ECT 24 COURSE

LANEY COLLEGE ENVIRONMENTAL CONTROL TECHNOLOGY Commercial HVAC Systems Program

ECT 24 Commercial HVAC Systems Troubleshooting Course Development

National Science Foundation - National Center for Building Technician Education







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Course Documentation

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Catalog description

Introduction to troubleshooting procedures for commercial HVAC systems: methods used for repairing, servicing and installing electrical and mechanical devices, including ventilation, filtration, air distribution, and air and water treatment systems.

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 ratio and proportions.
 - 7. Interpret data in graphs in rectangular coordinate systems.
 - 8. Use and apply Imperial and Metric systems of measurement.
 - 9. Solve problems involving area and perimeter.
- Commercial HVAC Systems skills:
 - 1. Describe and explain the functions of all the HVAC system components.
 - 2. Explain the principles of thermodynamics as they apply to HVAC systems.
 - 3. Use the psychrometric chart to evaluate thermal comfort conditions.
 - 4. Demonstrate proficiency in the electrical and mechanical aspects of HVAC systems.

- 5. Demonstrate proper use of instrumentation.
- 6. Use different software tools to measure and analyze HVAC systems.
- 7. Demonstrate a good understanding of mechanical, electrical, pneumatic and electronic controls.
- 8. Demonstrate proficiency on hydronic systems.

Syllabus

See <u>Appendix A</u> 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:

Tools and Instrumentation

Demonstrate proper use of tools and instrumentation for troubleshooting commercial building systems and controls.

Sequence of operations

Describe the mechanical and electrical equipment sequence of operations for building systems and controls.

Safety

Demonstrate proper safety practices when working on equipment and controls.

HVAC Maintenance & Operation

Describe proper maintenance procedures for optimizing system performance and energy savings.

Exit skills

Course content to achieve 4 outcomes listed above:

HVAC Systems & Components:

- Describe the functions of all the HVAC system components. Course Content for this objective:
 - a. Reading and analyzing mechanical and electrical diagrams.

- b. Review of building HVAC systems
- c. Integration of energy system control with fire, occupancy, lighting control systems.

Lesson Topics:

- Furnaces & boilers
- Hydronic systems
- Air side systems
- Chillers
- Cooling towers
- Package units
- Heat pumps
- Overview of proper building equipment operation and maintenance procedures.
- Lab 1: Observe system components. Gather name plate data.
- Lab 2: Put a workbook together with layout, data, operating characteristics of the system.

Troubleshooting

2. Demonstrate the necessary skills for troubleshooting mechanical, electrical, pneumatic and electronic control systems.

Course Content for this objective:

- a. Methods of evaluating comfort conditions
- b. Troubleshooting methods

Lesson Topics:

- Evaluation of system performance as compared to the design intent of the building
- Pressure-enthalpy diagram
- Lab 5: Troubleshoot heating side of system which happens to be operating correctly (to investigate operating characteristics).
- Lab 6: Troubleshoot 'bugged' heating side of system. Apply 'hop-scotch' method.
- Lab 7: Troubleshoot cooling side of system which happens to be operating correctly.
- Lab 8: Troubleshoot 'bugged' cooling side of system.

Psychrometrics

3. Use the psychrometric chart to evaluate thermal comfort conditions and troubleshoot a system.

Course Content for this objective:

- Evaluating thermal comfort conditions for troubleshooting HVAC a. systems
- b. Using psychrometric chart to make adjustments to HVAC systems Lesson Topics:
 - Overview of psychrometric processes of air
 - Lab 3: Take real time readings of system flows, input and output energy.
 - Lab 4: Calculate BTU transfer air-water-air for all stages of system.

Instrumentation

- 4. Demonstrate proper use of tools & instruments.
 - Lesson Topics:
 - Overview of test equipment

Software Tools for Energy Conservation

- 5. Use different software tools to measure and analyze HVAC systems. Course Content for this objective:
 - a. Software tools to measure and analyze HVAC systems
 - b. Use of software and instrumentation for collecting data and analyzing HVAC systems

Lesson Topics:

- Economizer programming to save energy •
- Using temperature reset to save energy. •
- Setting equipment schedules to save energy.

Safety

6. Demonstrate proper safety skills for working with electricity and mechanical equipment.

Course Content for this objective:

- a. Proper grounding techniques
 - **Lesson Topics:**
 - Lab safety
 - Proper use of electrical multi-meters •

Course materials

Principal text

Edward G. Pita <u>Air Conditioning Principles and Systems, 4th.edition</u>. Prentice Hall, (2002).

