# ECT 19 COURSE

LANEY COLLEGE ENVIRONMENTAL CONTROL TECHNOLOGY

Commercial HVAC Systems Program

# ECT 19 Psychrometrics & Load Calculations Course Development

National Science Foundation - National Center for Building Technician Education







# **Course Documentation**

This material is based upon work supported by the National Science Foundation under Grant Number (DUE 1204930).

Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

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# **Catalog description**

#### Brief catalog description:

Analysis of the physical properties of air in refrigeration and air conditioning. Use of proper analytical instruments and manual load calculation and software for calculating cooling and heating loads.

#### Detailed syllabus description:

You will develop an understanding of the basic concepts of psychrometrics including moist air properties, evaporation and enthalpy, plus basic thermodynamic processes. After completing the course, you should know how to: use a psychrometric chart; properly design an HVAC system based on psychrometric principles; conduct a psychrometric analysis of HVAC components such as air handling units, heating and cooling coils, and humidifiers; evaluate the needs of individual spaces within a building; and determine energy reduction opportunities for HVAC systems. This course will cover the data and procedures necessary to accurately calculate heat gain and heat loss of residential and commercial buildings.

## **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.

## Suggested co-requisite skills development

- Commercial HVAC Systems skills:
  - 1. Describe and explain the functions of all the system components.
  - 2. Demonstrate the skills necessary to troubleshoot electrical, pneumatic and electronic control systems.
  - 3. Use the psychrometric chart to evaluate thermal comfort conditions and troubleshoot systems.
  - 4. Demonstrate proficiency in the electrical and mechanical aspects of air conditioning and refrigeration.
  - 5. Demonstrate proper use of instrumentation.
  - 6. Use different software tools to measure and analyze HVAC systems.
  - 7. Demonstrate proper safety skills in troubleshooting practices.

## 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 3 outcomes:

# Terminology

Explain psychrometrics and terms used, such as dry bulb temperature, relative humidity, specific heat, dew point, and grains of moisture.

# Application

Demonstrate proper use of psychrometric chart and instruments for measuring and analyzing air properties.

#### **Software Use**

Demonstrate proficiency in using load calculation software for measuring heat gain and heat loss.

# **Exit skills**

Course content to achieve 3 outcomes listed above:

# **Definitions**

1. Define the terms psychrometric, dry-bulb temperature, relative humidity, specific humidity or grains of moisture, and dew point.

## Course Content for this objective:

a. Properties of moist air. Indicators of moisture concentration in air.

# **Chart Reading**

2. Identify the lines and scales representing these terms on the psychrometric chart.

## Course Content for this objective:

a. Explanation of all chart characteristics

# Lesson Topics:

- Air conditioning processes on the psychrometric chart -- the power of the psychrometric chart, heating air, and cooling air with dehumidification
- Exercise: Reading and plotting data points from/to chart

# **Psychrometric Application**

3. Use the psychrometric chart to determine the condition of air and occupant comfort conditions.

# Course Content for this objective:

- a. Modeling air condition processes
- b. Psychrometric analysis for HVAC Design

# **Lesson Topics:**

- Factors of human thermal comfort, comfort zone
- Adding/removing sensible heat and mixing air streams
- Sensible heat ratio
- Air quantity, coil curves, determining supply air flow per ton of refrigeration
- Sensible heat ratio at full-load conditions, constant volume systems, variable air volume systems
- Exercise: Determine air properties in laboratory systems.
- Exercise: Practice process models using the chart.

# Instrumentation

4. Use instruments to gather relevant data.

## Course Content for this objective:

- a. sling psychrometer
- b. air flow meters

# Lesson Topics:

• Exercise: Build a relative humidity meter

# **Load Calculation basics**

- Use industry-defined standards and variables to determine load calculations.
  Course Content for this objective:
  - a. Air conditioning loads introduction
  - b. Heat loss and heat gain
  - c. Fenestration heat gain & loss

# **Lesson Topics:**

- Cooling load components
- Outdoor design conditions
- Heat transfer, conduction, radiation, convection
- Simple ways to calculate heating and cooling loads on residential buildings
- Internal loads
- Exercise: California Title 24 load calculations
- Exercise: Determination of U-values from tables

# **Software Load Calculation**

- 6. Use load calculation software to find the heat gain and heat loss. Course Content for this objective:
  - a. Residential load calculations
  - b. Commercial load calculations
  - c. Psychrometrics software

# Lesson Topics:

- ACCA Manual "J" and "N" calculation methods
- Bin analysis and software tools to calculate energy usage by HVAC systems in residential and commercial buildings
- Exercise: Using Wrightsoft Right-Suite software for load calculations

# **Course materials**

# **Principal text**

See lecture and handouts for reading material.

Course outline lists:

Althouse, Andrew and et al. <u>Modern Refrigeration and Air Conditioning</u>. Goodheart and Willcox Co. Inc., (2004).

# Lecture materials and handouts

Presentation materials include PowerPoint slides to accompany lecture. Slide show topics include:

- Presentation: **Principles of Heat Transfer** –contextualizes and explains the 3 methods of heat transfer and how they apply to buildings. (Cpo Science, 2012). 43 slides.
- Reference: **Cooling and Heating Load Estimation** –covering Space Cooling Loads, Space Heating Loads, and System Loads Produced by Trane Company. Using ASHRAE manual calculation methods. TRG-TRC002-EN. (Trane Company) 50pp.

