Department of Meteorology and Oceanography

Rokkam Ramanadham Laboratoraries

Andhra University

Visakhapatnam

M. Sc. Physical Oceanography

Syllabi and Model Question Papers

(Effective from 2021-2022 Academic year)

Approved Course Pattern and Syllabi w.e.f. 2021-2022 academic year M.Sc. (Physical Oceanography)

First Semester

Course No.	Title of the Paper	Internal assessment marks	Semester end examination marks	Total Marks	Credits
Theory:					
PO–101	Physics and Dynamics of Climate	20	80	100	4
PO–102	Physical Meteorology	20	80	100	4
PO–103	Dynamics of the Atmosphere	20	80	100	4
PO–104	Physical Oceanography	20	80	100	4
Practicals:					
PO–105	Meteorology Computations	20	80	100	4
PO–106	FORTRAN Programming	20	80	100	4
PO–107	Viva-voce	-	50	50	2
	Total	120	530	650	26

Second Semester

Theory:					
PO–201	Dynamical Oceanography	20	80	100	4
PO–202	Geophysical Fluid Dynamics	20	80	100	4
PO–203	Meteorology and Oceanography Instruments	20	80	100	4
PO–204	Synoptic Meteorology	20	80	100	4
Practicals:					
PO–205	Ocean Computations	20	80	100	4
PO–206	Observational Techniques	20	80	100	4
PO–207	Viva-voce	-	50	50	2
	Total	120	530	650	26

Third Semester

Theory:					
PO–301	Numerical Weather Prediction	20	80	100	4
PO–302	Air Sea Interaction	20	80	100	4
PO–303	Indian Ocean Dynamics	20	80	100	4
PO–304	Coastal and Estuarine Process	20	80	100	4
Practicals:					
PO–305	Physical Oceanography	20	80	100	4
PO–306	Synoptic Meteorology	20	80	100	4
PO–307	Viva-voce	-	50	50	2
PO-308	Computer Graphics(MOOC I)	-	-	100	2
PO-309	Value added course(Intellectual Property Rights)	-	-	100	2
	Total	120	530	850	30

Fourth Semester

Theory					
PO–401	Climate and Ocean Modelling√	20	80	100	4
PO-402	Satellite Meteorology and Satellite Oceanography√	20	80	100	4
PO-403	Coastal Zone Management and Ocean Resources	20	80	100	4
PO-404	Acoustical Oceanography	20	80	100	4
Dissertation					
PO-405	Dissertation and Seminar	40	160	200	8
PO–406	Viva-voce	-	50	50	2
PO-407	Use of Satellite data in Meteorology & Oceanography (MOOC II)	-	-	100	2
PO-408	Value added course (Research Methodology)	-	-	100	2
	Total	120	530	850	30
Grand Total (1+2+3+4 semesters)		480	2120	3000	112

Program: M.Sc Physical Oceanography

Program Outcomes:

PO1: To train the students in the field of Oceanography and make them equipped with sufficient knowledge to do research on individual basis.
PO2: Basic idea about the physics of oceans and it helps to create new ideas in defense, Fishing, Shipping, Dredging, Tourism Industries and different parts of blue economy.
PO3: Knowledge on different natural hazards, development of new ocean modelling tools, which supports to Shipping industry, Navigation and Disaster Management.
PO4: Expertise in Indian ocean and circulation, its variability and change, and evaluate effectively the importance of tropical ocean-atmosphere coupled processes such as ENSO, IOD to circulation and climate of various regions of the Indian Ocean.
PO5.To impart a strong sense of continuous self-learning and collaborative teamwork

Program Educational Outcomes:

PEO1: To provide quality post–graduation education in Oceanography and to prepare students for entering teaching in Universities, PhD/research programs within India (National laboratories or in R&D wings of various industries/university laboratories) or abroad.

PEO2: To pursue jobs in earth sciences, atmospheric sciences and oceanography laboratories, universities, NIT's, IITs among other related fields.

PEO3: To equip students with the knowledge and ability to solve Oceanography problems of social relevance and to know the importance of weather in the real-time prediction like Cyclones, monsoons, RIP currents, Sea state.

PEO4: To apply their Oceanography skill set in regulating coastal erosions, coastal processes, prediction of micro, macro and synoptic scale to large scale systems with latest numerical models and coupled models

PEO5: The skilled professionals develop and apply critical and analytical thinking to address scientific challenges in CRZ, Blue economy, Coastal security.

Program Learning Outcomes

PLO1: Student will learn how to design instruments for ocean observations, to develop ocean models to estimate the state of the ocean and apply knowledge of Ocean to various allied fields.

PLO2: Acquire fundamental and coherent scientific knowledge of the coastal, estuarine system and its interactive components,

PLO3: Utilize the state-of-the-art scientific and technical knowledge, and tools such as Acoustic tomography and SONARS, and ocean bottom imaging data to analyze and interpret ocean vertical structure (Temperature and salinity) and ocean biological processes.
PLO4: Provide practical knowledge on collecting ocean and atmospheric observations, carrying out calculation, and analyzing various parameters for understanding the physics and dynamics of oceans.

PLO5: Demonstrate the ability to identify, construct, and analyze the interactions between oceanographic processes through a range of spatial and temporal scales.

M.Sc. Physical Oceanography
First Semester

Physics and Dynamics of Climate			
Common syllabus for M.SC Meteorology/Physical Oceanography - I semester			
Course Category	Basic Science core course	Course Code	PO-101
Course Type	Theory	Lectures-Training-Practical	3-1-0
Prerequisites	Basics of the classical mechanics and thermodynamics	Internal Assessment Semester End Examination Total Marks	20 80 100

Course Objectives

1. To address the global climatology and to demonstrate a scientific understanding of the physical and dynamical aspects of Earth's climate system
2. To concentrate on the causes and consequences of global warming and climate change and to impart knowledge on the changing climate over India
3. To evaluate the role of green house gases.

M.Sc Physical Oceanography
PO-101: Physics and Dynamics of Climate

Unit-I:
Introduction: Weather and climate concepts - World climate system - climate of the hemispheres. Global distribution of temperature, precipitation, pressure and winds - Circulation pattern during winter and summer seasons. Jetstreams. Monsoons: Asia, Australia, E. Africa and North America; Systems of climatic classification - Koppen - Thornthwaite.

Unit-II:
General circulation of the atmosphere - convective and meridional circulation - Rossby's Tricellular model - Palmen's modified model - Circulation indices - Experiments of General Circulation – Dishpan experiment; Dynamics of atmospheric circulation - Maintenance of the General circulation – Kinetic energy, angular momentum, absolute vorticity balance. NAO and Pacific oscillations.

Unit-III:
Global warming – Causes and consequences of global warming; Greenhouse effect, Effect of global warming on Indian monsoon systems, Volcanic eruptions and aerosols, Ozone hole; Acid rains, Nuclear winter, IPCC, Montreal Protocol, Kyoto Protocol and Copenhagen Protocol

Unit-IV
Fundamentals of Climate change - local and planetary evidences - carbon dating - theories of climate change; Paleoclimate - Climate change and variations in Earth's orbit; Climate trends - ENSO - Teleconnections of the world climate system - Impact of climate change on weather and climate; Climate change and agriculture.

Unit V:
Wind, temperature and rainfall distributions over India in summer monsoon and winter monsoon seasons. Observational evidence of climate change over India. Effect of global warming on Indian summer monsoon and winter monsoon. Anomalous behaviour of Indian monsoon system. Extremes in Indian summer monsoon and winter monsoon seasons.

Text Books:

1. Physical climatology, William D. Sellers.
2. Climatology - Bernhard, Haurwitz and James M. Austin.
3. Dynamical and physical Meteorology, George J.Haltiner and Frank L. Martin.
4. Physics of monsoon, Keshava Murthy and Sankar Rao
5. Essentials of Meteorology – C. Donald Ahrens
6. Global Physical Climatology by Dennis L. Hartmann
7. Global Warming- The complete briefing by Sir John Houghton

Upon the successful completion of the course will provide		**Cognitive Level**
CO1	Knowledge on the Physics and Dynamics of climate in the regional scale and global scale	Understanding
CO2	Knowledge on the causes and consequences of global warming.	Understanding
CO3	Knowledge on the climate change effects and changing climate scenarios over India.	Understanding
CO4	This course is useful for planning and taking precautionary measures in the perspective of extreme weather, global warming and global climate change with special emphasis on India.	Analysing
CO5	The students will realize the importance of clean atmosphere, how to minimize the effects of global warming and climate change and how to combat with today's burning problem of global warming.	Analysing

Course Specific Outcome (CSOs)

CSO1 Students become familiar with global climatology, feedbacks leading to global warming and climate change.

CSO2 Student can understand the role of green house gases and learn the measures to be taken to reduce the effect of global warming.

CSO3 Students can understand their role to combat with global warming and climate change.

Learning Outcomes (LOs)

LO1: After the course, students will have broad understanding on the regional & global climatology and global warming, global monsoons, climatic classifications.

LO2: General circulation of atmosphere and its dynamics will be learned.

LO3: Causes and consequences of Global warming will be demonstrated

LO4: Evidences and impacts of climate change will be taught.

LO5: Students will learn the Climate change over India with special reference to the global warming.

Contribution of Course Outcomes towards achievement of Program Outcomes (1 – Low, 2 - Medium, 3 – High)														
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	2	2	-	-	-	-	-	-	-	-	-	-	2
CO2	1	1	2	1	-	-	-	-	-	-	-	-	-	2
CO3	3	1	2	-	-	-	-	-	-	-	1	-	1	2
CO4	2	2	2	-	-	-	-	-	-	-	-	-	-	2
CO5	2	2	2	-	-	-	-	-	-	-	-	-	1	1

Physical Meteorology			
Common syllabus for M.SC Meteorology/Physical Oceanography - I semester			
Course Category	Basic Science core course	Course Code	PO-102
Course Type	Theory	Lectures-Training-Practical	3-1-0
Prerequisites	Basics of the classical mechanics and thermodynamics	Internal Assessment Semester End Examination Total Marks	20 80 100

Course Objectives

1. To provide the knowledge on Physics of the atmosphere
2. To impart the knowledge on radiation and mechanisms of the various convective systems.
3. To demonstrate the cloud classification and formation mechanisms in cold and warm clouds
4. To evaluate the role of cloud physics and artificial rain making experiments.
5. To impart knowledge on thunderstorm characteristics through advanced research.

M.Sc. Physical Oceanography
PO-102: Physical Meteorology

Unit-I: 16 hrs

The atmosphere- Composition of the atmosphere- major components- carbon dioxide, water vapour, aerosols, ozone and ozone depletion. Vertical thermal structure of the atmosphere - Scale height, Troposphere, Stratosphere, Mesosphere, Ionosphere, Thermosphere and Exosphere. Gas laws, Virtual temperature, the Hydrostatic equation, Geopotential, Hypsometric equation.

