E/ET 11 COURSE

LANEY COLLEGE
ENVIRONMENTAL CONTROL TECHNOLOGY

Commercial HVAC Systems Program

E/ET 11 Commercial Electricity for HVAC Course Development

National Science Foundation - National Center for Building Technician Education

COMMERCIAL ELECTRICITY FOR HVAC

Course Documentation

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Catalog Description

Introduction to advanced commercial electricity for heating and air conditioning: high voltage single-phase and three-phase, transformers, capacitors, HVAC system controls, motor controls, HVAC electrical schematic diagrams, instrumentation, national codes and safety.

Class hours

Lecture 26.25 Hours Lab 26.25 Hours

Units

Lecture 1.5 semester units Lab 0.5 semester units

Entry skills needed

- Reading level: College-level English technical reading. Ability to decode new technical terminology with reference help.
- Writing level: Ability to express complex technical concepts in English.
- Math level: college technical math
    1. Perform mathematical operations using real numbers, fractions, decimals and percentages.
    2. Solve simple linear equations.
    3. Demonstrate knowledge converting fractions to decimals and decimals to fractions.
    4. Solve basic math and geometry problems on area, angles, volume and percentages.
    5. Use algebraic equations to solve heating and cooling load calculation problems.
    6. Solve problems involving area and perimeter.
    7. Solve problems involving ratio and proportions.
    8. Interpret data in graphs in rectangular coordinate systems.
    9. Use and apply Imperial and Metric systems of measurement.

- Fundamentals of electricity skills:
    1. Understand and explain basic AC power concepts, such as phase angle and power factor.
    2. Read and explain single line power distribution diagrams.
    3. Wire Y and Delta connections step up and step down applications.
    4. Select and apply the proper instruments for diagnosing electrical problems.
    5. Understand and explain safe wiring practices including the concepts of proper grounding.

6. Demonstrate electrical safety practices including the use of personal protective equipment (PPE) and first aid.
7. Demonstrate proper knowledge of how to read and draw electrical schematic and pictorial diagrams.
8. Describe the different types of motor starters and over-current protection devices.

Syllabus

See Appendix A for sample Syllabus course schedule and policies. For Lesson Topics to include in course, see Exit Skills.

Student learning outcomes

The exit skills listed in the next section support these 4 outcomes:

Three - phase concepts

Explain and discuss high voltage and three-phase electricity concepts, their sources and applications

Interpreting diagrams

Demonstrate ability to read and interpret electrical diagrams, both pictorial and schematic.

Installation

Safely perform installation of typical commercial wiring branch circuits.

Troubleshooting

Demonstrate safe and proper procedures for troubleshooting high and low voltage electrical controls and devices.

Exit skills

Course content to achieve 4 outcomes listed above:

AC power concepts:

1. Understand and explain high voltage AC power concepts.
   Course Content for this objective:
   a. Review of basic electrical concepts
   b. General and electrical safety exam

c. Discussion of safety equipment and practices around live electrical equipment.

Reading diagrams

2. Read and interpret electrical sequence of operations and schematic diagrams.

Course Content for this objective:

a. Sequence of operations and schematic diagrams

Lesson Topics:

- 3-wire stop/start motor control diagrams
- 3phase motor & transformer wiring diagrams
- Heating elements
- Limit fuses
- Sequencers

Describe controls

3. Describe the different types of electrical controls and safety devices.

Course Content for this objective:

a. Semiconductor devices
b. Refrigeration basic principles and basic power and controls circuits
c. Gas furnace and heater basic principles with basic power and control circuits
d. General principles of boilers and controls with emphasis on boiler operating safety
e. Maintenance person's boiler concerns and responsibilities

Lesson Topics:

- Klixon operation
- Defrost timer operation & termination control
- Defrost timers
- Hot-gas defrost
- Special defrost circuits
- Overloads
- Motor starters
- Condensing units
- Electronic fan speed control
- Combination gas valves
- Thermocouples
- Limit switches
- Fan switches
- Time-delay fan switches

