"1. Check belt tension (deflect 1/2 inch per foot of span with moderate thumb pressure)."</p> <p>"2. Check sheaves (pulleys) for wear. Grooves should be smooth, not cupped."</p> <p>"3. Align sheaves with a straight edge."</p> <p>Lubrication</p> <p>"Some motors have sealed bearings (no lubrication). Others have oil ports (small holes or fittings)."</p> <p><i>"For motors with oil ports:"</i></p>	
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	<p>"1. Clean the area around the oil port (remove dirt that could enter)."</p> <p>"2. Use SAE 20 non-detergent electric motor oil (not WD-40, not 3-in-1 oil – those are not for electric motors)."</p> <p>"3. Add 3-5 drops per port. Do not over-oil – excess oil will leak into the windings."</p> <p>"4. Frequency: Every 6-12 months for motors in service."</p> <p>"For sealed bearings: Do not oil. Replace the motor when bearings fail."</p> <p>Capacitor Testing</p> <p>"For PSC motors, the run capacitor is critical. A weak capacitor causes:"</p> <p>"1. Motor won't start (humming)."</p> <p>"2. Motor runs slow."</p> <p>"3. High amperage."</p> <p>"4. Overheating."</p> <p>"Testing procedure:"</p> <p>"1. Disconnect power. Discharge the capacitor (short across terminals with an insulated screwdriver – the capacitor may hold a charge)."</p> <p>"2. Remove the wires from the capacitor."</p> <p>"3. Set multimeter to capacitance (μF)."</p> <p>"4. Place probes on the terminals. Read the value."</p> <p>"5. Compare to nameplate rating. Acceptable range: $\pm 10\%$ of rated value."</p> <p>"6. If outside range, replace with same rating (voltage and μF)."</p> <p>"Rule: Always replace the run capacitor when replacing a PSC motor. The old capacitor may be weak and will shorten the life of the new motor."</p>	
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	<p>Motor Replacement Procedure</p> <p>"1. Disconnect power (LOTO)."</p> <p>"2. Remove the fan blade (use a puller – do not hammer the shaft – it will damage bearings)."</p> <p>"3. Disconnect wires – label each wire (e.g., 'L1', 'L2', 'C', 'FAN')."</p> <p>"4. Remove mounting bolts."</p> <p>"5. Install new motor – use new mounting bolts and vibration isolators."</p> <p>"6. Transfer the fan blade to the new motor. Set the blade at the correct height (measure from the motor face to the blade center)."</p> <p>"7. Connect wires per the wiring diagram (match speed taps correctly)."</p> <p>"8. Install a new run capacitor (if PSC)."</p> <p>"9. Test run – check rotation direction (arrow on motor or blade should move air upward/outward). Reverse direction by swapping wires (if PSC) or control module programming (if ECM)."</p> <p>"10. Check amperage – should be within nameplate FLA."</p> <p>3. Developing Mastery</p> <p>Teacher's Script: "Capacitor calculation. A fan motor nameplate says: 'Run capacitor: 7.5 μF, 370V.' You test the capacitor and get 5.2 μF. Is it acceptable? What should you do?"</p> <p>Answer: "5.2 μF is 30% below 7.5 μF. $\pm 10\%$ is 6.75-8.25 μF. 5.2 is too low. Replace it."</p>	<p>Application of tolerance rules – students decide if a capacitor is good or bad.</p>
<p>C. Demonstrating Knowledge and Skills</p>	<p>1. Finding Practical Application</p> <p>Teacher's Script: "Shop activity – Fan motor maintenance. Your group will work on a practice motor (de-energized)."</p>	<p>Hands-on maintenance – students perform each skill step by step.</p>

	<p>"1. Identify motor type (PSC, ECM, etc.)."</p> <p>"2. Locate oil ports (if any) and lubricate correctly."</p> <p>"3. Test the capacitor (using a meter on a safe, low-voltage capacitor)."</p> <p>"4. Inspect the fan blade for dents or imbalance."</p> <p>"5. Check mounting bolts for tightness."</p> <p>"6. Complete a Fan Motor Maintenance Report."</p> <p>Teacher checks each group's work.</p> <p>2. Making Generalization</p> <p>Teacher's Script: "Complete this sentence: 'A fan motor that is not maintained will fail, and when it fails, the _____ will also fail.'"</p> <p>Expected Answer: "Compressor."</p> <p>3. Evaluating Learning</p> <p>Teacher: "Clear your desks. Get a 1/4 sheet of paper. Number 1 to 5."</p> <p>Quiz:</p> <p>1. What type of motor (PSC or ECM) requires a run capacitor?</p> <p>2. What is the acceptable tolerance range for a capacitor's microfarad rating?</p> <p>3. What type of oil is used for electric motor lubrication?</p> <p>4. True or False: You can hammer a fan blade off a motor shaft.</p> <p>5. What happens to amperage if voltage is too low?</p>	<p>System thinking – fan failure cascades to compressor failure.</p>
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	<p>Answer Key:</p> <ol style="list-style-type: none"> 1. PSC 2. $\pm 10\%$ 3. SAE 20 non-detergent electric motor oil 4. False – use a puller 5. Amperage increases (motor draws more current to compensate) <p>4. Additional Activities</p> <p>Remediation: Draw a wiring diagram for a PSC motor with a run capacitor, showing L1, L2, capacitor, and motor windings.</p> <p>Enrichment: Research the efficiency difference between a standard PSC motor and an ECM motor (percentage savings) and calculate the payback period for a typical commercial application.</p>	
VI. ASSESSMENT	<p>Performance Task: <i>Fan Motor Preventive Maintenance</i></p> <p>Scenario: You are performing annual preventive maintenance on a 20-ton commercial AC unit. The fan motor has been in service for 3 years.</p> <p>Task:</p> <ol style="list-style-type: none"> 1. Inspect the motor (use a mock motor or trainer). 2. Check and record: motor type, voltage, FLA, capacitor value (if PSC), bearing condition (by feel – spin the shaft). 3. Lubricate if applicable. 4. Inspect the fan blade for damage and proper mounting. 5. Check mounting bolts and vibration isolators. 6. Complete a Fan Motor Maintenance Checklist with pass/fail for each item and recommended actions. 	

	Rubric for Assessment:					
	Criteria	Excellent (4)	Satisfactory (3)	Developing (2)	Unsatisfactory (1)	Score
	Inspection	All parameters checked and recorded.	Missing 1-2 parameters.	Missing 3+ parameters.	No inspection.	
	Lubrication	Correct oil, correct amount, ports cleaned.	Minor error.	Wrong oil or amount.	No lubrication.	
	Capacitor Test	Correctly tested and compared to rating, replaced if bad.	Tested but not compared.	Tested incorrectly.	Not tested.	
	Blade/ Mounting	Blade secure, balanced, mounting bolts tight.	Minor issue.	Major issue.	Not checked.	

	<table><tr><td>Total (16 pts)</td><td></td><td></td><td></td><td></td><td></td></tr></table>	Total (16 pts)					
Total (16 pts)							
VII. REFLECTION	<p><i>To be completed by the teacher after the lesson:</i></p> <p>Highlights: Did the capacitor testing station build a skill that students mastered quickly? Did students understand the difference between PSC motors (run capacitor) and ECM motors (no capacitor)?</p> <p>Challenges: Did students over-oil motors with oil ports (10+ drops instead of 3-5)? Did any student try to hammer a fan blade off a motor shaft instead of using a puller? Were students confused about motor rotation direction?</p> <p>Adjustments: Should I use an eyedropper marked with a "3 drops" line to control oil quantity? Should I demonstrate the correct use of a puller? Should I provide a "rotation direction" quick reference (swap wires to reverse)?</p>						
VIII. USE OF GENERATIVE AI	<p>In preparing this Learning Exemplar (LE), the author used Generative AI to assist in structuring and drafting instructional content and assessment items. The author reviewed, edited, and finalized the writing of the content to ensure alignment with curriculum standards and contextual relevance. The author takes full responsibility for the final content of this LE.</p>						

LESSON EXEMPLAR			
Learning Area	Commercial Air-Conditioning Installation and Servicing	Lesson Exemplar	17

I. OBJECTIVES	
A. Content Standard	The learner understands the concepts and principles of the Commercial Air-Conditioning unit
B. Performance Standard	The learner performs maintenance, troubleshooting, and commissioning Commercial Air-Conditioning units with safety precautions.
C. Learning Competencies	1. Perform service and maintenance of the commercial air- conditioning units
II. REFERENCES and MATERIALS	<p>References:</p> <ol style="list-style-type: none"> 1. Institute of Integrated Electrical Engineers of the Philippines (IIEE). (2017). <i>Philippine Electrical Code (PEC) Part 1, 2017 Edition</i>. IIEE. 2. TESDA. (2021). <i>Training Regulation: Commercial Air-Conditioning Installation and Servicing NC III</i>. TESDA Philippines. <p>Materials & Integration:</p> <ul style="list-style-type: none"> • Tools: Multimeter (voltage, continuity), clamp meter, megohmmeter, non-contact voltage tester, screwdrivers, wire brush. • Materials: Replacement contactor, relay, overload protector, wire connectors, electrical tape, corrosion inhibitor spray. • PPE: Insulated gloves, safety glasses, LOTO kit.
III. CONTENT	<p>Title: Maintenance of Service Power</p> <p>Sub-Topics:</p> <ol style="list-style-type: none"> 1. Electrical controls/devices (contactor, relay, overload protector, thermostat). 2. Circuit connections (tightening, corrosion, arcing).

	3. Power source verification (voltage, phase balance, frequency). 4. Insulation resistance testing (megger).	
IV. OBJECTIVES	At the end of the lesson, the learners should be able to: <ol style="list-style-type: none"> 1. Explain the function of a contactor in an AC unit (switching high-amperage compressor and fan loads). 2. Perform an insulation resistance test (megger) on a compressor motor winding and interpret the results (pass > 10 MΩ, caution 1-10 MΩ, fail < 1 MΩ). 3. Always tighten electrical terminals to the correct torque specification (no guesswork). 	
V. PROCEDURES		ANNOTATIONS
A. Activating Prior Knowledge	<ol style="list-style-type: none"> 1. Activating Prior Knowledge <i>Teacher's Script:</i> "In your home AC, what device turns the compressor and fan on and off based on the thermostat?" <i>Expected Answer:</i> "Relay," "Contactor." <i>Teacher:</i> "Yes. In commercial, contactors are larger and handle more current. Today, we maintain the entire electrical power circuit." 2. Establishing the Purpose of the Lesson <i>Teacher's Script:</i> "A technician changes a burned-out compressor. He does not check the contactor. The contactor has pitted, welded contacts. One month later, the new compressor fails because the contactor stuck closed. Who pays for the second compressor?" 	<p>Bridge from prior learning – students know the thermostat sends the signal.</p> <p>Real-world liability – shows that failing to inspect related components is negligence.</p>

	<p>Expected Answer: "The technician."</p> <p>Teacher: "Today, you learn to inspect EVERYTHING in the power circuit."</p>	
<p>B. Instituting New Knowledge</p>	<p>1. Presenting Examples</p> <p>Teacher's Script: "I will show you three contactors. Contactor A: Clean, silver-colored contacts. Contactor B: Burned, black, pitted contacts. Contactor C: Coil burned (melted plastic). Which one can be reused? Which must be replaced?"</p> <p>Expected Answer: "A can be reused, B and C must be replaced."</p> <p>2. Discussing New Concept</p> <p>Teacher's Script: "Open your notebook. The service power circuit includes everything from the main panel to the compressor terminals."</p> <p>Detailed Lecture Guide:</p> <p>Electrical Controls and Devices</p> <p>"Contactor: A heavy-duty relay that switches the high-amperage compressor and fan motor. Has a 24V coil (low voltage from thermostat) and high-voltage contacts (L1, L2)."</p> <p>"<i>Contactor failure modes:</i>"</p> <p>"1. Pitted contacts: Arcing erodes the silver. Causes high resistance, heating, and voltage drop."</p> <p>"2. Welded contacts: Contacts stuck closed. Compressor runs continuously, freezing the coil or destroying the compressor."</p> <p>"3. Burned coil: Open coil. Contactor will not pull in. Unit will not start."</p>	<p>Visual inspection training – students learn to identify failed components.</p>

