ESE 319 (Electromagnetic Waves & Transmission Lines)
Fall 2024

Stony Brook University

# Syllabus

## 1. Instructor

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Light Eng. 225

## 2. Course Description

Properties of generic uniform plane waves including phase and group velocities and arbitrary direction of propagation. Uniform plane electromagnetic waves (UPEMWs) consisting of an electric field wave and a magnetic field wave, both moving synchronously in space and time; mutual right-handed orthogonality between the electric and magnetic field vectors and the direction of propagation; Poynting vector. Transmission lines (TLs): voltage and current behaving as waves on TLs, voltage reflection coefficient, impedance transformation law, VSWR, Smith Chart, impedance matching. Maxwell equations, EM wave equation, boundary conditions. Scattering of UPEMWs incident normally or obliquely at the interface plane between two dielectric media. Waveguides: TE and TM modes of a rectangular waveguide, cut-off frequencies, dominant mode, power flow

**Pre-requisites:** ESE 271;AMS 261 or MAT 203 or MAT 307; AMS 361 or MAT 303 or MAT 308

**Credits:** 3

## 3. Recommended Textbook

"Fundamentals of Applied Electromagnetics (7th Edition)", F. Ulaby and U. Ravaioli, Pearson 2015. This book is recommended but not required. Extensive class notes including sample problems with solutions will be provided by the instructor.

## 4. Course Learning Objectives

Upon completion of the course, students will have learnt

- about the extensive applications of microwaves that exist in all walks of life which make microwaves the mother of all technologies;
- properties of uniform plane electromagnetic waves (UPEMWs) in bounded and unbounded media;
- transmission lines including Smith Chart, impedance matching, theoretical and Smith Chart solution of transmission line circuit problems;
- Maxwell Equations and their use in solving diverse EM wave propagation problems, including scattering of UPEMWs incident normally as well as obliquely at one or more planar boundaries, perpendicular and parallel polarization configurations, Brewster angle and critical angle phenomena;
- Waveguides, TE and TM modes, cut-off frequencies, resonators.

## 5. Student Learning Outcomes

| | Student Outcomes | % contribution |
|---|---|---|
| **1** | an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics. | 100% |
| **3** | an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors. | |
| **3** | an ability to communicate effectively with a range of audiences. | |
| **4** | an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgements, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts. | |
| **5** | an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives. | |
| **6** | an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgement to draw conclusions. | |
| **7** | an ability to acquire and apply new knowledge as needed, using appropriate learning strategies. | |

## 6. Course Schedule

| MODULE | MODULE TOPICS | DATES |
|---|---|---|
| 1. Important Applications of Microwaves | Introduction to EM waves (also commonly called microwaves). Microwaves play a dominant and overreaching role in our everyday life, and may be called the mother of all technologies. Without microwaves, human life and civilization would be set back by about a century or more. Microwave applications include AM & FM radio, satellite communications, microwave ovens, RF Identification, radars, wify, Bluetooth, hotspot, IoT, etc. | Week 1 |
| 2. Generic uniform plane waves | Different types of waves including a water wave on a pond with a circular wavefront, audible sound wave propagating in air, waves on a string, acoustic waves in a solid (shear and longitudinal waves, surface acoustic waves), electromagnetic (EM) waves, and earthquake tremor waves. All these wavetypes share common properties.<br>Theory and properties of uniform plane waves (UPWs), amplitude, frequency, wavelength, wavenumber theory and physical meaning of phase and group velocities, Dispersive and non-dispersive waves, standing waves | Weeks 2 to 3 |
| 3. Uniform plane electromagnetic waves (UPEMWs) | Properties of UPEMWs including Poynting vector and propagation in an arbitrary direction, right-handed mutual orthogonality between the directions of the electric field, magnetic field, and direction of propagation, phasors, | Weeks 4 to 5 |

| | | |
|---|---|---|
| | wave equation | |
| 4. Transmission lines | TL as a distributed circuit, TL equations derived by representing an infinitesimal length of a TL in terms of lumped-parameter circuit elements, voltage reflection coefficient Γ, complex Γ plane, Smith Chart, VSWR, impedance transformation, Smith Chart applications, impedance matching using a quarter-wave transformer and a single stub tuner | Weeks 6 to 8 |
| 5. Maxwell Equations | Maxwell Equations, wave equation, proof of right-handed orthogonality of the unit vectors $\mathbf{i}_E$, $\mathbf{i}_H$ and $\mathbf{i}_k$, UPEMW propagation in a conductive medium, skin effect | Weeks 9 to 10 |
| 6. UPEMW scattering at the interface plane between two dielectric media | Boundary conditions, scattering of UPEMWs incident normally as well as obliquely at the interface plane between two dielectric media, perpendicular and parallel polarization configurations, Brewster angle, electric field and power reflection and transmission coefficients, equivalent transmission line circuit for finding reflection and transmission coefficients | Week 11 to 12 |
| 7. Waveguides | EM wave propagation in a rectangular waveguide, TE and TM modes, cut-off frequency, dominant mode, power flow, microwave cavities | Weeks 13 to 14 |

## 7. Homework Assignments

Homework Assignments will be issued usually once every week. All homework solutions must be submitted on Brightspace by the midnight of the assigned day. No late submission of homework is accepted except under extenuating circumstances.

## 8. No makeup Exams or Homeworks:

There will be no "make-up" exams or homeworks except under absolutely extenuating or exceptional circumstances.

## 9. Late submission of homework:

The grade for each homework will be out of 10 points. Late submission will be accepted but there will be a late submission penalty in that the grade will now be out of 7 points instead of out of 10 points. Late submission beyond the time the solution to the homework is released is absolutely unacceptable.

## 10. Questions on grading:

Any grading issues must be brought to the attention of the instructor and resolved within ten days of the return of the homeworks or exams to the students. Late queries will not be entertained.

## 11. Academic Honesty:

Cheating of any kind is considered a serious offence, and will be treated according to the university rules of academic dishonesty, which provide for failure, suspension, and/or dismissal of the students involved. Regarding homework assignments and test preparation, you may freely interact with other students. But when you do the actual homework assignment or exam, you are to work alone and your work is to be yours alone.

## 12. Teaching Modality:

The present course is taught primarily in the classroom. Instructor-prepared written material in the form of lessons, homework and sample problems with solutions will be distributed to students every week. Video recording of the lectures will also be distributed to the students. The student will study the distributed material and do assigned homework (typically one per week) which must be submitted to the instructor online in pdf format through the Brightspace. To assist the students in learning the material, the instructor will hold office hours twice a week when any issue relative to the course will be discussed, including answering any questions the students may have on the course material and homeworks.

## 13. Office Hours:

Mo. & We., 11:00 AM to 1:00 PM
Also by appointment

## 14. Attendance:

Students are required to attend all in-class lectures. Unannounced attendance will be taken, and, although attendance will not be considered directly in grading, students with grades in borderline regions will be adversely affected if their attendance record is not satisfactory. Regular attendance to the in-class lectures helps the student in being aware of what goes on in the class and affords the student the chance to participate in question and answer sessions.

## 15. Grading:

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|---|---|
| 1. 2 Term Exams @25% | 50% |
| 2. Homework | 20% |
| 3. Final Exam | 30% |

## 16. Exam Schedule:

Term Exam 1: Tu., Oct. 8, 12:30 pm to 1:45 pm
Term Exam 2: Tu., Nov. 19, 12:30 pm to 1:45 pm
Final Exam: Tu., Dec,17, 11:15 am to 1:45 pm

## 17. Syllabus subject to change:

This syllabus is subject to change in terms of course content or any other way as dictated by progress in the class.