Lecture materials and handouts

This course is used for hands-on solving of problem scenarios. There are no set materials besides the scenarios. Instructor/students may research and develop materials specific to the problems under consideration.

Scenarios used in course:

- Boiler will not fire (VFD frequency set too low, flow switch not contacting)
- Coil too cold or warm (plugged strainer)
- Air flow too low (clogged filter)
- Air flow too low (reversed fan due to 3ph wiring error)
- Valve or damper will not open (pneumatic transmitter leak, diaphragm leak, or loose line)

Other reference materials

ASHRAE offers education packages, publications, and resource materials.

Field Trips

• UC Berkeley mechanical rooms - Students can observe and measure the performance of equipment in the field and solve actual past problem scenarios involving these systems.

Software needed

- <u>LearnHVAC</u> simulates failures
- <u>Simutech</u> simulator software with modules for each system component
- Live log-in to UC Berkeley building automation systems to monitor and view control systems for troubleshooting.

Lab materials

• Safety glasses, gloves, medium flat & Phillips screwdrivers, adjustable wrenches (8" & 12"), combination wire-cutter stripper crimper, electrical tape, wire connectors, fuse puller, digital multi-meter, tool box.



Lab equipment & instruments required



FIGURE 1 - Economizer on built-up AHU in lab. Controls fully accessible for adjustment, setting up faults, or commissioning activities.

FIGURE 2 - Variable frequency drive, 3 are connected to water circulation pumps in lab. Can be programmed by students, faults can be set up by instructor.

Generally, hands-on implementation of concepts is key to successful learning of equipment function and relationships. Laney ECT department's lab has a fully functional commercial building central plant system for demonstration purposes. All components of the system are accessible to students for operation, measurement, diagnosis, servicing, and commissioning. See <u>Laney College - Commercial HVAC</u> <u>Systems</u> program documentation for lab layout and more detailed information on equipment and instruments.

A connected and functional commercial HVAC system should include a boiler, chiller, water pumps, air handling units, terminal units, cooling towers, control systems (pneumatic and/or DDC), sensors, and actuators. Monitoring access point computers

accompanied by one or more control system trainer boards (with equivalent connected controls and actuators) will allow students maximum access.

Economizers need to be set up to demonstrate response to any outdoor conditions regardless of the time of day or year the lab class is meeting. A furnace/AC unit has been installed to supply "outside air" to the economizers at a selected temperature between 55° F and 120° F.

Samples of weekly assignments

During each class meeting, students work on solving a troubleshooting problem included in the Labs section.

Project

The lab work in the class is based on the <u>problem based learning (PBL)</u> process. Students benefit from the framework encouraging them to research and confront the scenario. Students complete a small-scale PBL project with presentation (1 week).

The main PBL scenario for ECT 24 is: "How to Keep the Chiller Running". Description of the scenario:

"At the University of California, Berkeley, there is an 8 story building with a science laboratory in the basement. The building was undergoing a major infrastructure remodeling. In November, the nighttime outdoor temperature dropped into the high 30°F. This created problems for the chiller that was needed to supply water to keep the experiment running.

As a group, it is your job to identify how to put enough BTUs on the chiller to keep it running in order to continue a long term Physics Department experiment and prevent critical data from being lost."

See Appendix B for a sample PBL Project Assessment Rubric.

Assessment

Methods

- PBL Project team presentation Assessment Rubric
- Midterm Exam
- Final Practical exam

Sample test questions

- Midterm Exam: purpose is to assess troubleshooting thought process. Paper scenario with faults to detect and correct.
- Final Practical exam: 5 faults in system to find. Rubric: find 3 = C, find 4=B, 5=A. The student must fix fault 4 in order to find fault 5. Done in pairs or individually.

Adaptability to on-line format

This course is the core of hands-on troubleshooting. Student access to real equipment is critical for this course. If a college's program lacks lab facilities, real building facilities can be used if safety, liability and logistics will allow. A facsimile of the experience can be created using the aforementioned software to simulate systems with faults to detect and correct. Adaptation of laboratory equipment for video presentation might support on-line demonstrations. Refer to "<u>PNNL Retuning Commercial Buildings</u>" for examples of web-based interactive problem scenarios.

Appendix A - Sample syllabus

(See Exit Skills section for lesson topics.)

LANEY COLLEGE Environmental Control Technology Fall Semester

Course: Commercial HVAC Systems Troubleshooting Course Number/code: ECT 024 Time: Wednesday 7:00pm to 9:50pm. Instructor: Office: Office Hours Tuesday 5:00pm to 6:00pm Phone:

Units: 2 units.