	<p>"4. Chattering: Coil voltage too low or contacts dirty. Chattering destroys the coil quickly."</p> <p>"Relay: A smaller switching device. Used for control circuits (e.g., fan relay, compressor relay on some units)."</p> <p>"Overload protector (OLP): Protects the compressor from overcurrent. Can be internal (inside compressor) or external (bimetal disc on the compressor body). When the compressor overheats or over-amps, the OLP opens. It resets automatically when cool (but may take hours)."</p> <p>"Thermostat: The user control. Sends 24V signal to the contactor coil. Also controls temperature setpoint. Can fail with stuck contacts or dead batteries."</p> <p>Circuit Connections</p> <p>"<i>Loose connections cause:</i>"</p> <p>"1. Arcing: Sparking inside the terminal. Creates heat and carbon."</p> <p>"2. Voltage drop: The load sees lower voltage, draws higher current, overheats."</p> <p>"3. Fire: Loose connections are a leading cause of electrical fires."</p> <p>Inspection procedure:</p> <p>"1. With power OFF, use a screwdriver to check each terminal. If you can turn the screw, it was loose. Tighten to spec (typically 20-30 in-lbs for #10 wire)."</p> <p>"2. Look for discoloration (brown, black) on wires – indicates overheating."</p> <p>"3. Look for corrosion (white or green powder) – clean with wire brush or replace terminal."</p> <p>"4. Apply corrosion inhibitor (Noalox or similar) to aluminum terminals."</p>	
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	<p>"5. Check wire insulation for cracking or melting."</p> <p>Power Source Verification</p> <p>"At the AC unit's disconnect (line side – incoming power):"</p> <p>"- Voltage: Measure L1-L2 (single phase) or L1-L2, L2-L3, L3-L1 (three-phase). Must be within $\pm 10\%$ of nameplate."</p> <p>"- Phase balance (three-phase): (Max deviation from average / average) $\times 100\% < 2\%$."</p> <p>"- Frequency: 60 Hz ± 0.5 Hz (in the Philippines)."</p> <p>"If voltage is outside range, do not start the unit. Call the building electrician. Voltage problems are not the AC technician's responsibility, but you must document them."</p> <p>Insulation Resistance Test (Megger)</p> <p>"This test checks for moisture or carbon in the motor windings. It is the only way to predict a winding failure before it happens."</p> <p><i>Procedure (compressor):</i></p> <p>"1. Disconnect power. LOTO."</p> <p>"2. Disconnect the wires from the compressor terminals (C, S, R)."</p> <p>"3. Set the megohmmeter to 500V DC (for 230V motors) or 1000V DC (for 460V motors)."</p> <p>"4. Measure between each terminal and ground (C to ground, S to ground, R to ground)."</p> <p>"5. Also measure between terminals (C to S, C to R, S to R) – checks turn-to-turn insulation."</p> <p><i>Interpretation:</i></p> <p>"1. > 10 megohms (MΩ): Excellent. Winding is dry and clean."</p> <p>"2. 1-10 MΩ: Caution. May be acceptable but trending down. Monitor and retest in 6 months."</p>	
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	<p>"3. < 1 MΩ: Fail. Winding has moisture or carbon tracking. Compressor will fail soon. Recommend replacement."</p> <p>"Procedure (fan motor):"</p> <p>"Similar: Disconnect wires, test each winding to ground. Fan motors often fail to ground (short to the motor casing)."</p> <p>"Safety: Never megger a motor while it is connected to a control board or capacitor – the high voltage will damage electronics. Always disconnect first."</p> <p>Preventive Maintenance Schedule</p> <p>"1. Monthly: Visual inspection of contactor, wires, terminals."</p> <p>"2. Quarterly: Tighten all terminals (with power OFF)."</p> <p>"3. Annually: Megger compressor and fan motors. Replace any contactor with pitted contacts."</p> <p>"4. As needed: Replace any overload protector that has tripped more than twice (it may be weak)."</p> <p>3. Developing Mastery</p> <p>Teacher's Script: "Megger interpretation exercise. I give you three megger readings. Tell me if each compressor passes, is marginal, or fails."</p> <p>Readings:</p> <p>"1. C to ground: 25 MΩ (Pass)"</p> <p>"2. S to ground: 0.5 MΩ (Fail)"</p> <p>"3. C to R: 5 MΩ (Marginal – caution)"</p>	<p>Data interpretation – students must apply the rules to real numbers.</p>
C. Demonstrating Knowledge and Skills	<p>1. Finding Practical Application</p> <p>Teacher's Script: "Shop activity – Power maintenance. On a de-energized trainer (or mock panel), your group will:"</p>	

	<p>"1. Inspect the contactor (points, coil)."</p> <p>"2. Check and tighten all terminal screws (using a torque screwdriver if available)."</p> <p>"3. Measure voltage at the disconnect (simulated)."</p> <p>"4. Perform a megger test on a practice compressor (use a simulator or known-good motor – do not megger a live compressor without instructor approval)."</p> <p>"5. Complete a Power Maintenance Report."</p> <p>Teacher supervises megger use carefully.</p> <p>2. Making Generalization</p> <p>Teacher's Script: "Complete this sentence: 'A compressor with insulation resistance below 1 MΩ will fail within _____.'"</p> <p>Expected Answer: "Weeks to months," "The near future."</p> <p>3. Evaluating Learning</p> <p>Teacher: "Clear your desks. Get a 1/4 sheet of paper. Number 1 to 5."</p> <p>Quiz:</p> <p>1. What device switches the high-voltage compressor and fan on/off based on a 24V signal from the thermostat?</p> <p>2. What voltage (DC) should a megohmmeter be set to for testing a 230V compressor?</p> <p>3. A megger reading of 0.3 MΩ between a compressor terminal and ground indicates what?</p>	<p>Authentic maintenance – students perform the full electrical inspection.</p> <p>Predictive maintenance – teaches that megger readings predict failure.</p>
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	<p>4. What is one sign of a loose electrical terminal?</p> <p>5. True or False: You should megger a motor while it is still connected to the contactor.</p> <p>Answer Key:</p> <ol style="list-style-type: none"> 1. Contactor 2. 500V DC 3. Failed insulation (compressor will fail soon) 4. Discolored wire insulation, carbon, arcing marks, or screw turns easily. 5. False – disconnect first to avoid damaging the contactor or control board. <p>4. Additional Activities</p> <p>Remediation: Draw a simple schematic showing: thermostat → contactor coil → contactor contacts → compressor.</p> <p>Enrichment: Research the difference between a potential relay and a current relay (used for start capacitors on larger compressors).</p>	
VI. ASSESSMENT	<p>Performance Task: <i>Electrical Power Maintenance Report</i></p> <p>Scenario: You are performing annual preventive maintenance on a 10-year-old 15-ton commercial AC unit.</p> <p>Task:</p> <ol style="list-style-type: none"> 1. Inspect the contactor. Describe its condition (clean, pitted, welded, burned). 2. Check and record the torque of 5 sample terminals (simulated). 3. Measure voltage at the disconnect (simulated values provided). 4. Perform a megger test on a practice compressor (or use given simulated readings). 	

5. Complete the **Electrical Power Maintenance Report** with findings and recommended actions (e.g., "Replace contactor due to pitted contacts," "Compressor megger 0.8 MΩ – recommend replacement within 3 months").

Rubric for Assessment:

Criteria	Excellent (4)	Satisfactory (3)	Developing (2)	Unsatisfactory (1)	Score
Contactor Inspection	Correctly identifies condition and recommends action.	Identifies but action wrong.	Misses obvious failure.	No inspection.	
Terminal Check	All terminals checked, torque noted, action taken if loose.	Most terminals checked.	Few terminals checked.	No terminal check.	
Megger Test	Correct procedure, correct interpretation, correct action.	Procedure or interpretation minor error.	Major error.	Not performed or unsafe.	
Report Quality	Complete, clear, professional.	Missing one section.	Missing multiple sections.	No report.	

	Total (16 pts)					
VII. REFLECTION	<p><i>To be completed by the teacher after the lesson:</i></p> <p>Highlights: Did the megger demonstration help students understand how to predict compressor failure? Did the phrase "A megger sees what a multimeter cannot" stick with students?</p> <p>Challenges: Did students struggle with interpreting the "caution zone" (1-10 MΩ)? Did any student megger a motor while it was still connected to the contactor? Were students able to identify a pitted or welded contactor?</p> <p>Adjustments: Should I create a megger decision tree poster (Red/Yellow/Green)? Should I add a "disconnect before meggering" safety rule poster? Should I bring in failed contactors for students to examine?</p>					
VIII. USE OF GENERATIVE AI	<p>In preparing this Learning Exemplar (LE), the author used Generative AI to assist in structuring and drafting instructional content and assessment items. The author reviewed, edited, and finalized the writing of the content to ensure alignment with curriculum standards and contextual relevance. The author takes full responsibility for the final content of this LE.</p>					

LESSON EXEMPLAR			
Learning Area	Commercial Air-Conditioning Installation and Servicing	Lesson Exemplar	18

I. OBJECTIVES	
A. Content Standard	The learner understands the concepts and principles of the Commercial Air-Conditioning unit
B. Performance Standard	The learner performs maintenance, troubleshooting, and commissioning Commercial Air-Conditioning units with safety precautions.
C. Learning Competencies	1. Perform service and maintenance of the commercial air- conditioning units
II. REFERENCES and MATERIALS	<p>References:</p> <ol style="list-style-type: none"> 1. TESDA. (2021). <i>Training Regulation: Commercial Air-Conditioning Installation and Servicing NC III – Unit of Competency: Cost Services</i>. TESDA Philippines. 2. Sullivan, M. (2019). <i>HVACR Business Management and Estimating</i>. Cengage. <p>Materials & Integration:</p> <ul style="list-style-type: none"> • Software: Excel, Word, or Google Docs; optional: free CRM template (HubSpot or Zoho free tier). • Samples: Blank maintenance contract, service report form, invoice template, maintenance schedule spreadsheet. • Tools: Calculator.
III. CONTENT	<p>Title: Service Costing and Documentation (Maintenance)</p> <p>Sub-Topics:</p> <ol style="list-style-type: none"> 1. Calculating maintenance contract pricing (per visit vs. annual contract). 2. Preparing service reports for maintenance visits. 3. Tracking recurring maintenance (scheduling, reminders). 4. Legal aspects of maintenance documentation.

IV. OBJECTIVES	<p>At the end of the lesson, the learners should be able to:</p> <ol style="list-style-type: none"> 1. Explain the difference between time-and-materials billing and fixed-price maintenance contracts. 2. Prepare a preventive maintenance service report that includes: checklist of tasks performed, measurements taken, findings, and recommendations. 3. Recognize that detailed maintenance records are valuable assets that increase the resale value of a commercial HVAC business.
V. PROCEDURES	ANNOTATIONS
A. Activating Prior Knowledge	<ol style="list-style-type: none"> 1. Activating Prior Knowledge Teacher's Script: "In Lesson 13, we learned costing for installation. How is maintenance costing different?" Expected Answer: "Maintenance is recurring," "Smaller jobs." Teacher: "Yes. Today, we focus on maintenance contracts and service reports." 2. Establishing the Purpose of the Lesson Teacher's Script: "You have 20 commercial clients. Each needs quarterly maintenance. If you have no system for tracking, billing, or documenting, what happens?" Expected Answer: "You forget clients," "You lose money," "You get sued for missed maintenance." Teacher: "Today, you learn to run a professional maintenance operation."

