

COURSE INFORMATION					
Course Title	Code	Semester	C +P + L Hour	Credits	ECTS
Biomedical Electromagnetics	EE526	Fall/Spring	3 + 0 + 0	3	10

Prerequisites	EE421(proposed)
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Language of Instruction	English
Course Level	Master, Doctorate
Course Type	Elective
Course Coordinator	Prof. Dr. Cahit Canbay
Instructors	Prof. Dr. Cahit Canbay
Assistants	
Goals	Students will try to understand the complex relationships between natural or artificial origin electromagnetic fields and biological structures, especially living tissues, which we are widely in today. By using the beneficial and harmful effects of these areas on living things, especially the theories developed by the lecturer C. Canbay, they will have the chance to examine Multiple Sclerosis (MS), Alzheimer's, Cancer and Parkinson diseases in detail.
Content	Brief history of Biomedical Electromagnetic issues. Biomedical engineering applications in electromagnetic theory. Electromagnetic modeling of environmental parameters of biological tissues, dispersion (□□□□□□□□□□, T, H ₂ O, NaCl, Porozite, Relakssasyon süresi). Interaction mechanism of electromagnetic fields and biological tissues. Dielectrophoretic fields, Analytical and numerical (Method of Moment, MOM) solutions of electric and magnetic field integral equations (EFIE, MFIE). Harmful effects of electromagnetic fields on biological tissues (Etiology of Multiple Sclerosis disease, Alzheimer, Parkinson and cancer and relationship of Electromagnetic Fields), electromagnetic exposure standards. Electromagnetic sensitivity. The use of electromagnetic fields in medicine for diagnosis (Magnetic Resonance Imaging (MRI), microwave tomography) and therapeutic purposes (hyperthermia, DNA and RNA antenna arrays, antenna applicators). Investigation of the immune system in terms of E.M theory.

Learning Outcomes	Program Outcomes	Teaching Methods	Assessment Methods
1) Be able to apply given mathematical background to electromagnetic problems	1,2,3,4,5,6,11	1,2,3,6	A,D
2) Be able to solve the problems with respect to the electromagnetic scattering from regular,	1,2,3,4,5,6,11	1,2,3,6	A,D

cylindrical and spherical structures which are perfect conductors, lossy dielectric and dielectric. Be able to realize the computer simulations in the Light of the theoretical results.			
3) Be able to understand the converting mechanisms from plane waves to cylindrical waves and spherical waves each other, mutually.	1,2,3,4,5,6,11	1,2,3,6	A,D
4) Be able to solve the electromagnetic scattering problems by computer programs	1,2,3,4,5,6,9	1,2,3,6	A,D
5) Be able to present individual homeworks by each student as oral and to answer critics on their own topics	7,9	3,6	D
6) To reveal the relationships between diseases and electromagnetic fields and biological structures	7,9	1	A

Teaching Methods:	1: Lecture, 2: Problem Solving, 3: Simulation, 4: Seminar, 5: Laboratory, 6: Term Research Paper
Assessment Methods:	A: Exam, B: Quiz, C: Experiment, D: Homework, E: Project

COURSE CONTENT		
Week	Topics	Study Materials
1	Brief history of bioelectromagnetic theory, biomedical electromagnetic engineering applications in electronics.	Rec. Materials
2	Electromagnetic modeling of environmental parameters of biological tissues.	Rec. Materials
3	Brief history of bioelectromagnetic theory, biomedical electromagnetic engineering applications in electronics.	Rec. Materials
4	Interaction mechanism of electromagnetic fields and biological tissues.	Rec. Materials
5	Interaction mechanism of electromagnetic fields and biological tissues.	Rec. Materials
6	Dielectrophoretic Fields	Rec. Materials
7	Etiology of Multiple Sclerosis (MS) disease, alzaimer, Parkinson, cancer.	Rec. Materials
8	Etiology of Multiple Sclerosis (MS) disease, alzaimer, Parkinson, cancer.	Rec. Materials

