KACC-0253 HVAC Air Conditioning and Refrigeration Controls

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Competency and Learning Objectives

1. Explain the fundamental principles of electric motors.
    - Explain how motors work.
    - Identify motor types.
    - Define and determine motor speed, torque, and performance.
    - Differentiate between types of single phase motors.
    - Identify the characteristics of an electronically commutated motor (ECM).
2. Identify and wire residential motor starting and control components.
    - Identify motor starting components.
    - Identify the starting components for open motors.
    - Identify and wire the starting components for compressor motors.
    - Identify motor control circuit components.
    - Interpret wiring diagrams to wire residential motor control circuits.
3. Analyze, construct, and apply wiring diagrams to properly control different types of residential HVAC equipment.
    - Identify residential HVAC control circuit components and related wiring diagram symbols.
    - Interpret wiring diagrams to wire residential HVAC equipment.
    - Draw wiring diagrams per sequence of operation and wire control circuits.
4. Diagnose and correct electrical problems in residential HVAC equipment.
    - Identify the steps for troubleshooting.
    - Diagnose electrical control problems in residential equipment.
    - Repair electrical control problems in residential equipment.

Orientation to Course [Home Page]

Course Description

In KACC 0205 you explored the exciting area of basic electricity. Now in this course you are going to apply those fundamentals that you learned into specific HVAC applications. In this course you will be looking deeper into residential HVAC equipment's control circuits. You will also be introduced to how electric motors work and their control circuits. Motor and HVAC equipment control circuits troubleshooting and problem solving will also be covered.

Competencies

Upon completion of the course, you will be rated as MC (Mastered Competency) or NM (Not-Mastered Competency) based on your demonstrated ability of the course's established competencies. You will:

- Explain the fundamental principles of electric motors.
- Identify and wire residential motor starting and control components.
- Analyze, construct, and apply wiring diagrams to properly control different types of residential HVAC equipment.
- Diagnose and correct electrical problems in residential HVAC equipment.

Assessment

You will be given a written progress exam and/or a lab practical to see if you are on track in progressing toward the required competencies at the end of each module. You must pass these progress exams with a score of at least 80% before you can move on to the next module.

At the end of the course you will again be given a written exam and final lab practical that you must pass with at least a score of 80% before you will be rated with an MC as your grade for the course.

Labs

You will have 26 labs as a part of this course. There is a schedule for labs and other opportunities to work with instructors. Sign up ahead of time for labs, about a week before you want to work on a lab. Make sure you come at that time or reschedule it.

Syllabus and Textbooks *(Note: Books and materials required for this course are listed below. Instructor uses instructional materials from this publisher, including presentations, videos, and other learning materials.)*

Read the syllabus to understand the expectations for this course. The instructor will go through the syllabus and review the textbook with you on your first day of class.

- Heating and Cooling Essentials, 4th Edition, Crawshaw, ISBN: 978-1-63126-059-9
- Heating and Cooling Essentials Lab Workbook, 4th Edition, Crawshaw, ISBN: 978-1-63126-063-6

- Electricity for Refrigeration, Heating and Air Conditioning, 9th Edition, Smith, ISBN: 978-1-2851-7998-8
- Electricity for Refrigeration, Heating and Air Conditioning Lab Manual, 9th Edition, Smith, ISBN: 978-1-2851-8001-4

Course Navigation

In the left navigation bar is a Course Tools menu. It provides information about what tools you need for the course, and how to navigate in Canvas. Start the course with the first module below. You can also click on the **Modules** link in the left navigation bar to navigate through the course.

Modules

Module 1: Introduction to Residential Motors

Introduction to Residential Motors Overview

Almost every piece of HVAC equipment you will be working on in the field will contain some kind of motor. Whether the motor is a small shaded pole motor operating a small fan blade, or a compressor pumping refrigerant through an air conditioner, or even a large three phase motor running a cooling tower pump, motors are everywhere. In this module you will be learning how motors work and how to identify motors and their applications. You will learn about how to determine motor speed, torque and performance.

When you have completed this module, you will know how to:

- Explain how motors work.
- Identify motor types.
- Define and determine motor speed, torque, and performance.
- Differentiate between types of single phase motors.
- Identify the characteristics of an electronically commutated motor (ECM).

First let's watch two videos. The first is on Electric Motors. *(Note: The instructor uses a series of videos that he has received permission to stream on the learning management system.)*

Electric Motors Video

The second video is Motor Mastery Session 1.

Introduction to Residential Motors Assignments

In this module pay close attention to characteristics of the run and start windings in a motor and how they are connected and controlled. Also pay close attention to how run and start capacitors are used and wired as well. Knowing how to identify motor problems is a skill that will be very useful in your HVAC career.

Instructions

1. Read chapter 25 Induction Motors in your Heating and Cooling Essentials textbook.

2. Watch this PowerPoint video on Fan Motors. Note that there is no audio with this video.
3. Watch the video Motor Mastery Session 2.
4. Take the Check Your Knowledge: Chapter 25 Quiz.
5. Complete the 6 Lab Projects for this module.

Check Your Knowledge: Chapter 25 Review Quiz

After you have read the textbook chapter, take this open book chapter review quiz. This quiz is designed to help you know what you have learned from the textbook.