Wiring installation

4. Demonstrate safe and proper wiring

Course Content for this objective:

a. Commercial wiring practices and materials
b. Pipe bending, fabricating and installing
c. Lab: Wire and operate 120/208-volt, 3-phase, line-voltage, three-wire, stop-start motor control circuit and motor.
d. Lab: Wire mock up walls with branch circuits, 3pole switches and lights.
e. Lab: Wire 3-phase circuit panel and install breakers (hot).
f. Lab: Wire high & low voltage (240/480/24) wiring configurations for motors and contactors.

Troubleshooting

5. Apply troubleshooting theory for Y and Delta transformers, capacitors and motor controls.

Course Content for this objective:

a. AC electricity, both single- and three-phase and transformers
b. The effects of induction and capacitance with phase shifts and how they affect commercial electrical circuits
c. Electric motor theory, both single- and three- phase and beginning line voltage motor control circuits
d. How magnetic starters with overload protection work

Use of instrumentation

6. Demonstrate safe and proper use of instrumentation.

Lesson Topics:

- Current measurement with an Amprobe

Codes and safety

7. Understand and explain the national electrical codes and safety.

Course materials

Principal text

Electricity, Electronics and Wiring Diagrams for HVAC/R Second Edition
Edward F. Mahoney. Pearson/Prentice Hall, 2006. ISBN 0-13-ll9085-7.

Lecture materials and handouts

- Motor basics, presentation 57 slides
- Motor fundamentals-AC motor architecture and function handout
- Transformer configuration and calculation, wye and delta, handouts

Other reference materials

None specified for this course.

Software needed
None required for this course.

Lab materials
- Visual aids, many varieties of motor, control and wiring components
- Students to bring: Pen, pencils, color pencils, graph paper with 1/4" squares, circle template, line paper, safety glasses, medium flat blade screwdriver, Philips screwdriver, combination wire cutter, stripper and crimper, one roll of electrical tape, wire connectors, fuse puller, multi-meter, tool box or tool pouch, and digital multi-meter.

Equipment & instruments required
- EMT & fittings, raceway, MC cable & fittings, boxes, wiring devices
- 3 Phase circuit panels with compatible breakers, lugs and fittings
- Wall mock-ups for wiring installation
- Motors, contactor switches, transformers for motor wiring
- Multi-meters

Samples of weekly assignments
Use selected text's "Practical Experience" and "Review Questions accompanying chapters 18 – 23, 25 & 27. These include T/F, completion, short answer, "completion of drawings and diagrams" types of questions.

Project

Problem-based learning (PBL) project or other projects have not been considered for this course. This course focuses on basic applied knowledge and spatial skills. PBL recommended for higher level synthesizing courses.

Assessment

Methods
- Analysis of selected questions involving explanation of electrical concepts, electrical codes, and safety procedures
- Questions involving reading, explaining and drawing schematic diagrams
- Tests, take-home projects and hands-on work in the lab

Sample test questions
General and Electrical Lab Safety Test. 40 TF questions

1. (T F) It is OK for students to wear open-toed shoes in this lab if they are careful.
2. (T F) Hard hats must be worn on construction jobs where overhead work is being done.

