**Nazwa przedmiotu:**

Physics 2

**Koordynator przedmiotu:**

Bartłomiej Salski

**Status przedmiotu:**

Obowiązkowy

**Poziom kształcenia:**

Studia I stopnia

**Program:**

Computer Science

**Grupa przedmiotów:**

Technical Courses

**Kod przedmiotu:**

EPHY2

**Semestr nominalny:**

2 / rok ak. 2015/2016

**Liczba punktów ECTS:**

6

**Liczba godzin pracy studenta związanych z osiągnięciem efektów uczenia się:**

15 x 2h = 30h --- lectures
15 x 1h = 15h --- reviews before lectures
15 x 1h = 15h --- tutorials
15 x 3h = 45h --- preparation for tutorials (problem solving)
 5 x 3h = 15h --- laboratory exercises
 5 x 3h = 15h --- laboratory preparation

total: 135 h

**Liczba punktów ECTS na zajęciach wymagających bezpośredniego udziału nauczycieli akademickich:**

2.5

**Język prowadzenia zajęć:**

angielski

**Liczba punktów ECTS, którą student uzyskuje w ramach zajęć o charakterze praktycznym:**

4

**Formy zajęć i ich wymiar w semestrze:**

|  |  |
| --- | --- |
| Wykład:  | 30h |
| Ćwiczenia:  | 30h |
| Laboratorium:  | 0h |
| Projekt:  | 0h |
| Lekcje komputerowe:  | 0h |

**Wymagania wstępne:**

**Limit liczby studentów:**

60

**Cel przedmiotu:**

The main objective is to familiarize the students with waves, being the essential mechanism of communications. The students learn to understand fundamental properties of electromagnetic and acoustic waves in various propagation environments, which is essential for future design and educated use of communication systems. They also develop an ability to solve simple wave problems by analytical methods.
The other objective is to expose the students to contemporary electromagnetic simulators, which have become an inevitable tool in high frequency engineering and research. The students will be able to actually "see" wave phenomena during the lectures and they will also be offered hands-on experience during the computer laboratories.

**Treści kształcenia:**

Lectures:
Maxwell equations (2h): their history (when did Maxwell live and what was his name?..); differential and integral forms; real and complex notation; physical interpretations.
Environments of wave propagation (2h): media classification and constitutive relations; the hot topics of double-negative materials, a perfect planar lens, and perfect cladding (live computer simulations 0.5h).
Plane waves in infinite space (3h): wave equation; plane waves in lossless and lossy media; transverse electromagnetic (TEM) waves; wave impedance, medium intrinsic impedance, wavelength, attenuation, skin effect (live computer simulations 1h).
Plane waves in layered media (3h): boundary conditions; reflection of waves upon normal incidence; reflection coefficient, transmission coefficient, standing wave ratio; half- and quater-wave transformers – a transparent material plate; how do we shield devices at RF and microwave frequencies? (live computer simulations 1h).
Electromagnetic energy and power flow (2h): definitions of energy density, dissipated power density, power flux; Poynting theorem and its implications.
Waves in TEM transmission lines (4h): properties of waves in generic TEM lines (coax, parallel plate) and practical quasi-TEM lines (inhomogeneous coax, microstrip, coplanar waveguide); circuit parameters of TEM lines (live computer simulations 1h).
Introduction to computational electromagnetics (2h): why do analytical methods fail for practical devices – remarks on conformal mapping and separation of variables; FD algorithms for Laplace equation in TEM lines; FDTD algorithms for waves propagating in transmission lines (live computer simulations 1h).
Waves in cylindrical hollow waveguides (3h): TE and TM modes in rectangular and circular waveguides; cut-off frequencies, dispersion characteristics, propagating and evanescent waves; modal field patterns (live computer simulations 1h).
Waves in cavity resonators (1h): resona¬tors constructed as waveguide sections, eigenmodes, resonant and eigenfrequencies, Q-factors; why do we need resonators?; is my domestic microwave oven a resonator? (live computer simulations 0.3h)
Waves in dielectric waveguides (4h): oblique incidence and the effect of total reflection; modes in cladded core optical fibres; photonic crystals and PBG phenomenon; microstructured photonic fibers (live computer simulations 1h).
Acoustic waves (2h): wave equation for acoustic pressure, physical interpretations; basic solutions – the concept of longitudinal waves; soft and hard boundaries, a quest for their analogues in electromagnetics.
Waves radiated by antennas (2h): potentials and Green function; Hertz dipole; Huygens principle; near and far fields; radiation patterns, gain, radiation resistance, matching; scattering of electromagnetic and sound waves; when I speak on my mobile – is this the antenna or myself that radiate? (live computer simulations 0.5h).