Testing Procedures:

1. Click **Take this Quiz** link.
2. Read each question and choose the best answer(s).
3. When you have answered all the questions, click the **Submit** button. You will be shown your score.

Lab Project 25: Induction Motors

For this lab you will be using your Heating and Cooling Essentials Lab Workbook. You will be examining different types of single-phase motors like shaded pole, open-type, split-phase, and capacitor-start induction-run motors. You will also be learning how to test capacitors and how to identify hermetic motor problems.

Instructions

1. You will need to remove the lab sheets for Lab 25 from your lab manual.
2. Print your name and the date on the top of the first lab sheet.
3. Use the lab manual sheets for the lab.
4. Have your instructor sign off on the front page of your lab sheets that you have completed the lab.
5. Scan this page of the lab sheets and submit your scan into Canvas to complete your lab, so you can move on to the next assignment.

Lab Project: 10 Compressor Checkout

For this lab you will be using your multimeter to determine which terminals on a compressor are the common, start, and run terminals. This will be done by measuring the resistance between each terminal and then using your measurements to make your determination.

The lab is located at the west end of the fenced supply area. You will be using the 10 compressors on the small table.

Instructions

1. Print out the 10 Compressor lab worksheet.
2. Using the worksheet, follow the instructions for the lab.
3. Have your instructor sign off that you have completed the lab.

4. Scan the lab worksheet/checklist and submit your scan into Canvas to complete your lab, so you can move on to the next assignment.

Lab Project: Motor Speed and Torque

For this lab you will be using the blue Amatrol Motor Trainer. In this lab you will explore the motor characteristics of speed and torque. You will learn how to calculate and measure a motor to determine its speed and torque.

Instructions

1. Print out the Motor Speed and Torque lab worksheet.
2. Ask your instructor for a copy of the lab manual for this lab.
3. Using the worksheet and lab manual, follow the instructions for the lab.
4. Have your instructor sign off that you have completed the lab.
5. Scan the lab worksheet/checklist and submit your scan into Canvas to complete your lab, so you can move on to the next assignment.

Lab Project: Motor Performance

For this lab you will be exploring the motor characteristics of motor power performance. You will be learning how to calculate a motor's power performance.

Instructions

1. Print out the Motor Performance lab worksheet.
2. Ask your instructor for a copy of the lab manual for this lab.
3. Using the worksheet and lab manual, follow the instructions for the lab.
4. Have your instructor sign off that you have completed the lab.
5. Scan the lab worksheet/checklist and submit your scan into Canvas to complete your lab, so you can move on to the next assignment.

Lab Project: Split-Phase AC Motors

In this lab you will be studying the construction and operation of AC electric motors. The first part of this lab will introduce some of the basic characteristics of AC current that is applied to AC motor operation. Then you will cover the operation and applications of a split-phase motor.

Instructions

1. Print out the Split-Phase AC Motor lab worksheet.
2. Ask your instructor for a copy of the lab manual for this lab.
3. Using the worksheet and lab manual, follow the instructions for the lab.
4. Have your instructor sign off that you have completed the lab.
5. Scan the lab worksheet/checklist and submit your scan into Canvas to complete your lab, so you can move on to the next assignment.

Lab Project: Capacitor-Start AC Motors

This lab covers how power reacts in AC circuits with inductive loads such as motors. This includes power factors in AC circuits, why they are important, and the method used to correct them. In this lab you will also study another type of single-phase motor, called the capacitor-start AC motor.

Instructions

1. Print out the Capacitor-Start AC Motors lab worksheet.
2. Ask your instructor for a copy of the lab manual for this lab.
3. Using the worksheet and lab manual, follow the instructions for the lab.
4. Have your instructor sign off that you have completed the lab.
5. Scan the lab worksheet/checklist and submit your scan into Canvas to complete your lab, so you can move on to the next assignment.

Lab Project: Permanent-Capacitor and Two-Capacitor Motors

This lab covers two more types of single-phase AC capacitor motors: the permanent-capacitor and the capacitor-start capacitor-run. It also covers how the configuration of the capacitors in each of these motors affects the operational characteristics of the motors. The module also explains some applications for each of these types of motors.

Instructions

1. Print out the Permanent-Capacitor and Two-Capacitor Motors lab worksheet.
2. Ask your instructor for a copy of the lab manual for this lab.
3. Using the worksheet and lab manual, follow the instructions for the lab.
4. Have your instructor sign off that you have completed the lab.
5. Scan the lab worksheet/checklist and submit your scan into Canvas to complete your lab, so you can move on to the next assignment.

Electronically Communtated Motors (ECM) Technology Assignments

With the increased interest in energy savings and better indoor air quality (IAQ), the Electronically Communtated Motors or ECM was created. ECM motors are being installed in a lot more furnaces then before. So understanding what an ECM motor is and how it is constructed and its operation is very important. For this section you will need to borrow from your instructor the textbook Understanding Electronically Commutated Motors.

Instructions

1. Read chapters 1 and 2 in the Understanding Electronically Commutated Motors textbook.
2. Watch these two videos on ECM motors.