9	Midterm	Rec. Materials
10	Interaction of electromagnetic fields with cells.	Rec. Materials
11	Analytical and numerical solutions (MOM) of Electric and Magnetic Field Integral equations (EFIE, MFIE).	Rec. Materials
12	Analytical and numerical solutions (MOM) of Electric and Magnetic Field Integral equations (EFIE, MFIE).	Rec. Materials
13	Investigation of the harmful and beneficial effects of electromagnetic fields on biological tissues in terms of MS, cancer and other diseases.	Rec. Materials
14	Projects and oral presentations	

RECOMMENDED SOURCES	
Textbook	Jaakko Malmivuo and Robert Plonsey , "BIOELECTROMAGNETISM" Oxford University Press, New York, 1995, ISBN 0-19-505823-2
Additional Resources	<p>*Stratton Julius Adams, Electromagnetic Theory, Adams Press, 2007.</p> <p>*Cahit Canbay, Anten ve Propagasyon I, Yeditepe University Press, 1997.</p> <p>*IEEE Trans. on Bioelectromagnetics</p> <p>CAHİT CANBAY, Possible effects of dielectrophoretic fields in the brains of MRI operators and MS patients, RIS evaluation, Turk J Elec Eng & Comp, (2019) 27: 4354 – 4360, DOI: 10.3906/elk-1811-149, E-ISSN: 1303-6203, ISSN: 1300-0632</p> <p>CAHİT CANBAY, ÖZGÜN PALAK, AYDOĞA KALLEM, Investigating the occurrence mechanism of cytokine-like formations by the electromagnetic approach, Turk J Elec Eng & Comp, 27, (2019), 37-45. DOI:10.3906/elk-1803-197, E-ISSN:1303-6203,ISSN:1300-0632</p> <p>Cahit Canbay, Multiple Sclerosis is not a disease of the genetic and immune system origin, SYLWAN, march 2015,159/3 ,1-8.</p> <p>Canbay C, "The radiologically isolated syndrome is the last link of the chain for understanding the etiology of Multiple Sclerosis disease," European Scientific Journal, July 2014 Edition, Vol. 10, No: 21,pp. 20-35. ISSN:1857-7881(print) e-1857-7431.</p> <p>Cahit Canbay The Appraisal of the Etiology of the Multiple</p>

Sclerosis Disease In the Light of the Impact of the Dielectrophoretic Force
Presented at: The 7th World Congress on Controversies in Neurology (CONy), ISTANBUL, TURKEY • APRIL 11-14, 2013

Canbay, C. "The Essential Environmental Cause of Multiple Sclerosis Disease," Progress In Electromagnetics Research, PIER 101, 375-391, 2010. (DOI:10.2528/PIER08062004).

C. CANBAY, "Multiple Sclerosis (MS) Hastalığının Asıl Nedeni, Yeni Kanıtlar", Tıp Tekno 2011-Tıp Teknolojileri Ulusal Kongresi, 13-16 Ekim 2011, Belek, Antalya.

İ. Ünal, B. Türetken, U. Buluş and C. Canbay, "Analysis of Dispersive Effects of Breast Phantom Model on Ultra Wideband Microwave Imaging of Breast Cancer Tumor", BIOMED 2013, 13-15 Feb 2013, Innsbruck, Austria

C. CANBAY, "Multiple Sclerosis (MS) Hastalığının Asıl Nedeni", V. URSI Türkiye 2010 Bilimsel Kongresi ve Ulusal Genel Kurul Toplantısı, 25-27 Ağustos 2010, ODTU Kuzey Kıbrıs Yerleşkesi.

Canbay, C. and I. Unal, "Electromagnetic modeling of retinal photoreceptors," Progress In Electromagnetics Research, PIER 83,353-374, 2008.

İ. Ünal, B. Türetken, U. Buluş and C. Canbay, "Spherical Conformal Bow-tie Antenna for Ultra Wideband Microwave Imaging of Breast Cancer Tumor", ACES Journal. (under review)

İ. Ünal, B. Türetken, U. Buluş and C. Canbay, "Analysis of the Electromagnetic Field Scattered by a Spherical Breast Tumor Model", URSI-EMTS 2013, 20-24 May 2013, Hiroshima, Japan.

