Department of Physics

College of Education

University of Salahaddin-Erbil

Subject: Adv. Electromagnetic Theory

Course Book – (Ph. D.) Students

Lecturer's name: Dr. Sattar Othman Hasan

Academic Year: 2023-2024

Course Book

1. Course name	**Adv. Electromagnetic Theory**
2. Lecturer in charge	**Dr. Sattar Othman Hasan**
3. Department/ College	Physics / Education
4. Contact	e-mail: sattar.hasan@su.edu.krd e-mail: star_os2004@yahoo.com Tel: (**0750 4514637**)
5. Time (in hours) per week	**3 HOURS**
6. Office hours	**Sunday:** **From** **8**:30 AM To 11:30 PM **Monday:** **From** 12:30 AM To 2:30 AM **Thursday:** **From** 11:30 AM To 2:30 PM

7. Teacher's academic profile: I am a Staff member of physical Department of Education College at Salahaddin University-Erbil.

I earned a **BSc** degree in Physics at **1990-1991** with first class honour from Physical department of Education college, university of Salahaddin. **MSc** degree in theoretical nuclear physics at **1998-1999** under the title of "The Background Function Effects on the Analysis of Gamma-Ray Spectrum" with honour degree., and a **Ph.D.** in communication "Electromagnetic Theory" at **2006-2007** with the title of "Analysis and Design of Compact Microstrip Antenna Using Cavity Model" from Physical department of Science college, university of Salahaddin.

From **2000-2002**, I was a head of register unit within the college of education. During **2002-2003** I was a deputy of deans of Education College, University of Salahaddin. I was a representative of teaching staff at College of Education for about eight years.

I was a dean of Hawler Tourism Technical Institute during the years of **2008-2010** and also, I was a dean of Hawler Technology Institute during the years of **2010-2014**. I am an assistant professor of theoretical Electromagnetic Theory "Field of Communication", and I have **several** research publications in different field of physics. My research interests span a number of topical themes in electromagnetic wave propagation, theoretical physics and mobile communication. Finally, I supervised **four** **MSc**. students and **two** **Ph.D.** in the field of antenna design and mobile communication.

8. Course objective: The objective of this course is to introduce the fundamental principles of propagation of electromagnetic wave in different mediums using **Maxwell's** equations and studying the transmission lines, waveguide, optical fibre and radar radio wave propagation regarding ground, sky and space waves.

Students will learn the principle of voltage and current wave propagating along transmission lines and how they relate to the propagation of electric and magnetic field in space and along waveguide or optical fibres. Different types of waveguides and cavity resonators will be described and propagation of radio waves through the space will be studied in detail. Formation of the atmospheric layers around the earth is also learned and their benefits for radio wave propagation will be understood.

9. Forms of teaching: Different forms of teaching will be used to come across with objectives of the course. Power point presentations for the head titles, definitions, graphs and many useful illustrations with summary at the end of each chapter will be presented and discussed.

In addition, the lecture will cover enough information about the description of the subjects, solution of many examples, analysis and derivation for all necessary equations and proving theorems and many problems are presented as a home work for improving student abilities.

10. Assessment scheme: Attaining the **requirements** set to succeed in this study subject requires developing a **mathematical** sense, related to this topic, based on emergent analytical and problem-solving skills and memorizing topics cannot secure success.

In this system the **maximum** mark is **(100%)**. The grading system is based on the summation of three categories of **evaluations**:

- **First**, **(25%)** for **the** semester examination.
- **Second**, **(25%)** of the **mark** is based on the preparation of an **article review** about propagation of electromagnetic wave in specific medium or about communication in general.
- **Third**, **(50%)** of the **mark** is based on **final** examination that is comprehensive for the whole of the study material **reviewed** during the academic **semester** and it usually occurs after completing the course semester.

11. Student learning outcome: The learning objects and the main goals of studying antenna theory are summarized in the following important points:

- Studying the operation of **del** operators in different form $[\vec{\nabla}\,\text{grad}]$, $[\vec{\nabla}\cdot\,\text{divergence}]$, $[\vec{\nabla}\times$ Curl$]$ and $[\nabla^2\text{Laplace}]$in cartesian, cylindrical and spherical coordinates and their **benefits** in **reducing** electromagnetic problem calculations.
- Apply vector calculus to understand the behaviour of electrostatic and steady magnetic fields in standard configurations
- Using Gauss's, Ampere's and Faraday's Laws in the context of electric and magnetic devices
- Describing the boundary conditions for electric and magnetic fields at dielectric or magnetic interfaces.
- Listing Maxwell's equations and solving them for specific regular geometries and in different mediums with interpretation of the effects of lossy and low loss dielectrics medium upon the propagation of electromagnetic waves.
- Discussing the normal and oblique incidence of electromagnetic wave at the interface of two different mediums.
- Electromagnetic wave propagation inside waveguides and transmission lines will be understood and their difference will be specified completely.
- The fundamental principle of optical Fiber with their types and application in different branch of communication systems will be discussed clearly.

