

**EECS 1**

**Introduction to Electrical Engineering And  
Computer Science**

**RF, Antennas and Microwaves**

**Filippo Capolino  
Dept. of EECS**

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**Goals for the Course**

- **Learn about the EECS Dept and our 3 programs**
  - Electrical Engineering
- **Meet some of the faculty**
- **Learn about research going on in EECS at UCI**
- **Start to plan YOUR program**
  - What part of EE, CpE or CSE do YOU want to focus on?
  - What courses do I want to take?
  - How do I arrange my schedule so I can take them?
- **Explore one area of EECS in more detail**

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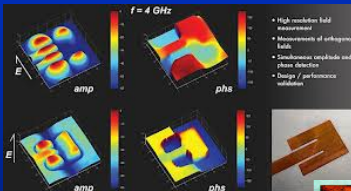
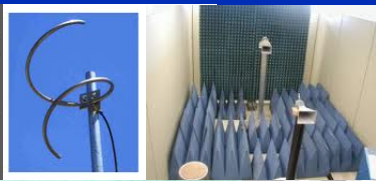

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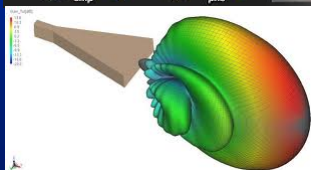
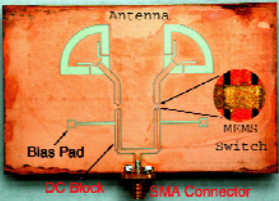
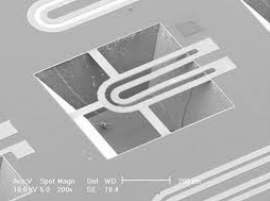
## RF, Antennas and Microwaves

<p><b>EECS 144*</b>  <b>EECS 180B*</b>  <b>EECS 182*</b>  <b>Physics 52A</b></p>	<p>Ant. Design for Wireless                  Electromagnetics II                  MMIC Design                  Optics, Lenses, Lasers</p>	<p><b>EECS 170D</b>  <b>EECS 170E</b>  <b>EECS 180C</b>  <b>EECS 188</b></p>	<p>IC Design                  Analog/Comm IC Design                  Electromagnetics III                  Optical Electronics</p>
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Specialized Electives 3 courses  
 \*Required for Specialization

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## RF, Antennas and Microwaves

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Specialized Electives 3 courses  
 \*Required for Specialization

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Microwave circuits = RF circuits

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## Examples



Horn antennas  
Prof. De Flaviis Lab.

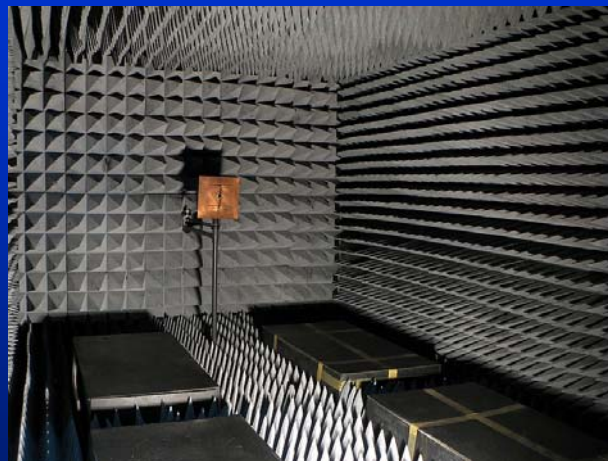


Probe station for RF  
circuits characterization

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## Examples

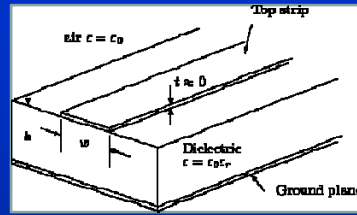
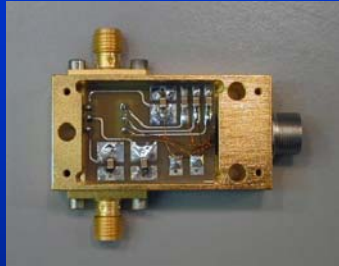


Anechoic chamber for antenna characterization  
(Wikipedia)