<p>B. Instituting New Knowledge</p>	<p>1. Presenting Examples</p> <p>Teacher's Script: "I will show you two maintenance service reports. Report A: 'Cleaned unit. OK.' Report B: Lists filter change, coil cleaning, pressures, temperatures, amperage, contactor condition, and recommendations. Which one protects you if the client claims you didn't do the work?"</p> <p>Expected Answer: "Report B."</p> <p>2. Discussing New Concept</p> <p>Teacher's Script: "Open your notebook. Maintenance costing and documentation have specific requirements." Detailed Lecture Guide:</p> <p>Maintenance Pricing Models</p> <p>"1. <i>Time and materials (T&M)</i>: Bill for hours worked plus materials. Best for one-time repairs or unpredictable work. For maintenance, T&M is less common because clients prefer predictable costs."</p> <p>"2. <i>Per-visit fixed price</i>: A set price for each maintenance visit (e.g., PHP 5,000 per quarterly visit). Includes standard tasks (filter change, coil cleaning, electrical check). Extra repairs (compressor replacement) are billed separately."</p> <p>"3. <i>Annual contract</i>: Client pays a monthly or annual fee. Includes all scheduled maintenance and often a discount on repairs. Provides steady income for your business. Typical annual contract: 1-2% of the equipment replacement cost per year."</p>	<p>Documentation quality – shows that vague reports are worthless in disputes.</p>
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	<p>"<i>Example:</i> A PHP 500,000 AC system might have an annual maintenance contract of PHP 5,000-10,000 per year (PHP 400-800 per month)."</p> <p>Calculating Maintenance Cost</p> <p>"To set a per-visit price:"</p> <p>"1. Estimate labor hours: For a 10-ton unit, a thorough maintenance visit takes 2-3 hours."</p> <p>"2. Labor cost: 2.5 hours x PHP 600/hr = PHP 1,500."</p> <p>"3. Materials: Filter (PHP 500), coil cleaner (PHP 200), belt if needed (PHP 300) = PHP 1,000."</p> <p>"4. Travel: PHP 1,000."</p> <p>"5. Overhead (20%): (1,500+1,000+1,000) x 0.20 = PHP 700."</p> <p>"6. Profit (25%): (1,500+1,000+1,000+700) x 0.25 = PHP 1,050."</p> <p>"7. Total before VAT = 1,500+1,000+1,000+700+1,050 = PHP 5,250."</p> <p>"8. Add 12% VAT = PHP 5,880."</p> <p>"So charge approximately PHP 6,000 per quarterly visit."</p> <p>Maintenance Service Report</p> <p>"A professional maintenance report MUST include:"</p> <p>"1. Header: Client name, site address, date, technician name."</p> <p>"2. Unit information: Brand, model, serial number, location."</p> <p>"3. Checklist of tasks performed (filter, coils, drain, electrical, fan motor, refrigerant)."</p> <p>"4. Measurements: Voltage, amperage, pressures, temperatures, subcooling, superheat, airflow (CFM), insulation resistance (megger)."</p> <p>"5. Findings: Any abnormalities (e.g., 'Contactor pitted – recommend replacement')."</p>	
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	<p>"6. Recommendations: What should be done next (e.g., 'Replace fan motor within 6 months')."</p> <p>"7. Parts used: Filter part number, belt size, etc."</p> <p>"8. Client signature: Acknowledges work was performed."</p> <p>"Why so detailed?"</p> <p>"1. Legal protection: If the unit fails a week later, your report proves the system was operating correctly at the time of your visit."</p> <p>"2. Trend analysis: Comparing measurements over time (e.g., compressor amperage increasing each quarter) predicts failure."</p> <p>"3. Professionalism: Clients trust detailed reports. They see value in your service."</p> <p>"4. Sales tool: Recommendations lead to repair work (e.g., 'Condenser coil needs replacement – quote attached')."</p> <p>Tracking and Scheduling</p> <p>"Use a spreadsheet or simple CRM (Customer Relationship Management) tool to track:"</p> <p>"1. Client contact information."</p> <p>"2. Equipment list (make, model, serial, age)."</p> <p>"3. Maintenance schedule (last visit date, next visit due)."</p> <p>"4. Service history (links to past reports)."</p> <p>"Send reminders to clients 2 weeks before maintenance is due. Offer discounts for scheduling multiple units or signing annual contracts."</p> <p>Legal Aspects</p> <p>"1. Maintenance contract: A legally binding agreement. Specify scope of work, exclusions (e.g., 'Acts of God not covered'), payment terms, termination clause."</p>	
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	<p>"2. Service report signed by client: Proof of work performed. Keep for at least 3 years (statute of limitations for contract disputes)."</p> <p>"3. Liability insurance: Carry at least PHP 1-2 million in general liability. If your maintenance misses a problem that causes a fire, you could be sued."</p> <p>"Never: Backdate a service report. That is fraud. If you forgot to get a signature, call the client and ask to sign later – do not forge."</p> <p>3. Developing Mastery</p> <p>Teacher's Script: "Pricing exercise. A client wants a quarterly maintenance contract for a 20-ton AC (2 hours per visit, PHP 700/hr labor, PHP 1,500 materials, PHP 1,500 travel). Compute the per-visit price before VAT (overhead 20%, profit 25%)."</p> <p>Answer: "Labor = 2 x 700 = 1,400. Materials = 1,500. Travel = 1,500. Subtotal direct = 4,400. Overhead = 4,400 x 0.20 = 880. Subtotal = 5,280. Profit = 5,280 x 0.25 = 1,320. Total before VAT = 6,600."</p>	<p>Math application – students apply the pricing formula to a new scenario.</p>
<p>C. Demonstrating Knowledge and Skills</p>	<p>1. Finding Practical Application</p> <p>Teacher's Script: "Using the template provided, create a complete Maintenance Service Report for a mock maintenance visit. Include:"</p> <p>"1. Client: 'ABC Office Building, 123 Main St.'"</p> <p>"2. Unit: 10-ton split, model ABC-123, serial 456."</p> <p>"3. Tasks performed: Filter change (MERV 8), coil cleaning (evaporator only), electrical inspection (found contactor OK), measured pressures (125/410 psi), temperatures (suction 55°F, liquid 100°F), calculated subcooling 10°F, superheat 13°F."</p>	<p>Authentic document creation – students produce a professional report.</p>

	<p>"- Recommendation: 'No issues found. Next maintenance due in 3 months.'"</p> <p>Students submit reports. Teacher reviews for completeness.</p> <p>2. Making Generalization</p> <p>Teacher's Script: "Complete this sentence: 'A maintenance contract is not just a service; it is a _____ between the technician and the client.'"</p> <p>Expected Answer: "Partnership," "Relationship," "Promise."</p> <p>3. Evaluating Learning</p> <p>Teacher: "Clear your desks. Get a 1/4 sheet of paper. Number 1 to 5."</p> <p>Quiz:</p> <ol style="list-style-type: none"> 1. What is the main difference between time-and-materials billing and a fixed-price maintenance contract? 2. List three items that must be included in a professional maintenance service report. 3. A 5-ton AC unit costs PHP 250,000. What is a typical annual maintenance contract price range (1-2% of equipment cost)? 4. True or False: A signed service report is legally valuable if a client disputes the work performed. 5. Why should you never backdate a service report? 	<p>Relationship framing – maintenance builds long-term trust and recurring revenue.</p>
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	<p>Answer Key:</p> <ol style="list-style-type: none"> 1. T&M bills actual hours/materials; fixed price is a set fee regardless of actual time. 2. Any three: Header (client/date/tech), unit info, checklist, measurements, findings, recommendations, parts used, client signature. 3. PHP 2,500 to PHP 5,000 per year (or PHP 200-400 per month). 4. True 5. It is fraud. <p>4. Additional Activities</p> <p>Remediation: Complete a partially filled maintenance service report by adding the missing sections.</p> <p>Enrichment: Research the legal requirements for service contracts in the Philippines (Civil Code provisions on service contracts) and write a one-page summary.</p>	
VI. ASSESSMENT	<p>Performance Task: <i>Maintenance Contract Proposal Package</i></p> <p>Scenario: A potential client with 5 commercial AC units (3 x 5-ton, 2 x 10-ton) requests a proposal for quarterly maintenance.</p> <p>Task:</p> <ol style="list-style-type: none"> 1. Calculate the per-visit cost for one 10-ton unit (use the formula). 2. Calculate the total quarterly cost for all 5 units (assume 5-ton units cost 70% of 10-ton units). 3. Prepare a Maintenance Contract Proposal including: scope of work, pricing (per visit and annual contract options), payment terms, and a sample service report form. 4. Submit the proposal as a professional document. 	

	Rubric for Assessment:					
	Criteria	Excellent (4)	Satisfactory (3)	Developing (2)	Unsatisfactory (1)	Score
	Cost Calculation	Correct for all units, clear breakdown.	Minor math error.	Major error.	No calculation.	
	Scope of Work	Detailed, specific tasks listed.	General but acceptable.	Vague.	No scope.	
	Sample Report	Complete, professional, includes all required sections.	Missing 1-2 sections.	Missing 3+ sections.	No sample.	
	Professional Format	Clean layout, no spelling errors, contact info included.	Minor issues.	Major issues.	Unprofessional.	
	Total (16 pts)					

VII. REFLECTION	<p><i>To be completed by the teacher after the lesson:</i></p> <p>Highlights: Did the maintenance contract role-play help students understand the value of recurring revenue? Did students see the difference between time-and-materials and fixed-price contracts?</p> <p>Challenges: Did students forget to include travel costs in the maintenance price? Were students able to create a complete maintenance service report with all required sections? Did any student skip the client signature line?</p> <p>Adjustments: Should I provide a maintenance report template with checkboxes? Should I add a "travel cost calculator" (km x PHP/km) to the pricing worksheet? Should I emphasize that an unsigned report is legally worthless?</p>
VIII. USE OF GENERATIVE AI	<p>In preparing this Learning Exemplar (LE), the author used Generative AI to assist in structuring and drafting instructional content and assessment items. The author reviewed, edited, and finalized the writing of the content to ensure alignment with curriculum standards and contextual relevance. The author takes full responsibility for the final content of this LE.</p>

LESSON EXEMPLAR			
Learning Area	Commercial Air-Conditioning Installation and Servicing	Lesson Exemplar	19

I. OBJECTIVES	
A. Content Standard	The learner understands the concepts and principles of the Commercial Air-Conditioning unit
B. Performance Standard	The learner performs maintenance, troubleshooting, and commissioning Commercial Air-Conditioning units with safety precautions.
C. Learning Competencies	2. Discuss pre-troubleshooting of commercial air- conditioning units
II. REFERENCES and MATERIALS	<p>References:</p> <ol style="list-style-type: none"> 1. Althouse, A. D., Turnquist, C. H., & Bracciano, A. F. (2020). <i>Modern Refrigeration and Air Conditioning</i> (21st ed.). The Goodheart-Willcox Company, Inc. 2. TESDA. (2021). <i>Training Regulation: Commercial Air-Conditioning Installation and Servicing NC III</i>. TESDA Philippines. <p>Materials & Integration:</p> <ul style="list-style-type: none"> • Tools: None for theory; optional: sample service manuals, wiring diagrams. • Visuals: Troubleshooting flowcharts, decision trees. <p>PPE: Not applicable for discussion.</p>
III. CONTENT	<p>Title: Pre-Troubleshooting of Commercial Air Conditioning Units</p> <p>Sub-Topics:</p> <ol style="list-style-type: none"> 1. Principles and concepts of systematic troubleshooting (observe, verify, isolate, test, correct). 2. Occupational Health and Safety (OHS) during troubleshooting (LOTO, PPE, refrigerant safety). 3. System specifications (nameplate data, manufacturer manuals, normal operating parameters).