Unit-II: 12 hrs

The first law of Thermodynamics- joules law, specific heat enthalpy. Adiabatic processes –concept of an air parcel, the dry adiabatic lapse rate, potential temperature, thermodynamic diagrams. moisture parameters, latent heat, saturated adiabatic and saturated adiabatic lapse rate. Static stability- unsaturated air, saturated air, conditional and convective instability. The second law of thermodynamics – entropy, the Clausius and Clapeyron equation

Unit-III: 12 hrs

Radiation: The spectrum of radiation – Black body radiation- Planck function, Wien’s displacement law, Stefan Boltzmann law, radiative properties of non black bodies, Kirchhoff’s law, green house effect. Scattering and absorption by air molecules and particles; Atmospheric windows, solar constant, radiative transfer in atmosphere, radiation balance at the top of the atmosphere, surface radiation budget, and net radiation.

Unit – IV 12 hrs

Clouds and precipitation: Cloud classification, cloud condensation nuclei, curvature and solute effects, growth of cloud droplets by condensation, collision – coalescence. Ice nuclei- Growth of ice particles in clouds Bergeron Findeisen process. Formation of precipitation, drop size distribution.

Unit – V 12 hrs

Artificial modification of clouds and precipitation - modification of cold clouds, modification of warm clouds, hail suppression, fog and cloud – dissipation, thunderstorm electrification – charge generation, lightning and thunder, global electric circuit. Nucleation scavenging, precipitation scavenging.

Text Books:

1. Dynamical and Physical Meteorology - G.J.Haltiner and F.L.Martin
2. Compendium of Meteorology (WMO Pub.) - Physical Meteorology, 1973, Vol.1, No.2
3. Physical Meteorology - H.G.Houghton
4. Atmospheric Thermodynamics - J.V.Iribarne and W.L.Godson.
5. J.M. Wallace, P.V. Hobbs, Atmospheric Science, 2nd ed., Academic Press
6. Meteorology for scientists and engineers –Roland B. Stull
7. Essentials of Meteorology – Donald Ahrens

Upon the successful completion of the course will provide		Cognitive Level
CO1	To understand the composition of the atmosphere, vertical structure of the atmosphere.	Understanding
CO2	To derive the hydrostatic , geopotential and hypsometric equation	Analyse
CO3	To Apply the first and second law of thermodynamics in Physics of the atmosphere, moisture parameters and stability of the atmosphere.	Analyse
CO4	To understand the spectrum of radiation, black body radiation and related laws, absorption, scattering and radiation balance of the surface and top of the atmosphere and radiation budget components.	Understanding
CO5	To understand the cloud formation, classification of clouds, growth of the raindrops, ice particles in warm and cold clouds. To understand the artificial modification of clouds and thunderstorm electrification.	Understanding

Course Specific Outcomes

1. To understand the basic structure of the atmosphere.
2. To understand the fundamentals of first law of and second law of thermodynamics.
3. To study Electromagnetic spectrum and radiation budget components at surface and top of the atmosphere.
4. To understand the physical mechanism of cloud formation in warm and cold clouds.
5. To understand the artificial rain making in clouds, Thunderstorm electrification.

Learning Outcomes (LOs)

1. Student will learn composition of the atmosphere, quantification of scale height and applications of the hydrostatic equation.
2. Student will learn adiabatic and isothermal process, thermodynamic diagrams.
3. Student will learn atmospheric attenuation, absorption, scattering and radiative transfer in the atmosphere.
4. Student will learn growth of the raindrop, curvature and solute effects, precipitation mechanism, and classifications cloud droplets by collision and coalescence and Bergeron Findeisen process.
5. This study will help the microphysical characteristics of the clouds and associated thermodynamics in monsoon clouds and severe storms.

Contribution of Course Outcomes towards achievement of Program Outcomes (1 – Low, 2 - Medium, 3 – High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	-	-	-	-	-	-	-	-	-	-	2
CO2	1	1	2	1	-	-	-	-	-	-	-	-	-	2
CO3	3	1	2	-	-	-	-	-	-	-	1	-	1	2
CO4	2	2	2	-	-	-	-	-	-	-	-	-	-	2
CO5	2	2	2	-	-	-	-	-	-	-	-	-	1	1

Dynamics of the Atmosphere			
Common syllabus for M.SC Meteorology/Physical Oceanography - I semester			
Course Category	Basic Science core course	Course Code	PO-103
Course Type	Theory	Lectures-Training-Practical	3-1-0
Prerequisites	Basics of the classical mechanics and thermodynamics and Mathematics	Internal Assessment Semester End Examination Total Marks	20 80 100

Course Objectives

1. To address the dynamics of the atmospheric systems and related forces
2. To derive the different types of circulation systems and their applications
3. To evaluate the role boundary layer and energetics in the dynamics of the atmosphere.

PO – 103: Dynamical of the Atmosphere

[Common Syllabus with M.Sc. (Meteorology) First Semester]

Unit I

Inertial and Non Inertial frames- Fundamental Forces-Pressure Gradient Force, Gravitational Force, Friction or Viscous Force. Apparent forces- Centrifugal Force, Coriolis force, Effective Gravity. Momentum Equations- Cartesian Coordinate System, Spherical–Polar coordinate system. Scale analysis of momentum equations. Hydrostatic approximation.

Unit II

Balanced motion- Geostropic Wind, Gradient wind, Thermal Wind. Continuity equation – Horizontal divergence, Vertical motion. Isobaric coordinate system – Transformation of momentum & continuity equations. Rossby, Richardson, Reynolds and Froude numbers.

Unit III

Circulation & Vorticity – Bjerknes circulation theorem. Applications to Land & Sea breeze. Vorticity equation. Potential Vorticity – Application to Lee of the mountain trough, CAV Trajectories, Scale analysis of Vorticity equation, inertial flow, stream function and velocity potential.

Unit IV

Atmospheric boundary layer: Atmospheric turbulence, Boussinesq approximation, Eddy Transport of heat, moisture and momentum, Reynolds equations, Turbulent kinetic energy; Momentum equations for PBL – well mixed boundary layer, the flux – gradient theory, mixing length theory, Ekman layer, Surface layer, Modified Ekman layer: Secondary circulations; Prandtl layer- Logarithmic Profile Properties of Prandtl Layer.

Unit V

Atmospheric energetics – Energy equation. Kinetic energy. Internal energy, Potential energy, Morgules theory of conversion of Potential & Internal energies into Kinetic energy. Available potential energy, CAPE, CINE. Expression for APE

Text Books

1. An Introduction to Dynamical Meteorology, J.R.Holton
2. Dynamical and Physical Meteorology, G.J.Haltiner and Martin
3. Dynamic Meteorology, Ed.Wiin Nielsen, WMO Publication
4. Dynamic Meteorology, B.Haurwith
5. Atmospheric and Oceanic Fluid Dynamics by Geoffrey K Vallis

COS	Upon the successful completion of the course will provide	Cognitive Level
CO1	Students will have a firsthand knowledge about the application of basic fluid dynamic principles on the atmosphere and ocean.	Analysing
CO2	Students learn about the different kinds of atmospheric motions and about the boundary layer which forms a crucial part of the vertical structure of the atmosphere.	Knowledge
CO3	Along with the various energetic terms involved in the maintenance of atmospheric circulations.	Understanding

Course Specific Outcomes(CSOs)

1. In this course, students will learn about the various forces acting on the atmosphere and its evaluation along with the fundamental equations derived in different coordinate systems.
2. They will learn about the different types of winds in the tropics as well as the extra-tropics. In addition they will learn about the basic fluid structure of the atmospheric flow patterns.
3. The lowest component of the atmosphere which is the boundary layer that is crucial for many activities of human beings will also be learnt.
4. Lastly in this course, students will get to know the various types of energies associated with the atmospheric flow, their evaluation and their conversion from one form to another.

Course Learning Outcomes (CLOs)

1. Students who finish this course will have an opportunity to work as researchers in various laboratories doing fundamental research in meteorology and oceanography and can find a place as faculty members in different educational institutions.

Contribution of Course Outcomes towards achievement of Program Outcomes (1 – Low, 2 - Medium, 3 – High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	-	-	-	-	-	-	-	-	-	-	2
CO2	1	1	2	1	-	-	-	-	-	-	-	-	-	2
CO3	3	1	2	-	-	-	-	-	-	-	1	-	1	2
CO4	2	2	2	-	-	-	-	-	-	-	-	-	-	2
CO5	2	2	2	-	-	-	-	-	-	-	-	-	1	1

Physical Oceanography			
Common syllabus for M.SC Meteorology/Physical Oceanography - I semester			
Course Category	Basic Science core course	Course Code	PO-104
Course Type	Theory	Lectures-Training-Practical	3-1-0
Prerequisites	Basics of the classical mechanics and thermodynamics	Internal Assessment Semester End Examination Total Marks	20 80 100

Course Objectives

1. To address the Physical characteristics of Ocean
2. To derive the currents, circulation and waves in the world oceans
3. To understand the water mass characteristics and marine biology and its applications

PO – 104: Physical Oceanography

[Common Syllabus with M.Sc. (Meteorology) First Semester]

Unit I:

Physical properties of seawater: Temperature, Salinity and Density; Temperature, Salinity and density distributions. Transparency of seawater, Sound in the sea, Light in the sea, Colour of seawater, Sea Ice. and anomalous properties of water. Geographical distribution of T & S.

Unit II:

Waves: wave parameters, deep water waves, shallow water waves, transformation of waves in shallow water, wave generation and dissipation, wave theories. Tides: tide producing forces, Types of tides, tidal theories. major tidal constituents-prediction of tides

Unit III:

Ocean circulation: wind induced currents, Upwelling, sinking; equatorial current system, warm and cold currents of major world ocean, seasonal currents in North Indian Ocean, west ward intensification of currents.

Unit IV:

Water masses: T-S diagram, Characteristics of water masses, Deep circulation water masses, Major water masses of the world oceans, Thermohaline circulation.

Unit V:

Marine geology: Continental shelf, Slope, Shelf sediments, submarine topography, mid oceanic ridge system, gas hydrates, manganese nodules, Bay of Bengal fans.

Marine biology: Classification of marine environment, Biogeochemical cycles. Influence of Physical parameters (Temperature, salinity, waves, currents, tides etc.). Nitrogen, Phosphorus and Silica controls, Residence time of elements in sea water. Marine Ecosystem: Mangroves, Coral Reefs.

