ENRG 52 - Energy and Building Science Fundamentals

COURSE DESCRIPTION: Fundamental concepts for understanding energy use in commercial buildings. Principles of energy, heat transfer, measurement and unit conversion, phase change, psychrometrics. Balance point and emissivity, delta flows, solar geometry. Energy efficiency improvement strategies.

36 Hours (27 lecture, 9 lab)

LEARNING OUTCOMES:

- Summarize the basic concepts of energy, including the first and second laws of thermodynamics, work, and power.
- Measure electricity, heat, pressure, and light, and calculate unit conversions to determine energy use in buildings over time.
- Analyze environmental conditions using the psychrometric chart and processes, and relate observations of variances in the environment to energy use in buildings.
- Describe and compare energy concepts including heat transfer, change of state or phase change, balance point, emissivity, and delta flows.
- Describe concepts of solar geometry and relate them to building science.

COURSE TOPICS:

I. Introduction
   A. Why energy auditors need to understand the concepts of energy and building science
      1. Whole building as complex system
      2. Variability of indoor environment characteristics such as light, temperature and humidity are variable
      3. Energy consumption by the systems that control indoor environmental conditions
      4. Slight changes in indoor environments can change energy consumption without affecting occupant comfort or productivity
   B. Critical terms for understanding and measuring environmental conditions and building energy use
      1. Voltage
      2. Amperage
      3. Resistance
      4. Safety or service factor
      5. Power factor
      6. True Power
      7. Luminance
      8. Apparent power
      9. Reactive power
      10. Correlated color
      11. British thermal units (Btu)
      12. Therms
      13. Foot-candle
      14. Kilowatt-hour (kWh)
      15. Temperature
   C. Tools used for measuring heat, light and energy

II. Concepts and principles of energy
   A. First law of thermodynamics
   B. Second law of thermodynamics
   C. Work
   D. Power

III. Heat transfer
   A. Methods of heat transfer

1. Conduction
2. Convection

B. Radiant Energy
1. Reflection
2. Transmission
3. Absorption
4. Units conversion
a. kWh to BTU/hr
b. Tons to pounds
c. Therms to BTUs
d. Foot-candle to kW

IV. Change of state (phase change)
A. Liquids phase change
B. Solids phase change
C. Vapors phase change
D. Dependence of boiling temperature on pressure
E. Molecular (kinetic) theory of liquids and gases
F. Saturated conditions
G. Sub-cooled conditions
H. Superheated conditions
I. Sensible and latent heat

V. Psychrometrics theory and applications
A. Understanding and reading the psychrometric chart
1. Dry bulb temperature
2. Wet bulb temperature
3. Dew point temperature
4. Specific humidity
5. Specific volume
6. Relative humidity
7. Enthalpy

B. Psychrometric processes and calculations
1. Sensible or latent processes
2. Combined sensible and latent processes
3. Air side equations
4. Mixing air

VI. Quantifying characteristics
A. Basic electricity
1. Measurement tools
2. Electrical theory
3. Alternating current
4. Direct current
5. Electric circuit

B. Heat basics
1. Measurement tools
2. Heat and power relationship
3. Temperature and temperature scales
4. Sensible heat
5. Latent heat

C. Pressure basics
1. Measurement tools
2. Atmospheric pressure
3. Vacuum pressures
4. Vacuum pressure calculations and conversions

D. Lighting basics
   1. Measurement tools
   2. Illuminance
   3. Correlated color
   4. Foot-candle
   5. Reflectors
E. Balance point and emissivity
F. Delta flows
G. Solar geometry
   1. Sun angles
   2. Altitudes
   3. Azimuth
   4. Plot of sun paths

TYPES OF ASSIGNMENTS:

I. In-class assignments
   A. Demonstrations and discussions of concepts such as the first and second laws of thermodynamics
   B. Lab activities such as using various tools to measure conditions and collect data
   C. Calculations from problem sets or data collected, such as unit conversions
   D. Possible field trips such as the Pacific Energy Center, or to various campus sites to observe and measure conditions

II. Out-of-class assignments
   A. Readings from textbooks, instructor handouts or websites
   B. Calculations from problem sets
   C. Projects demonstrating principles covered in class, such as building a simple sundial to demonstrate solar geometry

TEXTBOOKS & RESOURCES:

- Instructor handouts on topics such as the psychrometric chart thermodynamics and unit conversions
- Websites such as http://www.nibs.org/, http://www.bsc.ca.gov/home/calgreen.aspx, http://www.energy.ca.gov/title24/

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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Building Efficiency for a Sustainable Tomorrow

NSF National Science Foundation