Course Description: Introduction to commercial (HVAC) Heating, Ventilation and Air Conditioning Systems using proper tools and instrumentation for troubleshooting building components such as chillers, boilers, fans, pumps, variable frequency drives, and associated ventilation and zone equipment that form complex systems. This course will also cover proper maintenance procedures for energy conservation.

Student Outcomes:

1. Demonstrate proper use of tools and instrumentation for troubleshooting commercial building systems and controls.

2. Describe the mechanical and electrical equipment sequence of operations for building systems and controls.

- 3. Demonstrate proper safety practices when working on equipment and controls.
- 4. Demonstrate proper maintenance procedures for optimizing system performance and energy savings.

Recommended preparation: basic skill levels in reading, writing, and math,

Text Book: <u>Air conditioning Principles and Systems</u> by Edward G. Pita

Supplies Needed: Safety glasses, gloves, medium flat blade, flathead and phillips screwdrivers, two adjustable wrenches one 8" and one 12", combination wire cutter, stripper and crimper, one roll of electrical tape, wire connectors, fuse puller, digital multi-meter and tool box.

Lecture: The class will concentrate on the following areas:

- 1. Review of building HVAC systems
- 2. Overview of the psychometric processes of air
- 3. Review of electrical theory and instrumentation
- 4. Energy savings using economizer, temperature reset and equipment schedules
- 5. Overview of proper building equipment operation and maintenance procedures
- 6. Evaluation of system performance as compared to the design intent of the building

Grading Policy:	Problem based learning exercise Homework Midterm Final	25 points 25 points 25 points 25 points 100 points max			
		100 points max			
90-100 points A					
80-89 B					
70-79 C					
60-69 D					
August 21, 2013	Lab safety				
August 28, 2013	Proper use of electrical multimeters				
September 4, 2013,	Overview of test equipment				
September 11, 2013	Euroaces and boilers				
September 18, 2013	Hudronic systems				
September 25, 2013	Psychrometric chart				
October 2, 2013	Air side systems				
October 9, 2013	Pressure / Enthalow diagram				
October 16, 2013	Chillers				
October 23, 2013	Cooling towers				
October 30, 2013	Midterm				
November 6, 2013	Problem based learning exercise				
November 13, 2013	Problem based learning exercise presentations				
November 20, 2013	Package units				
November 27, 2013	Heat numos				
December 4 2013	Proper maintenance procedures				
December 11 2013	Final				
D ((1))(1), 2013	1 11141				

Attendance: Students may be dropped from the course if the number of absences exceeds two days' worth of class meetings. However, extenuating circumstances may warrant consideration.

Appendix B - Sample project rubric

This is a scoring rubric of what criteria your instructor will be using to grade your final team presentation.

SAMPLE: Write each student's name above a score column. For each presentation trait, rate each student using the scale shown.

	/	/	/	/	/ /						
		/	/		/ /		1	2	3	4	5
			' /	/ /			Strongly				Strongly
	' /	/					disagree				agree
1	1	1	1	/	1						

Score		Presentation Trait				
				Quality of information and organization: Presentation main points are clear and well developed; information is linked to presentation topic; information is organized.		
				 Nonverbal communication: Speaker appears comfortable and confident; speaker maintains good eye contact and posture; speaker shows engaging and inviting presence; speaker uses body motions and gestures effectively; speaker utilizes room effectively via movement. 		
				♀ Quality of verbal communication: Speaker's voice is confident, steady, strong and clear; speaker uses inflections to emphasize key points or to create interest.		
				⇐ Visual tools: Visual aids are creative, clear and easy to read; tools enhance the effectiveness of the presentation.		
				Appropriate use of terminology: All terms are included in the presentation; terms are used in unique and creative ways; terms are used in context.		
				Precision and detail in documents produced: Documents are clear, well constructed, accurate and show attention to detail; care has been taken in the production.		
				Overall presentation effectiveness		
				⇔ Total Score		

