

Identification	Subject	ETR 408 Electrodynamics and propagation of radio waves 6 ECTS credits
	Department	Physics and Electronics
	Program (Undergraduate, Graduate)	Bachelor
	Term	2026 fall
	Instructor	Shahmardan Sh. Amirov, Doctor of Physical sciences, assoc. prof.
	Email:	phys_med@mail.ru
	Classroom/hours	Thursday, 17:00-20:10
Consultations		IV gün 17:00-20:10
Prerequisites		
Language		English
Compulsory/Elective		Compulsory
Textbooks and course materials	Textbooks: 1. Frenzel, L. E., Jr. Principles of Electronic Communication Systems. 4th ed., McGraw-Hill Education, New York, 2016, 930 pp. 2. Balanis, C. A. Antenna Theory: Analysis and Design. 3rd ed., John Wiley & Sons/Wiley-Intercedence, Hoboken, NJ, 2005, 1117 pp. 3. Kraus, J. D., Marhefka, R. J., & Khan, A. S. Antennas and Wave Propagation. 4th ed., McGraw-Hill Education, New Delhi, 2010, 906 pp. 4. Jordan, E. C., & Balmain, K. G. Electromagnetic Waves and Radiating Systems. 2nd ed., Prentice-Hall, Englewood Cliffs, NJ, 1968, 753 pp. 5. Deepa, T. 15EC304 – Antenna and Wave Propagation. Department of Telecommunication Engineering, SRM Institute of Science and Technology, 2018. 6. Classical Electrodynamics. Chapter 7: “Propagation of Electromagnetic Waves,” 2015. Online Resources 7. Electronics Notes. “Skywaves, Skip Distance and Skip Zone.” Electronics Notes – Skywaves, Skip Distance and Skip Zone 8. BYJU’S. “Sky Wave Propagation.” BYJU’S – Sky Wave Propagation 9. U.S. Navy. Navy Electricity and Electronics Training Series (NEETS), Module 10. NEETS – Module 10 10. Wikipedia. “Maximum Usable Frequency.” Maximum Usable Frequency – Wikipedia 11. NASA Space Place. “Solar Activity.” NASA Space Place – Solar Activity 12. Stanford Solar Center. “The Ionosphere.” Stanford Solar Center – The Ionosphere	

Course description	The course of “Electrodynamics and propagation of radio waves” taught by the students of electronic engineering discipline provides following knowledge’s: antenna fundamentals, magnetic field around current carrying conductor and electric fields around electric charges at rest magnetic and electric fields around a transmission line and in a coaxial cable, antenna operation, conversion transmission line into antenna, magnetic and electric fields around a transmission line when an antenna is formed, impedance of space, wave impedance, antenna radiation resistance, radio frequency identification, polarization (horizontally, vertically, circular, right-hand circular and left hand circular) Maxwell’s equations, antenna reciprocity, common antenna types, the Marconi antenna, parasitic arrays., types of radio wave propagation (ground, sky and space), Reflection, refraction, index of refraction, Snell’s law, diffraction, shadow zone, Huygens’ principle, ground or surface waves, sky waves (reflection from ionosphere), skip zone, space waves, distance between transmitting antenna and horizon, LOS(line of sight), a repeater station, communication satellite, transponder, received power calculation, path attenuation, shadow fading, Rayleigh fading, diversity system.
Course objectives	Course objectives for the Students: • Develop a high level of understanding of the fundamental principles of DC and AC current Systems. Develop basic laboratory skills demonstrating the application of physical principles . • Work cooperatively to facilitate a collegial atmosphere conducive to learning for all students in the class. • Prepare for and attend each class by reading the assigned sections before class, completing homework, and participating in class discussions and team activities. Course objectives for the Instructor: • To provide all students the tools necessary to succeed in their pursuit of a high level of understanding of the principles of Electrodynamics and propagation of radio waves. • To provide all students with an atmosphere conducive to learning the principles of physics. • To provide sufficient feedback to students, enabling them to gauge their progress towards achieving their goal in learning the principles of physics. To facilitate student learning through the use of appropriate activities, appropriate technology, and the illustration of physics applications in the real world.
Learning Outcomes	Students will know and will be able to explain the concepts of antenna fundamentals, magnetic field around current carrying conductor and electric fields around electric charges at rest magnetic and electric fields around a transmission line and in a coaxial cable, antenna operation, conversion transmission line into antenna, magnetic and electric fields around a transmission line when an antenna is formed, impedance of space, wave impedance, antenna radiation resistance, radio frequency identification,