   Intro to ECM Technology

   The ECM motor construction and troubleshoot

3. Perform the Lab Project.

Lab Project: Electronically Communtated Motors (ECM)

For this lab you will be using Furnace #12 the ECM Trainer. You will be measuring the airflow through the furnace as the speed changes in the furnace. This is due to the programming of the ECM motor and furnace control board. You will use a special tester to check the operation of the ECM motor and you will disassemble an ECM motor.

1. Print out the ECM Motor lab worksheet.
2. Using the worksheet follow the instructions for the lab.
3. Have your instructor sign off that you have completed the lab.
4. Scan the lab worksheet/checklist and submit your scan into Canvas to complete your lab, so you can move on to the next assignment.

Introduction to Residential Motors Written Progress Exam

This exam will help you and your instructor see how you are progressing in the course. This exam covers chapter 25 in the Heating and Cooling Essentials Textbook and from the lab Self Reviews. This exam must be taken in the classroom. You must get a score of 80% or better to move on to the next assignment.

Introduction to Residential Motors Lab Practical

As stated at the beginning of this module: "Almost every piece of HVAC equipment you will be working on in the field will contain some kind of motor. Whether the motor is a small shaded pole motor operating a small fan blade, or a compressor pumping refrigerant through an air conditioner, or even a large three phase motor running a cooling tower pump, motors are everywhere. In this module you will be learning how motors work and how to identify motors and their applications. You will learn about how to determine motor speed, torque and performance."

So for this lab you will be identifying the different motor characteristics of 6 lab motors. Next you will be measuring and calculating the speed and torque of a lab motor. Lastly you will be wiring up 4 different types of motors and showing how you can change the wiring to change the rotation of the motors.

This lab practical must be performed in the presence of your instructor and will help you and your instructor see how you are progressing in the course. You will need a score of 80% or higher to show that you have mastered the competency.

1. Schedule time with your instructor when you are ready for your lab practical.
2. Your instructor will provide you with the worksheets for this lab.
3. Here is the checklist that will be used to grade you on your lab.
4. After the lab, your instructor will enter your score into Canvas.

Module 2: Residential Motor Control

Residential Motor Control Overview

Now that you have a good understanding on how motors work, we will move on to how to control them. Most of the time when you have a motor that isn't working the problem is in the control circuit, not the motor. So, understanding motor control circuits is an very important skill

for an HVAC tech. In this module you will look at the starting components for different types of motors, both open motors and compressor motors. You will also learn how to draw and wire motor control circuits using different control operations.

When you have completed this module, you will know how to:

- Identify motor starting components.
- Identify the starting components for open motors.
- Identify and wire the starting components for compressor motors.
- Identify motor control circuit components.
- Interpret wiring diagrams to wire residential motors.

Residential Motor Control Assignments

In this module you will need to pay close attention to the different motor starting devices and how to test them to see if they are working correctly. Also you will apply the training you had in control circuits to bigger projects by learning how to control motors.

Instructions

1. Read chapter 26 Electromagnetic Control Devices in your Heating and Cooling Essentials textbook.
2. Watch the PowerPoint video Compressor Relays and Capacitors. Note that there is no audio with this video.
3. Watch the PowerPoint video Contactors and Motor Starters. Note that there is no audio with this video.
4. Take the Check Your Knowledge Chapter 26 Quiz.
5. Read chapter 27 Motor Controls in your Heating and Cooling Essentials textbook.
6. Take the Check Your Knowledge Chapter 27 Quiz.
7. Complete the Lab Projects for this module.
8. Print off the Direct Start Box Instructions and ask your instructor about where to buy the parts that will be used in a later lab.

Check Your Knowledge: Chapter 26 Review Quiz

After you have read the textbook chapter, take this open book chapter review quiz. This quiz is designed to help you know what you have learned from the textbook.

Testing Procedures:

1. Click **Take this Quiz** link.
2. Read each question and choose the best answer(s).
3. When you have answered all the questions, click **Submit** button. You will be shown your score.

Check Your Knowledge: Chapter 27 Review Quiz

After you have read the textbook chapter, take this open book chapter review quiz. This quiz is designed to help you know what you have learned from the textbook.

Testing Procedures:

1. Click **Take this Quiz** link.
2. Read each question and choose the best answer(s).
3. When you have answered all the questions, click **Submit** button. You will be shown your score.

Lab Project 26 Electromagnetic Control Devices

For this lab you will be working with electromagnetic control devices, like solenoid valves, current and potential relays, contactors, and motor starters. You will be working on how to test and wire up these devices.

Instructions

1. You will need to remove the lab sheets for Lab 26 from your lab manual.
2. Print your name and the date on the top of the first lab sheet.
3. Use the lab manual sheets for the lab.
4. Have your instructor sign off on the front page of your lab sheets that you have completed the lab.
5. Scan this page of the lab sheets and submit your scan into Canvas to complete your lab, so you can move on to the next assignment.

Lab Project: Current Relay Wiring

For this lab you will be wiring up a current relay to control the starting process of a small compressor. You will be using the Electric Controls Project Board # 2 located on the end of the bench on the west side of the lab classroom.

Instructions

1. First watch this video: Current Relay: How it Starts a CSIR Hermetic Compressor.
2. Print off the Current Relay Wiring Lab worksheet.
3. Using the worksheet, follow the instructions for the lab.
4. Have your instructor sign off that you have completed the lab.
5. Scan the lab worksheet/checklist and submit your scan into Canvas to complete your lab, so you can move on to the next assignment.