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### Examples: microwave circuits



(from the internet)

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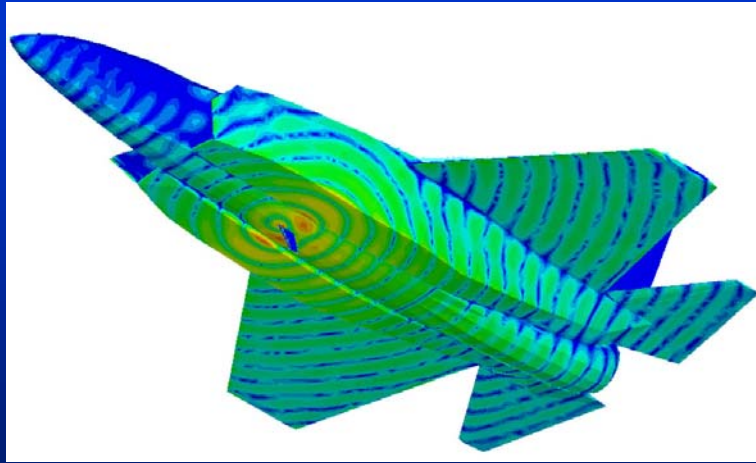
### Examples: microwave components and devices



(from the internet)

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### Examples: simulators

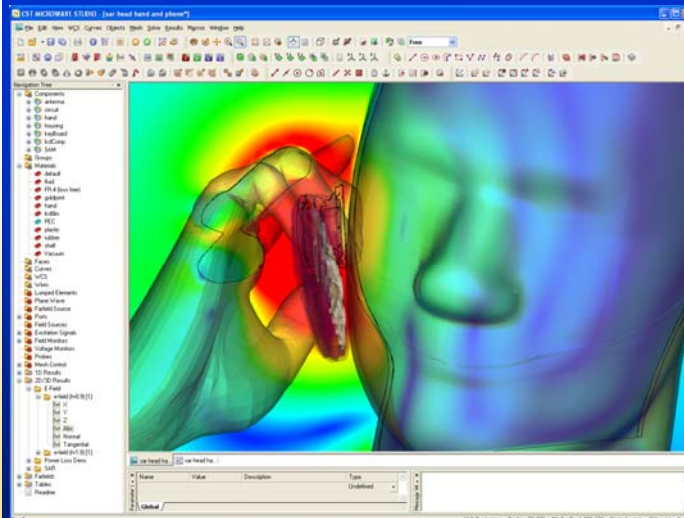


Ansys HFSS

(from the internet)

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### Examples: simulators

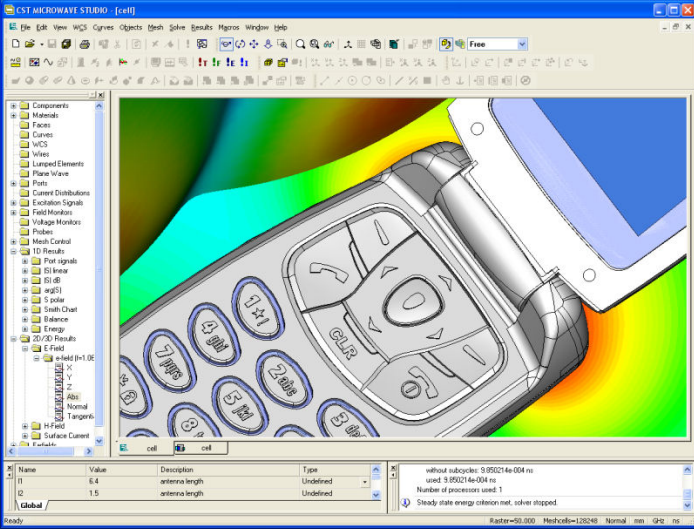


CST  
Microwave  
Studio

(from the internet)

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### Examples: simulators



Name	Value	Description	Type
I1	E 4	antenna length	Undefined
I2	1 G	antenna length	Undefined

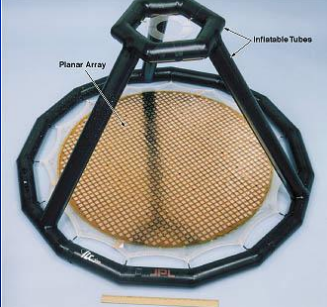

**CST  
Microwave  
Studio**

(from the internet)


