Washington State University

MAJOR CURRICULAR CHANGE FORM - - NEW/RESTORE COURSE

☐ Please attach rationale for your request, a complete syllabus, and explain how this impacts other units in Pullman and
other campuses (if applicable).
☐ Obtain all required signatures with dates.
☐ Provide original stapled packet of signed form/rationale statement/syllabus PLUS 10 stapled copies of complete packet
to the Registrar's Office, campus mail code 1035.
☐ Submit one electronic copy of complete packet to wsu.curriculum@wsu.edu.

Requested Future Effective Date: Fall 2016 (term/year) Course Typically Offered: Fall

DEADLINES: For fall term effective date: October 1st; for spring or summer term effective date: February 1st. See instructions.

NOTE: Items received after deadlines may be put to the back of the line or forwarded to the following year. Please submit on time.

☐ New Course  □ Temporary Course  □ Restore Course

ECE 533 Advanced Antenna Design

course subject/crosslist  course no.  title
3  ECE 370 and ECE 471

Credit hrs lecture hrs lab or studio hrs per week prerequisite

ECE 370 3

Description for catalog: Advanced antenna types and design methods, small antennas, reconfigurable antennas, wideband microstrip antennas, millimeter-wave antennas, phased arrays, design of array feed, mutual coupling.

Additional Attributes: Check all that apply.
☐ Crosslisting (between WSU departments)*  ☐ Conjoint listing (400/500):__________
☐ Variable credit:__________  ☐ Repeat credit (cum. max. hrs):__________

Special Grading: ☐ S, F; ☐ A, S, F (PEACT only); ☐ S, M, F (VET MED only); ☐ H, S, F (PHARMACY, PHARDSCI only)
☐ Cooperative with UI  ☐ Other (please list request):__________

The following items require prior submission to other committees/depts. (SEE INSTRUCTIONS.)
☐ Request to meet Writing in the Major [M] requirement (Must have All-University Writing Committee Approval.)
☐ Request to meet UCORE in__________ (Must have UCORE Committee Approval)  ☐ See instructions.
☐ Special Course Fee__________ (Must submit request to University Receivables.)

Contact: Tutku Karacolak  Phone number: (360) 546-9185  Campus mail code: 98686
Email: tutku.karacolak@wsu.edu  Instructor, if different:

Chair/date  Dean/date  All-University Writing Com / date

Chair (if crosslisted/interdisciplinary)*  Dean (if crosslisted/interdisciplinary)*  UCORE Committee Approval Date

Catalog Subcommittee Approval Date  GSC or AAC Approval Date  Faculty Senate Approval Date

*If the proposed change impacts or involves collaboration with other units, use the additional signature lines provided for each impacted unit and college.
Rationale: ECE 533 Advanced Antenna Design

ECE 533 Advanced Antenna Design is being proposed to provide electrical engineering graduate students with cutting edge antenna design techniques and applications to help them to become more competitive in their field of study. It aligns with WSU Vancouver’s electrical engineering curriculum as a continuation of ECE 471, Antenna Design and Analysis. ECE 471 covers fundamentals of antenna theory and introduces traditional antenna types and will be a prerequisite for this course. ECE 533 also supports the proposed MSEE program’s Lab-on-Chip (LoC) focus by teaching students the techniques necessary to design and analyze small size antenna systems of the LoC.

It does not affect other units in Pullman and other campuses.
ECE 533 Advanced Antenna Design Course Syllabus

Description: Advanced antenna types and design methods, small antennas, reconfigurable antennas, wideband microstrip antennas, millimeter-wave antennas, phased arrays, design of array feed, mutual coupling, system level implications such as full-duplex and MIMO.

Credits: 3

Prerequisite: ECE 370 Electromagnetic Fields and Waves and ECE 471 Antenna Design and Analysis


Instructor: Dr. Tutku Karacolak
Office: VECS 201N
Phone: (360) 546 9185
Email: tutku.karacolak@wsu.edu
Office hours: Open door policy
Lectures: VECS 104, MW 9:00-10:15 Am

Topics Covered

- Review of antenna and array theory
- Small antennas
- Wideband microstrip antennas
- Ultra-wideband antennas and arrays
- Phased arrays, design of array feed, mutual coupling
- Millimeter-wave antennas
- Reconfigurable antennas
- Metamaterial based antennas
- Antennas for wireless communications and related applications (medical, mobile handset, satellite, full-duplex, MIMO, underground antennas, etc.)