C. CANBAY and İ. ÜNAL, "Electromagnetic Modeling of Retinal Photoreceptors," Istanbul Conference on Mathematical Methods and Modeling in Life Sciences and Biomedicine 2009 (ICMMM-LSBM), 17-21 August, 2009, Sile, Istanbul, Turkey.

İ. Ünal, B. Türetken, U. Buluş ve C. Canbay, "Konformal Antenler Kullanarak Meme Kanseri Tümörünün Radar-Tabanlı Mikrodalga Görüntüleme Tekniği ile Tespit Edilmesi", BİYOMUT 2012, 3-5 Ekim 2012, İstanbul.

C. CANBAY and İ. ÜNAL, "Electromagnetic Modeling of Retinal Photoreceptors," Istanbul Conference on Mathematical Methods and Modeling in Life Sciences and Biomedicine 2009 (ICMMM-LSBM), 17-21 August, 2009, Sile, Istanbul, Turkey.

İ. ÜNAL, B. TÜRETKEN, K. SÜRMEİLİ and C. CANBAY, "An Experimental Microwave Imaging System for Breast Tumor Detection on Layered Phantom Model", URSI GASS 2011, 13-20 August 2011, İstanbul, Turkey.

İ. Ünal, Sarbesh B. Malla and C. Canbay, "Determining of Interaction Mechanism between Scattering Electromagnetic

Fields and Breast Cancer Tumor Using Theoretical Human Body Models", Istanbul Conference on Mathematical Methods and Modeling in Life Sciences and Biomedicine 2011 (ICMMM-LSBM), 15-19 August, 2011, Sile, Istanbul, Turkey.

İ. Ünal, B. Türetken, U. Buluş ve C. Canbay, "Meme Kanseri Tümörünün Tespit Edilmesi İçin Geliştirilen Mikrodalga Görüntüleme Sisteminin, Kalp Pili Kullananlar İçin Elektromagnetik Bağışıklık Açısından İncelenmesi", I. ULUSAL EMC (Elektromanyetik Uyumluluk) Konferansı, 14-16 Eylül 2011, İstanbul.

M. C. Akmehmet, İ. Ünal ve C. Canbay, "Dispersif ve Kayıplı Ortamda Keyfi Polarizasyonlu Antenler Arasındaki Elektromagnetik Etkileşimin İncelenmesi", I. ULUSAL EMC (Elektromanyetik Uyumluluk) Konferansı, 14-16 Eylül 2011, Doğu Üniversitesi, İstanbul.

C. Canbay, "Multiple Sclerosis(MS) hastalığının asıl nedeni, yeni kanıtlar", I. ULUSAL EMC (Elektromanyetik Uyumluluk) Konferansı, 14-16 Eylül 2011, Doğu Üniversitesi, İstanbul.

İ. Ünal, B. Türetken, U. Buluş, K. Sürmeli ve C. Canbay, "Elektromanyetik Dalgalar Kullanılarak Meme Kanseri Tümörünün Tespitine Yönelik Bir Analiz", Tıp Tekno 2011-Tıp Teknolojileri Ulusal Kongresi, 13-16 Ekim 2011, Belek, Antalya.

Cahit CANBAY, N. Özlem ÜNVERDİ , S. Utku AY , Vural BAYRAK. "0-100 GHz Frekans Aralığında Işıma Yapan Yapay ve Doğal Elektromagnetik Alan Kaynaklarının Çevre, İnsan Sağlığı Açısından İncelenmesi ". Elektrik Mühendisliği 5 Ulusal Kongresi, 13-18 Eylül 1993, KTÜ-Trabzon , Cilt 2, Sayfa 486-493. (Tez çalışması değil)

Cahit CANBAY, N. Özlem ÜNVERDİ, S. Utku AY. " Mobil ve Masaüstü Elektronik Araçların Dokulara Etkisi ". Elektrik Mühendisliği 5. Ulusal Kongresi, 13-18 Eylül 1993, KTÜ-Trabzon , Cilt 2 , Sayfa 494-498. (Tez çalışması değil)

CANBAY C., ÜNVERDİ N.Ö., "Elektriksel Kökenli Sistemlerin Elektromagnetik Işımalarının Stratejik Önem, İnsan Sağlığı ve Çevre Uyumluluğu Açısından Değerlendirilmesi," K.H.O 1. Sistem Mühendisliği Cilt 1, sayfa 319-329,12-13 Ekim 1995, Ankara (Tez çalışması değil)

CANBAY C,"Sıklıkla kullanılan elektromagnetik alan kaynaklarının ışıma alanlarının biyolojik dokularla etkileşme mekanizması ve epidemiolojik değerlendirme," Biyomut 1994, , Erciyes Üniversitesi-Kayseri.

