# Laurea Magistrale
# Atmospheric Science and Technology (LMAST)

| SUBJECT TITLE | Electromagnetics and radar meteorology |
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| **TEACHER NAME(S)** | Frank S. Marzano (3 CFU), Mario Montopoli (3 CFU) |
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| *Teacher phone* | +39.06.44585847 |
| *Teacher meeting* | Wednesday, h. 15-16 |
| *Teacher office address* | Via Eudossiana 18, Rome (S. Peter in chain site) |
| **DISCIPLINE (SSD)** | ING-INF/02 (Electromagnetic fields) |
| *Semester (1-4) and location* | 1 (first) & Rome at Via Eudossiana |
| *Credits (CFU/ECTS)* | 6 |
| *Lecture hours (h)* | 60 (45 lectures + 15 exercise/laboratory) |
| *Prerequisite and learning activity* | Physics, Algebra, Calculus & Fourier transform, Computer programming |
| *Teaching language and method* | English & Lectures, exercises and homeworks |
| *Assessment method* | Oral examination and optional dissertation on a selected state-of-the-art topic |
| **SUBJECT WEBSITE** | https://cispio.diet.uniroma1.it/marzano/RadarMeteorology.htm |

**OBJECTIVES**

Main goals are:
- to introduce the classical electromagnetic vector field theory and its main theorems;
- to derive properties of plane and spherical waves and the related reflection and refraction phenomena;
- to provide the basics of electromagnetic radiation theory, radiopropagation and particle scattering;
- to provide the basics of clouds and precipitation microphysics and the related radar observables;
- to describe the microwave Doppler polarimetric radar sensor principles and basic equations;
- to illustrate the main applications of radar meteorology and data processing.

**OUTCOMES (Dublin descriptors: knowledge, understanding, explain, skill, ability)**

After the successful completion of this module, the student should be able to:
- know the basic principles of electromagnetics and radar meteorology;
- identify the appropriate analytical techniques to approach an electromagnetic problem;
- understand the different processes involved within wave propagation and scattering in atmosphere;
- explain the signature of meteorological radar measurements for various applications;
- show skills for reading and understanding main scientific literature and texts on related topics;
- demonstrate the ability to process meteorological data and develop own algorithms.

**PROGRAM CONTENT**

FUNDAMENTALS. Introduction to electromagnetic vector field theory. Maxwell's vectorial equations in time and frequency domain. Medium constitutive relations. Helmholtz's vectorial equations.
THEOREMS AND WAVES. Uniqueness, duality, continuity, Poynting, reciprocity, equivalence theorems. Plane waves in vacuum. Reflection and refraction of polarized plane waves from specular surfaces.
ELECTROMAGNETIC RADIATION. Spherical waves. Hertzian source and Green function. Radiation integral in the far-field region. Antenna pattern, gain and effective aperture. Free-space propagation equation. Geometrical optics.
ELECTROMAGNETIC SCATTERING. Field integral equations. Scattering complex matrix. Rayleigh and Mie scattering. Optical scattering. Particle size distributions. Radar polarimetric observables in amplitude and phase.
RADAR SENSOR. Measurement principles. Radar sensor configurations and systems: incoherent, coherent, polarimetric. Doppler effect. Matched filter and signal statistics. Radar equation for single and distributed scatterers. Refraction effects. Ground-clutter removal. Radar calibration techniques.
RADAR METEOROLOGY. Elements of clouds and precipitation microphysics. Stratiform and convective systems. Classification and inversion techniques. Ground-based retrieval of hydrometeor type, precipitation rate, water content, wind velocity. Attenuation correction. Spaceborne meteorological radars.
LABORATORY. Cyclonic cloud features on radar imagery. Case studies and radar data processing applications. Guided tours to C-band and X-band meteorological radar sites.

**REFERENCES AND MATERIAL**


- Texts and slides provided by the teachers and available on the course web site.
- Bringi V.N. and V. Chandrasekar, *Polarimetric Doppler Weather Radar*. Cambridge Univ. Press, 2001.
- Collin R.E., *Antennas and radiowave propagation*, McGraw-Hill ISE, 1985.
- Sauvageot H., *Radar meteorology*, Artech House, 1992.
- Stull R.B., *Meteorology for scientists and engineers*, 2nd ed., Brooks/Cole, 2000.
- Ulaby F.T and U. Ravaioli, *Fundamentals of Applied Electromagnetics*, Pearson Education, 2015.
- Wallace J.M. and P.V. Hobbs, *Atmospheric Science*, *Second Edition*, Academic Press, 2006.