IV. OBJECTIVES	At the end of the lesson, the learners should be able to: 1. List the five steps of systematic troubleshooting in order (Observe, Verify, Isolate, Test, Correct). 2. Given a complaint (e.g., "AC not cooling"), correctly identify the first three pieces of information to gather from the client and the unit. 3. Commit to never guessing or replacing parts without diagnosis (no "parts changers").	
V. PROCEDURES		ANNOTATIONS
A. Activating Prior Knowledge	1. Activating Prior Knowledge <i>Teacher's Script:</i> "You arrive at a service call. The client says, 'My AC is not cooling.' What is the FIRST thing you do?" <i>Expected Answer:</i> "Ask questions," "Check the thermostat," "Turn it on." <i>Teacher:</i> "Good. Today, we formalize that process into a system. Troubleshooting without a system is just guessing."	Diagnostic thinking – students often think the first step is "check the refrigerant." The correct first step is "ASK QUESTIONS."

<p>B. Instituting New Knowledge</p>	<p>1. Presenting Examples</p> <p>Teacher's Script: "I will present two troubleshooting approaches. Approach A: 'The compressor is not running – must be bad. Replace it.' Approach B: 'The compressor is not running – check power, check contactor, check capacitor, check overload, then check compressor.' Which approach saves money and time?"</p> <p>Expected Answer: "Approach B."</p> <p>2. Discussing New Concept</p> <p>Teacher's Script: "Open your notebook. Pre-troubleshooting is the thinking you do before you touch any tools."</p> <p>Detailed Lecture Guide:</p> <p>The 5-Step Systematic Troubleshooting Method "Step 1: OBSERVE – Gather Information" "Talk to the client. Ask:" "1. 'When did the problem start?' (Suddenly? Gradually?)" "2. 'Has anyone else worked on it?' (Previous repairs?)" "3. 'What exactly happens? Does it run at all? Does it make noise?'" "4. 'Has there been any recent construction, electrical work, or weather events?'"</p> <p>"Then observe the unit visually (with power OFF first):" "1. Is the filter clean or dirty?" "2. Are the coils clean?" "3. Are there signs of oil leaks (indicates refrigerant leak)?"</p>	<p>Process comparison – students see the value of systematic elimination.</p>
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	<p>"4. Is there ice on the evaporator?"</p> <p>"5. Are wires burned or loose?"</p> <p>"6. Is the contactor pulled in or open?"</p> <p>"Step 2: VERIFY – Check the Basics First"</p> <p>"Before complex tests, verify the simple things that are most often the problem:"</p> <p>"1. Is the thermostat set to 'Cool' and below room temperature?"</p> <p>"2. Is the disconnect switch ON?"</p> <p>"3. Is the circuit breaker ON (not tripped)?"</p> <p>"4. Is the filter dirty?"</p> <p>"5. Is there power at the unit? (Use a non-contact voltage tester.)"</p> <p>"Step 3: ISOLATE – Divide the System"</p> <p>"Break the system into sections. For a split AC:"</p> <p>"1. Control circuit (24V): Thermostat → transformer → contactor coil."</p> <p>"2. Power circuit (230V): Breaker → disconnect → contactor contacts → compressor/fan."</p> <p>"3. Refrigerant circuit: Compressor → condenser → metering device → evaporator."</p> <p>"4. Air circuit: Filter → evaporator → blower → ducts."</p> <p>"Test each section separately. If the control circuit has 24V at the contactor coil but the contactor does not pull in, the problem is in the contactor (mechanical or coil). If the contactor pulls in but the compressor does not run, the problem is in the power circuit or compressor."</p> <p>"Step 4: TEST – Measure and Compare"</p> <p>"Now use your tools:"</p> <p>"1. Measure voltage at the contactor line side (incoming)."</p>	
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	<p>"2. Measure voltage at the contactor load side (when contactor is pulled in)."</p> <p>"3. Measure amperage of compressor and fan."</p> <p>"4. Measure pressures and temperatures."</p> <p>"5. Calculate subcooling and superheat."</p> <p>"6. Megger the compressor (if suspect)."</p> <p>"Compare measurements to nameplate and manufacturer specifications."</p> <p>"Step 5: CORRECT – Fix or Replace"</p> <p>"Only after identifying the specific failed component do you repair or replace."</p> <p>"1. Replace a burned contactor."</p> <p>"2. Add refrigerant if undercharged (but first find and repair the leak – do not just 'top off')."</p> <p>"3. Replace a failed fan motor."</p> <p>"Never: Replace a part because 'it might be bad.' Always test and confirm."</p> <p>Occupational Health and Safety (OHS) During Troubleshooting</p> <p>"Before any troubleshooting:"</p> <p>"1. LOTO (Lock-Out/Tag-Out) when removing panels or touching electrical components. Even if you think the unit is off, verify with a voltage tester."</p> <p>"2. PPE: Safety glasses, insulated gloves, hearing protection (for noisy equipment)."</p> <p>"3. Refrigerant safety: Wear gloves and glasses when connecting gauges. Refrigerant can cause frostbite. Work in a ventilated area – refrigerant displaces oxygen."</p> <p>"4. Ladder safety: For rooftop units, use a ladder with a stabilizer. Have someone hold the ladder. Do not carry</p>	
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	<p>tools in your hands while climbing – use a tool belt or hoist."</p> <p>"5. Confined space: Some mechanical rooms are tight. Have a spotter. Never enter a confined space alone."</p> <p>System Specifications</p> <p>"Before troubleshooting, you MUST know what 'normal' looks like for that specific unit."</p> <p>"Sources of specifications:"</p> <p>"1. Nameplate: Voltage, phase, MCA, MOP, refrigerant type, factory charge."</p> <p>"2. Manufacturer manual: Subcooling target, superheat target, pressure curves, wiring diagram."</p> <p>"3. P-T chart (Pressure-Temperature): Converts pressure to saturation temperature for the refrigerant."</p> <p>"4. Normal operating parameters (general guidelines):"</p> <p>"5. R-410A low side: 110-140 psi (35-45°F saturation)"</p> <p>"6. R-410A high side: 350-450 psi (100-120°F saturation at 95°F ambient)"</p> <p>" 7. Subcooling: 8-12°F (TXV systems)"</p> <p>" 8. Superheat: 10-15°F (TXV systems)"</p> <p>" 9. Compressor amperage: within ±10% of RLA"</p> <p>" 10. Airflow: 400 CFM per ton"</p> <p>"The Troubleshooting Mindset"</p> <p>"1. Be systematic. Follow the same steps every time."</p> <p>"2. Do not jump to conclusions. The most obvious answer is often wrong."</p> <p>"3. Document everything. Write down measurements before and after repairs."</p> <p>"4. Know your limits. If you are not qualified for three-phase or high-voltage work, call a licensed electrician."</p>	
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	<p>"Common Pre-Troubleshooting Mistakes"</p> <p>"1. Skipping the visual inspection."</p> <p>"2. Not checking the filter first."</p> <p>"3. Assuming the compressor is bad without checking power and capacitor."</p> <p>"4. Adding refrigerant without calculating subcooling/superheat."</p> <p>"5. Not wearing PPE."</p> <p>"6. Working on live equipment without LOTO."</p> <p>"7. Not having the manufacturer's manual."</p> <p>3. Developing Mastery</p> <p>Teacher's Script: "Troubleshooting scenario. I will give you a complaint. Your group will write down the first 5 things you would do (in order) following the systematic method."</p> <p>Scenario: "A restaurant owner says: 'Our 10-ton AC was working yesterday. Today, it is completely dead. Nothing runs. No fan, no compressor.'"</p> <p>Expected Answer Sequence: "1. Ask when it stopped (suddenly). 2. Check thermostat settings. 3. Check disconnect and breaker. 4. Check for power at the unit (voltage tester). 5. Check control voltage (24V at contactor coil)."</p>	<p>Application of process – students practice the 5 steps on a realistic scenario.</p>
<p>C. Demonstrating Knowledge and Skills</p>	<p>1. Finding Practical Application</p> <p>Teacher's Script: "Role-play. One student is the client, one is the technician. The client will describe a problem from a card. The technician must ask at least 5 questions before suggesting any test or repair."</p> <p><i>Client cards:</i></p>	<p>Communication skills – technicians must gather information effectively.</p>

	<p>"1. 'The AC runs but the air is warm.'"</p> <p>"2. 'The AC makes a loud banging noise when it starts.'"</p> <p>"3. 'The AC runs for 5 minutes then trips the breaker.'"</p> <p>Teacher observes and provides feedback on questioning technique.</p> <p>2. Making Generalization</p> <p>Teacher's Script: "Complete this sentence: 'The most expensive tool in my truck is not my gauge manifold; it is my _____.'"</p> <p>Expected Answer: "Brain," "Knowledge," "Troubleshooting process."</p> <p>3. Evaluating Learning</p> <p>Teacher: "Clear your desks. Get a 1/4 sheet of paper. Number 1 to 5."</p> <p>Quiz:</p> <ol style="list-style-type: none"> 1. List the five steps of systematic troubleshooting in order. 2. What is the first thing you should do before removing any panels on a commercial AC unit? 3. True or False: Adding refrigerant 'just to see if it helps' is an acceptable troubleshooting technique. 4. A contactor pulls in (you hear a click) but the compressor does not run. What is the next thing you should check? 	<p>Metacognition – emphasizes that thinking is the most valuable skill.</p>
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	<p>5. What safety procedure must be followed before touching electrical terminals?</p> <p>Answer Key:</p> <ol style="list-style-type: none"> 1. Observe, Verify, Isolate, Test, Correct 2. Verify power is OFF (LOTO) and wear PPE. 3. False 4. Voltage at the load side of the contactor (or check if the contactor contacts are actually closing). 5. LOTO (Lock-Out/Tag-Out) and verify with a non-contact voltage tester. <p>4. Additional Activities</p> <p>Remediation: Create a flowchart of the 5-step troubleshooting method with decision diamonds.</p> <p>Enrichment: Research a real HVAC troubleshooting case study online (e.g., from HVAC School or HVAC Talk forum) and write a summary of the technician's process.</p>	
VI. ASSESSMENT	<p>Performance Task: <i>Troubleshooting Pre-Call Questionnaire</i></p> <p>Scenario: You receive a service call from a hotel: "Our lobby AC is not cooling, and there is water on the floor."</p> <p>Task:</p> <ol style="list-style-type: none"> 1. Write a list of 8 questions you would ask the hotel manager BEFORE arriving on site. 2. Write a list of 5 things you will check visually as soon as you arrive (before any tools). 3. Outline the systematic troubleshooting sequence you will follow (O-V-I-T-C). 4. Identify at least 3 OHS hazards you anticipate and how you will mitigate them. 	

	Rubric for Assessment:					
	Criteria	Excellent (4)	Satisfactory (3)	Developing (2)	Unsatisfactory (1)	Score
	Pre-Call Questions	8+ relevant, insightful questions.	5-7 relevant questions.	3-4 basic questions.	<3 questions.	
	Visual Inspection Plan	5+ specific items to check.	3-4 items.	1-2 items.	No plan.	
	Troubleshooting Sequence	Correct O-V-I-T-C order with specific actions.	Correct order but vague actions.	Incorrect order.	No sequence.	
	OHS Identification	3+ hazards with specific mitigations.	2 hazards with mitigations.	1 hazard.	No hazards identified.	
	Total (16 pts)					

VII. REFLECTION	<p><i>To be completed by the teacher after the lesson:</i></p> <p>Highlights: Did the "5 questions before touching anything" activity stop the "parts changer" mentality? Did students remember the mnemonic "Old Vans Invite Total Chaos" (Observe, Verify, Isolate, Test, Correct)?</p> <p>Challenges: Did students struggle with the "Isolate" step (dividing system into control, power, and refrigerant circuits)? Did any student skip the visual inspection and go straight to gauges? Were students able to identify OHS hazards before starting?</p> <p>Adjustments: Should I use color-coded circuit tracing worksheets (red for power, blue for control, green for refrigerant)? Should I add a "visual inspection mandatory" step to the troubleshooting flowchart? Should I create an OHS hazard identification checklist?</p>
VIII. USE OF GENERATIVE AI	<p>In preparing this Learning Exemplar (LE), the author used Generative AI to assist in structuring and drafting instructional content and assessment items. The author reviewed, edited, and finalized the writing of the content to ensure alignment with curriculum standards and contextual relevance. The author takes full responsibility for the final content of this LE.</p>

LESSON EXEMPLAR			
Learning Area	Commercial Air-Conditioning Installation and Servicing	Lesson Exemplar	20

I. OBJECTIVES	
A. Content Standard	The learner understands the concepts and principles of the Commercial Air-Conditioning unit
B. Performance Standard	The learner performs maintenance, troubleshooting, and commissioning Commercial Air-Conditioning units with safety precautions.
C. Learning Competencies	2. Discuss pre-troubleshooting of commercial air- conditioning units
II. REFERENCES and MATERIALS	<p>References:</p> <ol style="list-style-type: none"> 1. TESDA. (2021). <i>Training Regulation: Commercial Air-Conditioning Installation and Servicing NC III – List of Tools and Equipment</i>. TESDA Philippines. 2. Whitney, L. (2018). <i>HVACR Troubleshooting Fundamentals</i>. Pearson. <p>Materials & Integration:</p> <ul style="list-style-type: none"> • Tools (physical or photos): Multimeter (digital and analog), clamp meter, gauge manifold (R-410A and R-22), electronic leak detector, micron gauge, thermometer (thermocouple), psychrometer, anemometer, megohmmeter. • PPE: Safety glasses, gloves, refrigerant gloves. <p>Visuals: Tool identification chart.</p>
III. CONTENT	<p>Title: Tools and Equipment for Troubleshooting</p> <p>Sub-Topics:</p> <ol style="list-style-type: none"> 1. Essential troubleshooting tools (multimeter, clamp meter, gauge manifold, thermometer). 2. Advanced diagnostic tools (megger, electronic leak detector, micron gauge, psychrometer, anemometer). 3. Proper use and care of each tool. 4. Tool safety and calibration.