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Traits	5 – Excellent	4 – Very Good	3 – Adequate	2 – Limited	1 - Poor	
ation • and ation	• Main points are very clear and very detailed	Main points are clear and detailedInformation is linked to	• Main points are somewhat clear but could use more detail	 Main points are not clear and lack significant detail 	• Presentation lacks main points and related details	
Inform: Quality Drganiz	• Information is directly linked to presentation topic	presentation topicInformation is well organized	• Most information is linked to the presentation topic	• Some information is linked to the presentation topic	• Information lacks connection to the presentation topic	
	 Information is very organized 	_	 Information is organized 	 Information is loosely organized 	• Information is not organized	
	• Speaker appears very comfortable and confident	• Speaker appears fairly comfortable and confident	• Speaker appears generally at ease and confident	• Speaker appears uneasy and somewhat insecure	• Speaker appears very uneasy and insecure	
nication	• Speaker consistently faces the audience and maintains good eye contact	• Speaker generally faces the audience and maintains good eye contact	 Speaker sometimes faces the audience and maintains eye contact Speaker sometimes appears to be engaging with the audience Speaker's body motions and gestures neither support nor detract from presentation Speaker moves about some of the room 	 Speaker rarely faces the audience or makes eye contact Speaker rarely appears to be engaging with the audience Speaker uses few body motions or gestures or has gestures or movements that distract the audience Speaker is mostly stationary 	• Speaker faces away from the audience or makes no eye contact	
Commu	• Speaker consistently appears to be engaging with the audience	 Speaker generally appears to be engaging with the audience Speaker uses body motions and gestures well Speaker utilizes much of the room via movement 			 Speaker appears disengaged from the audience Speaker lacks any body motions or gestures or demonstrates consistently 	
Nonverbal (Speaker uses body motions and gestures very effectively 					
	• Speaker utilizes the room very effectively via movement				distraction body motions or gestures	
					• Speaker is completely stationary	
_	• Speaker's voice is very confident, steady, strong, and	• Speaker's voice is steady, strong and clear	• Speaker's voice is generally steady, strong and clear	• Speaker's voice is frequently too weak or too strong	• Speaker's voice is consistently too weak or too strong	
of Verbal nication	 clear Speaker consistently uses inflections to emphasize key 	• Speaker often uses inflections to emphasize key points and create interest	 Speaker sometimes uses inflections to emphasize key points and create interest Speaker's talking pace is appropriate 	 Speaker rarely uses inflections to emphasize key points and create interest or speaker sometimes uses inflections inappropriately Speaker's talking pace is often too slow or too fast 	• Speaker fails to use inflections to emphasize key points and create interest or speaker	
ality . mmu	points or to create interest	• Speaker's talking pace is mostly			often uses inflections	
Qua Coi	 Speaker's talking pace is consistently appropriate 	appropriate			• Speaker's talking page is	
	consistently appropriate			100 510w 01 100 1251	consistently too slow or too fast	
al Tools	• Visual aids are very creative, clear, and easy to read	• Visual aids are usually creative, clear, and easy to read	 Visual aids are reasonably creative, clear, and easy to read Presentation is sometimes 	• Visual aids have limited creativity or clarity or are sometimes	• Visual aids demonstrate no creativity or clarity and are	
	Presentation is consistently aphanaad by the viewal tools	Presentation is often enhanced by the viewel tools		difficult to read	often difficult to read	
Visu	ennanced by the visual tools	by the visual tools	chilanced by the visual tools	Fresentation is not enhanced by the visual tools	Fresentation is weakened by the visual tools	
	-					

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Laney college, environmental Control Technology

ECT24 Course Commercial HVAC Systems Troubleshooting

Traits	5 – Excellent	4 – Very Good	3 – Adequate	2 – Limited	1 - Poor
Appropriate Use of Vocabulary	• All terms are included in the presentation	• All terms are included in the presentation	• Most terms are included in the presentation	• Several terms are included in the presentation	• Few or no terms are included in the presentation
	• Used in unique and creative ways	Used effectivelyUsed in context	Generally used appropriatelyGenerally used in appropriate	• May or may not be used appropriately	• May or may not be used appropriately
Precision and Detail in Documents Produced	 Used in context Documents are clear, well constructed, accurate and show attention to detail Extra care has been taken in the production 	 Clearly evident that documents are correct, detailed and accurate Care has been taken in the production 	 Evident that documents are correct and show a general attention to detail and accuracy General care has been taken in production 	 May lack context Documents may have some errors and show some detail Some care has been taken in production 	 Lacks context Documents have numerous errors and lack detail Little care taken in the production
Overall Presentation Effectiveness	 This was an exceptional presentation and extremely effective I'd give you a 10 	 This was a very good presentation and very effective I'd give you an 8 or 9 	 This presentation was good and effective I'd give you a 6 or 7	 This presentation was average and somewhat effective I'd give you a 3, 4 or 5 	This presentation was weak and not effectiveI'd give you a 0, 1, or 2

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