Specialization: Atmospheric Physics & Oceanography

Semester-III	
Course Code	**Course Name**
21MSP611T	Fundamentals of Ocean Sciences
21MSP612T	Instrumentation and modelling of Oceans and Atmosphere
21MSP613T	Physics and dynamics of the atmosphere
21MSP620P	Atmospheric Physics & Oceanography Laboratory
21MSP601	Project-I
	Semester-IV
	Project - II

M.Sc. Course					21MSP611T- Fundamentals of Ocean Sciences					
Teaching Scheme					**Examination Scheme**					
L	**T**	**P**	**C**	**Hrs/Week**	**Theory**			**Practical**		**Total Marks**
					MS	**ES**	**IA**	**LW**	**LE/Viva**	
3	**0**	**0**	**3**	**3**	**25**	**50**	**25**	**--**	**--**	**100**

COURSE OBJECTIVES

- To give an overview of the science of oceanography and how it is practiced
- To integrate all specific concepts of oceanography into a multidisciplinary analysis of the Earth
- To stimulate students' interest and curiosity in the many and varied sciences used in the study of the oceans
- To show importance of studying oceanography to understand future challenges.

UNIT 1 EVOLUTION OF EARTH'S OCEAN	10 Hrs.
Introduction, Evolution of earth's structure, Physiographic of ocean's origin and evolution of ocean basins (continental and oceanic basins), Continental drift, Sea floor spreading, Plate tectonics and deep sea sedimentation, Effect of glaciation and inter-glaciation on oceans.	
UNIT 2 PHYSICAL CHARACTERISTICS	**12 Hrs.**
Physical Characteristics of the Ocean: Ocean Basins, Sea floor features, Properties of sea water & Equation of State, Temperature, Salinity, Density and Oxygen characteristics, Vertical profile of temperature and salinity in the three major oceans. Water mass characteristics: Formation and Classification of water mass. T-S diagram, Mixing processes in the oceans, Upwelling and downwelling processes, Oceanic heat, salt and momentum budgets.	
UNIT 3 GENERAL CIRCULATION	**12 Hrs.**
General circulation of ocean, Thermohaline circulation, Conveyor belt formation, Abyssal circulation, mixing, ocean heat budget and transport, Wind stress, Geostrophic flow in Ocean - Ocean currents, Equatorial current systems; Wind driven ocean circulation, Ekman pumping, Ekman transports, Ocean waves, their generation and propagation, Wave spectrum, storm surges and tsunamis, Tides and tide generating forces, Atmospheric response to equatorial heating: Monsoons, Introduction to decadal phenomenon such as the PDO, Penetration of Solar Radiation, Oceanic Kelvin and Rossby waves, Indian Ocean Dipole, Madden-Julian oscillation (MJO), Elnino and Southern Oscillation (ENSO).	
UNIT 4 FUTURE OF OCEANS	**11 Hrs.**
Carbon sequestration, Effect of Global warming on oceans: Sea ice formation, modifications in polar ice, ocean biogeochemistry, ocean acidification, ocean circulations, effects over cyclones, stored CO2 at ocean bed, cloud formation, sea floor spreading, Future trends, Type of ocean pollution and available solutions, Sustainable development, Major challenges in oceanography of present and future.	
	Max. 45 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 - Explain basic theories explaining evolution of oceans along with the plate tectonics

CO2 - Analyse atmospheric and oceanic circulation systems as well as their interconnections and driving forces.

CO3 - Describe the principals involved in the generation of waves and tides and evaluate their effects on coastal processes and marine ecosystems.

CO4 - Explain the relationship between ocean and atmosphere

CO5 - Correlate the concepts learned so far with the Global warming.

CO6 - Develop the skills in solving various real world problems in Oceanography

TEXT/REFERENCE BOOKS

1. Introduction to Physical Oceanography: Robert Stewart
2. Regional Oceanography: Tomzack and Godfrey
3. Principles of Ocean Physics by J.R. Apel, Academic Press.
4. Atmospheric and Ocean Dynamics A.E. Gill, Academic Press.
5. The Oceans, their Physics, Chemistry and General Biology by H.U. Sverdrup
6. Principles of Physical Oceanography by G. Neumann & WJ Pierson, Jr.
7. Descriptive Physical Oceanography by G Dietrich
8. Physical Oceanography Vol I & II by A. Defant
9. Introduction to Physical Oceanography by W.S. VonArx
10. Ocean Currents by G. Neumann
11. Tides, Surges and mean sea level by D. T. Pugh

