Pro-Green Diploma
PRGR 633 Renewable Energy Systems and Energy Efficiency in Buildings

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Overview of the Course

The focus is on *HVAC* design optimization and energy conservation measures in built in environment to enhance the building's energy efficiency while maintaining space thermal comfort and indoor air quality requirement. In addition it includes concepts of district cooling/heating systems, dehumidification and personalized ventilation systems. It also covers renewable energy integration in building systems including photo-voltaics, solar-thermal and geothermal.
Performance and energy consumption of the conventional air conditioning system (constant and variable air volume) as well as the hybrid integrated air conditioning systems will be discussed and compared.
The course will include several demonstrations of concept experiments.

Credit Hours

This is a 2 credits course.

Delivery Format

This course will be delivered **online** where both students and instructor communicate via their computers. Note that ***no*** on-campus meetings will be offered for the PRGR 633 course. All assignments, class lectures, documents and responses will be on screen. Communication with the instructor and other students is through the sections called Discussion Forums and your personal e-mail. All these media are provided via the course Learning Management System, Moodle, which can be reached using the following link: moodle.aub.edu.lb.

Course Prerequisites

- Prior knowledge in Heat Transfer
- Introductory course in Thermodynamics

Course Goals

The main aim of this course is to provide the students with practical information of energy efficient technologies. This applies to heating, ventilation and air conditioning system designs along with understanding of indoor air quality (*IAQ*) problems and health and building safety issues. The course is designed to provide the student with the necessary knowledge that allows him to discern the weak spots in a building design and also provides him with the suitable tools that permit to "greenify" the building and make it comply with the energy efficiency standards.

Course Objectives

1- The student will be able to relate the effect of building envelope, air conditioning system and human use on the energy requirement of the building
2- The student will gain skills for designing an energy efficient buildings
3- The student will be able to evaluate and select appropriate sustainable energy design options for different types of building
4- The student will acquire an overview of the different heating and cooling air conditioning systems that relies on conventional and renewable energy
5- The student will be able to design ventilation systems that can provide good air quality with the efficient use of energy.
6- The student will be able to assess building efficiency with use of district cooling/heating systems, cleaning technologies, dehumidification and ventilation systems
7- The student will be able to solve 'real-world' engineering applications and present a Case Study via a concise mini-project report and presentation.

Topics Covered

- Factors effecting energy consumption in buildings: Building envelope: size, shape, material, orientation; Building service system: lighting, HVAC system; Human requirement: Comfort, IAQ, Ventilation.
- Guidelines for Building Envelope Design
- Outdoor and indoor air quality. IAQ standards of performance.
- Ventilation control strategies and technologies related to gaseous indoor air pollutants.
- IAQ and ventilation system performance and cost.
- HVAC systems (performance and efficiency)
- Heating, Cooling (using conventional & renewable energy)
- Hybrid air conditioning systems (performance and efficiency)
- Integrated building design
- Technologies associated with district cooling/heating systems, cleaning technologies, dehumidification methods, and ventilation systems
- Case studies of integrated building with renewable systems to meet heating, cooling, and power generation optimally.

Texts and Supplementary Materials

References

- A. Makhoul, K. Ghali and N. Ghaddar, The Energy Saving Potential and the Associated Thermal Comfort of Displacement Ventilation Systems Assisted by Personalized Ventilation, *Indoor and Built Environment* 2013, 22(3):508-519.
- A. Makhoul, K. Ghali and N. Ghaddar, Thermal comfort and energy performance of a low-mixing ceiling-mounted personalized ventilator system, *Building and Environment 2013*, 60: 126-136.
- A. Makhoul, K. Ghali and N. Ghaddar, Low-mixing coaxial nozzle for effective personalized ventilation, accepted for publication in *Indoor and Built Environment (October 2013),* doi: 10.1177/1420326X13508967
- B. Yassine, K. Ghali, N. Ghaddar, G. Chehab and I. Srour, Effectiveness of the earth tube heat exchanger system coupled to a space model in achieving thermal comfort in rural areas, *Int. Journal of Sustainable Energy 2014*, http://dx.doi.org/10.1080/14786451.2012.762776.
- M. Ibrahim, N. Ghaddar and K. Ghali, Optimal location and thickness of insulation layers for minimizing building energy consumption, *Journal of Building Performance Simulation 2012*, 5(6): 34-398.
- M. Hammoud, K. Ghali and N. Ghaddar, The Optimized Operation of a Solar Hybrid Desiccant/Displacement Ventilation Combined with a Personalized Evaporative Cooler, *International journal of Green Energy 2014*, 11(2): 141-160.
- M. El Hourani, K. Ghali and N. Ghaddar, Effective desiccant dehumidification system with two-stage evaporative cooling for hot and humid climates, Energy and Buildings 2014, 68:329-338.
- R. Farhat, W. Chakroun, K. Ghali and N. Ghaddar, Potential of solar applications in residential buildings in the Gulf countries, *11th international Energy Conversion Engineering Conference 2013*, California, USA.
- S. Makarem, K. Ghali and N. Ghaddar, A combined photovoltaic-thermal (PV/T) panel to minimize the electrical and air conditioning energy consumption of a typical office in Beirut, *11th international Energy Conversion Engineering Conference 2013*, California, USA.

