**United States Naval Academy**
**Mechanical Engineering Department**

**Catalog Description:** EM444 Solar Engineering **Credit:** 3 (3-0-3)
**Designation**: Elective, engineering major

An introduction to solar energy conversion and utilization. Topics covered include solar radiation, collectors, energy storage, solar heating, solar cooling, photovoltaic converters and wind energy.

**Prerequisites:** 1/C Engineering major or approval

**Corequisites:** None

**Textbooks:** John A. Duffie, William A. Beckman
Solar Engineering of Thermal Processes, 4th Edition
John Wiley and Sons, Inc

**Course Director:** Professor Keith W. Lindler

**Course Content:**

| No. | Topic or Subtopic | hrs. |
|---|---|---|
| 1 | The Sun / Extraterrestrial Radiation | 3 |
| 2 | Direction of Beam Radiation | 3 |
| 3 | Calculating Beam Radiation on Tilted Surfaces | 3 |
| 4 | Shading | 3 |
| 5 | Measuring Solar Radiation | 3 |
| 6 | Estimation of Average Solar Radiation | 3 |
| 7 | Selected Heat Transfer Topics | 3 |
| 8 | Radiation Characteristics of Opaque Materials | 3 |
| 9 | Radiation Transmission Through Glazing | 3 |
| 10 | Description of Flat Plate Collectors | 3 |
| 11 | Energy Balance / Temperature Distribution for Flat Plate Collectors | 3 |
| 12 | Collector Heat Loss Coefficient / Collector Efficiency | 3 |
| 13 | Testing Collectors | 3 |
| 14 | Concentrating Collectors | 3 |
| 15 | Energy Storage / System Design | 3 |
| 16 | Special Topics | 3 |

**Assessment Methods:**

| | | YES | NO |
|---|---|---|---|
| A | Quizzes | | X |
| B | Homework | X | |
| C | Exams | X | |
| D | Laboratory Reports | | X |
| E | Oral Presentations | | X |
| F | Design Reports/Notebooks | | X |
| G | Prototypes/Demonstrations | | X |

| | | |
|---|---|---|
| H | Projects | X |
| I | Other | X |

**Course Outcomes**[1]

1. Convert between clock time and solar time. (B,C)
2. Calculate the solar azimuth angle and solar zenith angle for any given location, date and time. (B,C)
3. Calculate the angle of incidence for solar radiation striking any surface for any given date and time. (B,C)
4. Use a solar position plot to determine when an obstruction will shade a given solar collector or window. (B,C)
5. Calculate the amount of solar radiation (beam, diffuse and reflected) striking a tilted surface by using radiation measurements for a horizontal surface at the same location. (B,C)
6. Calculate the amount of radiation (beam, diffuse and reflected) absorbed by a solar collector for known design parameters such as number of covers, cover material and absorptance of the paint used on the absorber plate. (B,C)
7. Calculate the collector efficiency and mean plate temperature for given design parameters such as tube spacing, plate material, plate thickness, and emissivity of the paint used on the absorber plate. (B,C)

[1] Letters in parenthesis refer to the assessment methods listed in the previous section.

| | **Course Outcomes** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Program Outcomes** | (1) | (2) | (3) | (4) | (5) | (6) | (7) | | | |
| (a) | X | X | X | X | X | X | X | | | |
| (b) | | | | | | | | | | |
| (c) | | | | | | | X | | | |
| (d) | | | | | | | | | | |
| (e) | X | X | X | X | X | X | X | | | |
| (f) | | | | | | | | | | |
| (g) | | | | | | | | | | |
| (h) | | | | | | | | | | |
| (i) | | | | | | | | | | |
| (j) | | | | | | | | | | |
| (k) | | | | | | X | X | | | |

**Date of Latest Revision:** 4 December 2017, Professor Keith W. Lindler