Lab Project: Potential Relay Wiring

For this lab you will be wiring up a potential relay to control the starting process of a small compressor. You will be using the Electric Controls Project Board # 2 located on the end of the bench on the west side of the lab classroom.

Instructions

1. First watch these videos:
   Potential Relays part 1
   Potential Relays part 2
2. Print off the Potential Relay Wiring Lab worksheet.
3. Using the worksheet, follow the instructions for the lab.
4. Have your instructor sign off that you have completed the lab.
5. Scan the lab worksheet/checklist and submit your scan into Canvas to complete your lab, so you can move on to the next assignment.

Lab Project: Solid State Relay

For this lab you will be wiring up a solid-state relay to control the starting process of a small compressor. You will be using the Electric Controls Project Board # 2 located on the end of the bench on the west side of the lab classroom.

Instructions

1. Print off the Solid-State Relay Wiring Lab worksheet.
2. Using the worksheet, follow the instructions for the lab.
3. Have your instructor sign off that you have completed the lab.
4. Scan the lab worksheet/checklist and submit your scan into Canvas to complete your lab, so you can move on to the next assignment.

Lab Project: Build Direct Start Box

For this lab you will be building your direct start box with the parts you bought earlier in this module.

Instructions

1. Print off the Direct Start Kit Instructions.
2. Follow the instructions for the lab. Ask your instructor to help if needed.
3. Have your instructor sign off that you have completed the lab.
4. Scan the lab worksheet/checklist and submit your scan into Canvas to complete your lab, so you can move on to the next assignment.

Lab Project: Compressor Direct Start Test

For this lab you will be using the direct start box to control a small compressor motor. You will be using the Electric Controls Project Board # 2 located on the end of the Bench on the west side of the lab classroom.

Instructions

1. Print off the Compressor Direct Start Test worksheet.
2. Using the worksheet, follow the instructions for the lab.
3. Have your instructor sign off that you have completed the lab.

4. Scan the lab worksheet/checklist and submit your scan into Canvas to complete your lab, so you can move on to the next assignment.

Lab Project 27 Motor Controls

For this lab you will be working with different motor controls like, thermostats, and low and high pressure controls. You will be working on how to adjust these devices.

Instructions

1. You will need to remove the lab sheets for Lab 27 from your lab manual.
2. Print your name and the date on the top of the first lab sheet.
3. Use the lab manual sheets for the lab.
4. You will not be doing Activity 27-5.
5. Have your instructor sign off on the front page of your lab sheets that you have completed the lab.
6. Scan this page of the lab sheets and submit your scan into Canvas to complete your lab, so you can move on to the next assignment.

Lab Project: 24 Volt Pump Down Wiring

For this lab you will be wiring and testing a compressor pump down control setup. In this control setup the thermostat does not control the compressor motor but controls a solenoid valve coil while a low-pressure switch controls the compressor motor.

Instructions

1. Print off the 24 Volt Pump Down Wiring worksheet.
2. Using the worksheet, follow the instructions for the lab.
3. Have your instructor sign off that you have completed the lab.
4. Scan the lab worksheet/checklist and submit your scan into Canvas to complete your lab, so you can move on to the next assignment.

Lab Project: Single Phase Compressor Controls

For this lab you will be using the Imperial Single Phase Compressor Control Board (Motor Controls Station #3). In this lab you will be wiring up and testing 7 different compressor motor control circuits.

Instructions

1. Print off the Single Phase Compressor Controls worksheet.
2. Using the worksheet, follow the instructions for the lab.
3. Have your instructor sign off that you have completed the lab.
4. Scan the lab worksheet/checklist and submit your scan into Canvas to complete your lab, so you can move on to the next assignment.

Lab Project: Motor Controls Wiring

In this lab you will be wiring up some common motor control circuits. There are 4 wiring diagrams provided that you will need to wire up. After you have wired the 4 wiring diagrams, you will then create 2 more control circuits using the controls on the trainer.

Instructions

1. Print off the Motor Controls Lab worksheet.
2. Using the worksheet, follow the instructions for the lab.
3. Have your instructor sign off that you have completed the lab.
4. Scan the lab worksheet/checklist and submit your scan into Canvas to complete your lab, so you can move on to the next assignment.

Residential Motor Control Written Progress Exam

This exam will help you and your instructor see how you are progressing in the course.

This exam covers chapters 26 and 27 in the Heating and Cooling Essentials Textbook. This exam must be taken in the classroom. You must get a score of 80% or better to move on to the next assignment.

Residential Motor Control Lab Practical

As stated at the beginning of this module: "Now that you have a good understanding on how motors work, we will move on to how to control them. Most of the time when you have a motor that isn't working the problem is in the control circuit, not the motor. So understanding motor control circuits is an very important skill for an HVAC tech. In this module you will look at the starting components for different types of motors, both open motors and compressor motors. You will also learn how to draw and wire motor control circuits using different control operations."

When you have completed this module, you will know how to:

- Identify motor starting components.
- Identify the starting components for open motors.
- Identify and wire the starting components for compressor motors.
- Identify motor control circuit components.
- Interpret wiring diagrams to wire residential motors.