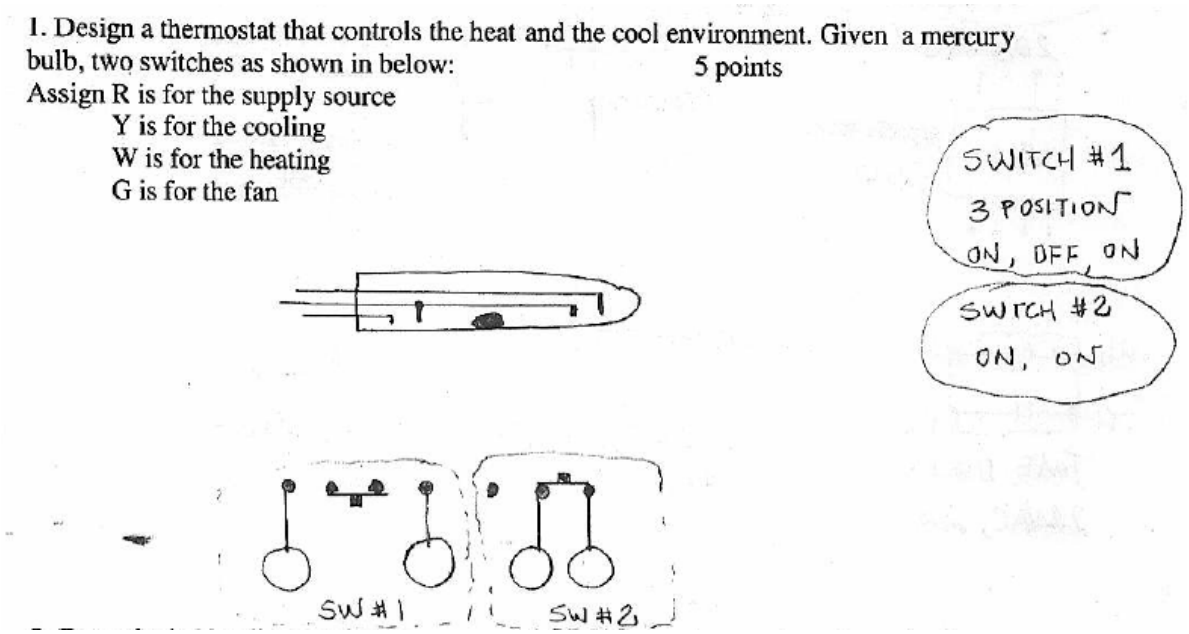
3. (T F) Goggles, a face shield, or safety glasses must be worn when operating a power grinder or any power tool.

Test 1: 10 multi-part drawing /design questions covering ladder diagrams, wire diagrams, control designs.

1. Given a split-phase motor and a current relay, draw a ladder diagram to show the circuit connection.(3points)

2. Design a manual control air conditioner given: on-off switch (10A), 208v-8A compressor.

Quiz 2: 3 design scenario-type questions. Given components, students must draw circuit and or create ladder diagram of the circuit.



Final: 33 short answer questions, plus 2 extra credit calculation questions covering basic electricity, circuits, safety, safety devices, Ohm's Law, power factor, wiring, AC motors.

1. Give a formula for Ohm's Law.

2. Using "ELI the ICEman," does an inductive circuit have a leading or lagging power factor?

3. A hand-held drill or other hand-held electrical tool typically uses what type of motor? _____What is different about this motor from other AC motors?_____.

Adaptability to On-Line format

Requirements: Adaptation of laboratory equipment for photographic presentation on-line. The hands-on wiring, operation, and troubleshooting components of the course cannot be replicated at distance.

Appendix A – Sample syllabus

LANEY COLLEGE
Commercial Electricity For HVAC
Fall semester 2013

Course: Comm. Electricity for HVAC
Course Number: E/ET 11
Time: Tuesday (Lecture) 5:30PM – 6:45 PM Thursday (Lab) 5:30PM - 6:45 PM
Instructor:
Office Hours:
Units: 2 units.
Phone:

Course Description: The course will introduce advanced commercial electricity for heating and air conditioning. Students will learn to analyze the logic control operation of electrical circuits applied to HVAC, the power control operation applied to motors, three phase commercial source, transformers, and safety codes applied to system.

Student Outcomes:
Demonstrate skills in reading and analyzing various electrical circuits of HVAC .
Provide solutions for solving electrical systems applied to commercial HVAC.

Recommended preparation: Fundamentals of Electricity E/ET 202, ECT 214

Text Book: Electricity, Electronics, and Wiring Diagrams for HVAC/R, Second Edition 2006, By Edward F Mahoney, Pearson Education, Inc.

