ECT 23
COURSE

LANEY COLLEGE
ENVIRONMENTAL CONTROL TECHNOLOGY

Commercial HVAC Systems Program

ECT 23 HVAC System Design
Course Development

National Science Foundation - National Center for Building Technician Education

HVAC SYSTEM DESIGN

Course Documentation

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Environmental Control Technology
900 Fallon St • Room B150
Oakland, CA 94607
Phone 510.464.3292

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Catalog description

Application of system sizing, duct layout and duct sizing to pre-existing building plans. Students cover manual load calculations and duct sizing methods, and use software tools to apply calculations and develop designs. Students create mechanical plans and present their designs. This course builds on the fundamentals learned in the Commercial HVAC Systems course and the psychrometrics and comfort parameters learned in Psychrometrics and Load Calculations.

Class hours

Lecture 35 Hours

Units

Lecture 2 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 HVAC mechanical, electrical and electronic controls.
8. Demonstrate proficiency in hydronics.

- Psychrometrics and Load Calculations skills:
  1. Define psychrometrics.
  2. Define the terms dry-bulb temperature, relative humidity, specific humidity or grains of moisture, and dew point.
  3. Identify the lines and scales representing these terms on the psychrometric chart.
  4. Use the psychrometric chart to determine the condition of air and occupant comfort conditions.
  5. Use instruments such as sling psychrometer and air flow meters to gather relevant data.
  6. Use industry-defined standards and variables to determine load calculations.
  7. Use load calculation software to find heat gain and heat loss.

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 3 outcomes:

HVAC Function

Understand and be able to apply the science of heat transfer, air flow, and psychrometrics to provide indoor comfort.

Design Knowledge

Demonstrate knowledge for properly laying out systems, selecting equipment, and sizing ducts for a small commercial system.

Design Application

Demonstrate ability to solve a small commercial system design problem including reading blueprints and proposing a system type, size, air flows ,duct layout, and conforming to applicable codes.

Exit skills

Course content to achieve 3 outcomes listed above:

HVAC Systems & Components

1. Describe the components and explain the functions of heating and air conditioning systems including boilers, chillers, cooling towers and their associated controls.

Course Content for this objective:

a. Assessment and review of competency with system structure.

Lesson Topics:

- Energy and laws of thermodynamics
- Residential & light commercial HVAC
- All-air systems

Hydronics

2. Understand how a hydronic sub-system works, basic principles of pumping, flow balancing and control.

Lesson Topics:

- All-water systems
- Air and water systems

Duct and Pipe Sizing

3. Demonstrate the ability to properly select and size ducts and piping systems.

Unitary System Design

4. Demonstrate the ability to design a small commercial system.

Lesson Topics:

- The design process
- Occupant comfort and health
- Load calculations
- System selection

Duct Design

5. Explain in some detail the various methods for designing an all-air system including all of the single duct variations.

Course Content for this objective:

a. Velocity sizing method
b. Constant pressure loss method
c. Static pressure recovery method

Zone Control

6. Identify and explain the various methods for zone temperature controls.

   Course Content for this objective:

   a. Terminal air flow control methods are not included in the design problems for this course.

Codes and Trades

7. Determine which codes apply to building examples. Understand work flow and trade responsibilities for a typical HVAC installation.

Course materials

Principal text

HVAC: Design Criteria, Options, Selection, William H. Rowe III
R.S. Means Co.; 1st edition (December 1988), ISBN 978-0876291023

Previously used texts:
"Principles of Air Conditioning" (5th Ed.). V Paul Lang,
Delmar, Cengage Learning, Albany, New York (1995).

"Air Conditioning System Design Manual", Walter Grondznik - editor ,
ASHRAE/Butterworth-Heinemann

Lecture materials and handouts

The following can be used to produce lecture presentations, hand outs or listed as reference materials for students.

- Heat gain and heat loss formula sheets
- Duct sizing method summary by Lawrence Berkeley Lab. Covers existing manual methods and discusses computerized calculation.

Other reference materials

None listed for this course.

Software needed

Although manual load calculation, flow calculation and duct design methods are covered, student project work is done using computerized design software. Two brands of software are used at Laney ECT, based on system availability and class size.:

- Trane Trace 700
- eQuest
- Manual/tutorial included for these software

Lab materials

This course involves lectures and computer lab with design software and internet access. CAD software is also helpful for the instructor; however CAD is not a requirement for the course.

