	Document Code	RG-712	Written by	Name	Dr. Waqas A. Qazi
				Date	2nd Sep., 2015
	Title	Radar Remote Sensing	Reviewed by	Name	
				Date	
	Credit Hours	3-0	Approved by	Name	
				Date	

INSTITUTE OF SPACE TECHNOLOGY

COURSE SYLLABUS

Program: RS & GISc
Department: Space Science (SS)
Course Code: RG-712
Course Name: Radar Remote Sensing
Credits: CR 3-0
Instructors: Dr. Waqas A. Qazi, Dr. Farrukh Chishtie
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COURSE DESCRIPTION:

This is a graduate-level course on remote sensing using active radar. It presents an overview of radar basics, radar signals, interaction of radar with targets, and different remote sensing applications.

It is expected that students will develop a quantitative understanding of radar system design and requirements for remote sensing, how different kind of targets interact with radar signals, and how the analysis of these returned signals can help us in gaining information about different properties of the target, e.g. composition, structure, shape etc. This course will NOT prepare you to build a radar hardware system, rather how the radar system can be used for remote sensing and extracting useful information from targets using remote sensing.

A course project will let students work on processing and analyzing data acquired from a radar remote sensing instrument of their choice, and present the results. More details about the project will be provided during the course.

Prerequisites: Basic knowledge of mathematics is required. Knowledge of Fourier transforms, signal processing, etc. is recommended and will be very helpful in this course. Knowing basics of programming will help students to gain more from this course. Students who don't have the recommended skills should be prepared to work and study extra.

Reading/Reference Materials:
Recommended Textbook:

- Richards (2009), Remote Sensing with Imaging Radar

Supporting & Reference Books and Readings:

- Sullivan (2004), Radar Foundations for Imaging & Advanced Concepts
- Radar books by Mahafza (very similar):
    - Mahafza (2009), Radar Signal Analysis & Processing using MATLAB
    - Mahafza (2000), Radar Systems Analysis & Design using MATLAB
- Oliver & Quegan (2004), Understanding Synthetic Aperture Radar Images
- Jackson & Apel (2004), SAR Marine User's Manual
- Weng (2006), Satellite Microwave Remote Sensing
- Lillesand & Kiefer (2007 6th ed. / 2003 5th ed.), Remote Sensing & Image Interpretation
- Lectures
- Relevant papers
- Assigned readings

COURSE PLAN:

Week	**Topic**	**Resource Persons**	**Reference Material**
1	- Introduction to Remote Sensing - Radar Basics	Dr. Waqas Qazi	Lillesand & Kiefer Ch. 1, Provided reading material
2	- Introduction to Radar RS - History of Radar RS - Mathematics for Radar I: Complex Numbers	Dr. Waqas Qazi	Readings from Richards2009

3	Fundamental Concepts:
	- Radar Fundamentals:
	  - Pulses
	  - Ranging & Range Ambiguity
	  - Doppler Radar
	- Mathematics for Radar II: Electromagnetic Waves
		Dr. Waqas Qazi	Readings from Richards2009 and Mahafza2009

4	- Mathematics for Radar II: Electromagnetic Waves (continued) - Radar Equation (derivation)	Dr. Waqas Qazi	
5	- Radar Equation with noise & losses - SNR - Radar equation analysis - Mathematics for Radar III: Decibels	Dr. Waqas Qazi	
6	- Antennas - Directivity & Gain	Dr. Waqas Qazi	

	- Antenna pattern - Array antennas - Imaging Radar		
7	- Imaging Radar - Mathematics for Radar IV: Fourier Transforms	Dr. Waqas Qazi	
8	- Mathematics for Radar V: Probability Distributions - Radar equation application for point, area and volume targets		
9	***MIDTERM EXAM*** - Pulse Compression - Intro to MATLAB	Dr. Waqas Qazi	
10	- Geometric Distortions in Imaging Radar: - Compressional distortion - Layover - Foreshortening - Shadow - Radar Cal/Val - Passive calibration targets - Active calibration targets (transponders)	Dr. Waqas Qazi	
11	- Radar Scattering Processes: - Radar cross section (RCS) - Basic scattering processes (Rayleigh/Mie/Non-selective) - Radar equation for a distributed target - Volume scattering application for radar remote sensing of precipitation - Radar RS Applications – SAR: - SAR signal formation - SAR imaging modes	Dr. Farrukh Chishtie / Dr. Waqas Qazi	
12	- Radar RS Applications – SAR: - Speckle noise - Radiometric calibration - Radar Signals: - Complex signals - Doppler spectrum -	Dr. Waqas Qazi	
13	- Radar Scattering from Earth Surface Features: - Surface/Volume/Hard target scattering - Relative permittivity and		

	dielectric constant
	- Signal penetration & absorption
	- Surface scattering
	  - Scattering from smooth surfaces
	  - Scattering from rough surfaces
	  - Rayleigh roughness criterion
	  - Penetration depth
	  - Polarization dependence
	- Volume scattering
	  - Backscatter models
	  - Depolarization
	- Hard target scattering
	  - Point targets
	  - Corner reflectors
	  - Urban areas
	- Ocean Surface Imaging with Radar/SAR:
	  - Two-scale model
	  - Bragg scattering
	  - Biogenic slicks and Bragg wave damping
	  - Oil spills
	  - Ship and wake detection
	- SAR for forest biomass estimation		

14	Radar RS Applications – SAR: - Interferometry - TerraSAR-X & TanDEM-X Radar RS Applications – Altimetry: - Radar altimetry - Sea Surface Height measurements - Jason-1/Jason-2 Radar RS Applications – Scatterometry: - Radar scatterometry - Ocean surface wind measurements - QuikSCAT	Dr. Waqas Qazi	
15	Radar RS Applications – Radar Meteorology: - Radar for meteorology - Precipitation measurements	Dr. Farrukh Chishtie	

	- Z-W Relationship - Z-R Relationship - TRMM		
16	Course project presentations	Dr. Waqas Qazi	
17	**Final Examination**		

TEACHING METHODOLOGY

The course will be taught using lectures, in-class discussions, homework assignments, and individual research projects.

ASSESMENT:

The general grading distribution is as follows (subject to change):

Assignments	30%
Course Project	15%
Mid-term Exam	25%
Final Exam	30%
Total	100%

General Course Policies:

- The Course Grading percentage distribution is loosely defined and may be changed by the end of the course. Students will be notified if such changes take place.
- The classroom environment shall preferably be active and open discussions are very much favored, but please try to stick to the topic under discussion.
- In assignments, any/all references must be PROPERLY quoted and cited and this must be STRICTLY followed. Marks will be deducted if this strict rule is not attended to.
- All graded work must be the original effort of the student. Plagiarism (either copying from another student or writing text without proper referencing) will NOT be tolerated. Severe grading loss may result, so please be careful. A quick search on Google will show you what plagiarism is and how to avoid it. It is your responsibility to avoid plagiarism.
- Do NOT take assignment deadlines lightly. If you have a problem, come to the instructor before the deadline, not after it. Deadlines will not be relaxed unless in case of an emergency. Marks will be deducted, as deemed suitable, for late submissions.