Technical Requirements

- The students are expected to have the following technical skills:
  o Advanced computer skills
  o MATLAB
  o Visual DOE 4.0 or any other Energy Analysis Software

Grading Policy

The grades in this class break down as follows:

Discussion Forum	16 pts
Knowledge checks	25 pts
Assignments	59 pts
Total Points	**100 pts**

Description of Course Requirements (assessments)

Discussion Forum
Discussion forums are the right place to ask questions and discuss the weekly topics. All students are encouraged to participate as this will reflect their interest in the topic at hand and their level of progress.
Every time a student misses a discussion forum, one point will be deduced from the 10 allocated points.

Homework/Assignments
There will be regular assignments throughout the semester. These assignments will be either a direct application on what students have learned from the covered topics or small projects that will challenge the students' imagination and critical thinking. Students are supposed to work individually on these assignments and submit them on time.

Knowledge Checks
You will take quizzes (Knowledge checks) throughout the semester, all delivered via Moodle. These quizzes include multiple-choice questions and problem solving. The quiz content will be largely based on video lectures and readings.

Group Project
There will be one final project that is due at the end of the semester. The aim of the project is to assess the level of acquired knowledge and the ability of the students to apply what they learned during the semester. The grade will be distributed evenly among the organization of the project, the content and the analysis.

Internet Etiquette

Netiquette (short for "network etiquette" or "Internet etiquette") is a set of social conventions that facilitate interaction over networks.

General Rules
1. Make your messages easier to read by making your paragraphs short and to the point.
2. TYPING IN ALL CAPS IS CONSIDERED SHOUTING ON THE INTERNET.
3. Messages in all lowercase letters can be difficult to read, instead, use normal capitalization.
4. *Asterisks* surrounding a word can be used to make a stronger point.
5. Be careful when using sarcasm and humor. Without face-to-face communications your joke may be viewed as criticism. When being humorous, use emoticons to express humor. (Tilt your head to the left to see the emoticon smile) :-) = happy face for humor
6. Never give your user ID or password to another person. System administrators that need to access your account for maintenance or to correct problems will have full privileges to your account.

Make-up Policy

No Make-up exams are given unless a solid excuse is provided.

Tentative Schedule

Day/Week	Topic	Activity	Due Date
Week 1	Building Design Factors from an energetic point of view.	Presentation Discussion 1	 February 15
Week 2, 3 & 4	Guidelines for Building Envelope Design	Presentation Assignment 1-Exercise 1 Assignment 1-Exercise 2 Discussion 2	 February 29 March 7 March 7
Week 5, 6 & 7	Ventilation and Indoor Air Quality	Presentation Video Knowledge Check 1	 March 14
Week 8 & 9	*HVAC* systems (performance and efficiency) - Heating, Cooling (using conventional & renewable energy)	Presentation Knowledge Check 2 Discussion 3 Assignment 2	 March 28 March 28 March 28
Week 10 & 11	Building Energy System Technologies	Presentation Knowledge Check 3 Knowledge Check 4	 April 10 April 10
Week 11 & 12	Hybrid air conditioning systems using solar energy	Presentation Assignment 3 Discussion 4 Assignment 4 Closure Activity	 April 20 April 20 April 26 April 26