	polarization (horizontally, vertically, circular, right-hand circular and left hand circular) Maxwell's equations, antenna reciprocity, common antenna types, the Marconi antenna, parasitic arrays., types of radio waves (ground, sky and space waves) , skip distance, maximum useable frequency , minimum useable frequency, Fresnel equations, boundary conditions.		
Teaching methods	Case analysis		x
	Group discussion		x
	Lecture		x
	Simulation		x
Evaluation Criteria	Methods	Date/deadlines	Percentage (%)
	Midterm Exam	TBA	30
	Quizzes	Four times during semester	10
	Practical Assignments	At the end of term	10
	Activity	During the term	5
	Attendance	At each lesson	5
	Final Exam	TBA	40
	Total		100
Class Policy	Preparation for class The pedagogical structure of this course necessitates diligent individual study and external preparation. Course sessions are designed to emphasize the primary theoretical frameworks introduced in the text. Pre-class engagement with assigned chapters is essential to facilitate a comprehensive understanding of the material. Subsequent to each session, students should synthesize their notes and resolve pertinent problems, case studies, and sample examination questions located at the conclusion of each chapter. Withdrawal (pass/fail) This course strictly adheres to the grading ordinances of the School of Science and Engineering. Consequently, students are required to achieve a minimum threshold of 60% to secure a passing grade. In the event of an unsatisfactory result, the student will be mandated to repeat the course in the following academic term or year. Cheating/plagiarism Any instance of academic dishonesty or plagiarism during Quizzes, Midterms, or Final Examinations will result in the immediate nullification of the assessment. In such cases, the student will automatically be assigned a score of zero (0) without further consideration. Generative AI Policy The use of Generative Artificial Intelligence (GAI) tools is partially permitted in this course. Students may use GAI tools for learning purposes, such as obtaining explanations of course concepts, organizing information, generating practice questions, and supporting their understanding of the course material. GAI tools may not be used to complete or generate answers for quizzes, midterm examinations, final examinations, or other assessed work unless explicitly authorized by the instructor. Students are responsible for the accuracy of any information obtained through GAI tools and must ensure that their submitted work reflects their own understanding, analysis, and intellectual contribution.		

	Any use of GAI in accordance with the permitted purposes should be appropriately acknowledged by the student. Professional behavior guidelines Students are expected to conduct themselves in a manner that fosters a constructive academic and professional environment during instructional hours. Unauthorized discourse and unethical behavior are strictly prohibited. Attendance Students who maintain full attendance for the duration of the course will be awarded 5 marks. Conversely, for every three absences recorded, the student will incur a deduction of 1 mark. Quizzes Four quizzes will be administered throughout the semester, with formal announcements made in class two weeks prior to the assessment date. The content of each quiz is based on assigned homework problems, which are curated from the questions and problems at the end of each chapter. Activity Students who demonstrate active engagement during the review of previous lessons and proficiently solve problems during seminar sessions will be awarded one activity mark.
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Tentative Schedule

Week	Date/Day (tentative)	Topics	Textbook/Assignments
1	16.09.2026-	Lecture №1. Introduction. Some basic sources of radiation. Single wire. Two wires. Dipole. Current distribution on a thin wire. Problem solving	[1] p. 12-18 [3] p. 9-20
2	23.09.2026	Lecture №2. Fundamental parameters of antennas. Radiation patterns. Field regions. Radian and steradian. Radiation intensity. Directivity. Problem solving	[1] p. 20-27 [3] p. 74-78
3	30.09.2026	Lecture №3 Antenna efficiency. Gain. Beam efficiency. Bandwidth. Linear and elliptical polarizations.. Problem solving	[1] p. 29-36 [3] p. 61-74
4	7.10.2026	Lecture №4 Modes of propagation. Types of radio waves. Ground wave propagation. Range of transmission. Sky wave of ionospheric propagation. Problem solving	[1] p. 20-27 [3] p. 40-45
5	14.10.2026	Lecture №5 Modes of propagation. Concept of free space. Space wave propagation. Free space wave equation. Limitations of space waves. Effect of curvature of Earth. Effect of imperfection of Earth. Range of space wave. Problem solving	[1] p. 32-39 [3] p. 27-48

6	21.10.2026	Lecture №6 Structure of ionosphere. Ionospheric regions. The ionospheric layers. Ionospheric storms. D layer absorption. Faraday rotation. Problem solving	[1] p. 41-52
7	28.10.2026	Lecture №7 Maximum directivity and maximum effective area. Friis transmission equation. Radar range equation. Problem solving	[1] p. 54-66 [3] p.92-98
	TBC	Midterm exam	
8	04.11.2026	Lecture №8 Maxwell's equations. Displacement current. Ampere's generalized law. The divergence and curl of magnetic field induction. Straight line currents. The divergence and curl of B. Applications of ampere's law. Comparison of magnetostatics and electrostatics. Problem solving	[1] p. 70-74 [3] p.99-106
9	11.11.2026	Lecture №9 Basics of propagation: Definition and General Different Modes of propagation of radio waves Problem solving	[1] p. 76-82 [3] p.110-116
10	18.11.2026	Lecture №10 Reflection, refraction and attenuation of radio waves. Fading and attenuation. Selective fading. Skip distance. Problem solving	[1] p. 76-82 [3] p.135-138
11	25.11.2026	Lecture №11. Magnetic charge. Maxwell's equations in matter. Boundary conditions. Fresnel equations. Effect of Solar activity and Sun spots. Problem solving	[1] p. 86-93 [3] p.140-148
12	02.12.2026	Lecture №12. Electromagnetic waves in one dimension. The wave equation. Plane waves. The wave impedance. Sinusoidal waves. Boundary conditions: reflection and transmission. Polarization. Problem solving	[1] p. 99-112 [3] p.150-159
13	09.12.2026	Lecture №13. Electromagnetic waves in vacuum. The wave equation for the electric and magnetic fields. Monochromatic plane waves. Energy and momentum in electromagnetic waves. Relation between MUF & Skip distance for flat Earth Problem solving	[1] p. 129-136 [3] p.162-168
14	16.12.2026	Lecture №14. Electromagnetic waves in matter. Propagation in linear media. Reflection and transmission at normal incidence. Reflection and transmission at oblique incidence. Problem solving	[1] p. 141-155 [3] p.538-550
15	23.12.2026	Lecture №5. Ionospheric abnormalities, Impact of solar activity Multi-Hop propagation Relationship between MUF & skip distance for curved Earth	[1] p. 164-178 [3] p.180-187
		Final exam	