In this lab you will be wiring up different motor control circuits, both open and compressor motors. You will be using the direct start box you built for the first part of this lab. Then you will wire up 3 different compressor starting control circuits. Lastly you will wire up two motor control circuits.

This lab practical must be performed in the presence of your instructor and will help you and your instructor see how you are progressing in the course. You will need a score of 80% or higher to show that you have mastered the competency.

1. Schedule time with your instructor when you are ready for your lab practical.
2. Your instructor will provide you with the worksheets for this lab.

3. Here is the checklist that will be used to grade you on your lab.
4. After the lab, your instructor will enter your score into Canvas.

Module 3: Residential HVAC Equipment Controls

Residential HVAC Equipment Controls Topic Overview

In this module you will be digging deeper into the control circuits that are used in residential HVAC equipment. Before you can troubleshoot HVAC equipment electrical problems (which you will be doing in the next module) you need to understand how to read, interpret, and draw equipment wiring diagrams. We will be revisiting residential HVAC control circuit components and related wiring diagram symbols.

When you have completed this module, you will know how to:

- Identify residential HVAC control circuit components and related wiring diagram symbols.
- Interpret wiring diagrams to wire residential HVAC equipment.
- Draw wiring diagrams per sequence of operation and wire control circuits.

Residential HVAC Equipment Controls Assignments

As you work through this module play close attention to the wiring diagrams used in different HVAC equipment. You must be able to read and interpret what the diagrams are telling you. You need to be able to recognize equipment components by their symbols on the diagrams. You also need to be able to draw a control circuit just by knowing the sequence of operation of the equipment.

Instructions

1. Read chapter 16 Residential Air-Conditioning Control Systems in the Smith Electricity textbook.
2. Watch the PowerPoint video: Relays, Refrigeration Controls and Timers. Note there is no audio in this video.
3. Take the Check Your Knowledge Chapter 16 Quiz.
4. Complete the Lab Projects for this module.

Check Your Knowledge: Chapter 16 Review Quiz

After you have read the textbook chapter, take this open book chapter review quiz. This quiz is designed to help you know what you have learned from the textbook.

Testing Procedures:

1. Click **Take this Quiz** link.
2. Read each question and choose the best answer(s).
3. When you have answered all the questions, click the **Submit** button. You will be shown your score.

Lab Project: 16-1 Identification of HVAC Equipment

In this lab you will be searching and identifying different types of HVAC equipment in the lab. In the field you must be able to identify what type of HVAC equipment you are working on.

Instructions

1. You will need to remove the lab sheets for Lab 16-1 from your Electricity lab manual.
2. Print your name and the date on the top of the first lab sheet.
3. Use the lab manual sheets for the lab.
4. We do not have the type of equipment asked for in Part B, #1a Electric air-conditioning packaged unit (AC only). Do all of the other sections in Part B except #1a.
5. Have your instructor sign off on the front page of your lab sheets that you have completed the lab.
6. Scan this page of the lab sheets and submit your scan into Canvas to complete your lab, so you can move on to the next assignment.

Lab Project: 16-2 Identification of Electrical Components Used in Conditioned Air Systems

In this lab you will be working with your instructor to identify the electrical components on different HVAC equipment in the lab. The instructor will take you to a unit and have you identify the components listed on your lab sheet.

Instructions

1. You will need to remove the lab sheets for Lab 16-2 from your Electricity lab manual.
2. Print your name and the date on the top of the first lab sheet.
3. Use the lab manual sheets for the lab.
4. Have your instructor take you to different pieces of lab equipment to identify their electrical components.
5. Have your instructor sign off on the front page of your lab sheets that you have completed the lab.
6. Scan this page of the lab sheets and submit your scan into Canvas to complete your lab, so you can move on to the next assignment.

Lab Project: 16-5 Wiring a Split System Conditioned Air System with a Gas Furnace and Condensing Unit

For this lab you will be disassembling both the power wiring and the control wiring of Furnace #11 and an AC unit in the lab. This includes the wires from the power disconnect to the furnace and AC units and thermostat to the units and those wires or circuits inside the units. You will draw a wiring diagram of the fan-coil and AC unit and their connecting circuits. Then you will reinstall both the power and control wiring to the unit and make sure that it is operational.

Instructions

1. You will need to remove the lab sheets for Lab 16-5 from your Electricity lab manual.
2. Print out this additional worksheet for this lab.

3. Print your name and the date on the top of the first lab sheet.
4. Use the lab manual sheets for the lab.
5. Let your instructor know you are ready to do this lab.
6. On this worksheet you will be drawing a wiring diagram for the lab units using the proper wiring diagram symbols for the components in the equipment.
7. After you have drawn your diagram show it to your instructor.
8. Remove the power and control wiring from the unit including the wires inside the equipment. You will be rewiring the unit using the same wires later.
9. You are now ready to work on the worksheet from your lab manual.
10. In Part A #3 it asks you to size the wire needed to hook up the equipment. You will use Figure 8.3 on page #193 of your Smith Electricity textbook to help figure out the wire size.
11. You do not need to do Part A #5. You will just be using what you removed instead of using new parts and wire.
12. Steps 1 through 7 are dealing with the power feed wires coming from the disconnect to the units. You will also replace the other wires removed at this point in the lab.
13. Have your instructor sign off on the front page of your lab sheets to show that you have completed the lab.
14. Scan this page of the lab sheets and submit your scan into Canvas to complete your lab, so you can move on to the next assignment.