Lab equipment & instruments required

See Software & Lab materials section.

Samples of weekly assignments

Five homework sets are assigned and coordinated with instruction throughout the semester. Topics covered in homework:

HW1: Ventilation requirements, permits and approvals, smoke evacuation, Title 24 (California) prescriptive measures.

> 1.2 What are the ventilation requirements for the following (use both ASHRAE and BOCA and show differences, if any)?
>
> a. offices
> b. theaters
> c. school laboratories

HW2: Equipment sizing for air and water, piping details, steam traps, control equipment identification and function.

> 2.2 An office space of 30' x 50' with a 10' ceiling is to have an air handling system capable of 6 air changes per hour. Calculate the air required, lay out the ductwork, and select a typical ceiling diffuser.

HW3: Installation requirements for HVAC equipment, flues, vibration isolation.

> 3.2 What size flue is required for a gas boiler with an input of MBtu/hr. and no draft hood?

HW4: Trade responsibilities on installations, capital vs. operating expenditures, environmental concerns for HVAC, duct system layout.

> 4.1 Which trade performs the following work?
>
> a. Internal wiring for elevator controls
> b. Coring through a foundation wall for a sprinkler pipe
> c. Scaffolding or ladders for installation of ductwork in a space that is 14 feet to the underside of the ceiling
> d. Furnishing duct smoke detectors
> e. Motor starter for a pump
> f. Installing electric duct heaters

HW5: Design life of building, air and hydronic system layout, pumps and pump curves, fans.

5.3 A 5 H.P. pump provides 100 gpm at a speed of 1,750 rpm at 60 hertz.
a. If the variable frequency drive drops the power to 50 hertz, what will be the flow rate of the pump?
b. At 50 hertz, how much will the horsepower of the pump decrease?
c. Comment on the variable speed drive's effectiveness in this case.

Project

This course utilizes problem-solving throughout. Students solve discrete problems related to separate system design issues. The course culminates in a 5-week design problem solution and presentation.

Based on student's entry competency level, the design problem will be a single-zone rooftop unit, or a multi-zone split system.

System sizing: See building plans: ECT23_Project_Plans.pdf

Description: The building has an office area and warehouse space. In the warehouse there is a product that needs to be kept at 68°F indoor temperature. The office area needs to be kept at 75°F indoor summer and 72°F indoor winter temperature.
Task: The students are HVAC contractors who are hired by the owner to install packaged rooftop unit for the warehouse and split system for the office. Their task is to gather the required information to properly size and select HVAC equipment and exhaust fans.
The goal is to right size the equipment, which will have lower first cost for the owner and will have lower energy cost.

Assessment

Methods

Pre-test: Student status assessed for competence with heat transfer concepts and equations, energy conversion equations, energy units, and pre algebra skills. Results of pre-test are used to set the level of complexity of the design problems used in the course.

See Appendix B – Sample project rubric for project assessment.

Sample test questions

Quiz 1: 12 short answer and calculation questions covering science of energy, HVAC equipment, coefficient of performance.

1. In a given building, where are the following pieces of equipment typically located?
    a. Boiler
    b. Hot water pumps
    c. Cooling tower
    d. Heat pumps
    e. Packaged HVAC unit

2. What is the difference between energy and power? In what units are they measured?

Quiz2: 10 multiple choice questions on duct sizing covering duct sizing calculator and friction loss chart.

1. Using the Duct Sizing Calculator, if the volume of air in a system is 1,600 CFM and the height of a rectangular duct is 8", what should be the width of the duct?
    A. 40"
    B. 30"
    C. 20"
    D. 16"

2. What do the vertical lines on the Friction Loss Chart represent?
    A. CFM
    B. fpm
    C. Inches WC
    D. Inches duct diameter

Test 1: Duct system design problem - given a ductwork plan stating diffuser CFM, determine the following:
    1. Determine the CFM in each run of duct.
    2. Determine the longest duct run.
    3. Size all ducts by the constant pressure drop method with pressure drop 0.08" w.c.
    4. Size the fan.

Test 2: Duct system design problem - given a ductwork plan stating diffuser CFM, SAT & SPT, determine the following:
    1. What is the total sensible cooling of the above system?
    2. Size all the ducts by the constant pressure drop method. Pressure drop is 0.08" w.c.
    3. Size the fan.