IV. OBJECTIVES	<p>At the end of the lesson, the learners should be able to:</p> <ol style="list-style-type: none"> 1. Match each troubleshooting tool to its specific function (e.g., "megger" → "measures insulation resistance"). 2. Correctly connect a gauge manifold to a service port without damaging the Schrader valve and without refrigerant loss (on a trainer). 3. Always inspect tools for damage before each use (e.g., cracked gauge manifold hoses).
V. PROCEDURES	ANNOTATIONS
A. Activating Prior Knowledge	<ol style="list-style-type: none"> 1. Activating Prior Knowledge <p>Teacher's Script: "In Domestic RAC, what tools did you use to check if an AC has the correct refrigerant charge?"</p> <p>Expected Answer: "Gauge manifold," "Thermometer."</p> <p>Teacher: "Today, we add 5 more tools to your diagnostic arsenal. Commercial systems require more precise measurements."</p> 2. Establishing the Purpose of the Lesson <p>Teacher's Script: "You suspect a compressor has bad insulation (windings shorting to ground). You have a multimeter but not a megger. You measure resistance and see 'OL' (over limit) – seems fine. But the compressor fails a week later. What tool did you need?"</p> <p>Expected Answer: "Megger (megohmmeter)."</p> <p>Teacher: "Today, you learn which tool for which job."</p>

<p>B. Instituting New Knowledge</p>	<p>1. Presenting Examples</p> <p>Teacher's Script: "I will pass around or show photos of 8 tools. Your group will write down: (1) Tool name, (2) What it measures, (3) One situation where you would use it."</p> <p>Tools: Multimeter, clamp meter, gauge manifold, electronic leak detector, micron gauge, psychrometer, anemometer, megger.</p> <p>2. Discussing New Concept</p> <p>Teacher's Script: "Open your notebook. We will go through each essential and advanced troubleshooting tool."</p> <p>Detailed Lecture Guide:</p> <p>Essential Tools (Every technician must own)</p> <p>"1. Digital Multimeter (DMM)" "a. Measures: AC/DC voltage, resistance (ohms), continuity (beep), capacitance (μF), sometimes temperature." "b. Use for: Checking voltage at disconnect, checking contactor coil continuity, testing capacitors, checking for shorts." "c. Safety: CAT III rated for commercial/industrial use. CAT II is for residential only." "d. Brands: Fluke, Klein, UEi, Fieldpiece."</p> <p>"2. Clamp Meter (Ammeter)" "a. Measures: Current (amps) without disconnecting wires. Clamp around one wire."</p>	<p>Active engagement – students interact with each tool (or photo) to build familiarity.</p>
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	<p>"b. Use for: Measuring compressor RLA, fan FLA, checking for overcurrent, checking phase balance."</p> <p>"c. Note: Clamp around ONLY ONE wire. Clamping around two wires (L1 and L2) cancels out and reads zero."</p> <p>"3. Gauge Manifold"</p> <p>"a. Measures: Refrigerant pressure (high and low side)."</p> <p>"b. Has: Two gauges (blue = low side, red = high side), hand valves, hoses with Schrader depressors."</p> <p>"c. Types: R-410A rated (800 psi high side, 600 psi low side, hoses rated 800 psi). Do not use R-22 gauges on R-410A – they will burst."</p> <p>"d. Use for: Checking operating pressures, diagnosing undercharge/overcharge, recovering refrigerant."</p> <p>"e. Care: Never open the hand valves with hoses disconnected (will suck in air). Keep hoses capped when not in use."</p> <p>"4. Thermometer (Thermocouple / Thermistor)"</p> <p>"a. Measures: Temperature (air, pipe, surface)."</p> <p>"b. Types: Penetration probe (for pipe temperature), air probe (for supply/return), infrared (non-contact – less accurate for pipe)."</p> <p>"c. Use for: Measuring suction line temp, liquid line temp, supply air temp, return air temp."</p> <p>"5. Electronic Leak Detector"</p> <p>"a. Detects: Refrigerant leaks (sniffs the air)."</p> <p>"b. Types: Heated diode (for HFCs like R-410A), ultrasonic (listens for hiss), heated diode for hydrocarbons (R-32, R-600a)."</p> <p>"c. Use for: Finding small leaks that bubble solution might miss."</p>	
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	<p>"d. Care: Calibrate per instructions. Replace sensor annually. Do not expose to large amounts of refrigerant (will damage sensor)."</p> <p>"Advanced Tools (For commercial work)"</p> <p>"6. Megohmmeter (Megger)"</p> <p>"a. Measures: Insulation resistance (megohms) by applying high voltage (500V, 1000V DC)."</p> <p>"b. Use for: Predicting compressor motor winding failure before it happens."</p> <p>"c. Interpretation: >10 MΩ = good; 1-10 MΩ = caution; <1 MΩ = fail."</p> <p>"7. Micron Gauge (Vacuum Gauge)"</p> <p>"a. Measures: Deep vacuum in microns (absolute pressure). 1 atmosphere = 760,000 microns."</p> <p>"b. Use for: Verifying that a system is properly evacuated (no leaks, no moisture) before charging."</p> <p>"c. Target: Pull vacuum to <500 microns and hold for 15 minutes (rise <100 microns)."</p> <p>"8. Psychrometer (Hygrometer)"</p> <p>"a. Measures: Relative humidity (%), wet-bulb temperature, dew point."</p> <p>"b. Use for: Calculating total heat load, checking if a system is removing humidity properly."</p> <p>"9. Anemometer"</p> <p>"a. Measures: Air velocity (feet per minute or meters per second)."</p> <p>"b. Types: Vane (spinning wheel) or hot-wire (more accurate for low velocity)."</p> <p>"c. Use for: Calculating CFM (airflow) at grilles and ducts."</p>	
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"10. Combustion Analyzer" (for gas heating – not common in pure AC but good to know)"
 "a Measures: Oxygen, carbon monoxide, flue temperature."
 "b. Use for: Checking efficiency of gas furnaces (if your commercial unit has heating)."

"Tool Care and Safety"

"1. Inspect before each use: Cracked gauge manifold hoses? Frayed multimeter leads? Damaged clamps?"
 "2. Calibrate annually: Send multimeters and gauges to a calibration lab (or use a known reference)."
 "3. Store properly: Keep gauges and electronics in a padded case. Do not leave in a hot truck (damages LCD screens and sensors)."
 "4. Clean after use: Wipe refrigerant oil from hoses. Oil degrades rubber over time."

Tool Selection Guide

Symptom/Question	Tool to Use
Is there power at the unit?	Non-contact voltage tester or multimeter
Is the compressor drawing correct amps?	Clamp meter
Is the system undercharged?	Gauge manifold + thermometer (calculate subcooling)

	<table><tr><td>Is there a refrigerant leak?</td><td>Electronic leak detector + bubble solution</td></tr><tr><td>Is the compressor winding failing?</td><td>Megger</td></tr><tr><td>Is the vacuum deep enough?</td><td>Micron gauge</td></tr><tr><td>Is the airflow correct?</td><td>Anemometer</td></tr><tr><td>Is the humidity too high?</td><td>Psychrometer</td></tr><tr><td>Is the capacitor good?</td><td>Multimeter (capacitance mode)</td></tr></table>	Is there a refrigerant leak?	Electronic leak detector + bubble solution	Is the compressor winding failing?	Megger	Is the vacuum deep enough?	Micron gauge	Is the airflow correct?	Anemometer	Is the humidity too high?	Psychrometer	Is the capacitor good?	Multimeter (capacitance mode)	
Is there a refrigerant leak?	Electronic leak detector + bubble solution													
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Is the humidity too high?	Psychrometer													
Is the capacitor good?	Multimeter (capacitance mode)													
	<p>3. Developing Mastery</p> <p>Teacher's Script: "Tool matching quiz. I will call out a troubleshooting task. You will hold up the correct tool card (or say the tool name)."</p> <p>Tasks:</p> <p>"1. 'Check if the compressor has a short to ground.' (Megger)"</p> <p>"2. 'Measure the temperature of the liquid line.' (Thermometer / thermocouple)"</p> <p>"3. 'Find a very small refrigerant leak.' (Electronic leak detector)"</p>	<p>Rapid recall – gamified learning to reinforce tool-function association.</p>												

Rapid recall – gamified learning to reinforce tool-function association.

	<p>"4. 'Check if the vacuum pump has pulled down to 250 microns.' (Micron gauge)"</p> <p>"5. 'Measure the CFM coming out of a supply grille.' (Anemometer)"</p>	
<p>C. Demonstrating Knowledge and Skills</p>	<p>1. Finding Practical Application</p> <p>Teacher's Script: "Station rotation. You will visit 5 stations. At each station, you will perform a specific tool skill."</p> <p>"Station 1 (Multimeter): Measure voltage of a battery (simulated). Measure continuity of a wire."</p> <p>"Station 2 (Clamp Meter): Clamp around a single wire (simulated) and read amperage."</p> <p>"Station 3 (Gauge Manifold): Connect hoses to a service port trainer without damaging the valve. Practice opening and closing valves."</p> <p>"Station 4 (Megger): On a practice motor (safe), megger from terminal to ground (instructor supervised)."</p> <p>"Station 5 (Leak Detector): Find a simulated leak (a pinprick hole with a drop of refrigerant or alcohol)."</p> <p>Teacher and assistant circulate to correct technique.</p> <p>2. Making Generalization</p> <p>Teacher's Script: "Complete this sentence: 'A tool is only as good as the technician's ability to _____ it.'"</p> <p>Expected Answer: "Use," "Interpret," "Maintain."</p>	<p>Hands-on practice – every student touches every tool.</p> <p>Emphasizes skill over equipment – expensive tools are useless without knowledge.</p>