Text books:

1. Introduction to Physical oceanography by M.P.M.Reddy.
2. Introduction to Physical oceanography by Robert.H.Stewart.
3. Introduction to dynamical oceanography by S.Pond and G.L.Pickard.
4. Oceans by Sverdrup, Johnson and Flemming.
5. Friedrich, H.: Marine Biology

COs	**Upon the successful completion of the course will provide**	**Cognitive Level**
CO1	General geographical taxonomic of physical properties related to world oceans	Understanding
CO2	Understanding the classification of waves and tide in the ocean	Knowledge
CO3	Analysing upwelling and ocean circulation, identify the hotspots which are key to Blue economy.	Analysing
CO4	Properties of western and eastern boundary currents.	Analysing
CO5	Understanding Marine biology particularly coastal area helps to initiate new pharma industry.	Understanding

Course Specific Outcomes (CSOs)

CSO1:Geographical distribution of temperature and salinty.
CSO2:Tidal analysis and measurements.
CSO3:Location and distribution of ocean minerals, clear energy sources (Gas Hydrates, manganese nodules ...) key role in Deep ocean mining and economy of the Country.
CSO4: Coral reef subsurface ecosystem, its classification and importance.
CSO5: How to protect Mangroves and its significance.

Course Learning Outcomes (CLOs)

LO1: Military (Submarine, Ships), Civilian (Ex. Fishing Industry) and Research applications.
LO2: Knowledge and understanding of density changes of major oceans.
LO3: Mathematical derivation of tidal, wave equations and its applications.
LO4: Waves and tides role in development or construction of any harbour or port in coastal area.
LO5:Using ocean circulation information understand the mass transport from one basin to another basin.
LO6: Transport of mass and heat from strong warm currents and its role on global climate.
LO7: Identifying the water masses, characteristics and its classification helps to understand the long-term changes (100 to 1000 years) in thermohaline circulation and its effect on global climate.
LO8: Understanding the health of coral reef gives at what rate ocean is warming.
LO9: Knowledge about the Ocean bathymetry and its classification.

Contribution of Course Outcomes towards achievement of Program Outcomes (1 – Low, 2 - Medium, 3 – High)														
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	2	2	-	-	-	-	-	-	-	-	-	-	2
CO2	1	1	2	1	-	-	-	-	-	-	-	-	-	2
CO3	3	1	2	-	-	-	-	-	-	-	1	-	1	2
CO4	2	2	2	-	-	-	-	-	-	-	-	-	-	2
CO5	2	2	2	-	-	-	-	-	-	-	-	-	1	1

Meteorology Computations			
Common syllabus for M.SC Meteorology/Physical **Oceanography** - I semester			
Course Category	Basic Science core course	Course Code	PO-105
Course Type	Practical	Lectures-Training-Practical	3-1-0
Prerequisites	Basics of the classical mechanics and thermodynamics	Internal Assessment Semester End Examination Total Marks	20 80 100

Course Objectives

1. To derive the dynamics and thermodynamics application using different kind of meteorological parameters.

PO – 105: Meteorology computations

[Same as M.Sc. (Meteorology) First Semester]

Practical

1. Calculation of horizontal divergence from wind data
2. Calculation of absolute vorticity from wind data
3. Calculation of geostrophic wind
4. Calculation of gradient wind
5. Calculation of thermal wind
6. Calculation of vertical velocity
7. T - Φ gram analysis: analysis of aerological data
8. Potential temperature
9. Equivalent temperature
10. Equivalent potential temperature
11. Lifting condensation level
12. Equilibrium level
13. Stability indices

COs	**Upon the successful completion of the course will provide**	**Cognitive Level**
CO1	first-hand knowledge of computing various physical and dynamical parameters of the above subjects.	Knowledge
CO2	handling of datasets relating to the various meteorological conditions.	Handling

CSOs: The students who have successfully gone through this course will have

CSO1: A capacity to have a knowledge of estimating the winds, the stability conditions and circulation features associated with different weather patterns.

Course Learning Outcomes (CLOs)

LO1: Students by learning the various techniques and practical implications will now be empowered to work independently in a forecasting center or a research institute.

LO2: One of the key components of the learning outcome of this course is to have knowledge of identifying the weather patterns of different seasons.

Contribution of Course Outcomes towards achievement of Program Outcomes (1 – Low, 2 - Medium, 3 – High)

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	2	2	-	-	-	-	-	-	-	-	-	-	2
CO2	1	1	2	1	-	-	-	-	-	-	-	-	-	2
CO3	3	1	2	-	-	-	-	-	-	-	1	-	1	2
CO4	2	2	2	-	-	-	-	-	-	-	-	-	-	2
CO5	2	2	2	-	-	-	-	-	-	-	-	-	1	1

FORTRAN Programming			
Common syllabus for M.SC Meteorology/Physical Oceanography - I semester			
Course Category	Basic Science core course	Course Code	PO-106
Course Type	Practical	Lectures-Training-Practical	3-1-0
Prerequisites	Basics of the computer science, Mathematics.	Internal Assessment Semester End Examination Total Marks	20 80 100

Course Objectives

1. To learn the fortran programming for various applications in the fluid dynamics.
2. To understand the importance of Fortran programming in the field of meteorology and Oceanography.
3. To understand the flow charts, data types, structures and arrays in the Fortran language.

PO-106: FORTRAN Programming (Practical)

[Common Syllabus with M.Sc. (Meteorology) Second Semester]

1. Correlation Coefficient and Linear Regression
2. Multiple Regression
3. Analysis of Variance (ANOVA)
4. Gauss Siedel Iterative Method
5. Newton Raphson Method
6. Simpson’s 1/3rd Method
7. Program for computation of winds

Upon successful completion of the course, the student will be able to:		**Cognitive Level**
CO1	**Understand the** basic structures of the Fortran programming.	Understanding
CO2	Update the knowledge on advance computational methods and applications.	Knowledge

Students will acquire the course specific outcome (CSOs)

CSO1 To understand the importance of Fortran programming in the field of meteorology and Oceanography.
CSO2 To understand the flow charts, data types, structures and arrays in the Fortran language.
CSO3 To study correlation coefficient, Regression and analysis of variance programs
CSO4 To understand the advanced computational techniques like Gauss Siedel Iterative method and Newton Raphson and Simpson's 1/3 method.

Course Learning Outcomes (CLOs) Students after completing this course will be able to

CLOs-1 Discriminate the Fortran data types, if then, while-do statement, structures and arrays.
CLOs-2 Apply their programming skills in different applications related to atmosphere and Ocean studies.

Contribution of Course Outcomes towards achievement of Program Outcomes (1 – Low, 2 - Medium, 3 – High)														
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	2	2	-	-	-	-	-	-	-	-	-	-	2
CO2	1	1	2	1	-	-	-	-	-	-	-	-	-	2
CO3	3	1	2	-	-	-	-	-	-	-	1	-	1	2
CO4	2	2	2	-	-	-	-	-	-	-	-	-	-	2
CO5	2	2	2	-	-	-	-	-	-	-	-	-	1	1

Viva-Voce			
Common syllabus for M.SC Meteorology/Physical Oceanography - I semester			
Course Category	Basic Science core course	Course Code	PO-107
Course Type	Viva-Voce	Lectures-Training-Practical	3-1-0
Prerequisites	Basics of the Oceanography	Total Marks	50

COURSE OBJECTIVES	
1	To evaluate the performance and knowledge of the student orally in the field of meteorology and Oceanography.
2.	To get the better placement opportunities and better performance in future.-

COs	Upon successful completion of the course, the student will be able to:	Cognitive level
CO1	Student can improve softskills , communication skills	Knowledge
CO2	Student can able to demonstrate the specific knowledge on the specialised area	Analysis
CO3	This viva-voce will help for his career progression to enhance profession etiquette	Analysis

Contribution of Course Outcomes towards achievement of Program Outcomes (1 – Low, 2 - Medium, 3 – High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	-	-	-	-	-	-	-	-	-	-	2
CO2	1	1	2	1	-	-	-	-	-	-	-	-	-	2
CO3	3	1	2	-	-	-	-	-	-	-	1	-	1	2
CO4	2	2	2	-	-	-	-	-	-	-	-	-	-	2
CO5	2	2	2	-	-	-	-	-	-	-	-	-	1	1

Second Semester

Dynamical Oceanography			
Common syllabus for M.SC Meteorology/Physical Oceanography - II semester			
Course Category	Basic Science core course	Course Code	PO-201
Course Type	Theory	Lectures-Training-Practical	3-1-0
Prerequisites	Basics of the Physical Ocenography	Internal Assessment Semester End Examination Total Marks	20 80 100

Course Objectives

1. To impart the knowledge on circulation systems in the Ocean
2. To learn physical and dynamical behaviour of the waves
3. To derive the mathematical equations for various applications in Oceans

PO-201: Dynamical Oceanography

[Common Syllabus with M.Sc. (Meteorology) Second Semester]

Unit I:

Geostrophic currents: Barotropic and baroclinic fields, relative and slope currents, level of no motion, computation of relative currents in a two layer motion and in stratified ocean, Bjerkne's circulation theorem

Unit II:

Currents without friction: Inertial motion, Geo potential, Geo potential surface and Isobaric surface, potential temperature, Margules's equation for two layer ocean, level of no motion and absolute currents.

Unit III:

Currents with friction: Ekman's solution to the equation of motion with friction present, Ekman transport, bottom friction and shallow water effect, Sverdrup, Stommel and Munk theory of western boundary currents.Vorticity in the ocean.

Unit IV:

Waves: refraction and breaking in shallow water, Tsunamis, internal waves, effects of rotation-Kelvin, Rossby waves.

Unit V:

Tides: Ocean response to the tide producing forces, tidal analysis, tides at the coast and estuaries, tidal currents, storm surges. Tidal dynamics: Tidal movement, amplification and tidal wave propagation.

Reference books:

1. Introduction to dynamical oceanography by S.Pond and G.L.Pickard
2. Fomin, L.M. 1964. Dynamic method in oceanography. Elsevier publication co.
3. http://www.sciencedirect.com/science

COs	**Upon successful completion of the course, the student will be able to:**	Cognitive Level
CO1	Physical and dynamical behaviour of internal waves, they play key role on submarine navigation.	Understanding
CO2	Derivation of Bjerkne's circulation theorem and its applications.	Analysing
CO3	Mathematical explanation (Margule's equations) of Ocean fronts and eddy dynamics. It is key to mesoscale Ocean modeling.	Knowledge
CO4	Ocean general circulation, its different theories and evaluation.	Understanding
CO5	Derivation of Ekman's theory and its solutions to equation of motion	Analysing

CSO **Course Specific Outcomes**

CSO1 Ocean thermodynamic process and potential temperature

CSO2 Role of wave refraction on coastal deposition and erosion

CSO3 Tsunami information helps the Disaster management department (National and State).
Relation between coastal kelvin waves and fresh water inputs to ocean

CSO4 Mathematical explanation (Margule's equations) of Ocean fronts and eddy dynamics. It is key to mesoscale Ocean modeling

CSO5 Mathematical explanation of inertial motion in the ocean and its trajectories

LOs **Course Learning Outcomes**

LO1 Understanding and examining the wave refraction and wave breaking, it helps to Shipping and port Industry.