Lab Project: Drawing and Wiring Control Circuits

One of the skills that is good to have is the ability to draw wiring diagrams from just a list of requirements or a sequence of operation. In this lab you will be doing just that. You will have three drawings to create just from a list of sequence requirements. After you draw each, you will wire them up and then test them for proper operation. You will be using the controls trainer station #3 for this lab, the Imperial Single Phase Compressor Trainer.

Instructions

1. Print off the Lab worksheet for this lab.
2. Using the worksheet, follow the instructions for the lab.
3. Have your instructor sign off that you have completed the lab.
4. Scan the lab worksheet/checklist and submit your scan into Canvas to complete your lab, so you can move on to the next assignment.

Residential HVAC Equipment Controls Written Progress Exam

This exam will help you and your instructor see how you are progressing in the course. This exam covers chapter 16 in the Smith Electrical Textbook. This exam must be taken in the classroom. You must get a score of 80% or better to move on to the next assignment.

Residential HVAC Equipment Controls Lab Practical

As stated at the beginning of this module: In this module you will be digging deeper into the control circuits that are used in residential HVAC equipment. Before you can troubleshoot HVAC equipment electrical problems (which you will be doing in the next module) you need to understand how to read, interpret, and draw equipment wiring diagrams. We will be revisiting residential HVAC control circuit components and related wiring diagram symbols.

When you have completed this module, you will know how to:

- Identify residential HVAC control circuit components and related wiring diagram symbols.
- Interpret wiring diagrams to wire residential HVAC equipment.
- Draw wiring diagrams per sequence of operation and wire control circuits.

In this lab you will be working on removing the power and control wires of a furnace and heat pump after drawing a wiring diagram of the equipment. You will then rewire the equipment and make sure that it operates correctly. Next you will draw and wire two control circuits from a sequence of operation used for the drawings.

This lab practical must be performed in the presence of your instructor and will help you and your instructor see how you are progressing in the course. You will need a score of 80% or higher to show that you have mastered the competency.

1. Schedule time with your instructor when you are ready for your lab practical.
2. Your instructor will provide you with the worksheets for this lab.
3. Here is the checklist that will be used to grade you on your lab.
4. After the lab, your instructor will enter your score into Canvas.

Module 4: Residential HVAC Equipment Electrical Troubleshooting

Residential HVAC Equipment Electrical Troubleshooting Overview

One of the biggest skills that HVAC service companies look for in service techs is very good troubleshooting skills. What are these skills? A service tech who can quickly and accurately troubleshoot and repair HVAC equipment with no call backs. This skill is a big asset to any service company. In this module you will be learning how to do just that. You will be given many opportunities to work on lab trainers as well as lab HVAC equipment.

When you have completed this module, you will know how to:

- Identify the steps for troubleshooting.
- Diagnose electrical control problems in residential equipment.
- Repair electrical control problems in residential equipment.

To begin please view this video: **Diagnostics of Electrical Equipment**

Residential HVAC Equipment Electrical Troubleshooting Assignments

As was stated before, a good troubleshooter can go far in this business. As you work through this module please pay close attention to the troubleshooting procedure steps. By following these steps, you will learn how to quickly and accurately troubleshoot and repair HVAC equipment.

Instructions

1. Read chapter 15 Troubleshooting Electric Control Devices in the Smith Electricity textbook.
2. Print out this handout on Troubleshooting and then watch the PowerPoint video **Unlocking the Mystery of Troubleshooting**. Note there is no audio on this video.
3. Watch the PowerPoint Video **Troubleshooting Motors**. Note there is no audio on this video.
4. Take the Check Your Knowledge Chapter 15 Quiz.
5. Complete the Lab Projects for this module.

Check Your Knowledge: Chapter 15 Review Quiz

After you have read the textbook chapter, take this open book chapter review quiz. This quiz is designed to help you know what you have learned from the textbook.

Testing Procedures:

1. Click **Take this Quiz** link.
2. Read each question and choose the best answer(s).
3. When you have answered all the questions, click **Submit** button. You will be shown your score.

Lab Project: HVAC Wiring Troubleshooting Trainer

For this lab you will be using the HVAC Wiring Troubleshooting Trainer lab control station #7. This trainer has the basic control circuit of an electric heating system with add on AC. It contains 8 problem switches which when flipped will insert a fault into the controls that you will need to identify.

Instructions

1. Print out the HVAC Troubleshooting Checklist to be used as a flowchart to help in troubleshooting the trainer.
2. Print out the HVAC Wiring Troubleshooting Diagram to be used in this lab.
3. Print out the worksheet for this lab. It will tell you what heating or cooling mode you need to set the thermostat to check for the fault.
4. Using your multimeter, work through each problem switch to identify each of the problems.
5. Discuss your results to your instructor.
6. Have your instructor sign off on the front page of your lab sheets to show that you have completed the lab.

7. Scan this page of the lab sheets and submit your scan into Canvas to complete your lab, so you can move on to the next assignment.