Course Procedures

There will be three hours of lecture each week. Reading from the required textbooks and journal articles from the literature will be assigned each week. There will be 6 or 7 homework assignments, approximately one every two weeks. Some of the homework assignments will involve using MATLAB software. In addition to the homework assignments, students will work on a term project utilizing one of advanced antenna types to design an antenna for wireless communication applications.
### Student Learning Outcomes (SLO) and Assessment

<table>
<thead>
<tr>
<th>Student Learning Outcomes for this Course:</th>
<th>Course Topics/Date(s):</th>
<th>Evaluation of Outcome:</th>
</tr>
</thead>
<tbody>
<tr>
<td>At the end of this course, students should be able to:</td>
<td>The following topic(s)/date(s) will address this outcome:</td>
<td>This outcome will be evaluated primarily by:</td>
</tr>
<tr>
<td>Have an understanding of advanced antenna concepts such as small antennas, millimeter-wave antennas, reconfigurable antennas, and metamaterial based antennas</td>
<td>Small antennas (week 4); millimeter-wave antennas (week 9); reconfigurable antennas (week 10); metamaterial based antennas (week 14)</td>
<td>Exams, homework</td>
</tr>
<tr>
<td>Design antenna arrays and analyze mutual coupling among antennas</td>
<td>Phased arrays, design of array feed, mutual coupling (week 8)</td>
<td>Exams, homework</td>
</tr>
<tr>
<td>Use numerical techniques to design and analyze wideband antennas</td>
<td>Wideband microstrip antennas (week 5); frequency independent antennas (week 6)</td>
<td>Homework, Design Project</td>
</tr>
<tr>
<td>Formulate and execute a research plan to design advanced antenna types including simulations and measured results</td>
<td>Small antennas, wideband microstrip antennas (weeks 4, 5); antennas for advanced applications (weeks 11-14)</td>
<td>Design project</td>
</tr>
</tbody>
</table>

### Website
All course materials (lecture notes, assignments, etc.) will be available on the course Blackboard website at [https://learn.wsu.edu/](https://learn.wsu.edu/).

### Attendance Policy
Lecture attendance is highly encouraged but not required. Students are nevertheless responsible for knowing any and all material presented in lecture.

### Composition of final grade
The course grade will be determined as follows:

<table>
<thead>
<tr>
<th>Component</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>Homework</td>
<td>20%</td>
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<tr>
<td>Midterm Exam</td>
<td>20%</td>
</tr>
<tr>
<td>Final Exam</td>
<td>25%</td>
</tr>
<tr>
<td>Design Project</td>
<td>35%</td>
</tr>
<tr>
<td>Total</td>
<td>100%</td>
</tr>
</tbody>
</table>

### Grading Scale (% of total score)
A 95-100; A- 90-94; B+ 85-89; B 80-84; B- 75-79; C+ 70-74; C 65-69; C- 60-64; D+ 55-59; D 50-54; F <50
NOTE: Grades will be rounded up to the next point as letter grades for the course are assigned at the end.

Make-up Exam/Assignment Policy
No make-up exam, assignments or quizzes will be given unless a medical or other emergency was the reason for missing the exam or the assignment. For any other reason you must first contact the instructor before missing an exam, a quiz or an assignment.

Late Homework Submission Policy
Late homework will not be entertained unless dire circumstances warrant it. Without a valid reason, there will be a 10% deduction grade for submitting late by a day. If the submission is two days late, a 20% deduction in grade will be enforced. The homework will not be accepted after three days of original submission.

Design Project
During the semester, students will work on a term project utilizing one of advanced antenna types to design an antenna for wireless communication applications. Consistent with the frequencies assigned by FCC (Federal Communications Commission), you may pick any frequency bands (you can choose more than one for a single antenna) for your antenna. You will work in groups of 2-3 students and each group is expected to identify a problem of their interest. You will start with performing a literature survey in that topic and develop research type questions of your own. Following the design, students will fabricate and test their antennas and compare with simulations. A project report will be submitted.