LO2 Understand the adiabatic processes in the vertical column of the ocean.

LO3 Knowledge on tsunami formation and its inundation.

LO4 Fundamentals of tsunami sources and its formation, propagation.

LO5 Storm surge characteristics and its prediction, it is also come under Disaster Management
Rossby waves, its characteristics.

LO7 Behaviour of tidal currents in coastal connecting fresh water body.

LO8 Effect of vorticity on ocean circulation its different forms.

LO9 Practical knowledge on relative currents computation.
Tidal analysis techniques and its amplification process

Contribution of Course Outcomes towards achievement of Program Outcomes (1 – Low, 2 - Medium, 3 – High)

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	2	2	-	-	-	-	-	-	-	-	-	-	2
CO2	1	1	2	1	-	-	-	-	-	-	-	-	-	2
CO3	3	1	2	-	-	-	-	-	-	-	1	-	1	2
CO4	2	2	2	-	-	-	-	-	-	-	-	-	-	2
CO5	2	2	2	-	-	-	-	-	-	-	-	-	1	1

Geo-Physical Fluid Dynamics			
Common syllabus for M.SC Meteorology/Physical Oceanography - II semester			
Course Category	Basic Science core course	Course Code	PO-202
Course Type	Theory	Lectures-Training-Practical	3-1-0
Prerequisites	Basics of the Physical and classical mechanics	Internal Assessment Semester End Examination Total Marks	20 80 100

Course Objectives

1. To learn the fluid dynamics and its application in atmosphere and Oceans.
2. To understand the wave motions in simplified equations .
3. To identify the barotropic and baroclinic instability in mean flow
4. To understand the relationship between the middle atmosphere and wave flow interaction in fluid dynamics

PO – 202: Geophysical Fluid Dynamics

Unit I

Wave motion in the Atmosphere: Linearized equations, vertical sound waves, horizontal sound waves and internal gravity waves, surface gravity waves, inertial gravity waves, inertial oscillations, Rossby Waves, Gravity waves, the geostrophic adjustment process, equatorial wave theory.

Unit II

Simplified Equations for Ocean and Atmosphere: Geostropic Scaling, The Planetary, Geostrophic Equations, The Shallow Water Quasi Geotropic Equations, The Continuously Stratified Quasi Geostrophic System, Quasi geostrophy and Ertel potential vorticity, Energetics of Quasi Geostrophy, Rossby Waves, Rossby Waves in Stratified Quasi Geostrophic Flow

Unit III

Barotropic and Baroclinic Instability: Kelvin Helmholtz Instability, Instability of Parallel Shear Flow, Necessary Conditions for Instability, Baroclinic Instability, Linearized Quasi Geostrophic Equations, The Eady Problem, Two Layer, Baroclinic Instability, An Informal View of the Mechanism of Baroclinic Instability, The Energetics of Linear Baroclinic Instability, Beta, Shear and Stratification in a Continuous Model

Unit IV

Wave–Mean Flow Interaction: Quasi geostrophic Preliminaries, The Eliassen Palm Flux, The Transformed Eulerian Mean, The Non-acceleration Result, Influence of Eddies on the Mean Flow in the Eady Problem, Necessary Conditions for Instability. Charney **-**Drazin Theory.

Unit V

Middle Atmosphere Dynamics: Structure and Circulation of the Middle Atmosphere. The Zonal Mean Circulation, Vertically propagating Planetary waves, Sudden Stratospheric warmings, Waves in the Equatorial Stratosphere. The Quasi Bienniel Oscillation.

Text Books

1. Introductory dynamical Oceanography, Stephen Pond, G.L. Pickard
2. Atmospheric and Oceanic fluid dynamics, Geoffrey, K. Villas
3. Numerical Weather Prediction, G. J. Haltiner

COs	The students pursuing this course will learn about the application of fluid dynamics to the	Cognitive level
CO1	Frame work of the two fluids atmosphere and ocean of the planet Earth.	Understanding
CO2	This course will facilitate the students to get expose to the various facets of the combined system of earth's atmosphere and ocean.	Analysing

Course Specific Outcomes (CSOs)

CSO1	This course will teach about the different kinds of waves associated with the atmosphere and ocean
CSO2	The equatorial wave theory and the processes involved in the mid-latitudes will be taught.
CSO3	In this course the fundamental equations associated with the Earth's ocean and atmospheric system and the various instabilities in the atmosphere and ocean will be taught
CSO4	The necessary conditions in the wave mean flow interaction and the associated theories will also be taught.
CSO5	Apart from the tropospheric dynamics, the stratospheric dynamics and its influence on Earth's atmosphere and ocean will also be taught.

Course Learning Outcomes (CLOs)

CLO1: Students of this course will find a suitable employment in various research centers like the Indian Institute of Tropical Meteorology (IITM) and the Geophysical Fluid Dynamics Laboratories (GFDL).

Contribution of Course Outcomes towards achievement of Program Outcomes (1 – Low, 2 - Medium, 3 – High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	-	-	-	-	-	-	-	-	-	-	2
CO2	1	1	2	1	-	-	-	-	-	-	-	-	-	2
CO3	3	1	2	-	-	-	-	-	-	-	1	-	1	2
CO4	2	2	2	-	-	-	-	-	-	-	-	-	-	2
CO5	2	2	2	-	-	-	-	-	-	-	-	-	1	1

<table>
<tr><td colspan="4">Meteorology and Oceanography instruments</td></tr>
<tr><td colspan="4">Common syllabus for M.SC Meteorology/Physical Oceanography - II semester</td></tr>
<tr><td>Course Category</td><td>Basic Science core course</td><td>Course Code</td><td>PO-203</td></tr>
<tr><td>Course Type</td><td>Theory</td><td>Lectures-Training-Practical</td><td>3-1-0</td></tr>
<tr><td>Prerequisites</td><td>Basics of the Electronics and Physical meteorology</td><td>Internal Assessment
Semester End Examination
Total Marks</td><td>20
80
100</td></tr>
</table>

Course Objectives

1. The instruments that are used to find the state of atmosphere and ocean at some given time.

2. Meteorological and Oceanographic instruments are the equipment used to measure different atmospheric parameters like temperature, humidity, pressure, wind speed, salinity, ocean currents and wave height.

PO – 203: Meteorology and Oceanography Instruments

Unit-I

Measurements of air temperature - Liquid in glass and electrical resistance thermometer.Measurement of atmospheric pressure – kewpattern barometer, corrections of mercury barometer reading and aneroid barometer. Measurement of humidity - psychrometer, dew point hygrometer, electrical resistive hygrometer.

Unit-II

Measurement of surface wind- wind wane, cup anemometer, sonic anemometer.Measurement of precipitation-non recording rain gauges, tipping bucket gauge, optical rain gauge.Measurement of radiation-Pyrheliometer, Pyranometer, net radiometer. Measurement of upper air-pressure temperature and humidity, radio sonde, upper air wind - GPS system, pilot balloon observations.

Unit –III

Ground based remote sensing - Lidar, radar, Principles of radar, weather radar, precipitation estimation, radar equation for precipitation targets, Doppler radar-velocities measurements. Basic concept of satellite sensors – advanced very high resolution radiometer-AVHRR, advanced microwave sounding unit-AMSU, scatterometer, synthetic aperture radar, altimeter, ocean color monitor, passive microwave radiometer.

Unit –IV

Marine observations- method of observation of atmospheric pressure, air temperature, humidity, wind, precipitation, salinity and sea surface temperature on board ships. Hydrographic instruments- echo sounder, CTD

Unit-V

Measurement of dynamic properties of the sea-current meter and wave measurements, tide gauges. Platforms for ocean measurements-research vessels, mooring, satellites – geostationary, polar orbiting, sea glider, Argo floats.

Text Books:

1. Guide to Meteorological and Oceanographic Instruments. WMO – No. 8
2. Meteorological instruments – Knowles Middleton and Athelstan F. Splihaus
3. An introduction to Meteorological instruments and measurement – Thomas D. Defelice
4. http:// www.es.flinders.edu.au
5. Satellite Oceanography – An Introduction to Oceanographers and Remote Sensing scientists. I.S.Robinson, Ellis Forward Limited.
6. Descriptive Physical Oceanography by M.P.M. Reddy

COs	In this course, the candidate will familiarise	Cognitive level
CO1	basic parameters like temperature,pressure, and humidity, which are the basic parameters observed in the earth's atmosphere.	Understanding
CO2	The design of the instruments that measure the wind and the various types of instruments are taught here. The student will also learn about the different types of rain gauges used in the measurement of rainfall.	Knowledge
CO3	In addition they learn about the pilot balloon observation techniques used in radio sondes and GPS, which are useful for upper air measurements.	Knowledge
CO4	Ground based remote sensing instruments and the principles of basic satellite sensors like AVHRR, SAR, and the various techniques used in observing both the atmosphere and the oceans will be understood in practical knowledge.	Knowledge
CO5	In addition, to the atmospheric observations, students will learn about the measurements of the different ocean parameters like salinity, SST, and currents by using CTD hydrographer sea gliders and Argo floats.	Understanding
CO6	It is critical to have an accurate observation of the above two fluids in order to define the final characters of the two fluids, such as the atmosphere and the ocean to have an accurate observation of the above two fluids.	Analyzing
CO7	The students pursuing this course will get the firsthand knowledge about the various instruments used, their designs, and how to measure the atmosphere and ocean parameters.	Analyzing

Course Specific Outcomes(CSOs)

CSO1: Students know about the various instruments used in measuring both the atmosphere and the oceans.

CSO2: The type of accuracy, calibration and the uses of these instruments will be known.

CSO3: The development, validation, and forecasting of the atmosphere and oceans rely heavily on observational techniques.

CSO4: Oceanographic instruments provide important data about tides and currents, as well as water quality characteristics such as chemical composition and salinity.

CSO5: The student knows how to apply statistical time-space methods used in analyses of geophysical data.

Course Learning Outcomes (CLOs)

CLO1: Students know about the various instruments used in measuring both the atmosphere and the oceans with type of accuracy, calibration and the uses of these instruments will be known. The development, validation, and forecasting of the atmosphere and oceans rely heavily on observational techniques.

CLO2: Oceanographic instruments provide important data about tides and currents, as well as water quality characteristics such as chemical composition and salinity. The student knows how to apply statistical time-space methods used in analyses of geophysical data.

CLO3: The student knows how to analyse and interpret geophysical problems and interaction between the various components in the climate system. The student knows how oceanography connects to relevant areas of mathematics, physics, computer science, geosciences, chemistry and meteorology.

CLO4: The student can apply advanced mathematical, computational and statistical methods to meteorological problems

CLO5: This course provides an opportunity to the students to get a first-hand experience of the instrumentation used in Atmospheric Sciences.