12. Course Reading List and References

1- Engineering Electromagnetic, Sixth Edition, by **William** H. **Hayt**, **2006**.
2- **Schoum's** online of Theory and Problems of Electromagnetics, by Joseph A. Administers **1979**.
3- Elements of Electromagnetics, by Matthew N. O. **Sadiku**, **2011**.
4- Fundamentals of Applied Electromagnetics, by Fawwaz T. **Ulaby**, **2004**.
5- Fundamentals of Electromagnetics with Engineering Application, by Stuart M. Wentworth, **2005**.
6- Marshal S. V. and Skitek G.G., [Electromagnetic Concept and Application], Second Edition, London, 1987.

13. The Topics:	Syllabus
CHAPTER ONE **Review of Electrostatic and Magnetostatic Fields with Vector Calculus** **(2 Weeks)**	**1-1:** Introduction **1-2:** Divergence of a Vector and Divergence theorem **1-3:** Curl of a Vector and Stokes's Theorem **1-4:** Laplacian of a Scalar and Vector Functions **1-5:** Classification of Vector Field **1-6:** Electric and Magnetic Forces **1-7:** Coulomb's Law and Charge Configurations **1-8:** Biot-Savart's Law and Current Configurations **1-9:** Electric and Magnetic Flux Densities with Gauss's Law **1-10:** Ampere's Law **1-11:** Electric and Magnetic Potential Fields **1-12:** Final Form of Maxwell's Equations in Static Fields **1-13:** Energy density in static electric &magnetic field **1-14:** Polarization and Electric and Dipole Moment **1-15:** Magnetization and Magnetic Dipole Moment **1-16:** Current Continuity Equations and Relaxation Time
CHAPTER TWO **Maxwell's Equations in Time-Varying Fields and Boundary Conditions** **(2 Weeks)**	**2-1:** Boundary Conditions in Electrostatic Field **2-2:** Boundary Conditions in Magnetostatic Field **2-3:** Faraday's Law **2-4:** Displacement Current **2-5:** Time Varying Potentials **2-6:** Final Forms of Maxwell's Equations in Time-Varying Fields **2-7:** Derivation of EMW-Equation of Motion **2-8:** Time- Varying Harmonic Fields
CHAPTER THREE **Electromagnetic Wave Propagation in Different Mediums** **(3 Weeks)**	**3-1:** General Plane EMW Equation of Motion **3-2:** Concept of Uniform Plane Wave (UPW) and its properties **3-3:** Propagation of (UPW) in Lossless Media or free space: **3-4:** Propagation of (UPW) in Perfect Dielectric Media **3-5:** Propagation of (UPW) in Good Conductor Media **3-6:** Power Flow of EMW and the Poynting Vector **3-7:** Polarization of UPW
CHAPTER FOUR **Reflection and Transmission of Electromagnetic UPW at the Interface of two Different Mediums** **(3 Weeks)**	**4-1:** Normal Incident of UPW on Plane Boundaries **4-2:** Power Flow of UPW on Plane Boundaries **4-3:** Communication with Submarine **4-4:** Snell's Law **4-5:** Wave Reflection and Transmission at Oblique Incidence **4-5-1:** Perpendicular Polarization **4-5-2:** Parallel Polarization **4-6:** Brewster Angle **4-7:** Reflectivity and Transmissivity **4-8:** Design of Radar Radomes **4-9:** Shielding of Electronic Equipment

CHAPTER FIVE **Transmission Line** **(2 Weeks)**	**5-1:** Introduction **5-2:** Common Type of Transmission Line **5-3:** Transmission Line Definition **5-4:** Distributed Parameter Representation of TL **5-5:** Lossless Transmission Line **5-6:** Distortion-less Transmission Line **5-7:** Transmission Line Circuit **2-7-1:** Open Circuited Lossless Line **2-7-2:** Short Circuited Lossless Line **5-8:** Reflection Coefficient and VSWR
CHAPTER SIX **Waveguide and Cavity Resonator** **(2 Weeks)**	**6-1:** Introduction - Metal waveguide - Dielectric waveguide **6-2:** Ideal Metal Waveguide **6-3:** TE and TM- Modes in Waveguide **6-4:** Rectangular Waveguide - Rectangular Waveguide TE-mode - Rectangular Waveguide TM-mode **6-5:** Waveguide Group Velocity and Phase Velocity **6-6:** Attenuation in Wave Guide **6-7:** Cavity Resonators **6-8:** Circular Waveguide **6-9:** Optical Fiber

14. Examinations: Different types of questions will be provided to the student as an exercise and also in examinations such as given them in the question banks which contain each of the following ones:

1. Mathematical **derivation** and **explanation** questions for different subjects in transmission line, waveguide and radio wave propagation are provided.
2. **Description** questions for every subject that are given in radio wave propagation topics are also provided to them.

15. Extra notes: Due to a number of unforeseen reasons that may lead to the shifting of the academic season program, it may be subjected to modifications. Also, extra curriculum hours may be needed to cover all the topics mentioned above. The students shall be notified of the changes if and when they may occur.