	<p>3. Evaluating Learning</p> <p>Teacher: “Clear your desks. Get a 1/4 sheet of paper. Number 1 to 5.”</p> <p>Quiz:</p> <ol style="list-style-type: none"> 1. What tool measures insulation resistance in megohms? 2. What is the main difference between a multimeter and a clamp meter? 3. A technician wants to measure the CFM of air leaving a supply grille. What tool should they use? 4. True or False: You can use R-22 gauge manifold hoses on an R-410A system. 5. What tool is used to verify that a vacuum pump has achieved a deep vacuum (below 500 microns)? <p>Answer Key:</p> <ol style="list-style-type: none"> 1. Megohmmeter (megger) 2. Clamp meter measures current (amps) without disconnecting wires; multimeter measures voltage, resistance, capacitance, etc. (A clamp meter often includes multimeter functions.) 3. Anemometer 4. False – R-410A operates at much higher pressure; R-22 hoses can burst. 5. Micron gauge <p>4. Additional Activities</p> <p>Remediation: Create flashcards with tool names on one side and functions on the other. Quiz a partner.</p>	
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	Enrichment: Research the cost of a complete commercial HVAC tool set (catalog or online) and create a budget spreadsheet with justification for each tool.												
VI. ASSESSMENT	Performance Task: <i>Tool Selection and Use Practical Exam</i>												
	Scenario: You are troubleshooting a 15-ton commercial AC with the following symptoms: "Compressor runs but system has low cooling capacity. No obvious leaks."												
	Task: 1. Select the correct tools from the tool crib (or list them). 2. Using a trainer or simulation, perform the following measurements: <ul style="list-style-type: none">○ Measure voltage at the disconnect.○ Measure compressor amperage.○ Connect gauge manifold and record pressures.○ Measure suction line and liquid line temperatures.○ Calculate subcooling and superheat. 3. Record all measurements on a Diagnostic Worksheet . 4. Based on the measurements (provided by instructor), state the likely problem.												
	Rubric for Assessment: <table><tr><th>Criteria</th><th>Excellent (4)</th><th>Satisfactory (3)</th><th>Developing (2)</th><th>Unsatisfactory (1)</th><th>Score</th></tr><tr><td>Tool Selection</td><td>Correct tools for all measurements</td><td>Missing 1 tool.</td><td>Missing 2+ tools.</td><td>Wrong tools.</td><td></td></tr></table>		Criteria	Excellent (4)	Satisfactory (3)	Developing (2)	Unsatisfactory (1)	Score	Tool Selection	Correct tools for all measurements	Missing 1 tool.	Missing 2+ tools.	Wrong tools.
Criteria	Excellent (4)	Satisfactory (3)	Developing (2)	Unsatisfactory (1)	Score								
Tool Selection	Correct tools for all measurements	Missing 1 tool.	Missing 2+ tools.	Wrong tools.									

	Tool Use	Correct technique for each tool (clamp, gauge connection, etc.).	Minor errors.	Major errors.	Unsafe use.	
	Measurement Recording	All measurements recorded correctly.	1-2 errors.	3+ errors.	No recording.	
	Diagnosis	Correctly identifies problem based on measurements	Partial diagnosis.	Wrong diagnosis.	No diagnosis.	
	Total (16 pts)					
VII. REFLECTION	<p><i>To be completed by the teacher after the lesson:</i></p> <p>Highlights: Did the station rotation allow every student to touch every tool? Which station was most popular (gauges, megger, leak detector)?</p> <p>Challenges: Did students confuse clamp meter (amps) with multimeter (volts/ohms)? Were students able to correctly connect gauge manifold hoses without damaging Schrader valves? Did any student use R-22 gauges on an R-410A system?</p>					

	<p>Adjustments: Should I add a "Tool Showdown" quiz where students race to grab the correct tool for a given symptom? Should I color-code gauge sets (blue for low pressure, red for high pressure)? Should I post a "R-410A ONLY" warning on high-pressure gauges?</p>
<p>VIII. USE OF GENERATIVE AI</p>	<p>In preparing this Learning Exemplar (LE), the author used Generative AI to assist in structuring and drafting instructional content and assessment items. The author reviewed, edited, and finalized the writing of the content to ensure alignment with curriculum standards and contextual relevance. The author takes full responsibility for the final content of this LE.</p>

LESSON EXEMPLAR			
Learning Area	Commercial Air-Conditioning Installation and Servicing	Lesson Exemplar	21

I. OBJECTIVES	
A. Content Standard	The learner understands the concepts and principles of the Commercial Air-Conditioning unit
B. Performance Standard	The learner performs maintenance, troubleshooting, and commissioning Commercial Air-Conditioning units with safety precautions.
C. Learning Competencies	3. Perform troubleshooting of commercial air-conditioning units
II. REFERENCES and MATERIALS	<p>References:</p> <ol style="list-style-type: none"> 1. Althouse, A. D., Turnquist, C. H., & Bracciano, A. F. (2020). <i>Modern Refrigeration and Air Conditioning</i> (21st ed.). The Goodheart-Willcox Company, Inc. 2. TESDA. (2021). <i>Training Regulation: Commercial Air-Conditioning Installation and Servicing NC III</i>. TESDA Philippines. <p>Materials & Integration:</p> <ul style="list-style-type: none"> • Tools: All tools from Lesson 20 (multimeter, clamp meter, gauges, thermometer, megger, leak detector). • Visuals: Schematic wiring diagrams, troubleshooting flowcharts, error code tables. • Equipment: AC trainer with fault switches (or simulated faults). • PPE: Full PPE, LOTO kit.
III. CONTENT	<p>Title: Troubleshooting of Commercial Air-Conditioning Units</p> <p>Sub-Topics:</p> <ol style="list-style-type: none"> 1. Schematic wiring diagrams, signs, charts, and symbols. 2. Electrical and mechanical parameters (target ranges).

	3. Testing mechanical systems (compressor, fan, metering device). 4. Testing electrical systems (contactors, capacitors, relays, overloads). 5. Faults, problems, and error codes. 6. Control system types and specifications. 7. Remedy procedures. 8. Recovery and recycling of refrigerants. 9. Testing of repaired units. 10. Code of Practice for RAC (Philippine setting).	
IV. OBJECTIVES	At the end of the lesson, the learners should be able to: 1. Read and interpret a basic schematic wiring diagram for a commercial AC unit, identifying the compressor, contactor coil, fan motor, and capacitor. 2. Diagnose a given fault (simulated) on an AC trainer using systematic troubleshooting (O-V-I-T-C) and correctly identify the failed component. 3. Follow the Code of Practice for RAC, including proper refrigerant recovery (never vent to atmosphere).	
V. PROCEDURES		ANNOTATIONS
A. Activating Prior Knowledge	1. Activating Prior Knowledge <i>Teacher's Script:</i> "In Lesson 19, we learned the 5-step troubleshooting method. What are they again?" <i>Expected Answer:</i> "Observe, Verify, Isolate, Test, Correct." <i>Teacher:</i> "Today, you will APPLY that method to real (simulated) faults. You will become diagnostic detectives." 2. Establishing the Purpose of the Lesson <i>Teacher's Script:</i> "A hospital's AC fails in the operating room. The backup system is also down. Patients are in	Recall and reinforcement – reviews the framework for the hands-on application to follow.

	<p>danger. You have 30 minutes to find and fix the problem. No pressure. What if you guess wrong?"</p> <p>Expected Answer: (Serious attention.)</p> <p>Teacher: "Today, we practice under pressure (simulated). You will learn to find faults quickly and correctly."</p>	<p>High-stakes scenario – emphasizes that troubleshooting speed and accuracy save lives and money.</p>
<p>B. Instituting New Knowledge</p>	<p>1. Presenting Examples</p> <p>Teacher's Script: "I will project a simple schematic wiring diagram for a commercial AC. Let's trace the 24V control circuit together."</p> <p>Teacher points: "Here is the transformer (230V to 24V). Here is the thermostat (R to G for fan, R to Y for cooling). Here is the contactor coil (24V). When the thermostat calls for cooling, 24V flows from R to Y, through the contactor coil, to C (common). The contactor pulls in, closing the high-voltage contacts, and the compressor and fan run."</p> <p>2. Discussing New Concept</p> <p>Teacher's Script: "Open your notebook. We will cover the most common commercial AC faults and how to diagnose them."</p> <p>Detailed Lecture Guide:</p> <p>Diagrams</p> <p>"There are two types of diagrams:"</p> <p>"1. Schematic (ladder) diagram: Shows electrical function. Easy to trace circuits. Used for troubleshooting."</p>	<p>Visual literacy – many students struggle with schematics; guided practice is essential.</p>