Contribution of Course Outcomes towards achievement of Program Outcomes (1 – Low, 2 - Medium, 3 – High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	-	-	-	-	-	-	-	-	-	-	2
CO2	1	1	2	1	-	-	-	-	-	-	-	-	-	2
CO3	3	1	2	-	-	-	-	-	-	-	1	-	1	2
CO4	2	2	2	-	-	-	-	-	-	-	-	-	-	2
CO5	2	2	2	-	-	-	-	-	-	-	-	-	1	1

Synoptic Meteorology			
Common syllabus for M.SC Meteorology/Physical Oceanography - II semester			
Course Category	Basic Science core course	Course Code	PO-204
Course Type	Theory	Lectures-Training-Practical	3-1-0
Prerequisites	Basics of the Physical and Dynamical meteorology	Internal Assessment Semester End Examination Total Marks	20 80 100

Course Objectives

1. To demonstrate the structure, development, and decay of synoptic-scale weather systems, air masses and fronts
2. To address the kinematics of wind fields, pressure systems, monsoons, prediction and rain-bearing systems.
3. To provide basic understanding and principles leading to synoptic analysis.

PO-204: Synoptic Meteorology

[Common Syllabus with M.Sc. (Meteorology) Second Semester]

Unit-I:

Synoptic data and collection: Surface and upper air weather data transmission **-** Code for inland, coastal and ship stations. Upper air data – PILOT and TEMP codes. Station models, Scales of atmospheric Motions, Weather charts and analysis, synoptic weather forecasting.

Air masses and fronts: Air mass production **-** Classification **-** Sources of air masses in winter and summer and their modification. Fronts and frontal surfaces – slope of frontal surface-Principal frontal zones **-** frontogenesis and frontolysis. Extra **-** tropical cyclones **-** formation **-** Life cycle **-** Structure and movement. Zonal Index, Anticyclones and blocking.

Unit-II:

Kinematics of the pressure field: Characteristic curves **-** General expressions for their velocity and acceleration – Movement of troughs, ridges and pressure centres, Intensification and Weakening, deepening and Filling of surface pressure systems.

Unit-III:

Kinematics of the wind field: Relation between streamlines and trajectories. Isotachs and contour analysis; tilt & slope of pressure/weather systems with height. Trajectories in moving cyclones and anticyclones. Differential properties of the wind field. Application of geostrophic, gradient and thermal winds, divergence and vertical velocity computations, Confluence, Difluence, Dines compensation

Unit-IV:

Indian monsoons: Land and sea breezes – Definition of monsoon – Monsoon theories, Objective Criteria of onset of southwest monsoon over Kerala**,** Synoptic features associated with onset, withdrawal, active and break situations of southwest monsoon. Rainfall distribution and rain bearing systems during summer monsoon season **-** monsoon depression, Mid **-** tropospheric cyclones and Onset vortex. Semi-permanent systems of summer monsoon, Variability of summer monsoon. Prediction of weather elements: Seasonal prediction of monsoon rainfall and date of onset of summer monsoon. Maximum and minimum temperatures – Fog**.**

Unit-V:

Northeast monsoon **-** onset and seasonal rainfall distribution – rain bearing systems. Storm surge, Prediction of the onset and rainfall of winter monsoon over South Peninsular India, Western disturbances, Extreme weather events over India, Heat waves and cold waves.

Text Books:

1. Weather analysis and forecasting – Vol.1 & 2 by B. Patterson
2. Tropical meteorology by H. Riehl
3. Climate and circulation of the tropics by S. Hasternath
4. Monsoon meteorology by C.S. Ramage
5. Jet stream meteorology by E.R. Reiter
6. Synoptic-Dynamic Meteorology in Midlatitudes: Volume II: Observations and Theory of Weather Systems by Howard B. Bluestein
7. Synoptic Meteorology-A Dictionary of Earth Sciences | 1999 | Ailsa Allaby and Michael Allaby.

COs	**Upon successful completion of the course, the student will be able to:**	Cognitive level
CO1	This course will provide knowledge on synoptic weather analysis,	Knowledge
CO2	This course will provide knowledge on the air-masses, fronts, extra-tropical cyclones	Knowledge
CO3	This course will provide knowledge on the kinematics of pressure fields, kinematics of wind fields, Indian monsoon system, prediction and Extreme weather events over India.	Knowledge
CO4	This course provides basis for the synoptic analysis of weather systems, prediction of weather, monsoon variability, rain-bearing systems and for the understanding the circulation patterns.	Analysis
CO5	This is useful for the cop planning over India and the sector of generation of hydro-electric power	Analysis

Course Specific Outcomes (CSOs)

CSO1: Students will acquaint knowledge and on the three dimensional structure and behavior of the real atmosphere, air masses, fronts frontal systems

CSO2: tudents can understand the science behind the monsoon and importance of monsoon.

CSO3: Students can get an ability to apply their knowledge to real weather scenarios, crop planning and power generation sectors .

Course Learning Outcomes (CLOs)

LO1: After the course, students will have broad understanding on the analysis of weather charts, classification of air masses and fronts, frontal systems and blocking phenomenon.

LO2: The students will learn the movement of pressure systems, intensification and deepening of pressure systems.

LO3: Kinematics of the wind field, the stream line analysis, application of differential properties of wind field and computations of geostrophic wind, gradient wind and thermal winds, divergence and vertical wind velocities will be taught. This is useful in the weather anyalysis.

LO4: Different phases of Indian summer monsoon , rain-bearing systems, quasi-permanent systems, variability of monsoon and prediction will be learned. It gives good idea for starting of agricultural practices and crop planning.

LO5: Northeast monsoon confined to South Peninsular India will be learned. It demonstrates the rain-bearing systems in NE monsoon season and extreme events. It gives good idea for rabi crop planning.

Contribution of Course Outcomes towards achievement of Program Outcomes (1 – Low, 2 - Medium, 3 – High)

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	2	2	-	-	-	-	-	-	-	-	-	-	2
CO2	1	1	2	1	-	-	-	-	-	-	-	-	-	2
CO3	3	1	2	-	-	-	-	-	-	-	1	-	1	2
CO4	2	2	2	-	-	-	-	-	-	-	-	-	-	2
CO5	2	2	2	-	-	-	-	-	-	-	-	-	1	1

Ocean Computation Practical			
Common syllabus for M.SC Meteorology/Physical Oceanography - II semester			
Course Category	Basic Science core course	Course Code	PO-205
Course Type	Practical	Lectures-Training-Practical	3-1-0
Prerequisites	Basics of the Electronics and Physical meteorology	Internal Assessment Semester End Examination Total Marks	20 80 100

Course Objectives

1. To derive the shortwave, longwave, latent heat flux, sensible heat flux using atmospheric and Oceanic heat budget equation
2. To derive the physical characteristics of the Ocean
3. To derive the stability criteria and various applications like upwelling and sinking

PO-205: Ocean Computations practical

1. Computation of short-wave Radiation at the Ocean surface
   a) Octa model, b) Synoptic approach
2. Computation of Long-wave Radiation at the Ocean surface
   a) Brunt's formula, b) Anderson's formula
3. Computation of Wind Stress at the ocean surface
   a) For different wind speeds (5, 10, 15 m/s),
   b) With variable coefficient of Cd
4. Computation of Latent Heat Flux at the Ocean surface
   a) For different wind speeds (5, 10, 15 m/s)
   b) With variable coefficient of Ce
5. Computation of sensible heat flux at the ocean surface
   a) For different wind speeds (5, 10, 15 m/s)
   b) With variable coefficient of Ch
6. Computation of Atmospheric Heat Budget.
7. Computation of Bowen's ratio.
8. Determination of Density using temperature and salinity.
9. Determination of Specific volume anomaly using S, T and D.
10. Stability and Richardson number.
11. Analysis of temperature data
    a. Vertical profiles
    b. Horizontal profiles
    c. Identification of Upwelling and sinking

COs	**Upon successful completion of the course, the student will be able to:**	Cognitive level
CO1:	Mathematical calculation of shortwave radiation using two different approaches	Analysing
CO2:	Longwave radiation and its estimation with the help of dual methods.	Derivation
CO3:	Wind stress computation using different wind speed and drag coefficient.	Computation
CO4:	Latent heat flux and role of wind speed, transfer coefficient.	Analysis
CO5:	Role of exchange coefficients on sensible heat flux.	Derivation
CO6:	Estimation of atmospheric heat budget and its variations with locations.	Computation
CO7:	Computation of stability of the water column.	Analysis

Course Specific Outcomes (CSOs)

CSO1 Knowledge on shortwave radiation estimate at particular location
CSO2 Ratio of sensible and latent heat fluxes
CSO3 Specific volume anomaly using hydrographic data.
CSO4 Upwelling and sinking signature from temperature profile.
CSO5 Knowledge on Richardson number and its criteria to determine the stability of the water column.
CSO6 Interpretation and identification of Upwelling and sinking signature from temperature profile.

LOS **Course Learning Outcomes (CLOs)**

LO1 Understand the role of sst and cloud on calculation Longwave radiation
LO2 Relation between different wind speeds and drag coefficients and its effect on Wind stress estimation.
LO3 Knowledge on Latent heat flux and wind speed relation
LO4 Ocean-atmospheric temperature difference role on sensible heat flux estimation.
LO5 Determination of atmospheric heat budget
LO6 Understand the Bowen's ration and role of evaporation
LO7 Significant of Specific volume anomaly and its calculation using vertical temperature and salinity profiles.

Contribution of Course Outcomes towards achievement of Program Outcomes (1 – Low, 2 - Medium, 3 – High)														
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	2	2	-	-	-	-	-	-	-	-	-	-	2
CO2	1	1	2	1	-	-	-	-	-	-	-	-	-	2
CO3	3	1	2	-	-	-	-	-	-	-	1	-	1	2
CO4	2	2	2	-	-	-	-	-	-	-	-	-	-	2
CO5	2	2	2	-	-	-	-	-	-	-	-	-	1	1

<table>
<tr><th colspan="4">Observational Techniques</th></tr>
<tr><td colspan="4">Common syllabus for M.SC Meteorology/Physical Oceanography - II semester</td></tr>
<tr><td>Course Category</td><td>Basic Science core course</td><td>Course Code</td><td>PO-206</td></tr>
<tr><td>Course Type</td><td>Practical</td><td>Lectures-Training-Practical</td><td>3-1-0</td></tr>
<tr><td>Prerequisites</td><td>Basics of the Electronics and Physical meteorology</td><td>Internal Assessment
Semester End Examination
Total Marks</td><td>20
80
100</td></tr>
</table>

Course Objectives

1. This course provides an opportunity to the students to get a first-hand experience of the Instrumentation used in Atmospheric Sciences.
2. Student will handle sophisticated instruments and understand their working principles, maintenance and calibration procedures.
3. Through this course they will gain familiarity with many of the key instruments involved in weather observations.

