

City College of San Francisco
Course Outline of Record

I. GENERAL DESCRIPTION

A. Approval Date	September 2012
B. Department	Engineering
C. Course Number	ENRG 54
D. Course Title	Introduction to Lighting Systems and Controls
E. Course Outline Preparer(s)	Wendy Miller
F. Department Chairperson	<hr/> Hitesh Soneji
G. Dean	<hr/> David Yee

II. COURSE SPECIFICS

A. Hours	Lecture: 20 total Laboratory: 10 total
B. Units	1.5
C. Prerequisites	ENRG 50, ENRG 52
Corequisites	None
Advisories	None
D. Course Justification	Commercial buildings consume more electricity than any other building sector, and are the second largest consumers of natural gas. California has set aggressive energy efficiency and greenhouse gas reduction goals. In February 2011 San Francisco passed the Existing Commercial Buildings Energy Performance Ordinance, requiring all commercial buildings over 10,000 square feet to benchmark their energy use annually, and be audited every five years. This class is part of a comprehensive training program developed with grant funds from the CCCCOEWD. Almost 35% of a building's energy use is attributable to lighting systems. Auditors need to understand the fundamentals of lighting systems and controls in order to identify energy efficiency opportunities and quantify energy savings.
E. Field Trips	Yes
F. Method of Grading	Letter, Pass/No Pass
G. Repeatability	0

III. CATALOG DESCRIPTION

Fundamentals of lighting systems and controls for energy auditors. Concepts of lighting, terminology, measurement tools, identifying energy efficiency opportunities, codes, standards.

IV. MAJOR LEARNING OUTCOMES

Upon completion of this course a student will be able to:

- A. Summarize terminology, physics and principles of lighting.
- B. Identify and compare various types of lighting systems, including field identification and interpretation of nameplate data.
- C. Measure illuminance and lighting intensity.
- D. Describe the theory and operations of various lighting control systems.
- E. Evaluate energy use by various types of lighting systems and identify opportunities for energy efficiency measures.
- F. Calculate energy savings of energy efficiency measures and estimate their financial impact.
- G. Apply relevant local, state and national codes, standards and regulations relevant to lighting system recommendations.

V. CONTENTS

- A. Introduction to fundamentals of lighting
 1. Lighting terminology
 - a. Luminous flux
 - b. Illuminance
 - c. Reflectance
 - d. Power
 - e. Efficacy
 - f. Lighting power density
 - g. Lamp life
 - h. Lumen depreciation
 - i. Correlated color temperature
 - j. Color rendering index (CRI)
 - k. Ballast factor
 2. Physics and principles of lighting
 - a. Spectral power distribution
 - b. Inverse square law
 3. Units of measurement
 - a. Lumen
 - b. Foot-candle
 - c. Power (wattage)
 - d. kWh
 4. Vision and colors
 5. Ambient, directional and task lighting
 6. Over- and under-illuminance
- B. Lighting systems
 1. Components
 - a. Luminaire

- b. Lamp
 - c. Ballast
 - d. Reflector
 - e. Diffuser, lens or louver
- 2. Types of lamps
 - a. Incandescent
 - b. Halogen
 - c. Fluorescent
 - d. High intensity discharge
 - 1. Metal halide
 - 2. Mercury vapor
 - 3. High pressure sodium
 - 4. Low pressure sodium
 - e. Induction lamps
 - f. Light emitting diodes (LED)
 - g. Neon
- 3. Ballasts
 - a. Electro-magnetic (magnetic) ballast
 - b. Electronic ballast
 - c. Ballast factor
- 4. Lamp comparison matrix
- 5. Types of lighting luminaires and intensities
- 6. Energy efficiency measures (EEMs)
 - a. Lamp replacement
 - b. Ballast replacement
- C. Lighting controls
 - 1. Basic concepts of effectiveness of lighting control
 - 2. Types and appropriate applications of lighting controls
 - a. Manual switches
 - b. Schedule controls or sweeps (building automation systems)
 - c. Timers and time clocks
 - d. Infrared and ultrasonic occupancy sensors
 - e. Manual dimmers
 - f. Daylight controls or photo sensors
 - g. Bi-level switching
 - 3. Lighting control equations
 - 4. Energy efficiency measures (EEMs)
- D. Additional EEMs
 - 1. De-lamping
 - 2. Scotopic lighting
 - 3. Task and ambient light levels
 - 4. Circadian rhythms
- E. Lighting measurements
 - 1. Tools
 - a. Flicker checker
 - b. Illuminance meter

- c. Luminance meter
 - d. Lighting measurement devices
 - e. Spectrophotometer
 - f. Goniophotometer
 - g. Circuit tracer
- 2. Data loggers and applications
 - a. Occupancy
 - b. Hours of use
- F. Lighting calculations
 - 1. Equation and method of calculating lumens (zonal cavity formula)
 - 2. Equation and method of calculating energy savings
 - 3. Method of calculating skylight energy savings
- G. Lighting standards, codes and regulations
 - 1. Underwriters' Laboratory (UL)
 - 2. Uniform Building Code (UBC)
 - 3. Americans with Disabilities Act (ADA)
 - 4. Title 24 applications
- H. O&M (operations and maintenance) measures to assure optimal performance

VI. INSTRUCTIONAL METHODOLOGY

- A. Assignments
 - 1. In class
 - a. Class discussions and demonstrations.
 - b. Perform energy usage and energy savings calculations from assigned problem sets.
 - c. Hands-on tool and meter use and interpretations.
 - d. Field trips such as visiting the Pacific Energy Center lighting lab, walk-throughs of various campus facilities to identify lighting types.
 - e. Small group projects such as oral presentation of findings from field trip site visits.
 - 2. Out of class
 - a. Readings from texts, websites and instructor handouts.
 - b. Calculations of energy use and energy savings from assigned problem sets.
 - c. Research and prepare brief (1-2 page) report comparing strengths and weaknesses of different lamp types.
 - d. Brief written paper (2-3 pages) on topics such as appropriate applications for various lighting types.
- B. Evaluation
 - 1. Participation in class discussions, demonstrations and field trips.
 - 2. In-class and out-of-class energy use and savings calculations.
 - 3. Tool use and meter interpretation.
 - 4. Small group projects, including oral presentations.
 - 5. Written report and paper.
 - 6. Quizzes on subjects covered in class and readings.
 - 7. Final exam.

C. Textbooks and other instructional materials

1. Websites, such as FILL IN HERE
2. Instructor handouts on such topics as comparison of qualities of various lamp types.
3. Lighting wattage tables.

VII. TITLE 5 CLASSIFICATION

CREDIT/DEGREE APPLICABLE (meets all standards of Title 5. Section 55002(a)).

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