Laurea Magistrale
Atmospheric Science and Technology (LMAST)

SUBJECT TITLE	**Foundations of meteorology - Part 1 and 2 (6+3 CFU)**
TEACHER NAME(S)	Anna Maria Siani (6 cfu), Marco Cacciani (3 cfu)
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Teacher meeting	Tuesday h 16.00-18.00 and by appointment
Teacher office address	University Campus, Sapienza Universitàdi Roma, Fermi Building, room 308-501
DISCIPLINE (SSD)	FIS06 Physics for Earth and Atmospheric Sciences
Semester (1-4)	1
Credits (CFU/ECTS)	6+3
Lecture hours (h)	Siani: 45 lectures + 15 exercises; Cacciani:30 lectures)
Prerequisite and learning activity	fundamentals of classical physics
Teaching language and method	English
Assessment method	Mid-term written exam and final oral exam
SUBJECT WEBSITE	

OBJECTIVES

This introductory course aims to show how weather phenomena are linked to classical physical principles applied to the atmosphere. Main goals are:
-to provide the fundamentals physical concepts and equations necessary for understanding the state of the atmosphere;
- to introduce mathematical simplifications of the terms in the equations;
- to provide the basis for an examination of adiabatic processes and the atmospheric stability and instability ;
- to illustrate basic instruments used for surface and upper meteorological observations
- to introduce the theory of Atmospheric Radiative Transfer;
The course will deal also with exercises involving calculations on temperature inversions, lapse rate, moisture in atmosphere; some types of exercises require practise (weather symbols, weather maps analysis and soundings)

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

After the successful completion of this module, the student should be able to:
- be confident with the terminology used in meteorology;
- acquire a basic knowledge on atmospheric dynamics necessary for understanding synoptic atmospheric motions;
- understand synoptic charts and identify the most relevant weather patterns.
- use thermodynamic diagrams to determine cloud bases, tops, stability and instability and other information;
- acquire a basic knowledge on Atmospheric Radiative Transfer

PROGRAM CONTENT

INTRODUCTION. Historical background of Meteorology. Introduction and characteristics of the atmosphere (atmospheric composition, pressure and vertical temperature profile). Weather symbols and definitions. Basic instruments used for meteorological observations from surface and upper air stations. Definitions of properties of the horizontal flow.
ATMOSPHERIC CIRCULATION. Fundamental forces, Non inertial reference frames and "Apparent" Forces. Structure of the Static Atmosphere, geopotential height. Vertical coordinate systems. The Momentum Equation, the Continuity Equation, The Thermodynamic Energy Equation. Scale Analysis of the Equations applied to different atmospheric motions, in particular to mid-latitude synoptic systems. The hydrostatic approximation. Natural coordinates, Balanced flow: geostrophic wind and the effect of friction; gradient wind and cyclostrophic flow. Thermal wind, Thickness and Temperature. Pressure tendency equation. Quasi-static approximation. Circulation and vorticity, the vorticity equation.
ATMOSPHERIC THERMODYNAMICS. Complements of thermodynamics: Gas laws of dry and moist air, virtual temperature, the first law of thermodynamics, adiabatic processes, potential temperature, the moisture parameters (mixing ratio, absolute humidity, specific humidity). Saturation vapour pressure and saturation moisture parameters (relative humidity, wet bulb temperature and dew point temperature). Saturated adiabatic and pseudo-adiabatic processes. Lifting Condensation Level. Dry and saturated adiabatic lapse rates. Equivalent potential temperature and wet-bulb potential temperature.
Static Stability and stability indices. CAPE, CIN. Precipitable water content.
APPLICATIONS. Exercises: meteorological maps (surface pressure maps, thickness and heights of constant pressure maps); wind and pressure. The psychrometric chart. Thermodynamic diagrams, soundings plotting and atmospheric stability indices.
RADIATIVE TRANSFER. Introduction to the radiative transfer. Basic radiometic quantities. Blackbody radiation. Natural greenhouse effect: surface temperature, Kirchhoff law, selective atmospheres. General equation of radiative transfer. Beer-Lambert law. Schwarzchild equation. Plane-parallel atmosphere. Absorption of Solar and Terrestrial radiation. Scattering from molecules and aerosol: Rayleigh and Mie scattering, cross section, phase function, extinction coefficient, single scattering albedo, asymmetry factor. Equation of radiative transfer for diffusive atmospheres. Radiative heating and cooling. Actinic flux.

REFERENCES AND MATERIAL

J.R. Holton, Introduction to dynamic Meteorology, 2004; **J. M.Wallace and P. V. Hobbs**, Atmospheric Science, An Introductory Survey,2005; **A. A. Tsonic**, An Introduction to Atmospheric Thermodynamic, Cambridge University Press, 2002; **K.N.Liou,** An Introduction to Atmospheric Radiation, 2002