PO – 206: Observation Techniques (Practical)

[Common Syllabus with M.Sc. (Meteorology) Second Semester]

1. Measurement of atmospheric pressure by Fortin barometer, Kew pattern barometer, gravity and temperature corrections.
2. Computation of MSL pressure and height difference between two stations.
3. Measurement of relative humidity and calculation of actual vapour pressure.
4. Measurement of wind velocity using anemometer and air meter.
5. Determination of wind direction and wind velocity at standard levels using Pilot balloon data.
6. Measurement of Bulk SST and Skin SST, Salinity.
7. Measurement of shortwave and Longwave radiation
8. Plotting the AWS data using Grapher software and Matlab.
9. Mapping of satellite derived data – SST, Air Temperature using Grads software and matlab.

COs	**Upon successful completion of the course, the student will be able to:**	Cognitive level
CO1	To introduce students to different meteorological instruments used for taking atmospheric observations.	Knowledge
CO2	To impart knowledge on measurement techniques and calibration procedures.	Knowledge
CO3	Meteorological instruments are the equipment used to measure different atmospheric parameters like temperature, humidity, pressure, wind speed,	Knowledge
CO4	Meteorological instruments are described as the tools utilized to circumscribe the nature of the environment at any instant.	Analysis
CO5	Experience of operating and calibrating instruments and generating quality data.	Analysis
CO6	Ability to partake and integrate easily in experimental setups w.r.t. both field and laboratory based experiments	Analysis

Course Specific Outcomes (CSOs)

CSO1: Experience of operating and calibrating instruments and generating quality data.

CSO2: Ability to partake and integrate easily in experimental setups w.r.t. both field and laboratory based experiments.

Course Learning Outcomes (CLOs)

CLO1: Understand the history, operation, and use of meteorological instruments those monitor the atmosphere, with emphasis on practical applications.
CLO2: Modern meteorology includes a wide variety of in situ and remote sensing instruments that are designed to observe aspects of our atmospheric environment.
CLO3: Analyzing the resulting data, and producing realistic interpretations using appropriate statistical arguments.
CLO4: This course aims to provide useful reference information in a lecture format but to reinforce practical skills with both group and individual activities.

Contribution of Course Outcomes towards achievement of Program Outcomes (1 – Low, 2 - Medium, 3 – High)													
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	2	2	-	-	-	-	-	-	-	-	-	-	2
CO2	1	1	2	1	-	-	-	-	-	-	-	-	-	2
CO3	3	1	2	-	-	-	-	-	-	-	1	-	1	2
CO4	2	2	2	-	-	-	-	-	-	-	-	-	-	2
CO5	2	2	2	-	-	-	-	-	-	-	-	-	1	1

Viva-Voce			
Common syllabus for M.SC Meteorology/Physical Oceanography - II semester			
Course Category	Basic Science core course	Course Code	PO-207
Course Type	Viva-Voce	Lectures-Training-Practical	3-1-0
Prerequisites	Basics of the computer science, Mathematics.	Total Marks	50

COURSE OBJECTIVES	
1	To evaluate the performance and knowledge of the student orally in the field of meteorology and Oceanography.
2.	To get the better placement opportunities and better performance in future.-

COs	Upon successful completion of the course, the student will be able to:	Cognitive level
CO1	Student can improve softskills , communication skills	Knowledge
CO2	Student can able to demonstrate the specific knowledge on the specialised area	Analysis
CO3	This viva-voce will help for his career progression to enhance profession etiquette	Analysis

Contribution of Course Outcomes towards achievement of Program Outcomes (1 – Low, 2 - Medium, 3 – High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	-	-	-	-	-	-	-	-	-	-	2
CO2	1	1	2	1	-	-	-	-	-	-	-	-	-	2
CO3	3	1	2	-	-	-	-	-	-	-	1	-	1	2
CO4	2	2	2	-	-	-	-	-	-	-	-	-	-	2
CO5	2	2	2	-	-	-	-	-	-	-	-	-	1	1

Third Semester

Numerical Weather Prediction			
Common syllabus for M.SC Meteorology/Physical Oceanography - III semester			
Course Category	Basic Science core course	Course Code	PO-301
Course Type	Theory	Lectures-Training-Practical	3-1-0
Prerequisites	Basics of the Dynamics and Physical meteorology	Internal Assessment Semester End Examination Total Marks	20 80 100

Course Objectives

1. To understand the various numerical methods
2. To impart knowledge on Quasi-geostrophic and primitive equation models and their applications
3. To understand the role physical processes and role of objective analysis in the numerical weather prediction models

PO-301: Numerical Weather Prediction
[Common Syllabus with M.Sc. (Meteorology) Third Semester]

Unit I

Numerical models – Filtered models: Filtering of sound and gravity wave models: Barotropic model; Equivalent barotropic model; Barotropic instability, Numerical methods – Computation of Jacobian and Laplacian; solution of Helmholtz and Poisson equations using relaxation method; Finite difference method- Forward and centered finite difference methods, semi–implicit method- computational instability.

Unit II

Quasi Geostrophic Models – Barotropic and Baroclinic models, Two level model; Quasi- Geostropic multi level models; Omega equation; Linear balanced model; Nonlinear balanced model. Short, medium and long range weather prediction.

Unit III

Primitive equation models–sigma coordinate system; Two level primitive equation model; multilevel primitive equation models. Introduction to meso scale models: Non-hydrostatic assumption, basic structure of MM5 and WRF models and their applications. Application of satellite and Remote sensing data in NWP.

Unit IV

Representation of Physical Processes. Inclusion of moisture, Kuos method and Arakawa Schubert's method. Boundary layer parameterisation, Deardorff's method. Radiation parameterisation- Representation of radiation in numerical models.

Unit V

Objective analysis- Cressman method, method of optimum interpolation. Initialization; Static initialisation; Dynamic initialisation–Normal mode initialisation, Newton relaxation or Nudging. Nonlinear instability, Aliasing. Arakawa Jacobian. Staggered grid systems. Data Assimilation.

Text Books

1. Numerical Weather Prediction G.J. Haltiner, John Wiley
2. Numerical Prediction and Dynamical Meteorology by G.J.Haltiner , R.T.Williams, John Wiley
3. Numerical weather analysis and forecasting by P.D.Thompson.
4. An Introduction to Dynamical Meteorology, J.R.Holton
5. Introduction to Theoretical Meteorology by S.L. Hess
6. Tropical Meteorology by T.N.Krishnamurti, WMO publications

COs	**M.Sc students of Meteorology course will be taught about the practical aspects of**	**Cognitive level**
CO1	handling the outputs of various Numerical models	Analysing
CO2	Interpreting the results of the various Numerical Weather Prediction products is the main outcome of this course.	Analysing

CSO	**Course Specific Outcomes (CSOs)**
CSO1	The students will be taught the fundamentals of numerical weather prediction and the various finite difference schemes used in the model integration along with the merits and demerits of each scheme.
CSO2	They will also be taught about the design of both the numerical models of the mid-latitudes and the tropical latitudes apart from the nuances of short, medium and long range weather prediction models.
CSO3	The latest meso-scale models and the widely used Weather Research and Forecasting (WRF) model will be learnt and the incorporation of satellite data in NWP models will be taught
CSO4	The important physics parameterizations like moisture, radiation, boundary layer and microphysics and how they are included in the NWP models will be learnt.
CSO5	Data processing, objective analysis and the methods of initialization, various types of grid systems along with data assimilation techniques will be learnt.

Course Learning Outcomes (CLOs)

CLO1: Students who successfully finish this course will find a suitable place as an NWP specialist at the various forecasting centers like the India Meteorological Department (IMD), National Center for Medium Range Weather Forecast (NCMRWF) and various meteorological agencies in and outside India.

Contribution of Course Outcomes towards achievement of Program Outcomes (1 – Low, 2 - Medium, 3 – High)

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	2	2	-	-	-	-	-	-	-	-	-	-	2
CO2	1	1	2	1	-	-	-	-	-	-	-	-	-	2

Air -Sea Interaction Common syllabus for M.Sc Meteorology and Physical Oceanography - III semester			
Course Category	Basic Science core course	Course Code	PO-302
Course Type	Theory	Lectures-Training-Practical	3-1-0
Prerequisites	Basics of the Physical meteorology and Physical Oceanography, dynamical and synoptic meteorology	Internal Assessment Semester End Examination Total Marks	20 80 100

Course Objectives

1. To provide the basic information related to Air-sea Interaction studies
2. To impart knowledge on atmospheric boundary layer, estimation of air sea fluxes
3. To provide a thorough investigation of large scale air-sea interactions and middle latitude interaction with special reference to Indian Monsoon

PO-302: Air Sea Interaction

[Common Syllabus with M.Sc. (Meteorology) Third Semester]

Unit-I: The significance of Air-Sea Interaction: Atmospheric and Oceanic Interaction at various scales; Concept of Boundary Layer. Barrier Layer, surface Layer, Ekman Layer, Upper ocean boundary layer Atmospheric Heat Budget, Oceanic heat budget.

Unit-II: Estimation of Air-sea fluxes: Drag coefficient, wind stress, heat and moisture exchange coefficients, bulk formula for momentum flux, sensible heat flux and latent heat flux, Physical interaction between the ocean and atmosphere; Oceanic impact on the marine atmospheric circulation.

Unit-III: The Origin of Wind Waves: Properties of Instability Waves, Mixed layers, Thermoclines, Hot towers, Thermodynamics of hot towers, Breaking of the waves.

Unit-IV: Large Scale Air-Sea Interaction: Ocean – Atmosphere interaction in tropics; Characteristics of ENSO; ENSO and Air – Sea coupling; ENSO and the Indian Monsoon, Warm Pool in Indian and Pacific Oceans.

