King Fahd University of Petroleum & Minerals
MECHANICAL ENGINEERING DEPARTMENT
ME 439: Solar Energy Conversion

Catalogue Description: (3-0-3)
Thermal aspects of solar energy conversion. Solar radiation measurement and prediction. Selected topics in heat transfer. Flat plate and focusing collector analysis. Solar energy storage. Solar systems including hot water, space heating and cooling, distillation and thermal power conversion.

Status in Curriculum (Required or Elective): Elective (offered Fall and/or Spring)

Prerequisites: ME 315

Co-requisites: None

Prerequisites by Topics:
- First and Second Law of Thermodynamics (ME203/204)
- Different modes of heat transfer (ME 315)
- Black and gray bodies' radiation interactions (ME 315)
- Ability to use computer-based solar thermal analysis programs

Textbook: **SOLAR ENGINEERING OF THERMAL PROCESSES**, J.A. Duffie and W.A. Beckman, Wiley & Sons Inc., New York, 4th Edition, 2013.

References:
1) **Principles of Solar Engineering**, D .Y. Goswami, F. Kreith and J.F. Kreider, 2nd Edition,Taylor & Francis, Philadelphia, 2000.
2) **Solar Energy Engineering: processes and systems,** Kalogirou, Soteris, 2d Edition, Academic Press, 2014.

Instructor: **Dr. P. Gandhidasan,** Professor of Mechanical Engineering

Goals: **(general objectives)**
This course is designed to give seniors in Mechanical Engineering an ability to estimate solar radiation and to integrate it into the overall design and thermal analysis of solar collectors and solar-based thermal systems.

Course Outline (Lecture Topics):
1. Solar radiation characteristics: *Nature of solar radiation, geometric considerations, angle of incidence on various surfaces, radiation received over various time spans, etc.* (6 classes)
2. Measurement of solar radiation: *The effects of the atmosphere, radiation measurements, data manipulation*. (3 classes)
3. Estimation of solar radiation: *Estimation of beam and diffuse radiation from total radiation, time distribution of radiation in a day, radiation on surfaces other than horizontal.* (3 classes)
4. Selected topics in heat transfer: *Review of radiation, convection and conduction heat transfer in the solar systems performance.* (3 classes)
5. Radiation characteristics of opaque materials: *Radiation characteristics of surfaces, calculation of broadband properties from spectral properties, selective surfaces, etc.* (3 classes)
6. Radiation transmission through glazing: *Optical properties of cover systems, ($\tau\alpha$) product, absorbed solar radiation, etc.* (3 classes)
7. Design and analysis of flat-plate solar collectors: *Theory of flat-plate collectors, performance measurements, testing of collectors, etc.* (8 classes)
8. Design and analysis of concentrating collectors: *Optical principles and heat transfer analysis of linear concentrating collectors.* (3 classes)
9. Energy storage in solar process systems. *Principles of energy storage methods, sensible and latent heat storage.* (2 classes)
10. System thermal calculations. *Formulation of collector, storage and heat exchangers, system models and their solution.* (2 classes)
11. Solar heating - active and passive systems. *Solar heating of hot-water systems.* (2 classes)
12. Solar space heating and cooling. *Active solar heating and cooling systems.* (2 classes)
13. Solar distillation and thermal power conversion. *Solardistillation, conversion of solar to mechanical and electrical energy by thermal processes.*(2 classes)
14. Tests. (3 classes)

Design Activities/Projects:

Design-oriented simulation problem is assigned.

Computer Usage:

Students are encouraged to solve some assigned homework problems using the available engineering software, such as EES.

Laboratory:

None

Assessment Tools:

i- Three Major Examinations
ii- Homework Assignments
iii- EES Assignments
iv- Final Exam

Course Learning Outcomes:

I- Demonstrate a basic understanding of solar radiation and its measurements.
II- Demonstrate the calculation of needed information from the available solar radiation data.
III- Demonstrate ability to use the interaction of radiation and opaque and transparent materials to perform the analysis of the performance of different types of solar collectors.
IV- Demonstrate ability to develop mathematical models for collectors and storage units.
V- Demonstrate ability to formulate collector circuits with controls and heat exchangers.
VI- Demonstrate ability to use solar energy to meet various energy needs particularly to buildings for heating, hot water, and cooling and for desalination.
VII- Demonstrate ability to give a professional and well-organized presentation of their design and analysis through the use of written and oral reports.

Course Learning Outcomes mapped to Student Outcomes:

Student Outcomes	*a*	*b*	*c*	*d*	*e*	*f*	*g*	*h*	*i*	*j*	*k*
Course-to-Student outcome mapping	I, II, III, IV	II, VI	III, IV, V	VII	IV, V, VI		VII	VI		III, IV, V, VI	VII
Emphasis*	**S**	M	**S**	L	**M**		M	L		M	L

* **L**:: Little/None **M**: Moderate **S**: Strong

Status of Continuous Improvement review of this Course:

Date reviewed: ----------
Prepared by: Dr. P. Gandhidasan

Reviewed by: ----------
Date prepared: December 08, 2014