Midterm: Manual load calculations

1. A one-story office building in Boston (see Figure 1) has 8-foot ceilings, has a slab on grade, and is 25 feet on each side. Each elevation has two 3' x 5' double hung, double glazed windows; the east and west walls each have 3'x 7' solid wood doors; U door = 0.7, U window = 0.9.
   The exterior walls of the building are constructed of 2" x 4" frame construction, wood siding, *5/16"* plywood sheathing (R=1.28), and 3/8"gypsum wallboard (R=0.45) on the interior. The walls are filled with 3" of fiberglass insulation (R=13).
   The roof is a 1" wood deck supported on wood framing with a suspended acoustical tile ceiling. There is 3" of insulation on the wood deck. It has U value of 0.65 Btu/hr.sq.ft.°F.. Delta T between indoor and outdoor temperature is 60°F.
   Find the building design heat loss.

Adaptability to on-line format

This course could be offered on-line, provided students have access to required design software.

Appendix A – Sample syllabus

(See Exit Skills section for lesson topics.)

ECT 23 HVAC SYSTEMS DESIGN: SYLLABUS

Course Number/Code: ECT 23- **Course Term:**
Time: Monday 8:00pm to 9:50pm **Units:** 2 units
Instructor: **Phone:**
Office Hours: Wednesday 7:45 pm to 8:15 pm **Email:**

Course Description: This course introduces HVAC systems design and principles, such as heating and cooling loads, descriptions of system components, distribution piping and/or ductwork.

Student Outcomes: Understand basics of heating and cooling systems design, equipment selection and specifications; demonstrate familiarity with HVAC design professional software.

Text: Power point materials; *HVAC: Design Criteria, Options, Selection* by William H. Rowe III

Supplies Needed: Calculator, note book, pen or pencil, scale, USB

Evaluation: Classroom work and projects will be evaluated and graded accordingly.

1. Attendance and Participation in class: 25%
2. Midterm and quizzes 50%
3. Final Exam 25%

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. The department head will decide what are extenuating circumstances. Tardiness (more than 30 minutes) will count as a missed day unless previous arrangements are made with the instructor. Missing more than one day will effect a student's grade.

Conduct: **No cell phone or electronics use is allowed in class**. Returning calls/texting must wait until break or the end of class. Any other phone use must be cleared with the instructor before each session starts. **Cell phone calculators are not acceptable; you must have a real calculator.** Laney is a tobacco free environment, including smokeless tobacco.

HINT: Reading the chapters before the session will expedite absorption of the material. ***Read chapters before attending class.***

NOTE: CHEATING = FAILING GRADE

***Disclaimer: The syllabus is subject to modification. The instructor will communicate to students any changes or revisions*.**

Wk 1 **Energy and Laws of Thermodynamics Review**
Wk 2 **The Design Process**
Wk 3 **---------- HOLIDAY ----------**
Wk 4 – **Heating Load Calculations**
Wk 5 – **Cooling Load Calculations**
Wk 6 – **Duct Design**
Wk 7 – **Problem Based Exercise Intro/Discussion**
Wk 8 – **Occupant Comfort and Health**
Wk 9 – **----------MIDTERM----------**
Wk 10 **Systems Selection**
Wk 11 – **Residential/Light Commercial HVAC**
Wk 12 – **All Water Systems**
Wk 13 **All Air Systems**
Wk 14 – **Air and Water Systems**
Wk 15 – **Problem Based Exercise Review**
Wk 16 – **Course Review**
Wk 17 – **----------FINAL----------**

.

Appendix B – Sample project rubric

Project Rubric Guide: Modify to suit your needs…

Task/score:	**3 good**	**2 ok**	**1 lacking**	**0 missing**
Loads	All factors calculated accurately	Some factors missing	Calculations inaccurate	Mostly missing and wrong
Duct Layout	*Rubric to be developed….*			
Duct sizing				
Equipment selection				
Equipment sizing				
EF sizing				
Communication of the design				

Student score: (sum of score for each task) Max 21points
Grade: A ≥ 18, B ≥16, C ≥ 14, D≥12.

(verify tasks, assign success characteristics, you can add multiplier to important tasks, and adjust Max accordingly)

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