Unit-V:
Role of mid-latitude on Indian monsoon: Rossby wave dynamics, Silk Road Pattern, South Asian High, south Indian Ocean, Indonesian Through Flow, coupled models in air -sea Interaction studies

Text Books:

1. Atmosphere – Ocean Dynamics, Adrian E. Gill, 1992.
2. Climate and Circulation of the Tropics, S. Hasternath, 1988.
3. The Oceans and climate by G.R.Bigg, 1996.
4. Ocean – Atmosphere interaction and climate modeling, Beris A. Kagan, 1995
5. Air-Sea Interaction Law and Mechanisms by G.T. Csanady

Upon successful completion of the course, the student will be able to:		Cognitive level
CO1	Understand the principles of air-sea interaction processes, concept of boundary layer and also can differentiate between atmospheric and oceanic boundary layer.	Understanding
Co2	Derive and analyse the different methods to estimate the air-sea fluxes and the impact of ocean on marine atmospheric circulation.	Analysis
CO3	Learn the instability theories like Bjerkens and Kelvin Helmholtz, mixed layer, thermocline, hot towers and breaking of the waves.	Knowledge
CO4	Define and evaluate the small scale and large scale systems in tropical regions. and coupling mechanisms.	Knowledge
CO5	Distinguish the SSTs over Indian, Pacific and Atlantic Ocean SSTs in ENSO phenomena.	Analysis
CO6	Understand the Indian monsoon characteristics and their relationship with El Nino , IOD conditions.Analyze the basics of the feedback mechanism like cloud-albedo, Bjerkens, WES feed backs.	Understanding
CO7	Analyse the Indian Ocean warming influences the monsoons and other teleconnection parameters like Pacific ocean, walker circulation, current systems	Analysis

Course Specific Outcomes (CSOs)

1. To understand the basic air-sea interaction processes in the different time scales.
2. To derive the air-sea fluxes and physical interaction ,oceanic impact on atmospheric marine circulation.
3. To study the Instability and breaking of waves, Mixed layer dynamics and hot towers.
4. To understand the large scale interaction with special reference to ENSO and its impact on Indian monsoon, warm pool regions in the Pacific and Indian Ocean.
5. To understand the Mid latitude interaction on Indian monsoon and recent developments in the coupled models

Student can learn after completing the course (CLOs)

1. Learn different methodologies to describe the boundary layer.
2. Detail analysis and methods to estimate the drag and wind stress.
3. Application of this study will help them to parameterize the micro scale systems in the boundary layer.
4. Detail analysis of mixed layer and thermoclines .
5. Identify El Nino condition on real-time basis in models as well as in analysis.
6. Adopting of the methodology in recent coupled model simulations on monsoons and can easily analyze by the students.
7. The statistical metrics will be calculated with critical thinking and communicate in oral as well scientific publication.

Contribution of Course Outcomes towards achievement of Program Outcomes (1 – Low, 2 - Medium, 3 – High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	-	-	-	-	-	-	-	-	-	-	2
CO2	1	1	2	1	-	-	-	-	-	-	-	-	-	2
CO3	3	1	2	-	-	-	-	-	-	-	1	-	1	2
CO4	2	2	2	-	-	-	-	-	-	-	-	-	-	2
CO5	2	2	2	-	-	-	-	-	-	-	-	-	1	1
CO6	3	2	2	-	-	-	-	-	-	-	-	-	1	1
CO7	2	2	2	-	-	-	-	-	-	-	1	-	1	2

Indian Ocean Dynamics Common syllabus for M.Sc Meteorology and Physical Oceanography - III semester			
Course Category	Basic Science core course	Course Code	PO-303
Course Type	Theory	Lectures-Training-Practical	3-1-0
Prerequisites	Basics of the Physical meteorology and Physical Oceanography, dynamical and synoptic meteorology	Internal Assessment Semester End Examination Total Marks	20 80 100

Course Objectives

1. To provide the basic information of Indian Ocean physical, chemical characteristics.
2. To impart knowledge on role of surface forcing and currents in the Indian Ocean
3. To understand the thermohaline circulation and water mass characteristics in Indian Ocean

M.Sc. Physical Oceanography
PO-303: Indian Ocean Dynamics

Unit-I

Physical characteristics of the Indian Ocean – size, shape, ocean basin, mid oceanic ridge system, ocean floor and seas. Physical, dynamical and biological characteristics of the Arabian Sea, Bay of Bengal and Equatorial Indian Ocean .Physio – Chemical and marine ecosystem of the Andaman Sea and Lakshadweep sea.

Unit- II

Surface forcing – winds, radiation, river discharge, Ekman spiral/transport, Geostrophic currents, meanders and rings, Warm pool, Langmuir cells/circulation. Regions of upwelling and sinking along Indian Ocean.Surface circulation– Gyre systems along north and south Indian Ocean

Unit-III

Indian Ocean currents **-** SW & NE monsoon drift (Indian monsoon current), Somali Current, Equatorial counter current, Indonesian through flow, south equatorial current, East Madagascar current, Mozambique current, Agulhas current, Leeuwin current, west Australian current, south Australian counter current, west wind drift.

Unit-IV

Indian Ocean cross-equatorial flow, meridional overturning, Conveyor belt, subtropical gyres. Variability of Indian Ocean currents – monsoon circulation, Great Whirl, circulation pattern during the events of ENSO and IOD, Equatorial Indian Ocean – Wyrtki jet, Indian Ocean Dipole.

Unit-V

Thermohaline circulation **-** Thermal structure of Indian Ocean, variability of Mixed Layer and Barrier Layer, thermocline, salinity fluctuations, water mass characteristics of Indian Ocean, under currents and thermohaline circulation.

Text books

1. Ocean Circulation – Prepared by open university course team
2. The Indian Ocean : A Perspective – by Rabin Sen Gupta, Ehrlich Desa
3. Ocean circulation and climate – Observing and modeling the global ocean **-** Gerold Siedler, John Church, John Gould.
4. Ocean and Climate – Grant R. Bigg

COs	**Upon successful completion of the course, the student will be able to:**	Cognitive level
CO1	A formative idea about physical, geographical and different aspects to Indian Ocean and its uniqueness.	Knowledge
CO2	Indian ocean floor characteristics and its monitoring.	Understanding
CO3	Construct a detail map related to productive zones in the Arabian Sea..	Analysis
CO4	Physio-chemical characteristics of Andaman and Lakshadweep Islands.	Knowledge
CO5	Dynamical aspects of equatorial Indian Ocean.	Understanding

Course Specific Outcomes(CSOs)

1. Physical and dynamical behaviour of Arabian Sea and Bay of Bengal, its role on monsoons.
2. Assemble the warmpool and its linkage with monsoon
3. Equatorial jet and its behaviour with seasons.
4. Small scale mesoscale process (Langmuir) and its importance
5. New seasonal gyral map design related to North Indian Ocean.
6. Vertical thermal structure of Indian Ocean
7. Analyses of Indian Ocean and ocean-atmospheric teleconnections (ENSO, IOD), help to operational forecast of ocean circulation.

Course Learning Outcomes (CLOs)

1. Discrimination between Arabian Sea and Bay of Bengal.
2. Ocean basin and ridges systems in the western and eastern Indian Ocean.
3. Significance of Islands and its surrounding marine ecosystem which will boost to tourism industry.
4. Area expansion and dynamics of warm pool, Arabian Sea mini warm pool.
5. Appraise of upwelling and its intensity along the Indian coastline.
6. Strength and vertical changes of seasonal gyres in the North Indian Ocean.
7. Distinguish between mixed layer and barrier layer in the Indian Ocean.
8. Understand salinity changes in both spheres of the Indian ocean and its role on thermohaline circulation

Contribution of Course Outcomes towards achievement of Program Outcomes (1 – Low, 2 - Medium, 3 – High)														
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	2	2	-	-	-	-	-	-	-	-	-	-	2
CO2	1	1	2	1	-	-	-	-	-	-	-	-	-	2
CO3	3	1	2	-	-	-	-	-	-	-	1	-	1	2
CO4	2	2	2	-	-	-	-	-	-	-	-	-	-	2
CO5	2	2	2	-	-	-	-	-	-	-	-	-	1	1

Coastal and Estuarine Process Common syllabus for M.Sc Meteorology and Physical Oceanography - III semester			
Course Category	Basic Science core course	Course Code	PO-304
Course Type	Theory	Lectures-Training-Practical	3-1-0
Prerequisites	Basics of the Physical meteorology and Physical Oceanography, dynamical and synoptic meteorology	Internal Assessment Semester End Examination Total Marks	20 80 100

Course Objectives

1. To understand the various coastal processes and classification of the coast.
2. To study the changes in sea level, beach features and classification of estuaries
3. To understand the salinity intrusion and stratification along the coastal regions.

M.Sc. Physical Oceanography
PO-304: Coastal and Estuarine Process

Unit I:
Coastal Process, Coastal classification, Morpho dynamic approaches and behavior to coastal systems, long-term changes. Coastal sand dunes, coasts and climate. Submerged aquatic vegetation-seagrasses. Coastal and near shore circulation-long shore currents.

Unit II:
Sea level changes : Periodic sea level changes – short term variations – long term changes – Impact of global warming on sea level – impacts of sea level rise.

Unit III:
Beach features: Beach cycles, beach profiles-erosion and accretion, Sediment transport rate – onshore and offshore transport – coastal features – LEO observation beach stability – artificial nourishment – coastal defence structures – planning and design of coastal structures – tidal inlets and Lakes, deltas. Minerals of the deep seabed -Technology and economics. Indian Deep Sea mining program

Unit IV:
Estuaries: Classification, tides in estuaries, estuarine circulation and mixing, Hydrology and hydrograph, sedimentation in estuaries. Estuarine Habitats, Natural, Human Disturbances and monitoring the estuaries

Unit V:
Salinity intrusion in estuaries, effect of stratification, coastal pollution: mixing and diffusion dispersal of pollutants in estuaries, tidal prism concept. Geo-spatial technology, lake dynamics (chilika, kolleru, and pulicat). Coastal pollution - Black tide, HAB, oxygen depletion in coastal waters, Mixing and dispersal of pollutants in estuaries.

Reference books:

1. Coastal and Estuarine Dynamics by A.T. Ippen
2. Estuaries: A Physical Introduction by K.R. Dyer
3. Coastal Engineering by Kiyoshi Horikawa

COs	**Upon successful completion of the course, the student will be able to:**	Cognitive level
CO1	Sediment transport changes in nearshore area.	Knowledge
CO2	Coastal process and its influencing factors.	Analysis
CO3	New technologies to extract deep sea resources, it will boost the blue economy.	Understanding
CO4	Coastal sand dunes and its morphology	Analysis
CO5	New methods in monitoring the estuaries	Analysis

Course Specific Outcomes (CSOs)

1. Nearshore process, longshore current, Fresh and sea water habitats, its characteristics and classification.
2. Develop new ideas to protect ground water contamination from salt water intrusion in coastal urban cities.
3. Create new designs or coastal structures to protect the coastline.
4. Coastal pollution, Black tide and HAB.
5. Acquire fundamental and coherent scientific knowledge of the coastal, estuarine system and its interactive components.
6. Analysing parameters that influence global and regional sea level changes,shor term sea level changes, precautionary measures.

Course Learning Outcomes(CLOs)

1. Describe various characteristics of coast and beach.
2. Coastal and climate relation, significance of submerged aquatic vegetation.
3. Understanding new space technology to monitoring lake dynamics, pollution in coastal and estuaries.
4. Knowledge on location and deposition of deep sea bed minerals.
5. Demonstrate an understanding of Artificial nourishment program
6. LEO observations and its validation.
7. Acquaint Indian deep sea mining program and its developments.
8. Rip currents and safety measures.