	<p>"2. Pictorial (wiring) diagram: Shows physical location of wires. Used for installation and tracing wire colors."</p> <p>"Common symbols:"</p> <p>"1. Contactor coil: A circle or half-circle."</p> <p>"2. Contactor contacts: Two parallel lines with a diagonal line through them (normally open)."</p> <p>"3. Thermostat switch: A circle with a temperature scale."</p> <p>"4. Capacitor: Two parallel lines (one curved for polarized)."</p> <p>"5. Ground: Three horizontal lines decreasing in length."</p> <p>"6. Resistor: A zigzag line."</p> <p>"How to read a ladder diagram:"</p> <p>"1. Power comes in on the left (L1, L2)."</p> <p>"2. It flows through switches (thermostat, pressure switches, overloads)."</p> <p>"3. It ends at a load (contactor coil, fan motor, compressor)."</p> <p>"4. Returns on the right (neutral or L2)."</p> <p>"Troubleshooting with a diagram:"</p> <p>"1. Identify the symptom (e.g., 'compressor does not run, fan runs')."</p> <p>2. Trace the circuit from power to the compressor.</p> <p>3. Use a multimeter to find where voltage stops."</p> <p>Electrical Parameters (Target Ranges)</p> <p>"1. Voltage: $\pm 10\%$ of nameplate."</p> <p>"2. Compressor RLA: $\pm 10\%$ of nameplate. High = overcharge or tight bearings. Low = undercharge or bad valves."</p> <p>"3. Capacitor: $\pm 10\%$ of rated μF. High or low = replace."</p> <p>"4. Contactor coil resistance: 10-30 ohms (typical). Open = bad coil. Shorted = very low ohms."</p>	
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	<p>"5. Overload protector: Should have continuity when cool. Open = tripped or bad."</p> <p>"Mechanical Parameters</p> <p>"1. Subcooling: 8-12°F for TXV (check manual)."</p> <p>"2. Superheat: 10-15°F for TXV."</p> <p>"3. Compressor discharge temperature: 180-220°F. Higher = high compression ratio (low suction or high head)."</p> <p>"4. Oil level: Should be visible in compressor sight glass (if equipped)."</p> <p>"Common Faults and Diagnosis</p> <p><i>"Fault 1: Unit does not run at all (no fan, no compressor)"</i></p> <p>"1. Check thermostat: Set to 'Cool' and below room temp. Is there 24V between R and Y? If no, thermostat problem."</p> <p>"2. Check disconnect: Is it ON? Is there voltage at the unit (line side)?"</p> <p>"3. Check breaker: Tripped? Reset once. If trips again, short circuit."</p> <p>"4. Check transformer: Is there 24V at the contactor coil? If no, check transformer primary (230V) and secondary (24V)."</p> <p>"5. Check contactor coil: Does it have continuity (10-30 ohms)? If open, replace contactor."</p> <p>"6. Check contactor contacts: Are they closing? If not, mechanical failure."</p> <p><i>"Fault 2: Compressor runs but no cooling (or poor cooling)"</i></p> <p>"1. Check filter: Dirty? Replace."</p> <p>"2. Check evaporator coil: Dirty? Clean."</p> <p>"3. Check condenser coil: Dirty? Clean."</p>	
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	<p>"4. Connect gauges: Low suction pressure? High or low head pressure?"</p> <p>" a. <i>Low suction + low head</i>: Undercharge or restriction in liquid line (filter drier)."</p> <p>" b. <i>Low suction + high head</i>: Restriction in suction line (kink) or non-condensable (air in system)."</p> <p>" c. <i>High suction + low head</i>: Bad compressor valves (pumping poorly)."</p> <p>" d. <i>High suction + high head</i>: Overcharge or condenser airflow problem."</p> <p>"5. Calculate subcooling: Low = undercharge. High = overcharge or restriction."</p> <p>"6. Calculate superheat: High = undercharge or TXV stuck closed. Low = overcharge or TXV stuck open."</p> <p>"Fault 3: Unit short cycles (runs for 2-5 minutes then stops)"</p> <p>"1. Check airflow (dirty filter, dirty coil, fan speed). Low airflow causes coil to freeze, then overload trips."</p> <p>"2. Check overload protector: Is it tripping? Compressor overheating? Check amperage (high?)."</p> <p>"3. Check low-pressure switch (if equipped): May be set too high or system undercharged."</p> <p>"4. Check high-pressure switch: May be set too low or condenser airflow blocked."</p> <p>"Fault 4: Unit runs continuously, space too cold"</p> <p>"1. Check thermostat: Is it satisfied? Stuck contacts?"</p> <p>"2. Check contactor: Welded contacts (stuck closed). Replace."</p> <p>"3. Check refrigerant charge: Overcharge can cause evaporator to stay cold even when compressor should cycle off (if unit has pump-down)."</p>	
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	<p>"Error Codes</p> <p>"Modern commercial units (especially VRF and packaged units with microprocessors) display error codes on the controller or LED blink codes on the board."</p> <p>"Procedure:"</p> <p>"1. Look up the error code in the manufacturer's manual."</p> <p>"2. Do not replace parts based on the code alone – the code is a symptom, not a diagnosis. Example: 'Low suction pressure' could be undercharge OR a bad sensor OR a clogged filter OR a TXV stuck closed."</p> <p>"3. Verify with measurements before replacing."</p> <p>"Control Systems</p> <p>"Types:"</p> <p>"1. Electromechanical: Thermostat + contactor + pressure switches. Simple, reliable."</p> <p>"2. Microprocessor (board): More complex, can store error codes, control multiple stages, communicate with a building management system (BMS)."</p> <p>"3. VRF (Variable Refrigerant Flow): Central controller, communicates with multiple indoor units via shielded cable. Requires specialized training."</p> <p>"Testing Repaired Units</p> <p>"After repair:"</p> <p>"1. Run the unit for at least 15 minutes to stabilize."</p> <p>"2. Re-measure all parameters (voltage, amperage, pressures, temperatures, subcooling, superheat)."</p> <p>"3. Verify they are within target ranges."</p> <p>"4. Cycle the unit off and on (at thermostat) to verify it restarts properly."</p> <p>"5. Check for leaks (electronic leak detector)."</p> <p>"6. Document final readings on the service report."</p>	
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	<p>"Refrigerant Recovery and Recycling (Code of Practice)</p> <p>"Under the Philippine Code of Practice for RAC (DENR-EMB) and the Montreal Protocol (Philippines is a signatory):"</p> <p>"1. NEVER vent refrigerant to the atmosphere. It is illegal and damages the ozone layer (CFCs, HCFCs) or contributes to global warming (HFCs)."</p> <p>"2. Recover refrigerant using a recovery machine and recovery cylinder before opening the system."</p> <p>"3. Recycle (clean) the recovered refrigerant if it will be reused."</p> <p>"4. Reclaim (send to a certified facility) if the refrigerant is contaminated."</p> <p>"5. Use certified recovery cylinders (gray body, yellow top). Do not overfill (never exceed 80% of cylinder capacity)."</p> <p>"Penalties for venting: Fines up to PHP 500,000 and possible imprisonment under the Philippine Clean Air Act."</p> <p>3. Developing Mastery</p> <p>Teacher's Script: "Fault diagnosis worksheet. I will give you 5 symptom descriptions. For each, list the top 3 things you would check and the most likely cause."</p> <p>Example: "Symptom: Compressor hums but does not start, then trips overload after 3 seconds."</p> <p>Expected Answer: "Check capacitor (run/start), check voltage at compressor, check for mechanical seizure (try to spin with hex key). Most likely: bad run capacitor."</p>	<p>Critical thinking practice – students apply the fault diagnosis tables.</p>
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<p>C. Demonstrating Knowledge and Skills</p>	<p>1. Finding Practical Application</p> <p>Teacher's Script: "Troubleshooting practical exam (simulated). I have set up 4 different faults on our AC trainers (or simulated trainers). Your group will rotate to each station. You have 10 minutes per station to:"</p> <p>"1. Observe (ask questions, visual inspection)."</p> <p>"2. Verify basics (power, thermostat, filter)."</p> <p>"3. Isolate (control vs. power vs. refrigerant)."</p> <p>"4. Test (use your tools)."</p> <p>"5. Identify the failed component."</p> <p>"6. Write your diagnosis on the answer sheet."</p> <p>"Fault stations" (examples):</p> <p>" <i>Fault 1:</i> Loose wire at contactor coil (no 24V)."</p> <p>" <i>Fault 2:</i> Bad run capacitor (compressor hums, does not start)."</p> <p>" <i>Fault 3:</i> Dirty filter + low refrigerant (low suction pressure)."</p> <p>" <i>Fault 4:</i> Contactor with welded contacts (compressor runs continuously)."</p> <p>Teacher observes and records diagnostic time and accuracy.</p> <p>2. Making Generalization</p> <p>Teacher's Script: "Complete this sentence: 'The difference between a parts changer and a technician is that a technician ____.'"</p> <p>Expected Answer: "Diagnoses before replacing," "Understands why the part failed."</p>	<p>Authentic assessment – students diagnose real (simulated) faults under time pressure.</p> <p>Professional identity – reinforces that diagnosis, not replacement, defines a technician.</p>
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	<p>3. Evaluating Learning Teacher: “Clear your desks. Get a 1/4 sheet of paper. Number 1 to 5.”</p> <p>Quiz:</p> <ol style="list-style-type: none"> 1. A compressor runs but the suction pressure is low and the head pressure is low. What is the most likely cause? 2. What is the legal requirement under the Philippine Clean Air Act regarding refrigerant? 3. A contactor coil should have what approximate resistance (in ohms)? 4. What does a welded contactor cause? 5. After repairing a unit, how long should you run it to stabilize before taking final measurements? <p>Answer Key:</p> <ol style="list-style-type: none"> 1. Undercharge or restriction in liquid line (e.g., clogged filter drier). 2. Refrigerant must be recovered, not vented to the atmosphere. 3. 10-30 ohms (typical – varies by contactor size) 4. Compressor runs continuously (will not shut off). 5. 15 minutes (minimum) <p>4. Additional Activities</p> <p>Remediation: Practice reading a simple schematic and tracing the path of 24V control voltage.</p> <p>Enrichment: Research the error codes for a specific commercial AC brand (e.g., Daikin, Mitsubishi, Carrier) and create a quick-reference card.</p>	
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VI. ASSESSMENT

Performance Task: *Troubleshooting Practical Exam*

Scenario: An AC trainer has one of 6 possible faults installed (simulated). You do not know which fault. You have 20 minutes to diagnose and report.

Task:

1. Follow the O-V-I-T-C method.
2. Use appropriate tools (multimeter, clamp meter, gauges, thermometer).
3. Identify the failed component or condition.
4. Complete a **Troubleshooting Report** showing:
 - Initial observations.
 - Basic verifications performed.
 - Isolation steps.
 - Test measurements (record values).
 - Diagnosis (specific failed component).
 - Recommended remedy.
5. Present your diagnosis to the instructor.

Rubric for Assessment:

Criteria	Excellent (4)	Satisfactory (3)	Developing (2)	Unsatisfactory (1)	Score
Systematic Process	Follows O-V-I-T-C clearly, each step documented.	Missing one step.	Missing 2+ steps.	Random, no process.	
Tool Use	Correct tool for each test, used safely.	Minor error.	Major error.	Unsafe or wrong tool.	

	Diagnosis Accuracy	Correctly identifies fault.	Identifies general area but not specific component.	Wrong diagnosis.	No diagnosis.	
	Time Management	Completes within 20 minutes.	Completes within 25 minutes.	Completes within 30 minutes.	Exceeds 30 minutes or incomplete.	
	Total (16 pts)					
VII. REFLECTION	<p><i>To be completed by the teacher after the lesson:</i></p> <p>Highlights: Did the simulated fault stations engage students the most of any activity in the quarter? Did students feel a sense of accomplishment when they correctly diagnosed a fault?</p> <p>Challenges: Did time pressure cause some groups to skip the "Verify" step (e.g., not checking the filter first)? Were students able to read and interpret schematic wiring diagrams? Did any student guess instead of testing?</p> <p>Adjustments: Should I add a mandatory "Verification Checklist" that must be signed off before moving to testing? Should I provide a laminated schematic diagram with a tracing tool (dry-erase marker)? Should I deduct points for "guessing without testing"?</p>					
VIII. USE OF GENERATIVE AI	<p>In preparing this Learning Exemplar (LE), the author used Generative AI to assist in structuring and drafting instructional content and assessment items. The author reviewed, edited, and finalized the writing of the content to ensure alignment with curriculum standards and contextual relevance. The author takes full responsibility for the final content of this LE.</p>					

LESSON EXEMPLAR			
Learning Area	Commercial Air-Conditioning Installation and Servicing	Lesson Exemplar	22

I. OBJECTIVES	
A. Content Standard	The learner understands the concepts and principles of the Commercial Air-Conditioning unit
B. Performance Standard	The learner performs maintenance, troubleshooting, and commissioning Commercial Air-Conditioning units with safety precautions.
C. Learning Competencies	4. Perform commissioning of commercial air conditioning units
II. REFERENCES and MATERIALS	<p>References:</p> <ol style="list-style-type: none"> 1. ASHRAE. (2020). <i>ASHRAE Handbook – HVAC Systems and Equipment (Commissioning)</i>. ASHRAE. 2. TESDA. (2021). <i>Training Regulation: Commercial Air-Conditioning Installation and Servicing NC III</i>. TESDA Philippines. <p>Materials & Integration:</p> <ul style="list-style-type: none"> • Tools: All performance test tools (gauges, multimeter, clamp meter, thermometer, anemometer, psychrometer, leak detector). • Documents: Commissioning checklist template, manufacturer’s startup manual, service report form. • PPE: Full PPE.
III. CONTENT	<p>Title: Commissioning of Commercial Air Conditioning Units</p> <p>Sub-Topics:</p> <ol style="list-style-type: none"> 1. Commissioning checklist (pre-start, start-up, operational, post-start). 2. Testing of parameters (pressure, current, temperature, air velocity). 3. Manufacturer’s manual compliance.

	4. Start-up and commissioning sequence. 5. Service costing and documentation for commissioning.	
IV. OBJECTIVES	<p>At the end of the lesson, the learners should be able to:</p> <ol style="list-style-type: none"> 1. List the four phases of commissioning (pre-start, start-up, operational, post-start). 2. Complete a full commissioning checklist for a commercial AC unit, recording all measurements and verifying that they meet manufacturer specifications. 3. Recognize that commissioning is not optional – it is a quality assurance process that protects the technician, the client, and the equipment manufacturer. 	
V. PROCEDURES		ANNOTATIONS
A. Activating Prior Knowledge	<ol style="list-style-type: none"> 1. Activating Prior Knowledge <p>Teacher's Script: "In Lesson 12, we performed a performance test on a running unit. How is commissioning different from a performance test?"</p> <p>Expected Answer: "Commissioning is before the unit is handed over," "Commissioning includes startup."</p> <p>Teacher: "Yes. Commissioning is the entire process from pre-start checks to final sign-off. Today, you learn to commission a unit from zero."</p> 2. Establishing the Purpose of the Lesson <p>Teacher's Script: "A new building opens. The AC units were installed but never commissioned. Six months later, three compressors fail. The manufacturer denies warranty because 'the system was never properly started up.' Who pays for PHP 500,000 in replacements?"</p> 	<p>Distinguishing concepts – performance test is part of commissioning, but commissioning is broader (includes pre-start checks, documentation).</p> <p>Real-world consequence – skipped commissioning voids warranties and leads to lawsuits.</p>