Lab Project: 15-5 Troubleshooting Heating Controls

In this lab you will be troubleshooting 4 lab furnaces with different ignition systems. The objective of this lab is to be able to find and repair the faults that have been inserted into the furnaces.

Instructions

1. You will need to remove the lab sheets for Lab 15-5 from your Electricity lab manual.
2. Print your name and the date on the top of the first lab sheet.
3. Use the lab manual sheets for the lab.
4. You will not be doing sections E and F that deal with oil heating systems. Complete sections A-D only.
5. Let your instructor know that you are ready for this lab so they can insert the fault into the furnace.
6. Have your instructor sign off on the front page of your lab sheets that you have completed the lab.
7. Scan this page of the lab sheets and submit your scan into Canvas to complete your lab, so you can move on to the next assignment.

Lab Project: Troubleshooting Furnace # 27

In this lab you will be troubleshooting 8 fault problems with furnace #27. This furnace has 8 fault switches. You will insert a different fault into the furnace by flipping a switch into the up position. Insert only one fault at a time. Using your multimeter, troubleshoot and identify what the 8 faults are.

Instructions

1. Print out the worksheet for this lab.
2. Insert one fault at a time and record your findings on the worksheet.
3. Have your instructor sign off on your lab sheets that you have completed the lab.
4. Scan this page of the lab sheets and submit your scan into Canvas to complete your lab, so you can move on to the next assignment.

Lab Project: Residential Furnace and AC Troubleshooting

In this lab you will again be working on troubleshooting lab equipment that has had faults inserted into them.

Instructions

1. Print out 4 of the HVAC Lab Work Order for this lab.
2. Let your instructor know that you are ready for this lab so they can insert the fault into the lab equipment.
3. Record your findings on the worksheet.

4. Ask your instructor to insert faults into 3 other pieces of lab equipment.
5. Have your instructor sign off on the front page of your lab sheets that you have completed the lab.
6. Scan this page of the lab sheets and submit your scan into Canvas to complete your lab, so you can move on to the next assignment.

Residential HVAC Equipment Electrical Troubleshooting Written Progress Exam

This exam will help you and your instructor see how you are progressing in the course. This exam covers chapter 15 in the Smith Electrical Textbook. This exam must be taken in the classroom. You must get a score of 80% or better to move on to the next assignment.

Final Competency Exam and Practical Assessment

As stated at the beginning of this course the Competencies for this course, are to be able to:

- Explain the fundamental principles of electric motors.
- Identify and wire residential motor starting and control components.
- Analyze, construct, and apply wiring diagrams to properly control different types of residential HVAC equipment.
- Diagnose and correct electrical problems in residential HVAC equipment.

At the end of each module you should have showed that you have mastered the competency for each module. This Written Exam and Lab Practical are going to make sure that you have fully mastered this course's competencies.

Final Competency Exam Form A *(There is a Form B in case the student does not pass Form A)*

This summative assessment will measure your knowledge of air conditioning and refrigeration controls. Topics include residential motors and controls, residential HVAC equipment controls, and the steps for troubleshooting HVAC equipment. The assessment consists of 36 questions. To pass this assessment, you will need a score of 80% (29 out of 36 points).

If you do not pass on the first attempt, you will have the opportunity to meet with your instructor, study and practice the content further, and retake a different version of the assessment.

Testing Procedures:

1. Click **Take this Quiz**
2. Read each question and choose the best answer(s).
3. When you have answered all the questions, click the **Submit** You will be shown your score.

Final Competency Lab Practical Form A *(There is a Form B in case the student does not pass Form A)*

This lab practical is a summative assessment that will measure your knowledge and skills for air conditioning and refrigeration controls. Topics include residential motors and controls, residential HVAC equipment controls, and performing steps for troubleshooting HVAC equipment.

This lab practical consists of 6 parts that will be completed in sequence. This assessment represents the culmination of the competencies for this course. You will work through each part, then proceed only after your instructor has checked your work at the end of each part for safety.

The lab practical will be evaluated according to a checklist and must receive a minimum of 80% to pass (72 out of 90 points). If you do not pass on the first demonstration, you will receive feedback and have the opportunity to make a second attempt after revision. The second attempt will be on an alternate version of the lab.

This lab practical must be performed in the presence of your Instructor.

Fundamentals of Gas Heating Final Lab Practical Checklist for Evaluation

Student Name: Score:

Part 1: Motor Identification

Aspect	Meets Expectations (Proficient) 1 Point	Identify Horsepower	Identify Phase	Identify Volts	Identify Amps	Identify Service Factor	Identify Service Factor Amps	Identify Furnace RPM	Identify Frame #	Identify AMB Specs	Identify FINS Specs	Identify Shaft Size	Identify Rotation	Identify Mounting	Identify Motor Type
		Score (0-1)													
Motor #1	Motor Identification														
Motor #2															
Motor #3															
Motor #4															
Motor #5															
Motor #6															