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100	**Exam Duration: 3 Hrs**
Part A/Question: 10 objective questions of 2 marks each from all 4 units	20 Marks
Part B/Question: 8 long questions of 10 marks each from all 4 units	80 Marks

M.Sc. Course					21MSP612T- Instrumentation and modelling of Oceans and Atmosphere					
Teaching Scheme					**Examination Scheme**					
L	**T**	**P**	**C**	**Hrs/Week**	**Theory**			**Practical**		**Total Marks**
					MS	**ES**	**IA**	**LW**	**LE/Viva**	
3	**0**	**0**	**3**	**3**	**25**	**50**	**25**	**--**	**--**	**100**

COURSE OBJECTIVES

- To introduce working principles of instrumentations employed for atmospheric studies.
- To introduce working principles of instrumentations employed for oceanic studies.
- To familiarize with various weather and climate models and simulation approaches.
- To overview the basic characteristics of remote sensing imagery and its applications

UNIT 1 ATMOSPHERIC MEASUREMENTS	08 Hrs.
General principles of surface instrumental measurements, accuracy requirements, Barometer, hygrometer, anemometer, rain gauge, conventional measurements of pressure, temperature, humidity, wind, precipitation, visibility, clouds, radiosondes, radiometersondes, ozonesonde, Basic working principles of LIDARS, SODARS, RADAR, Doppler weather radar, Disdrometer, Aerosol measurements, Satellite meteorology: atmospheric satellite system, orbits and characteristics of different atmospheric satellite system, geostationary system, polar orbiting system component of satellite systems, meteorological satellites, polar orbiting & geo stationary satellites, current and future meteorological satellites of the world	
UNIT 2 OCEAN INSTRUMENTATION	**12 Hrs.**
Nature of Ocean instrumentation: environmental considerations, design constraints, power requirements, operational features, relevance of in-situ measurements. Sensors for salinity, DO, pH, ammonia, turbidity, wind, Solar radiation, atmospheric pressure, Portable instruments : ST meter, STD meter, CTD systems current meter, Underwater LUX meter, Shipborne Data Acquisition Systems, Marine Meteorological Data Acquisition Systems, ocean data buoys, wave rider buoys, SONAR systems, Acoustic tomography, Fundamentals of remote sensing in Oceanography.	
UNIT 3 MODELING AND SIMULATIONS	**08 Hrs.**
Introduction to weather and climate models - regional and coastal ocean models, shallow water models, multi-level basin scale and global ocean models, ocean wave modelling; Numerical Modeling Vs. Other Modeling Approaches, Model Hierarchy (Simple, Intermediate, Complex); Examples of atmospheric and oceanic simulations, Governing equations in Cartesian, Isobaric and sigma coordinate systems; global and regional models used in weather forecasting and climate simulations.	
UNIT 4 REMOTE SENSING	**12 Hrs.**
Fundamentals of remote sensing, methods for detecting trace gases and particles in the atmosphere, satellite-based Sensors in Visible and Infrared Wavelengths: Low, medium and high spatial resolution sensors, tools to acquire and process remotely sensed data, satellite spectroscopy, applications of remote sensing in synoptic scale meteorology and climate change studies, space borne LIDARs, Earth Observation Satellite systems.	
	Max. 40 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 - Know the basic working principles of various instrumentations used for the atmosphere and ocean studies.

CO2 - Record and analyse data acquired for the measurement of turbidity, humidity, satellite sensors, wind, Solar radiation, atmospheric pressure, etc.

CO3 – Explain the choice of portable instruments for atmospheric and ocean studies based on the application requirement.

CO4 - Describe various atmosphere and ocean instrumentations such as LIDARS, SODARS, RADAR, satellite sensors and image acquisition methods.
CO5 - Learn how to apply different atmosphere and ocean models based on parameterization of data and condition.
CO6 - Develop understanding of various methods and techniques employed for determining weather and climate changes.