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### Examples: Antennas



Planar Array  
Inflatable Tubes



**Inflatable Antennas**

(from the internet)

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### Examples: Antennas

FB friend: "Here is my baby! In the first picture you can see my antenna on the top deck of the SMAP spacecraft before it was covered in thermal blankets. In the second picture you can see the entire observatory with the stowed reflector. Now it's flying in this configuration except with opened solar panels"



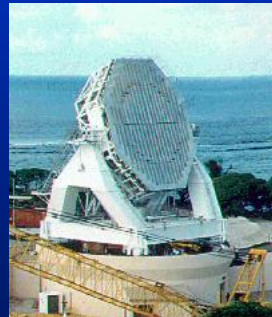
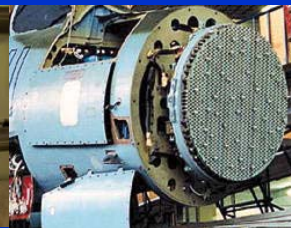
"We just separated from the launch vehicle and opened the solar panel!!!"



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### Examples: Array antennas for radars






(from the internet)

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### Examples: parabolic antennas

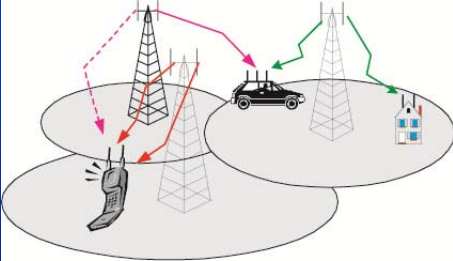




(from the internet)

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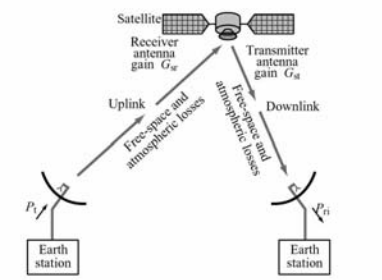
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### Wireless links



(from the internet)



Satellite  
 Receiver antenna gain  $G_{re}$       Transmitter antenna gain  $G_{st}$   
 Uplink      Free-space and atmospheric losses      Downlink  
 Earth station  $P_t$       Earth station  $P_r$


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### Complex EM environments

Everything is interacting with everything else, via EM fields: Compatibility problem

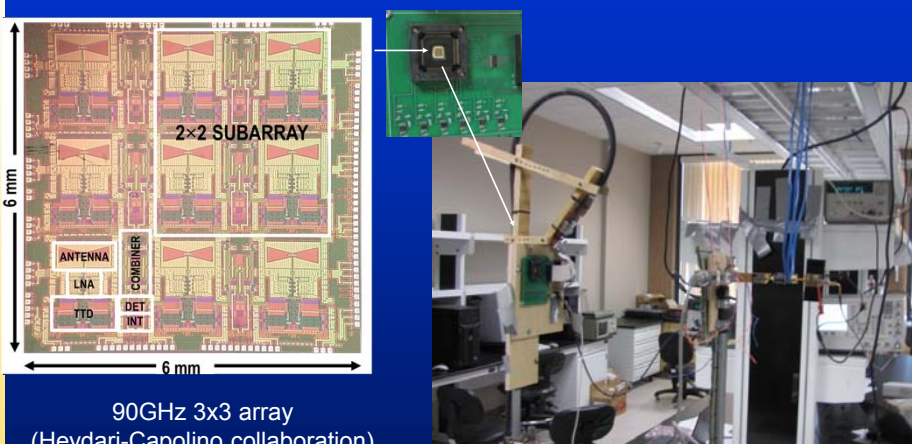


(from the internet)

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### Example: Integrated RF circuits and antennas