- The project teams will be formed and topics will be chosen during third and fourth weeks.
- You will use ANSYS HFSS during the design process for the simulations.
- Dielectric substrate (FR4: $\varepsilon_r = 4.4, \tan \delta \text{ (loss tangent)} = 0.02, \text{thickness} = 1.5 \text{ mm}$) will be provided for fabrication. The antennas will be fabricated in VECS 322 (RF Research Laboratory) using LPKF Protomat S63 Circuit Board Plotter.
- Computer simulations and experimental results should match, and they should be around the preselected design specifications. Measurements will be performed in VECS 322.
- The device that you manufacture should be solid enough such that same results must be obtained in many consecutive measurements.
- A formal report will be submitted due week 14. Report will include the sections of abstract, theoretical background (introduction), antenna design process, layout of the design with its picture, results and analysis (computer simulations vs. measurements), and conclusion. Project success depending on the antenna performance as well as novelty of design will be taken into account.

Academic Integrity
Academic integrity is the cornerstone of the university and will be strongly enforced in this course. Any student found in violation of the academic integrity policy will be given an “F” for the course and will be referred to the Office of Student Conduct. For additional information about WSU’s academic integrity policy/procedures, please contact (360) 546 9573.
**Student with Disabilities**
Reasonable accommodations are available for students with a documented disability. If you have a disability and need accommodations to fully participate in this class, please call the Access Center at (360) 546-9238 or van.access.center@wsu.edu. Accommodations may take some time to implement so it is critical that you contact the Access Center as soon as possible.

**Emergency Notification System**
WSU has made an emergency notification system available for faculty, students, and staff. Please register at zzusis with emergency contact information (cell, email, text, etc.). You may have been prompted to complete emergency contact information when registering for classes at RONet. In the event of a building evacuation, a map at each classroom entrance shows the evacuation point for each building. Please refer to it. Finally, in case of class cancellation campus-wide, please check local media, the WSU Vancouver web page and/or http://www.flashalert.net/. Individual class cancellations may be made at the discretion of the instructor. Each individual is expected to make the best decision for their personal circumstances, taking safety into account. Safety plan website.

**Audio, video, digital, commercial note-taking and other recording during class**
Copyright 2015 <instructor name> covers this syllabus, all lectures, and course-related written materials. During this course students are prohibited from making audio, video, digital, or other recordings during class, or selling notes to or being paid for taking notes by any person or commercial firm without the permission of the faculty member teaching this course.

**ECE 533 Tentative Weekly Schedule**

<table>
<thead>
<tr>
<th>Week</th>
<th>Topics</th>
<th>Homework / Exam</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Review of fundamental parameters of antennas</td>
<td></td>
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<tr>
<td>2</td>
<td>Friis transmission equation and radar range equation</td>
<td>HW # 1</td>
</tr>
<tr>
<td>3</td>
<td>Review of array theory</td>
<td>Project teams formed</td>
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<tr>
<td>4</td>
<td>Small antennas</td>
<td>Projects assigned, HW #2</td>
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<tr>
<td>5</td>
<td>Wideband microstrip antennas</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Frequency independent antennas</td>
<td>HW # 3</td>
</tr>
<tr>
<td>7</td>
<td><strong>Review and Midterm Exam</strong></td>
<td>Midterm</td>
</tr>
<tr>
<td>8</td>
<td>Phased arrays, design of array feed, mutual coupling</td>
<td></td>
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<tr>
<td>9</td>
<td>Millimeter-wave antennas</td>
<td>HW # 4</td>
</tr>
<tr>
<td>10</td>
<td>Reconfigurable antennas</td>
<td>HW # 5</td>
</tr>
<tr>
<td>11</td>
<td>Antennas for medical applications</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Antennas for MIMO / Full-Duplex Systems</td>
<td>HW # 6</td>
</tr>
<tr>
<td>13</td>
<td>Antennas for mobile communications</td>
<td></td>
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<td></td>
<td>Thanksgiving holiday – no class</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Metamaterial based antennas</td>
<td>Project report due</td>
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<tr>
<td>15</td>
<td>Review</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>FINAL EXAM</td>
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