Tutorials:
Tutorials illustrate the theoretical content of the lectures with examples of practical applications and numerical calculations. The students learn to determine basic parameters of wave propagation in various environments. Special attention is devoted to understanding, drawing, and interpreting of field patterns. Full-wave computer simulations will be demonstrated by the tutor to confirm the solutions obtained analytically.
Differential operators in field theory (2h): curl, divergence, gradient; Gauss and Stokes theorem; identities of vector algebra; angle between field vectors in various media.
Plane waves in lossless space (2h): mathematical expressions for E- and H-fields; linear, circular, and elliptical polarization; time- and space-envelopes of power and energy.
Plane waves in lossy space (2h): mathematical expressions for E- and H-fields; shape of their envelopes; validating Poynting theorem.
Plane waves in layered media (2h): wave incidence onto a dielectric half-space; designing a quarter-wave transformer.
Waves in TEM transmission lines (2h): unit parameters of TEM and parallel-plate lines;
Waves in cylindrical hollow waveguides (2h): drawing modal field patterns in waveguide cross-section; comparison of wavelength and wave impedance with TEM lines.
Waves in cavity resonators (2h): calculating resonant frequencies and modal field patterns in sections of coax and rectangular waveguide.
Waves radiated by antennas (1h): a simple array of two Hertzian dipoles.

Laboratory:
Laboratories take place in a computer laboratory. Contemporary electromagnetic software tools of QuickWave series, awarded with the European Information Technology Prize, are applied to illustrate the wave phenomena. The considered subjects are:
• TEM waves in lossless (2h) and lossy (2h) media: virtual measurements of wavelength, wave impedance, attenuation; understanding hill-top and thermal field displays;
• normal incidence of TEM waves onto PEC and PMC walls: understanding of reflected waves transient phenomena, steady-state virtual measurements of reflection coefficient, standing wave ratio, and phase-shift between E- and H- fields (2h);
• normal incidence of TEM waves onto dielectric half-space and layered media: single and multiple reflections in transient state, steady-state virtual measurements of standing wave ratio, verification of half-wave and quarter-wave transformer concepts (2h);
• modes in transmission lines: TEM lines (2h), rectangular waveguide (2h), dielectric guide (1h);
• fields radiated by simple antennas: matching, radiation patterns, gain (2h).
The emphasis is on critical correlation between numerical results and analytical predictions. The students are expected to learn and understand various computer displays of EM fields (1D/2D/3D, instantaneous / envelopes) and to enhance their perception of wave phenomena.

**Metody oceny:**

During the 6 lab exercises it is possible to score up to 30 points:
• 12 points for entry tests (6\*2)
• 18 points for exercise execution (6\*3)
Maximum score for the mid-term test is 30 points and for final test is 30 points. There are also
5 quiz-type tests (during tutorials), each one for 2 points. Two non-obligatory homeworks will be suggested, one before each test, with the total value of 10 points.
The final result is based on the following pattern:
• A: 91-110 points
• B+: 81-90 points
• B: 71-80 points
• C+: 61-70 points
• C: 51-60 points
• D: 0 -50 points

**Egzamin:**

nie

**Literatura:**

Fundamental:
S.Ramo, J.Whinnery, and T.van Duzer, “Fields and Waves in Communication Electronics”, John Wiley & Sons, 1984.
Extended reading:
C.Balanis, "Advanced Engineering Electromagnetics", John Wiley & Sons, Inc. 1989.
Illustrative:
M.Celuch and W.K.Gwarek, “Industrial design of axisymmetrical devices using a customized FDTD solver from RF to optical frequency bands”, IEEE Microwave Magazine, vol. 9, No. 6, Dec. 2008, pp. 150-158.
B.Salski, M.Celuch, and W.Gwarek, "FDTD for nanoscale and optical problems", IEEE Microwave Magazine, vol.11, No.2, April 2010, pp.50-59.

**Witryna www przedmiotu:**

https://studia.elka.pw.edu.pl

**Uwagi:**

## Efekty przedmiotowe

### Profil ogólnoakademicki - wiedza

**Efekt EPHY2\_W01:**

Student has a basic knowledge of electromagnetic waves, their mathematical description and the principles of propagation. Student has a basic knowledge of the boundary conditions for electromagnetic fields.

Weryfikacja:

Tests, labs

**Powiązane efekty kierunkowe:** K\_W02

**Powiązane efekty obszarowe:** T1A\_W01, T1A\_W02, T1A\_W03, T1A\_W07

**Efekt EPHY2\_W02:**

Student has a basic knowledge of waveguides used in high-frequency electronics. Has a basic knowledge of the principles of design of microwave resonators. Student has a basic knowledge of radiation of electromagnetic waves and fundamental parameters of antennas.

Weryfikacja:

Tests, labs

**Powiązane efekty kierunkowe:** K\_W02

**Powiązane efekty obszarowe:** T1A\_W01, T1A\_W02, T1A\_W03, T1A\_W07

### Profil ogólnoakademicki - umiejętności

**Efekt EPHY2\_U01:**

Student knows how to interpret some basic physical phenomena in the field of electrodynamics and electromagnetic waves using mathematical apparatus applied in Maxwell's equations. He/she can distinguish when it is possible to apply mathematical model of classical electrodynamics, formalized by Maxwell's equations .

Weryfikacja:

Tests, labs

**Powiązane efekty kierunkowe:** K\_U01, K\_U02

**Powiązane efekty obszarowe:** T1A\_U01, T1A\_U02