Part 2: Motor Speed and Torque

Aspect	Meets Expectations (Proficient) 1 Point	Measured RPM at 20% Voltage	Measured RPM at 40% Voltage	Measured RPM at 60% Voltage	Measured RPM at 80% Voltage	Measured at 4 oz Scale Reading	Measured at 8 oz Scale Reading	Measured at 12 oz Scale Reading	Measured at 16 oz Scale Reading	Measured at 20 oz Scale Reading	Measured at 24 oz Scale Reading	Comments
		Score (0-1)										
Motor RPM	Measuring Motor RPM											
Motor Amps	Measuring Motor Amps											
Motor Torque	Measuring Motor Torque											

Part 3-6: Motor Wiring

Aspect	Meets Expectations (Proficient) 1 Point	Split-Phase Motor	Capacitor-Start Motor	Permanent-Capacitor Motor	Capacitor-Start Capacitor-Run Motor	Comments
		Score (0-1)				
Motor Wiring	Wiring from Diagram					
Motor Rotation Reversal	Proper rewiring for rotation Reversal					

Residential Motor Control Lab Practical Checklist for Evaluation

Student Name:_____ Score:_____

Part 1: Compressor Direct Start Test

Aspect	Meets Expectations (Proficient) 1 Point	Hook up Test Box Correctly	Motor Started Correctly	Comments
		Score (0-1)		
Compressor Motor	Starting Compressor Motor with Direct Text Box			

Part 2: Current Relay Wiring, Part 3: Potential Relay Wiring, Part 4: Solid State Relay Wiring

Aspect	Meets Expectations (Proficient) 1 Point	Used Correct Start Components	Correctly Wired Circuit from Drawing	Compressor Starts Correctly	Comments
		Score (0-1)			
Current Relay	Wiring Current Relay				
Potential Relay	Wiring Potential Relay				
Solid State Relay	Wiring Solid State Relay				

Part 5: Motor Control Wiring

Aspect	Meets Expectations (Proficient) 1 Point	Used Correct Components	Correctly Wired Circuit from Drawing	Motor Starts Correctly	Comments
		Score (0-1)			
Drawing #1	2 Voltages Circuit				
Drawing #2	Motor Start/Stop Circuit				

Residential HVAC Equipment Controls Lab Practical Checklist for Evaluation

Student Name: Score:

Part 1: Wiring up Heat Pump and Furnace

Aspect	Meets Expectations (Proficient) 1 Point	Make Correct Diagram	Unwired equipment	Rewired equipment	Unit Started OK	Comments
		Score (0-1)				
Wiring Heat Pump and Furnace	Power and Control Wiring					

Part 2: Drawing and Wiring Control Circuits

Aspect	Meets Expectations (Proficient) 1 Point	Used Correct Components	Made Correct Diagram	Wired up Circuit corrctly	Circuit Worked Correctly	Comments
		Score (0-1)				
Drawing #1	Sequence of Operation Drawing and Wiring					
Drawing #2						

Air Conditioning and Refrigeration Controls Final Lab Practical Checklist A

Student Name: Score:

Part 1: Motor Identification

Aspect	Meets Expectations (Proficient) 1 Point	Identify Horsepower	Identify Phase	Identify Volts	Identify Amps	Identify Service Factor	Identify Service Factor Amps	Identify Furnace RPM	Identify Frame #	Identify AMB Specs	Identify FINS Specs	Identify Shaft Size	Identify Rotation	Identify Mounting	Identify Motor Type
		Score (0-1)													
Motor #1	Motor Identification														
Motor #2															
Motor #3															

Part 2: Motor Wiring and Measuring Motor Speed and Torque

Aspect	Meets Expectations (Proficient) 1 Point	Motor wired Correctly	Motor has right Rotation	Brake Drum Installed Correctly	Prony Brake installed Correctly	Water Added to Brake Drum	Comments
		Score (0-1)					
Motor Wiring and Testing	Capacitor-Start Capacitor-Run Motor						

Aspect	Meets Expectations (Proficient) 1 Point	Measured at 4 oz Scale Reading	Measured at 8 oz Scale Reading	Measured at 12 oz Scale Reading	Measured at 16 oz Scale Reading	Measured at 20 oz Scale Reading	Measured at 24 oz Scale Reading	Measured at 28 oz Scale Reading	Measured at 32 oz Scale Reading	Measured at 36 oz Scale Reading	Measured at 40 oz Scale Reading	Comments
		Score (0-1)										
Motor Amps	Measuring Motor Amps											
Motor RPM	Measuring Motor RPM											
Motor Torque	Calculating Motor Torque											

Part 3: Current Relay wiring and Part 4: Potential Relay Wiring

Aspect	Meets Expectations (Proficient) 1 Point	Used Correct Start Components	Correctly Wired Circuit from Drawing	Compressor Starts Correctly	Comments
		Score (0-1)			
Current Relay	Wiring Current Relay				
Potential Relay	Wiring Potential Relay				

Part 5: Drawing and Wiring Control Circuits

Aspect	Meets Expectations (Proficient) 1 Point	Used Correct Components	Made Correct Diagram	Wired up Circuit correctly	Circuit Worked Correctly	Comments
		Score (0-1)				
Wiring Diagram	Sequence of Operation Drawing and Wiring					

Part 6: Motor Control Wiring

Aspect	Meets Expectations (Proficient) 1 Point	Used Correct Components	Correctly Wired Circuit from Drawing	Motor Starts Correctly	Comments
		Score (0-1)			
Wiring Diagram	2 Voltages Circuit				