CANBAY C,"Mikroşerit Anten Dizisiyle Yoğun Bakım hastalarının Vücut Fonksiyonlarının Uzaktan izlenmesi," Biyomut 1995, 137-139, Boğaziçi Üniversitesi.

Cahit CANBAY,"Elektromagnetik Çevre Kirliliği ve Canlılar Üzerindeki Etkisi" Cumhuriyet Gazetesi 29 Mayıs 1990.

Cahit CANBAY, 'Elektromagnetik Çevre Kirliliği' Günaydın

	Gazetesi Cahit CANBAY, "Yüksek gerilim hatları tehlike sağıyor" Hürriyet Gazetesi, 23 Aralık 1995
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MATERIAL SHARING	
Documents	Cahit Canbay, Anten ve Propagasyon I, Yeditepe University Press, 1997, http://ee.yeditepe.edu.tr/staff/canbay/ee421coursebook.htm ,
Assignments	Each student has unique homework. Since students are supposed to accomplish their oral presentations, separately, other students will be able to learn and see the solutions of other homeworks, too.
Exams	Questions and Answers of Mid-terms

ASSESSMENT		
IN-TERM STUDIES	NUMBER	PERCENTAGE
Midterm I	1	50
Midterm II	-	-
Homework Assignment	1	50
Total		100
CONTRIBUTION OF FINAL EXAMINATION TO OVERALL GRADE		40
CONTRIBUTION OF IN-TERM STUDIES TO OVERALL GRADE		60
Total		100

COURSE CATEGORY	Field Course
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COURSE'S CONTRIBUTION TO PROGRAM						
No	Program Learning Outcomes	Contribution				
		1	2	3	4	5
1	Can reach information in breadth and depth, and can evaluate, interpret and apply this information to scientific research in the area of Electrical and Electronics Engineering.					x
2	Can complete and apply information with scientific methods using limited or missing data; can integrate information from different disciplines.					x
3	Sets up Electrical and Electronics Engineering problems, develops and implements innovative methods for their solutions.					x
4	Develops new and/or original ideas and methods; finds innovative solutions					x

	to the system, component, or process design.						
5	Has comprehensive knowledge about the state-of-the-art techniques and methods in Electrical and Electronics Engineering and their limitations.						x
6	Can design and conduct research of analytical, modeling or experimental orientation; can solve and interpret complex cases that come up during this process.					x	
7	Can communicate verbally and in writing in one foreign language (English) at the General Level B2 of the European Language Portfolio.						x
8	Can assume leadership in multi-disciplinary teams; can develop solutions in complex situations, and take responsibility.						
9	Can systematically and openly communicate in national and international venues the proceedings and conclusions of the work he/she performs in Electrical and Electronics Engineering.					x	
10	Respects social, scientific and ethical values in all professional activities performed during the collection, interpretation and announcement phases of data.						
11	Is aware of new and emerging applications in Electrical and Electronics Engineering; investigates and learns them, whenever necessary.						x
12	Can identify the social and environmental aspects of Electrical and Electronics Engineering applications.						

ECTS ALLOCATED BASED ON STUDENT WORKLOAD BY THE COURSE DESCRIPTION			
Activities	Quantity	Duration (Hour)	Total Workload (Hour)
Course Duration (including 2 midterms: 14xtotal lecture hours)	14	3	42
Hours for off-the-classroom study (Pre-study, practice)	14	8	112
Midterm I	1	2	2
Midterm II	-	-	-
Homework assignment	14	7	98
Final examination	1	2	2
Total Work Load			256
Total Work Load / 25 (h)			10.24
ECTS Credit of the Course			10