جامعة الملك عبدالله
للعلوم والتقنية
King Abdullah University of
Science and Technology

Course Syllabus: Advanced Topics in Wave Propagation - AMCS 353

Division	Computer, Electrical and Mathematical Sciences & Engineering
Course Number	AMCS 353
Course Title	Advanced Topics in Wave Propagation
Academic Semester	Spring
Academic Year	2016/2017
Semester Start Date	01/22/2017
Semester End Date	05/18/2017
Class Schedule (Days & Time)	10:30 AM - 12:00 PM | Mon Wed

Instructor(s)

Name	Email	Phone	Office Location	Office Hours
Ying Wu	Ying.Wu@kaust.edu.sa	+966128080432	4207, 1, Al-Khawarizmi (bldg. 1)	Tuesday afternoons from 2pm to 4pm.

Teaching Assistant(s)

Name	Email

Course Information

Comprehensive Course Description

AMCS 353 (3 credits). This course starts from the basic linearized theory of wave phenomena: examples are chosen from electromagnetics, acoustics, elastics and other subjects, and explores the recent developments in wave propagation. The topics include: basic concepts in wave propagation; waves in layered media; two and three dimensional cases; scattering, transmission and reflection; waves in random media; effective medium properties; resolution analysis; applications in wave functional materials and imaging; and numerical techniques in solving wave equations in heterogeneous media. Knowledge on Fourier transform, eigenvalue problem, Special functions (Bessel/Hankel/Spherical Harmonics), vector analysis is desired.

Course Details

1. Introduction: wave equations (Electromagnetic, acoustic and elastic wave equations) and relevant length scales
2. Waves in Homogeneous Media: Solutions to wave equations, and Green’s functions
3. Waves in Complex Media: One dimensional layered media: (Scattering by a single interface; Single-layer case: Reflection and Transmission; Multilayer cases); Two and three dimensional cases with isotropic scatterers: (Single scatterer; Multiple scatterers)
4. Effective Medium Theory: Introduction to random media and law of large numbers; EMT based on transmission and reflection coefficients (parameter retrieval); EMT based on coherent potential approximation; EMT based on multiple-scattering theory
5. Wave Functional Materials: photonic/phononic crystal; wave guide; metamaterials, super-resolution
6. Numerical Methods and Fast Algorithms

Course Description from Program Guide	This course starts from the basic linearized theory of wave phenomena: examples are chosen from electromagnetics, acoustics, elastics and other subjects, and explores the recent developments in wave propagation. The topics include: basic concepts in wave propagation; waves in layered media; scattering, transmission and reflection; waves in random media; effective medium properties, resolution analysis; applications in wave functional materials and imaging; and numerical techniques in solving wave equations in heterogeneous media. Basic knowledge on eigenvalue problem, Fourier transform, linear algebra, vector analysis is desired.
Goals and Objectives	At the end of the course, the students are expected to 1. Understand the basic concepts about wave propagation; know the difference between quantum and classical waves; familiar with the d'Alembert solution, spherical mean methods 2. Familiar with waves in layered media: master the derivation of transmission and reflection coefficients 3. Understand the concept of homogenization; know the derivations and limitations of different effective medium theories 4. Be aware of the cutting-edge developments on metamaterials, artificial materials.
Required Knowledge	The students should have basic knowledge on PDE (method of characteristics, separation of variables, eigenvalue problem); vector analysis; complex analysis; Fourier analysis.
Reference Texts	References: [1] Jean-Pierre Fouque, Josselin Garnier, George Papanicolaou, and Knut Solna; *“Wave Propagation and Time Reversal in Randomly Layered Media”* Springer 2007 [2] Ping Sheng, *“Introduction to Wave Scattering, Localization and Mesoscopic Phenomena”* Springer 2006
Method of evaluation	**50.00**% - Exam 1 **20.00**% - Oral Quizzes **30.00**% - Homework /Assignments
Nature of the assignments	3-5 written assignements Students will choose the way of the final exam (an oral presentation with a written report or a standard written exam).
Course Policies	Three times of absences without acceptable justifications will result in a fail of the course. Late assignment will not be graded.
Additional Information	Oral quizzes refer to the in-class activities.

Tentative Course Schedule *(Time, topic/emphasis & resources)*		
Week	**Lectures**	**Topic**
1	Mon 01/23/2017 Wed 01/25/2017	Introduction: about the course; brief review of quantum and classical wave systems; important lengths
2	Mon 01/30/2017 Wed 02/01/2017	Introduction: General properties of solutions to wave equations. Derivations of electromagnetic, acoustic wave equations
3	Mon 02/06/2017 Wed 02/08/2017	Introduction: Derivation of elastic wave equation; vector analysis
4	Mon 02/13/2017 Wed 02/15/2017	Introduction: Important quantities in elastic wave equations. Summary of classical wave equation. Waves in homogeneous systems: Solutions to 1D wave equation
5	Mon 02/20/2017 Wed 02/22/2017	Waves in homogenous systems: Solution to 3D wave equation by spherical means; 3D wave equation with source; Green's function
6	Mon 02/27/2017 Wed 03/01/2017	Waves in homogeous systems: Wave decomposition; plane wave, spherical wave,Weyl representation of spherical waves:propagating and evanscenent waves
7	Mon 03/06/2017 Wed 03/08/2017	Waves in layered media: single interface, single layer; transmission and reflection coefficients; propagator
8	Mon 03/13/2017 Wed 03/15/2017	Waves in layered media: Scattering matrix, multilayer cases; periodic media; dispersion relations
9	Mon 03/20/2017 Wed 03/22/2017	Waves in layered media: Periodic structures; photonic and phononic crystals; effective medium theory based on parameter retrieval
10	Mon 03/27/2017 Wed 03/29/2017	Waves in higher dimensions: scattering coefficients, Green's function, multiple-scattering theory
11	Mon 04/03/2017 Wed 04/05/2017	Waves in higher dimensions: effective medium theories based on coherent potential approximation, multiple-scattering theory, and field-averaging
12	Mon 04/10/2017 Wed 04/12/2017	Wave functional materials: resonances, metamaterials, super-resolution
13	Mon 04/17/2017 Wed 04/19/2017	Wave functional materials: zero-index material and super-anisotroipc material
14	Mon 04/24/2017 Wed 04/26/2017	Miscellaneous: cutting-edge developments,numerical methods,etc
15	Mon 05/01/2017 Wed 05/03/2017	Project presentation
16	Mon 05/08/2017 Wed 05/10/2017	
17	Mon 05/15/2017 Wed 05/17/2017	
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Note

The instructor reserves the right to make changes to this syllabus as necessary.