האוניברסיטה העברית בירושלים
THE HEBREW UNIVERSITY OF JERUSALEM

The Hebrew University of Jerusalem

Syllabus

ELECTROMAGNETIC WAVES AND ANTENNAS - 83888

Last update 09-03-2023

HU Credits: *4*

Degree/Cycle: *1st degree (Bachelor)*

Responsible Department: *Applied Physics*

Academic year: *0*

Semester: *2nd Semester*

Teaching Languages: *Hebrew*

Campus: *E. Safra*

Course/Module Coordinator: *Dr Adi Pick*

Coordinator Email: *adi.pick@mail.huji.ac.il*

Coordinator Office Hours: *Sunday 14:00-15:00*

Teaching Staff:

Dr. Adi Pick

<u>Course/Module description:</u>

Nowadays, most people rely heavily on devices that transmit and receive electromagnetic radiation via antennas, including cellular phones, radio, internet routers, and GPS. This course will introduce the mathematical and physical framework that explains the working principle of microwave antennas. The course is divided into four sections. The first section deals with mathematical and physical analysis of transmission and reception. Starting from Maxwell’s equations, we will learn how electric currents generate radiation fields. The second part of the course surveys fundamental parameters and figures-of-merit of antennas. The third part introduces the most important antenna types, including the dipole, loop, patch, and microstrip antennas, and antenna arrays. In the final part of the course, we will talk about numerical simulations, design and measurements of antennas.

<u>Course/Module aims:</u>

The students of this course will acquire a theoretical understanding and analytic and numerical tools for analyzing problems pertaining to wireless communication. The course goal is to teach students how to relate the abstract electromagnetic wave equations and practical questions that arise when designing and characterizing antennas.

<u>Learning outcomes - On successful completion of this module, students should be able to:</u>

After taking this class, the students will be able to:
1. Explain the working principle of antennas in their environment.
2. Present quantitative models that describe radiation patterns of known and new antennas.
3. Use computer software to solve mathematical models.
4. Define parameters to evaluate antenna performance.
5. Design antennas with desired properties.

<u>Attendance requirements(%):</u>

0

Teaching arrangement and method of instruction: Frontal lecture and exercise. 5 assignments will be submitted and graded.

<u>Course/Module Content:</u>

1. Formal description of electromagnetic radiation: Maxwell's equations, wave equations, electromagnetic potentials, Green's function, radiation from a wire element, Poynting's theorem, radiation resistance, near- and far-field approximation, plane waves, polarization, resonant modes, Q factor

2. Fundamental parameters and figures of merit: Radiation pattern, power density and intensity, beamwidth, directivity, antenna efficiency, gain, bandwidth, polarization factor, input impedance, effective length and equivalent area, Friss equation, antenna temperature.

3. Antenna types:
3.1. Dipole antenna: infinitesimal, short, and finite-length dipole, radiation regions, linear elements near perfect-electric and magnetic conductors, loop antenna
3.2 Antenna arrays: One-, two- and three-dimensional arrays, Chebyshev and binomial arrays, circular arrays
3.3. Aperture antennas
3.4. Horn and patch antennas

4. Selected chapters
4.1. Numerical simulations
4.2. Optical antennas
4.3. Noise and information
4.4. Nano-antennas

Required Reading:

1. Sophocles J. Orfanidis, "Electromagnetic Waves and Antennas", ECE Department Rutgers University, 94 Brett Road Piscataway, NJ 08854-8058.

2. Constantine A. Balanis, "Antenna Theory Analysis and Design," Fourth edition, John Wiley & Sons, Inc., Hoboken, New Jersey (2016)

Additional Reading Material:

1. David R. Jackson, "Plane Wave Propagation and Reflection", Department of Electrical and Computer Engineering, University of Houston, Houston, TX77204-479. http://www0.egr.uh.edu/courses/ece/ece6340/SectionJackson/Handouts/plane%20waves%20chapter.pdf

2. J.D. Kraus, "Antennas, McGraw-Hill", 1988.

3. R. E. Collin, "Field Theory of Guided Waves", 2nd Ed., IEEE Press, 1991.

Course/Module evaluation:

End of year written/oral examination 90 %
Presentation 0 %
Participation in Tutorials 0 %
Project work 0 %
Assignments 10 %
Reports 0 %
Research project 0 %
Quizzes 0 %
Other 0 %

Additional information:

Prerequisites: Introductory math class (including differential and integral calculus) and electromagnetism class.