ME810 Advanced Optical Simulation and Optimization Methods 3-0-1 4

Year of introduction: 2022

Course Objective:
The course is intended to teach students advanced topics in optical simulation and optimization, especially focusing on applications in concentrating solar thermal energy systems. The course will be taught using Matlab and Zemax OpticStudio ray tracing software.

Course Outcomes:
CO1 : Understand how to integrate Matlab with Zemax OpticStudio software, primarily using the Interactive Extension mode of OpticStudio, allowing Matlab to remotely call the various functions of OpticStudio and integrate analysis results into Matlab.

CO2 : Utilize the OpticStudio Path Analysis feature in Matlab for detailed study and understanding of how the various optics paths are contributing to the final results.

CO3: Implement OpticsStudio and Matlab in High Performance Computing (HPC) environments for significantly increased simulations speeds, which are necessary when incorporating time series analysis and optimizations of large, complex systems.

CO4 : Ability to perform independent research on solar energy systems and present in written and oral formats.

Modules:
Introduction: Zemax OpticStudio functions and capabilities; Non-sequential Lens Editor; Non-standard surfaces; Applications for concentrating solar thermal energy

Matlab Integration: Third party software support in Zemax; Types of connections and work flow; Interactive Extension mode; Programming Syntax; Solar Position Algorithms; Time-series data

Path Analysis: Ray database; Results analysis; Saving results and file types; Calling within Zemax; Calling from Matlab

Optimization: Boundary conditions; Iteration steps; Blocking and Shading; Geometry optimization; High temperature; Heliostat Field constraints; Other losses and errors

Benchmarking and Validation: Comparison with other types of systems and heliostats; Energy and efficiency metrics; Validation considerations

Marks:
Submit a paper to a Scopus indexed journal for an optimized concentrating solar thermal energy system

Textbook:

1. W.B. Stine, R.W. Harrigan, “Solar Energy Systems Design", John Wiley and Sons, Inc., 1986
2. "Power from the Sun", https://www.powerfromthesun.net, William Stine and Michael Geyer, 2021 (Online, open, updated version of Solar Energy Systems Design)
3. Optical System Design, 2nd ed., Robert Fisher, MacGraw-Hill, 2008

References:

1. Perlin, John, “Let It Shine: The 6,000 Year Story of Solar Energy”, New World Library, 2013
2. John J. Craig, “Introduction to Robotics: Mechanics and Control”, Pearson Education, 2008
3. Introduction to Lens Design: With Practical Zemax Examples, Willmann-Bell, 2002
4. www.zemax.com

Prerequisites:

1. Linear algebra / vector algebra, College level calculus, College level Physics, Matlab programming or similar would be very helpful, Excel or similar
2. ME809 - Optical Simulation Methods for Concentrating Solar Energy Applications

Pedagogy: Lecture material with lab type exercises to apply concepts in real-life scenarios through the use of programming, ray-tracing, and analysis. Writing paper and software and analysis to support designing and optimizing an innovative and novel concentrating solar thermal system.

Evaluation Pattern:
100% Scopus-Indexed Paper Submission

Activities/Content with direct bearing on Employability/ Entrepreneurship/ Skill development:
Learning to define, model, simulate and analyze systems, especially using ray tracing applied to solar energy systems. Learning and gaining aptitude with world-class Matlab and Zemax OpticsStudio software systems and integration.