6 mm

6 mm

2x2 SUBARRAY

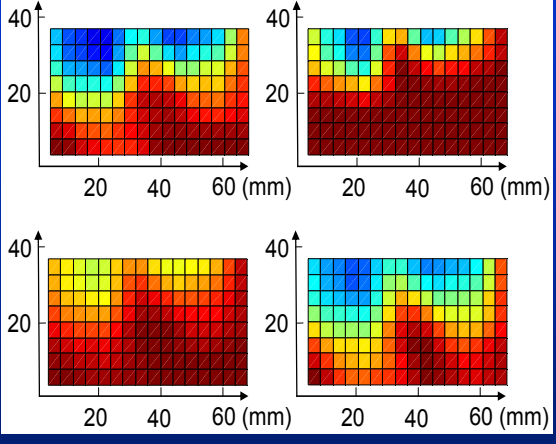
ANTENNA  
LNA  
COMBINER  
TTD  
DET  
INT

90GHz 3x3 array  
(Heydari-Capolino collaboration)


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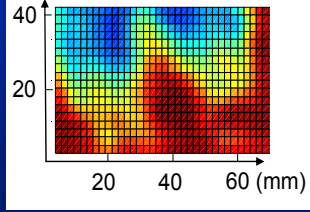
### Example: Imaging Chip Experiment 90GHz



(Heydari-Capolino collaboration)



**Object Imaged**

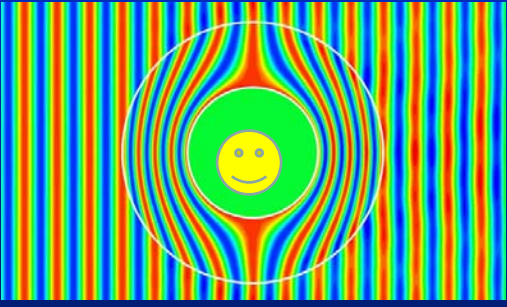


**Composite Image**



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### Can you make things invisible?



(from the internet)

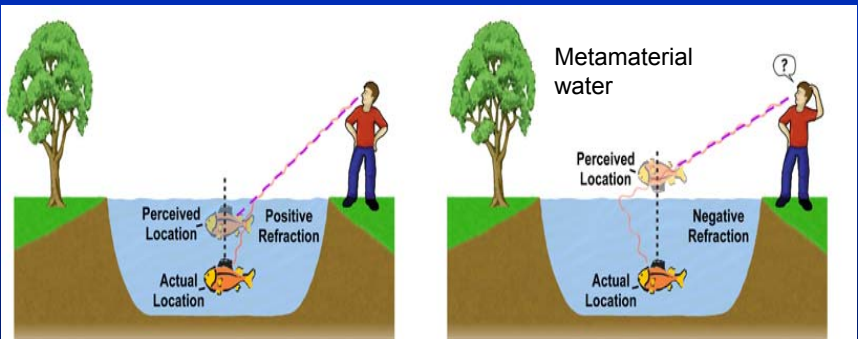


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## WHAT ARE METAMATERIALS?

- ARTIFICIAL STRUCTURES WITH PROPERTIES NOT READILY AVAILABLE IN NATURE
- HAVE A NEGATIVE REFRACTIVE INDEX  $n = \pm \sqrt{\epsilon_r \mu_r}$




(from the internet)

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## Negative Refraction



water:  $n = 1.3$

"negative" water:  $n = -1.3$

(from the internet)

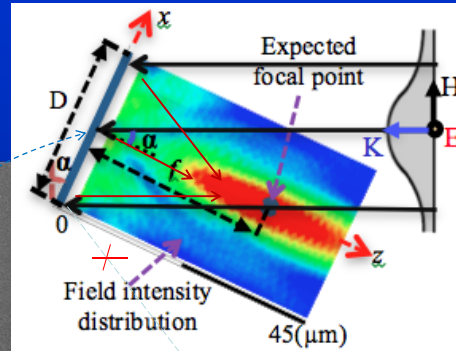
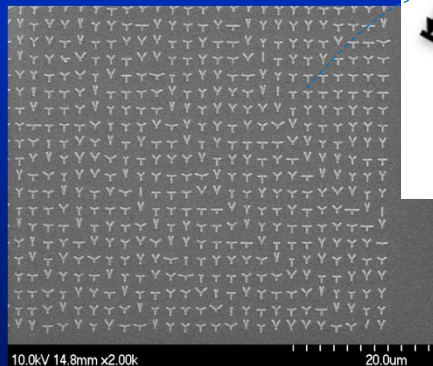
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**Metasurfaces: Flat lenses – Generalized Fermat principle**