# **Other reference materials**

None listed for this course.

# Software needed

- Wrightsoft Right-Suite Manual J & N load calculation software used. Building tree data entry system covered and applied. Critical output analysis used to understand program outputs.
- ACCA Manual J & N Excel Spreadsheets.

# Lab materials

This is a lecture only format course.

# Lab equipment & instruments required

None required.

# Samples of weekly assignments

Reading assignments, answering questions based on reading and lecture content, and problem solving exercises.

# Project

This 2 hour/week lecture format course does not have a problem-based learning (PBL) project.

# Assessment

## Methods

Two quizzes and final exam, written reports, hands-on demonstration on instruments, take-home computer-based projects.

# Sample test questions

Quiz 1 12 multi-part calculation questions accompanying Cooling and Heating Load Estimation handout (Trane Co).

1) Fill in the following table, indicating whether each component of the space cooling load contributes sensible heat and/or latent heat.

Sensible heat gain Latent heat gain

- conduction through roof
- conduction through exterior walls
- conduction through windows
- solar radiation through windows or

skylights

heat gain from people

heat gain from lights

air infiltrating from outdoors through cracks

Quiz 2 13 multi-part calculation and application questions on psychrometrics:

- Given outdoor air conditions of 95°F DB, 78°F WB; indoor design conditions of 80°F DB, 67°F WB; total airflow of 20,000 cfm; and outdoor airflow of 4,000 cfm:
  - a. Find the dry-bulb temperature of the mixture.
  - b. Plot all three conditions on the psychrometric chart.
  - c. Find the wet-bulb temperature of the mixture.

Final Exam: 13 multi-part calculation and application questions

- 1) In the attached psychrometric chart indicate the following processes:
  - a. Sensible cooling
  - b. Evaporative cooling
  - c. Cooling and humidification
  - d. Chemical dehumidification

# Adaptability to on-line format

## **Requirements**:

- Develop software component to work possibly using the demonstration version of Right-Suite software, so students can download and run software on their own Windows PC or
- Create a slide presentation of the inputs and outputs to Right-Suite so students can follow the process without access to the software.

# Appendix A - Sample syllabus

(See Exit Skills section for lesson topics.)

#### LANEY COLLEGE ENVIRONMENTAL CONTROL TECHNOLOGY

**Course:** Psychrometrics and Load Calculations

Course No. /Code: ECT 19

Units: 2 Units

Date/Time:

Instructor:

Email:

**Course Description:** You will develop an understanding of the basic concepts of psychrometrics including moist air properties, evaporation and enthalpy, plus basic thermodynamic processes. After completing the course, you should know how to: use a psychrometric chart; properly design an HVAC system based on psychrometric principles; conduct a psychrometric analysis of HVAC components such as air handling units, heating and cooling coils, and humidifiers; evaluate the needs of individual spaces within a building; and determine energy reduction opportunities for HVAC systems. This course will cover the data and procedures necessary to accurately calculate heat gain and heat loss of residential and commercial buildings.

#### **Exit 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 the heat gain and heat loss.

#### Prerequisites: NONE

Text: None

Supplies Needed: Three ring binder.

Special Notes: The following is recommended but not a requisite to take this course:

- Email account to received electronic files
- Laptop computer
- Knowledge of spreadsheets (excel)

#### Class Schedule:

WEEK 01: **Fundamentals:** The Theory of Moist Air -- The nature of air-water mixtures, indicators of moisture concentration in air, properties of air, the basic psychrometric chart, air conditioning processes.

Air Conditioning Processes on the Psychrometric Chart -- The power of the psychrometric chart, heating air, and cooling air with dehumidification.

WEEK 02: Introducing the Psychrometric Chart -- Modern age of psychrometrics, creating the psychrometrics chart, and psychrometrics software

Factors of human thermal comfort, comfort zone, adding/removing sensible heat, mixing air stream, sensible heat ratio.

- WEEK 03: Psychrometric Analysis for HVAC Design Air quantity, coil curves, determining supply air flow, ton of refrigeration
- WEEK 04: Psychrometrics Analyses SHR at full-load conditions, constant volume systems, variable air volume systems.

#### MID-TERM EXAM

- WEEK 05: Cooling load estimating –Cooling load components, outdoor design conditions, heat transfer, conduction, radiation, convection, .
- WEEK 06: Building loads Simple ways to calculate heating and cooling loads on residential buildings, conduction through surfaces.
- WEEK 07: External and internal loads
- WEEK 08: ACCA Manual "J" and "N". Energy use by HVAC systems

Bin analysis and software tools to calculate energy usage by HVAC systems in residential and commercial buildings.

#### FINAL EXAM

Evaluation: The final grade will be assigned based on the following components:

1. Attendance and participation20 points2. Midterm40 points3. Final Exam40 pointsTOTAL: 100 points

**Attendance:** Students may be dropped from this course if the number of unjustifiable absences exceeds four weeks of class meetings.

**Class Behavior:** Students are encourage to observe a respectful behavior during class, no cell phones or iPads are allowed in class

# **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

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