TEXT/REFERENCE BOOKS

1. Wallace, J. M. and P. V. Hobbs, Atmospheric Science - An Introductory Survey, Academic Press, 2006.
2. Stull, R.B., Meteorology for Scientists and Engineers, Brooks/Cole, 2000.
3. Buyers, H.R., General Meteorology, McGraw Hill Book Company, 1977.
4. Jacobson M. Z., Fundamental of Atmospheric Modelling, Cambridge University Press, 1999.
5. Vallis G.K., Atmospheric and Oceanic Fluid Dynamics, Cambridge Univ. Press, 2006.
6. Pedlosky J., Geophysical Fluid Dynamics, Springer-Verlag, 1979.
7. Holton J.R., An Introduction to Dynamic Meteorology, Academic Press, 1992.
8. Pedlosky J., Geophysical Fluid Dynamics, Springer-Verlag, 1979.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100	**Exam Duration: 3 Hrs**
Part A/Question: 10 objective questions of 2 marks each from all 4 units	20 Marks
Part B/Question: 8 long questions of 10 marks each from all 4 units	80 Marks

M.Sc. Course					21MSP613T- PHYSICS AND DYNAMICS OF THE ATMOSPHERE					
Teaching Scheme					**Examination Scheme**					
					Theory			**Practical**		
L	**T**	**P**	**C**	**Hrs/Week**	**MS**	**ES**	**IA**	**LW**	**LE/Viva**	**Total Marks**
3	**0**	**0**	**3**	**3**	**25**	**50**	**25**	**--**	**--**	**100**

COURSE OBJECTIVES

- To introduce atmospheric physics, thermodynamics, turbulence in the atmospheric boundary layer
- To familiarize with physical principles and how they determine the structures of the atmosphere and clouds
- To discuss application relevant for studies pertaining to various disciplines of atmospheric sciences
- To teach students the fundamental principles of atmospheric dynamics to understand various atmospheric circulations/phenomena.

UNIT 1 FUNDAMENTALS OF ATMOSPHERE	10 Hrs.
Structure of the atmosphere; Hydrostatic equilibrium, Geopotential, Hypsometric equation and scale height, Altimetry; Adiabatic processes, Lapse rates, Static stability, dynamic stability; Atmospheric Boundary Layer, Structure and evolution, turbulence etc.	
UNIT 2 ATMOSPHERIC THERMODYNAMICS	**12 Hrs.**
Thermodynamic laws; Thermodynamics of water vapour and moist air: Moisture parameters, Saturated adiabatic and Pseudo adiabatic processes, Conditional and convective instability, Free and forced convection; Thermodynamic diagrams; Phase change and Clausius-Clapeyron equation; Clouds: Formation and classification, Precipitation; Atmospheric visibility: Dew, Frost and fog, smog.	
UNIT 3 PHYSICS OF RADIATION	**11 Hrs.**
Solar and terrestrial radiation, radiation laws; absorption, emission and scattering in the atmosphere, Schwarzchild's equation; Radiation in the earth-atmosphere system: Geographical and seasonal distribution, Radiative heating and cooling of the atmosphere, Surface energy budget, The mean annual heat balance.	
UNIT 4 DYNAMICS OF ATMOSPHERE	**12 Hrs.**
Fundamental forces; basic laws of conservation; hydrodynamic equations in rotating frame of reference; geostrophic and hydrostatic approximations; Atmospheric stability; Isobaric coordinate system; Gradient wind approximation; thermal wind; vertical motion; Circulation and vorticity; potential vorticity conservation. Boussinesq approximation; Reynolds averaging; mixing length hypothesis; Acoustic, gravity, Poincare, Rossby and Kelvin waves.	
	Max. 45 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 - Know the basic thermodynamic concepts for the atmosphere and be able to apply thermodynamic diagrams to assess stability and cloud conditions

CO2 - Be able to set up and make simple numerical simulations to illustrate cloud droplet formation and energy transport by radiation

CO3 - Explain the physical laws governing the structure and evolution of atmospheric phenomena spanning a broad range of spatial and temporal scales.

CO4 - Develop a background in the mathematical description of atmospheric and geophysical fluid dynamics, and apply mathematical tools to study atmospheric processes.

CO5 - Learn how to apply fundamental equations of fluid flow to understand atmospheric circulation, wind patterns, jet streams.

CO6 - Develop integrated knowledge of the fundamentals of atmospheric dynamics that govern weather and climate of the earth.

TEXT/REFERENCE BOOKS

1. Wallace, J. M. and P. V. Hobbs, Atmospheric Science - An Introductory Survey, Academic Press, 2006.
2. Stull, R.B., Meteorology for Scientists and Engineers, Brooks/Cole, 2000.
3. Buyers, H.R., General Meteorology, McGraw Hill Book Company, 1977.
4. Jacobson M. Z., Fundamental of Atmospheric Modelling, Cambridge University Press, 1999.
5. Vallis G.K., Atmospheric and Oceanic Fluid Dynamics, Cambridge Univ. Press, 2006.
6. Pedlosky J., Geophysical Fluid Dynamics, Springer-Verlag, 1979.
7. Holton J.R., An Introduction to Dynamic Meteorology, Academic Press, 1992.
8. Pedlosky J., Geophysical Fluid Dynamics, Springer-Verlag, 1979.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100	**Exam Duration: 3 Hrs**
Part A/Question: 10 objective questions of 2 marks each from all 4 units	20 Marks
Part B/Question: 8 long questions of 10 marks each from all 4 units	80 Marks

