# Progress In Electromagnetics Research Symposium
## PIERS 2014 in Guagzhou, CHINA 25-28 August, 2014

==========

# Short Course SC001
## Transformation Electromagnetics, Cloaking and Metamaterials

**Professor Raj Mittra**
**The Pennsylvania State University, USA**
http://www.ee.psu.edu/ecrl

**Tuition Fee: (USD 150)**

## Course Objective:

In this short course we will touch on several different topics, namely Metamaterials, Cloaking and Transformation Optics (TO), also known as Transformation Electromagnetics (T-EM). All of these are closely related to each other, and the course presentation will entail a synergistic coverage of the three. It will start by presenting some background materials for each one of these topics, to set the stage for follow-on discussion of their practical applications. We will identify the challenges we face in designing metamaterial (MTM) antennas and cloaks, whether or not they have been designed by using the TO.

## Who Should Attend:

Students, postdocs and antenna engineers interested in learning about MTMs and Invisibility cloaks. Prior background, in the areas of either MTM or Cloaking, is not required.

## Course Outline:

1. **Metamaterials**

a. Introduction to Metamaterials—Popular definitions of MTMs in terms of ε and μ. Classifications of MTMs into four categories, viz., ENG, MNG, DNG and DPS.
b. Realization of MTMs
c. Loss, Dispersion and Bandwidth issues
d. Integrating MTMs into antennas for performance enhancement
e. MTM lenses

2. **Transformation Optics (TO)**
   a. Basic principles of TO
   b. Illustrative examples of antennas and cloaks designed by using the TO
   c. Realization of Materials needed to fabricate TO-based antennas and cloak designs

3. **Cloaks**
   a. Invisibility cloaks
   b. Carpet cloaks
   c. Practical Realizations of Cloaks
   d. Metamaterials and Cloaks

4. **Field Transformation (FT)**
   a. Field Transformation as an alternative to Coordinate Transformation
   b. Fabry-Perot and Lens Antenna designs carried out by using the FT approach.
   c. Performance comparison of TO- and FT-based deigns of antennas and cloaks..

## Instructor(s) Biography:

Raj Mittra is a Professor in the Electrical Engineering department of the Pennsylvania State University, where he is the Director of the Electromagnetic Communication Laboratory. Prior to joining Penn State he was a Professor in the Electrical and Computer Engineering at the University of Illinois in Urbana Champaign from 1957 through 1996, when he moved to his present position at the Penn State University. He is a Life Fellow of the IEEE, a Past-President of AP-S, and he has served as the Editor of the Transactions of the Antennas and Propagation Society. He won the Guggenheim Fellowship Award in 1965, the IEEE Centennial Medal in 1984, and the IEEE Millennium medal in 2000. Other honors include the IEEE/AP-S Distinguished Achievement Award in 2002, the Chen-To Tai Education Award in 2004, the IEEE Electromagnetics Award in 2006, and the IEEE James H. Mulligan Award in 2011. He has been a Visiting Professor at Oxford University, Oxford, England and at the Technical University of Denmark, Lyngby, Denmark.

**Any Inquiry To: PIERS OFFICE**
**EMAIL: office@piers.org and/or tpc@piers.org**