	<p>Expected Answer: "The installing contractor."</p> <p>Teacher: "Today, you learn to commission correctly. Your commissioning report is your warranty protection."</p>	
<p>B. Instituting New Knowledge</p>	<p>1. Presenting Examples</p> <p>Teacher's Script: "I will show you a commissioning checklist for a 10-ton split system. Notice it has 4 sections: Pre-Start, Start-Up, Operational, and Post-Start. Each section has 10-15 checks."</p> <p>Teacher points to sections. "This is the document that protects you. Never commission without a checklist."</p> <p>2. Discussing New Concept</p> <p>Teacher's Script: "Open your notebook. Commissioning is a systematic process. Follow these phases in order."</p> <p>Detailed Lecture Guide:</p> <p>Phase 1: Pre-Start Checks (Power OFF) "Before applying power, verify:" "1. Electrical:" " a. All connections tight (torque checked)." " b. Correct voltage at disconnect (line side)." " c. Correct breaker size (MOP)." " d. Correct wire size (MCA)." " e. Ground wire present and connected." " f. Control wiring (thermostat) connected correctly."</p> <p>"2. Refrigerant piping:" " a. All brazed joints visually inspected."</p>	<p>Visual overview – students see the scope of commissioning.</p>

	<p>" b. Nitrogen pressure test completed (typically 150-300 psi for 24 hours, no drop)."</p> <p>" c. System evacuated to <500 microns and held for 15 minutes (rise <100 microns)."</p> <p>" d. Factory charge recorded. Additional charge added per lineset length (if needed)."</p> <p>"3. <i>Mechanical:</i>"</p> <p>" a. Fan blades secure and spin freely."</p> <p>" b. Filter installed."</p> <p>" c. Drain line slope verified, P-trap present, termination correct."</p> <p>" d. Condensate pump (if any) wired and tested (pour water into pan to trigger)."</p> <p>" e. All panels and access doors closed and secured."</p> <p>"4. <i>Safety:</i>"</p> <p>" a. LOTO removed only when ready to start."</p> <p>" b. Area clear of tools and debris."</p> <p>" c. Fire extinguisher nearby (Class B:C for electrical/refrigerant)."</p> <p>"Phase 2: Start-Up (First Power Application)"</p> <p>"1. <i>Apply power</i> to the disconnect. Do not turn on the thermostat yet."</p> <p>"2. <i>Verify transformer output:</i> 24V at the thermostat subbase."</p> <p>"3. <i>Set thermostat to 'Cool'</i> and lowest temperature setting."</p>	
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	<p>"4. Observe start sequence:"</p> <ul style="list-style-type: none"> " a. Contactor should pull in (click)." " b. Compressor should start (may have a slight delay if equipped with anti-short cycle timer)." " c. Condenser fan should start." " d. Evaporator blower should start." <p>"5. Listen for abnormal sounds:"</p> <ul style="list-style-type: none"> " a. Grinding (bad bearings)." " b. Hissing (leak)." " c. Rattling (loose panels)." <p>"6. Watch for immediate trips: If breaker trips or overload opens immediately, shut down and investigate (likely short circuit or locked rotor)."</p> <p>"Phase 3: Operational Testing (Run and Stabilize)"</p> <p>"Let the unit run for 15-20 minutes to stabilize. Then measure and record:"</p> <p>"1. Electrical:"</p> <ul style="list-style-type: none"> " a. Voltage at contactor (L1-L2)." " b. Compressor amperage (RLA)." " c. Fan motor amperage (FLA)." " d. Total unit amperage." <p>"2. Refrigerant:"</p> <ul style="list-style-type: none"> " a. Low side pressure and saturation temperature." " b. High side pressure and saturation temperature." " c. Suction line temperature." " d. Liquid line temperature." " e. Calculate subcooling." " f. Calculate superheat." " g. Adjust charge if needed (add or recover refrigerant to achieve target subcooling)." 	
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	<p>"3. Airflow:"</p> <ul style="list-style-type: none"> " a. Supply air temperature (at grille)." " b. Return air temperature." " c. Temperature drop (should be 15-20°F)." " d. Air velocity (anemometer). Calculate CFM (should be 400 CFM/ton ±10%)." <p>"4. Drainage:"</p> <ul style="list-style-type: none"> " a. Pour water into drain pan. Verify flow to termination." " b. Check for leaks at joints." <p>"5. Controls:"</p> <ul style="list-style-type: none"> " a. Raise thermostat setpoint above room temperature. Unit should cycle OFF." " b. Lower setpoint below room temperature. Unit should cycle ON." " c. Check any safety switches (low pressure, high pressure) by simulating (e.g., block condenser fan briefly – high pressure should trip)." <p>"Phase 4: Post-Start Documentation"</p> <p>"After the unit is running correctly:"</p> <ul style="list-style-type: none"> "1. Complete the Commissioning Checklist with all measurements and pass/fail status." "2. Note any deviations from manufacturer specifications and corrective actions taken." "3. Provide a copy to the client (or site representative) and obtain signature." "4. Keep a copy for your records (warranty protection)." "5. Set up maintenance schedule (e.g., 'Next filter change in 3 months, next full maintenance in 6 months')." 	
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	<p>"Manufacturer's Manual" "The commissioning procedure in the manufacturer's manual supersedes any general guidelines. Some manufacturers require:"</p> <p>"1. Specific subcooling targets (e.g., 7°F for a specific model)." "2. Specific charging methods (e.g., weigh-in only, not by subcooling)." "3. Specific start-up sequence (e.g., crankcase heater must be on for 24 hours before starting)."</p> <p>"Always read the manual before commissioning."</p> <p>"Service Costing for Commissioning" "Commissioning is a billable service. Include in your quotation:" "1. Labor: 4-8 hours for a typical 5-10 tons system." "2. Nitrogen for pressure test." "3. Refrigerant for additional charge (if line set exceeds factory charge)." "4. Vacuum pump and recovery machine use (depreciation cost)." "5. Documentation time (1 hour for report writing)."</p> <p>"Typical commissioning fee: PHP 10,000-25,000 depending on system size."</p> <p>"Common Commissioning Mistakes" "1. Skipping the pressure test – leads to undetected leaks." "2. Not pulling a deep enough vacuum – moisture left in system destroys oil and causes acid." "3. Not calculating subcooling – guessing at charge."</p>	
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	<p>"4. Not checking airflow – low CFM causes freezing." "5. Not cycling the unit off and on – may hide a sticking contactor." "6. Not getting client signature – no proof of commissioning."</p> <p>3. Developing Mastery</p> <p>Teacher's Script: "Commissioning sequencing game. I will give you 15 commissioning tasks (shuffled). Your group must arrange them in the correct order (Pre-Start → Start-Up → Operational → Post-Start)."</p> <p>Groups race to complete. Teacher reviews correct order.</p>	<p>Sequencing activity – ensures students understand the logical flow, which is critical for safety.</p>
<p>C. Demonstrating Knowledge and Skills</p>	<p>1. Finding Practical Application</p> <p>Teacher's Script: "Commissioning simulation. We will use an AC trainer (or a known-good unit). Your group will perform a full commissioning following the checklist."</p> <p>"Stations:" "1. Pre-Start: Verify all pre-start checks (simulated – instructor will tell you which checks are 'failed' for you to identify)." "2. Start-Up: Apply power and start the unit (instructor supervised)." "3. Operational: Measure and record all parameters. Calculate subcooling and superheat." "4. Post-Start: Complete the checklist, note any issues, obtain 'client signature' (instructor)."</p> <p>Teacher observes and evaluates each group.</p>	<p>Authentic commissioning – students perform the entire process on real equipment.</p>

	<p>2. Making Generalization</p> <p>Teacher's Script: "Complete this sentence: 'Commissioning is not the end of the installation; it is the beginning of the equipment's _____.'"</p> <p>Expected Answer: "Life," "Reliability," "Warranty period."</p> <p>3. Evaluating Learning</p> <p>Teacher: "Clear your desks. Get a ¼ sheet of paper. Number 1 to 5."</p> <p>Quiz:</p> <ol style="list-style-type: none"> 1. List the four phases of commissioning in order. 2. Before applying power, what test verifies that the refrigerant piping has no leaks? 3. After starting the unit, how long should you let it run before taking final measurements? 4. Why is a client signature on the commissioning checklist important? 5. True or False: You can skip reading the manufacturer's manual if you have commissioned similar units before. <p>Answer Key:</p> <ol style="list-style-type: none"> 1. Pre-Start, Start-Up, Operational, Post-Start 2. Nitrogen pressure test 3. 15-20 minutes (until stabilized) 4. Legal proof that commissioning was performed and accepted; warranty protection. 5. False – each model may have specific requirements. 	<p>Long-term perspective – commissioning sets the stage for the entire life of the equipment.</p>
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	<p>4. Additional Activities</p> <p>Remediation: Complete a partially filled commissioning checklist by adding the missing measurements.</p> <p>Enrichment: Research the commissioning requirements for a VRF (Variable Refrigerant Flow) system, which are more complex than a standard split system.</p>	
VI. ASSESSMENT	<p>Performance Task: <i>Complete Commissioning Report</i></p> <p>Scenario: You have just installed a new 7.5-ton commercial split system. The client requires a signed commissioning report before final payment.</p> <p>Task:</p> <ol style="list-style-type: none"> 1. Using the provided Commissioning Checklist, perform a mock commissioning on an AC trainer (or use simulated data if a trainer is not available). 2. Complete all sections of the checklist with: <ul style="list-style-type: none"> ○ Pre-start verification (check off each item). ○ Start-up observations. ○ Operational measurements (record all values). ○ Subcooling and superheat calculations. ○ Pass/fail for each parameter. ○ Any corrective actions taken (e.g., "Added 0.8 kg R-410A to achieve 10°F subcooling"). 3. Obtain a "client signature" (instructor). 4. Submit the completed Commissioning Report as a professional document. 	

	Commissioning Checklist (Sample Format):				
	Phase	Item	Status (Pass/Fail)	Measured Value	Target
	Pre-Start	All electrical connections tight	Pass	N/A	N/A
	Pre-Start	System evacuated to <500 microns	Pass	220 microns	<500
	Start-Up	Contactor pulls in	Pass	Yes	Yes
	Operational	Voltage (L1-L2)	Pass	235V	230V ±10%
	Operational	Compressor Amps	Pass	18.2A	18.0A RLA
	Operational	Subcooling	Pass	10°F	8-12°F
	Operational	Superheat	Pass	13°F	10-15°F
	Operational	Temperature drop (supply-return)	Pass	18°F	15-20°F
	Post-Start	Client notified of maintenance schedule	Pass	Yes	Yes

	Rubric for Assessment:					
	Criteria	Excellent (4)	Satisfactory (3)	Developing (2)	Unsatisfactory (1)	Score
	Checklist Completeness	All items checked, all values recorded.	Missing 1-2 items.	Missing 3+ items.	Mostly blank.	
	Measurement Accuracy	All measurements correct and within target ranges (or corrected).	Minor errors or out-of-range not corrected.	Major errors.	No measurements.	
	Calculations	Subcooling and superheat correctly calculated.	One calculation error.	Both errors.	No calculations.	
	Professionalism	Report neat, signed, client signature obtained.	Missing one element.	Missing multiple elements.	Unprofessional or unsigned.	
	Total (16 pts)					

VII. REFLECTION	<p><i>To be completed by the teacher after the lesson:</i></p> <p>Highlights: Did the full commissioning simulation tie together everything from the entire course? Did students feel like "real technicians" when they completed the commissioning report?</p> <p>Challenges: Did students rush through pre-start checks (e.g., skipping the nitrogen pressure test verification)? Were students able to correctly calculate subcooling and superheat under time pressure? Did any student forget to get the client signature?</p> <p>Adjustments: Should I implement a "two-person rule" for commissioning (one performs, another verifies and signs off)? Should I provide a commissioning checklist with mandatory sign-offs at each phase? Should I add a "no signature, no payment" rule to emphasize its importance?</p>
VIII. USE OF GENERATIVE AI	<p>In preparing this Learning Exemplar (LE), the author used Generative AI to assist in structuring and drafting instructional content and assessment items. The author reviewed, edited, and finalized the writing of the content to ensure alignment with curriculum standards and contextual relevance. The author takes full responsibility for the final content of this LE.</p>