M.Sc.					21MSP620P- Atmospheric Science and Oceanography Lab					
Teaching Scheme					**Examination Scheme**					
L	**T**	**P**	**C**	**Hrs/Week**	**Theory**			**Practical**		**Total Marks**
					MS	**ES**	**IA**	**LW**	**Viva**	
0	**0**	**6**	**3**	**6**	**-**	**-**	**-**	**50**	**50**	**100**

COURSE OBJECTIVES

- To obtain practical knowledge of the instruments used in atmospheric science and oceanography.
- To interpret and analyse remote sensing data for better understanding of short and long term weather patterns.
- To understand ocean and atmospheric dynamics using simulations and modelling.

List of Experiments

Suitable experiments may be selected by the teacher from the list given below depending on availability of time and resources.

1. To examine air quality using concentration of CO and CO2 using digital sensor ar various spatial resolutions.
2. To do programming and data analysis of various atmospheric parameters such as temperature and humidity using Arduino UNO Mini Weather Station.
3. To analyze atmospheric data of atmospheric science with the help of MATLAB and visualization of atmospheric datasets using GRADS.
4. To do programming and data analysis of various atmospheric parameters using Arduino UNO Mini Weather Station.
5. Implementation of atmospheric parameters to understand spatial and temporal variation using Arduino UNO Mini Weather Station.
6. To examine spatial distribution of humidity at various scales using dry and wet bulb hygrometer.
7. Vector analysis of wind speed and direction using Smart Vane Anemometer.
8. To examine indoor and outdoor air quality using using various parameters.
9. To interpret diurnal variation of humidity and temperature using humidy and temperature sensor.
10. Validation of digital hygrometer with wet and dry bulb hydrometer.
11. To study wind trajectory using Hysplit model.
12. To quantify salinity as well as density of ocean water with the help of Hydrometer and plot TSD graph.
13. To determine amount of chloride ion, salinity and dissolved oxygen (DO) in the ocean water.
14. To examine acid-base indicators of seawater with the help of pH meter.
15. Levitus climatology of temperature and salinity – estimation of ocean mixed layer depth and climatology – T-S diagram and water mass analysis
16. Computation of latent and sensible heat fluxes using bulk formula – radiation budget – heat budget using OAFlux data – interannual variations in heat balance – heat transport
17. Ocean circulation: seasonal wind pattern over Indian Ocean – wind stress distribution – ocean circulation using SODA data
18. Study of ENSO - Southern Oscillation index – Pacific Ocean warm pool variability – Nino index – Indian Ocean Dipole Mode (IOD) to understand Interannual variability of ocean
19. Lab and/or field based student mini project

COURSE OUTCOMES

On completion of the course, the students will be able to

CO1 - Understand the various concepts of atmospheric science, oceanography and remote sensing.
CO2 - Apply basic concepts of atmospheric science and oceanography to understand practical current problems.
CO3 - Demonstrate and implement the variation of basic atmospheric and oceanographic parameters.
CO4 – Analyze in-situ and remote sensing data to study nature and pattern of parameters.
CO5 – Examine and calculate the error in various data sets.
CO6 – Design circuits using various components of Arduino kit to study various paramenters.

TEXT/REFERENCE BOOKS

1. The Atmosphere: An introduction to Meterology, Frederick K. Lutgens, Edward J. Tarbuck, Illustrated by Dennis G. Tasa, PHI Learning Private Limited.
2. Introduction to Satellite Remote Sensing, William Emery, Adriano Camps, IEEE publication.
3. Image Processing and GIS for Remote Sensing: Techniques and Applications, Jian Guo Liu, Philippa J. Mason, Wiley Blackwell.
4. Measurement Methods in Atmospheric Sciences: In Situ and Remote, American Meteorological Society Education Program by Stefan Emeis.
5. Introductory Dynamical Oceanography: Stephen Pond & George L. Picard, 1986, 329p.
6. Computer Modeling in Atmospheric and Oceanic Sciences: Peter Muller and Hans Von Storch, springer, 2004, 304p.
7. Numerical Modelling of Oceans and Oceanic Processes: Lakshmi H.Kantha & Carol AnneClaysor, Academic Press, 2000,943p