Supplies Needed: Pen, pencils, color pencils, graph paper with 1/4" squares, circle template, line paper, safety glasses, medium flat blade screwdriver, Philips screwdriver, combination wire cutter, stripper and crimper, one roll of electrical tape, wire connectors, fuse puller, multi-meter, tool box or tool pouch, and digital multi-meter.

Lecture: The class will concentrate on the following areas:
1. Air-Conditioning and Heating Controls and Circuits
2. Commercial Systems - Three Phase
3. Standing Pilot Furnaces
4. Electronic Ignition Gas-Fired Furnaces
5. Electric Heat

Lab Work: Students will explore:
1. Troubleshooting Strategies
2. Repair Strategies
3. Testing and Replacing Common Devices

Grading Policy:

1.	First Test	(Sept 24)	15%
2.	Second Test	(Oct.22)	15%

3.	Third Test	(Nov.19)	15%
4.	Final Test	(Dec.10)	20%
5.	Home work Participation		20%
6.	Lab and Lecture Participation		15%

Attendance: Students shall attend the class on time. The attendance verification starts at 6:15 PM.

Absent four times from the class will be automatically dropped from the semester. Students are responsible to drop promptly from the class.

Students are failed to attend the test, also failed showing a legitimate paper. Then, make up test will be salvaged at 80% of the face value. Students who completely ignore taken the test will be subjected to withdraw from the class.

Texting during the test, if caught ,will be immediately withdrawn from the class. Cell phone conversation is strictly prohibited in the class.

Class Schedule

Week#:	Class Content
1	Course Overview, Simple air conditioning Homework Assignment#1
1	Lab #1 Electrical Safety Unit #9
2	Window Air Conditioner. Homework Assignment#2
2	Lab #2 Simple Motor Start Control
3	Capacitor Application to Window Air Conditioner Unit #10 Assignment #3 Ladder Diagram application.
3	Lab # 3
4	Ladder Diagram application, Phase Shift and Power Factor to Window Air Conditioner with Electric Heat Unit13 Homework Assignment #4
4	Lab. #4
5	First Test at 5:30 PM
5	Thermostats, Homework Assignment #5
6	Control Circuits for Rooftop Air Conditioner, Homework Assignment #6
6	Lab #5
7	Power Circuits for Rooftop Air Conditioner, Homework Assignment #7
7	Lab #6
8	Air Conditioning System with Resistance Heaters - Pictorial and Ladder Diagrams, Homework Assignment #8
8	Lab # 7
9	Electric Wiring application, Homework Assignment #9
9	Lab #8
10	Second Test at 5:30 PM
10	Lab #9
11	Standing Pilot Furnaces-Furnace Circuit #1, Homework Assignment #10
11	Lab #10
12	Standing Pilot Furnaces-Furnace Circuit #2, Homework Assignment #11
12	Lab #11
13	Electronic Ignition Gas-Fired Furnaces, Homework Assignment #12
13	Lab #12

14	Third Test at 5:30PM
14	Lab.#13
15	Electronic Ignition Gas-Fired Furnaces, Homework Assignment #13
15	Holiday Observance
16	Troubleshooting Strategies, Homework Assignment #
16	Review
17	Final Exam at 5:30PM

BEST Center Curricula, Resources & Recordings

Academic Programs
Georgia Piedmont Technical College - Building Automation Systems
Milwaukee Area Technical College - Sustainable Facilities Operations
Laney College - Commercial HVAC Systems
City College San Francisco - Commercial Building Energy Analysis & Audits

Professional Development Materials, Presentations & Videos
National Institutes
Building Automation Systems Instructor Workshops
Webinars (e.g., BEST Talks)

Faculty Profile Videos
Reports & Case Studies
Marketing Resources

BEST
Building Efficiency for a Sustainable Tomorrow

NSF National Science Foundation