Collaboration with Prof. Boyraz  
 PhD students:  
 M. Veysi, C. Guclu

Metasurface for mid-IR focusing

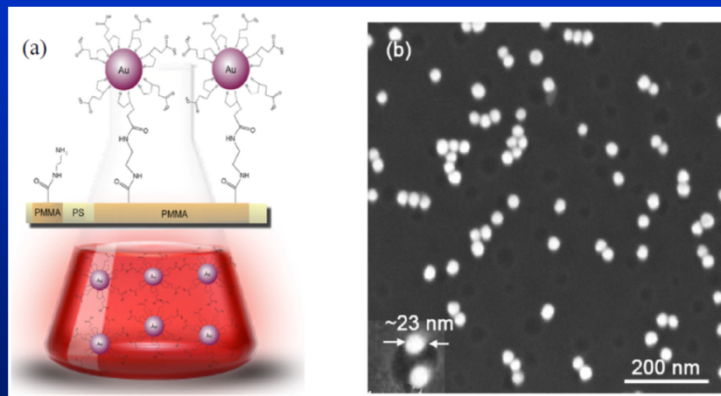


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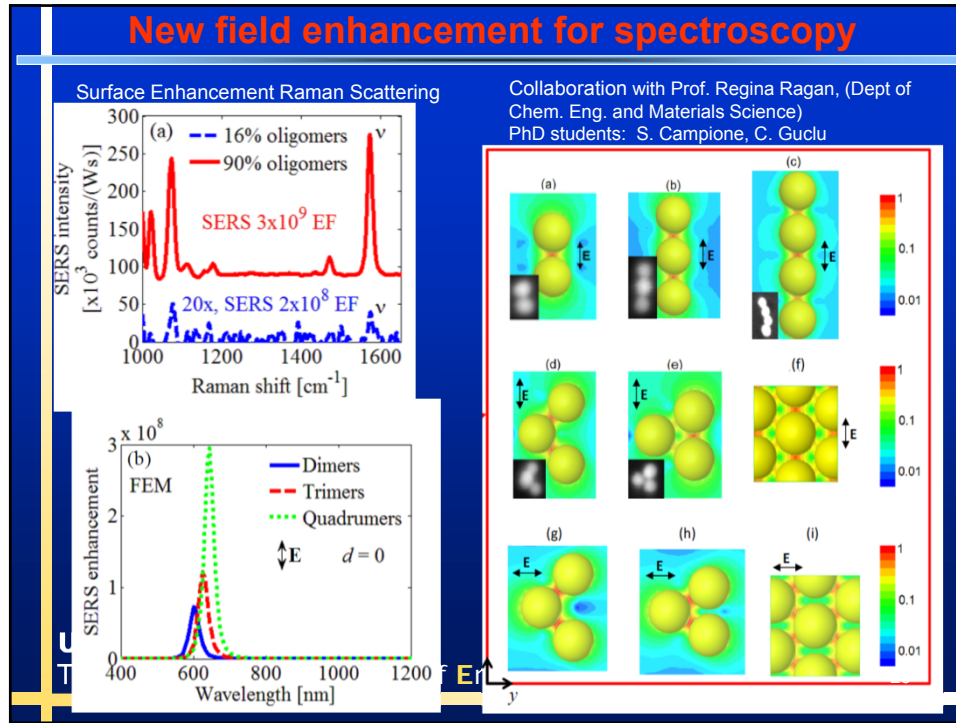
**New field enhancement for spectroscopy**

Collaboration with Prof. Regina Ragan, (Dept of Chem. Eng. and Materials Science)

PhD students: S. Campione, C. Guclu

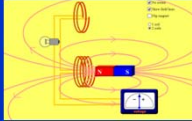




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## Electromagnetics: Historical Perspective

- Michael Faraday (1791 – 1867) discovered magnetic field induction
 



  
- James Clerk Maxwell (1831 – 1879) discovered that electricity, magnetism, and light are all manifestations of the same phenomenon
 



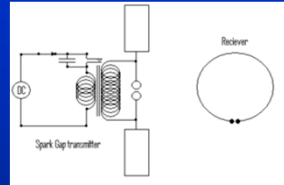
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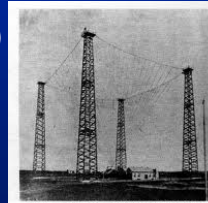
## Electromagnetics: Historical Perspective

- Heinrich Rudolf Hertz (1857 – 1894) conclusively prove the existence of electromagnetic waves

1887 experimental setup of Hertz's apparatus



- Guglielmo Marconi (1874 – 1937) long distance radio transmission



Marconi station at Poldhu, Cornwall, England, about 1905. The four wooden towers support a network of wires which converge to a point just above the transmitting and receiving buildings between the towers.



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## RF circuits: Historical Perspective

- Edwin Howard Armstrong (1890 – 1954) invented the FM radio and heterodyne and regenerative receivers



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## EE Core

<b>Math 2A</b>	1-D Calculus I	<b>EECS 1</b>	Introduction to EECS
<b>Math 2B</b>	1-D Calculus II	<b>EECS 10</b>	Computational Methods
<b>Math 2D</b>	M-D Calculus I	<b>EECS 31</b>	Digital Systems
<b>Math 2E</b>	M-D Calculus II	<b>EECS 31L</b>	Digital Logic Lab
<b>Math 3A</b>	Linear Algebra	<b>EECS 50</b>	Discrete-Time Systems
<b>Math 3D</b>	Differential Equations	<b>EECS 55</b>	Probability
<b>Physics 7C/L</b>	Force, Energy, Motion	<b>EECS 70A/L</b>	Network Analysis I
<b>Physics 7D/L</b>	Electricity, Magnetism	<b>EECS 70B/L</b>	Network Analysis II
<b>Physics 7E</b>	Fluids, Waves, Optics	<b>EECS 145</b>	Adv. EE Mathematics
<b>Physics 51A</b>	Modern Physics	<b>EECS 150</b>	Cont-Time Systems
<b>Chem 1A</b>	General Chemistry	<b>EECS 160A/L</b>	Intro Control Systems
<b>Engr 190W</b>	Tech Communications	<b>EECS 170A/L</b>	Electronics I
		<b>EECS 170B/L</b>	Electronics II
		<b>EECS 170C/L</b>	Electronics III
		<b>EECS 180A</b>	Electromagnetics I
		<b>EECS 189A</b>	Senior Design I
		<b>EECS 189B</b>	Senior Design II

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## EE Specializations: common aspects

- Electronic Circuit Design
- **RF, Antennas and Microwaves**
- Semiconductors and Optoelectronics
- Communications

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## RF, Antennas and Microwaves

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Specialized Electives 3 courses  
 \*Required for Specialization

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<div style="display: flex; flex-direction: column; gap: 10px;"> <div style="display: flex; align-items: center;"> <div> <p><b>Filippo Capolino</b>                      Optics, Plasmonics, Antennas</p> </div> </div> <div style="display: flex; align-items: center;"> <div> <p><b>Franco DeFlaviis</b>                      Antennas for Wireless Comm</p> </div> </div> <div style="display: flex; align-items: center;"> <div> <p><b>Payam Heydari</b>                      High Speed Analog RF/Mixed Signal Circuits</p> </div> </div> <div style="display: flex; align-items: center;"> <div> <p><b>Peter Burke</b>                      Quantum Electronics, Nanotechnology</p> </div> </div> </div>	<div style="display: flex; flex-direction: column; gap: 10px;"> <div style="display: flex; align-items: center;"> <div> <p><b>Ozdal Boyraz</b>                      Integrated Optics, Optical Comm Systems</p> </div> </div> <div style="display: flex; align-items: center;"> <div> <p><b>Chen Tsai</b>                      Micro- and Nanophotonics, Magnetics, Metamaterials</p> </div> </div> <div style="display: flex; align-items: center;"> <div> <p><b>Kumar Wickramasinghe</b>                      Nanotechnology, Force microscopes</p> </div> </div> <div style="display: flex; align-items: center;"> <div> <p><b>G. P. Li</b>                      High Speed Semiconductors, Optoelectronics</p> </div> </div> </div>
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### Besides research and classes

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### You can also enjoy the amazing places near here

Laguna Beach (18 mins away)

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