Contribution of Course Outcomes towards achievement of Program Outcomes (1 – Low, 2 - Medium, 3 – High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	-	-	-	-	-	-	-	-	-	-	2
CO2	1	1	2	1	-	-	-	-	-	-	-	-	-	2
CO3	3	1	2	-	-	-	-	-	-	-	1	-	1	2
CO4	2	2	2	-	-	-	-	-	-	-	-	-	-	2
CO5	2	2	2	-	-	-	-	-	-	-	-	-	1	1

Physical Oceanography Practical Common syllabus for M.Sc Meteorology and Physical Oceanography - III semester			
Course Category	Basic Science core course	Course Code	PO-305
Course Type	Practical	Lectures-Training-Practical	3-1-0
Prerequisites	Basics of the Physical meteorology and Physical Oceanography, dynamical and synoptic meteorology	Internal Assessment Semester End Examination Total Marks	20 80 100

Course Objectives

1. To analyse the wave data and wave refraction along with longshore and relative currents
2.To estimate the BLD , beach profiles using the Temperature and salinity profiles
3. Analysis of argo data and tides and ENSO phenonmenon

PO-305: Physical Oceanography Practicals

1. Wave Data Analysis – Rose Diagrams
2. Wave Refraction Diagrams
3. Computation of Longshore currents
4. Computation of relative currents.
5. Beach Profiles and slope estimation
6. Estimation of MLD and BLT from T/S profiles
7. Argo data analysis.
8. Tidal analysis – a) calculation of Form number, b) tidal interpolation and c) datum correction
9. Identifying ENSO and IOD years by computing the respective indices using long term SST data.
10. Identifying the dominant modes of short-term climate variability (El Nino in the Indo-Pacific region and IOD patterns in the Indian Ocean) using EOF technique.
11. Scaling of Eqaution
12. Compute Rossby Number, Fraud Number etc.

COs	**Upon successful completion of the course, the student will be able to:**	Cognitive level
CO1	Plotting the wave rose diagram using wave data in all directions.	Analysis
CO2	Construction of wave refraction diagram with the help of ocean bathymetry and wave crest data.	Understanding
CO3	Manual and also mathematical estimation of longshore current speed and estimation of relative current using hydrographic data between two stations.	Understanding
CO4	Observation of beach profile and slope estimation at different locations and Identification of different ocean processes using argo data	Analysis
CO5	Observation of different type of tide using tidal analysis and form number Computation of ocean indices using sea surface temperature data to identify ENSO and IOD.	Knowledge
CO6	Extracting short term climate modes from sea surface temperature using EOF technique.	Knowledge

Course Specific Outcomes (CSOs)

1. Knowledge on plotting wave refraction diagram with the help of wave plotter.
2. Determination of mixed layer depth and Barrier layer thickness using t-s profiles at different locations.
3. Circulation between two stations and its advantage, disadvantages.
4. Understand the role of ocean thermal property on short to long term Ocean-atmospheric teleconnections like ENSO and IOD.
5. Acquire knowledge on advanced mathematical techniques to get short term climate modes.

Course Learning Outcomes (CLOs)

1. Understand the wave climate at a particular location.
2. Longshore current speed and its seasonal changes.
3. Changes in erosion and depostion at different locations.
4. Ocean-atmospheric exchange and stratification in the water column at different locations.
5. Practical knowledge on identification of different ocean processes.
6. Identification of type of tide present in a particular location.

Contribution of Course Outcomes towards achievement of Program Outcomes (1 – Low, 2 - Medium, 3 – High)														
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	2	2	-	-	-	-	-	-	-	-	-	-	2
CO2	1	1	2	1	-	-	-	-	-	-	-	-	-	2
CO3	3	1	2	-	-	-	-	-	-	-	1	-	1	2
CO4	2	2	2	-	-	-	-	-	-	-	-	-	-	2
CO5	2	2	2	-	-	-	-	-	-	-	-	-	1	1

Synoptic Analysis Practical			
Common Syllabus for M.SC Meteorology/Physical Oceanography - III semester			
Course Category	Basic Science core course	Course Code	PO-306
Course Type	Practical	Lectures-Training-Practical	3-1-0
Prerequisites	Basics of the concerned specialization	Internal Assessment Semester End Examination Total Marks	20 80 100

Course Objectives

1. To demonstrate the synoptic weather analysis and weather forecasting.
2. To impart knowledge on the tropical synoptic weather systems.
3. To address the analysis of western disturbance.
4. To address the analysis of break monsoon situation.

PO-306: Synoptic Analysis(Practical)

[Common Syllabus with M.Sc. (Meteorology) Third Semester]

1. Decoding weather messages of surface and upper air
2. Plotting of surface and upper air data and preparation of weather chart
3. Analysis of surface and upper data
4. Case study of Bay cyclone.
5. Case study of Monsoon disturbance.
6. Case study of western disturbance.
7. Case study of break monsoon situation

COs	The practicals demonstrate the synoptic weather analysis and forecasting of weather	Cognitive level
CO1	It is useful to various sectors like agriculture, power generation, industries etc.	Knowledge
CO2	This course will provide knowledge on the decoding the weather messages of surface and upper air.	Analysis
CO3	This course will provide knowledge on the plotting of surface and upper air data and preparation of weather charts.	Analysis
CO4	Bay of Bengal cyclones are devastating rain-bearing systems which provide copious amounts of rainfall to India. Analysis as well as forecasting of such systems is a challenging task to the meteorologists. Three case studies included in the practicals give an insight on the genesis, development and decay of tropical cyclones and their tracks.	Analysis
CO5	Majority of monsoon depressions in prime monsoon months (July and August) offer good amounts of rainfall in the central parts of India. One Case study of Monsoon disturbance will be studied. This provides knowledge on the distribution of rainfall activity, track and low level as well as upper level circulations in the troposphere.	Knowledge
CO6	Western disturbances are eastward moving rain-bearing systems which provide appreciable amounts of rainfall particularly over Northwest India. The students will learn the distribution of rainfall, movement of disturbance and circulation patterns.	Knowledge
CO7	Break monsoon situations occur in the months of July and August. August is more susceptible to breaks. The features related with the break monsoon situation will be learned.	Analysis

Course Specific Outcomes (CSOs)

1. The students will understand three dimensional structures of the weather systems and learn how to make a weather forecast.
2. The students will acquaint knowledge on the distribution of various weather parameters and rainfall in different synoptic weather systems.
3. The students will gain knowledge on the plotting of surface and upper air data and preparation of weather charts.

Course Learning Outcomes (CLOs)

LO1: The synoptic weather analysis and forecasting of weather using surface and upper data will be taught
LO2: The decoding weather messages of surface and upper air will be demonstrated.
LO3: Plotting of surface and upper air data and preparation of weather charts will be learned.
LO4: The synoptic surface and upper air data for three Bay cyclones will be analyzed.
LO5: The synoptic surface and upper air data for a monsoon depression will be analyzed .
LO6: The synoptic surface and upper air data for a western disturbance will be analyzed.
LO7: The synoptic surface and upper air data for a break monsoon situation will be analyzed.

Contribution of Course Outcomes towards achievement of Program Outcomes (1 – Low, 2 - Medium, 3 – High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	-	-	-	-	-	-	-	-	-	-	2
CO2	1	1	2	1	-	-	-	-	-	-	-	-	-	2
CO3	3	1	2	-	-	-	-	-	-	-	1	-	1	2
CO4	2	2	2	-	-	-	-	-	-	-	-	-	-	2

CO5	2	2	2	-	-	-	-	-	-	-	-	-	1	1

Viva-Voce			
Common syllabus for Physical Oceanography - III semester			
Course Category	Basic Science core course	Course Code	PO-307
Course Type	Viva-Voce	Lectures-Training-Practical	3-1-0
Prerequisites	Basics of the computer science, Mathematics.	Total Marks	50
COURSE OBJECTIVES			
1	To evaluate the performance and knowledge of the student orally in the field of meteorology and Oceanography.		
2.	To get the better placement opportunities and better performance in future.		

COs	**Upon successful completion of the course, the student will be able to:**	**Cognitive level**
CO1	Student can improve softskills , communication skills	Knowledge
CO2	Student can able to demonstrate the specific knowledge on the specialised area	Analysis
CO3	This viva-voce will help for his career progression to enhance profession etiquette	Analysis

Contribution of Course Outcomes towards achievement of Program Outcomes (1 – Low, 2 - Medium, 3 – High)														
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	2	2	-	-	-	-	-	-	-	-	-	-	2
CO2	1	1	2	1	-	-	-	-	-	-	-	-	-	2
CO3	3	1	2	-	-	-	-	-	-	-	1	-	1	2

Fourth Semester

Climate and Ocean Modelling			
Common Syllabus for M.SC Meteorology/Physical Oceanography - IV semester			
Course Category	Basic Science core course	Course Code	PO-401
Course Type	Theory	Lectures-Training-Practical	3-1-0
Prerequisites	Basics of the concerned specialization	Internal Assessment Semester End Examination Total Marks	20 80 100

Course Objectives
1. To understand the basic components of the climate models and different types
2. To study the importance of the parameterization in the general circulation models.
3. To know the basic concepts of the Ocean models and the status of ocean models in India.

PO-401: Climate and Ocean Modelling

Unit I

General circulation and climate modeling: Introduction to climate modeling. Energy balance models- their structure; zero dimensional energy balance models; one dimensional energy balance models. Radiative convective models: The structure of Global Radiative convective models: Radiation computation – Short wave radiation, long wave radiation, heat balance at the ground, Convective adjustment; Sensitivity experiments with radiative convective models. Meridional circulation models, mean meridional and eddy transport of energy and momentum.

Unit II

Two dimensional models- zonally averaged climate models – spatial and temporal structure; statistical and dynamical climate models; representation of convection, cloud cover, precipitation, radiation and surface characteristics in 2-D SDMs. Physics in climate models – Radiative transfer, Boundary layer; surface parameterization; Zonal circulation in tropics: climate variability and forcings, feedback processes, low frequency variability, MJO, ENSO, QBO, and sunspot cycles.

Unit III

Three dimensional atmospheric general circulation models – the structure of general circulation climate models. Numerical information – Grid point general circulation models; Phillips experiment. Spectral general circulation models- Spectral method; Triangular and rhomboidal truncation; spectral Transform method. Regional climate models: Formulation; boundary conditions, specific applications-ICTP-RegCM and ETA_Clim. Convection; large scale rainfall.

Unit IV

Introduction to Ocean modeling; Basic equations, wind driven barotropic models, simple thermohaline models, baroclinic models, mixed layer models. Shallow water models. Status of operational models in Indian Ocean: Global ocean models: Modular Ocean model (MOM), Princeton ocean model (POM), Regional oceanic Modelling Systems (ROMS). Interannual variability of ocean fields and its relationship with monsoon.

Unit V

Coupled Ocean Atmospheric Models, Physics in ocean modeling – Shallow water equation, sub-grid scale parameterization, Indian Ocean boundary conditions, model forcing conditions over Indian Ocean.

Text Books

1. A Climate Modelling Primer. A.H Sellers and K. Mc Guffie.
2. Introduction to three dimensional general circulation models. W.M.Washington and Parkinson.
3. Numerical Modeling of Ocean Circulation. Robert N. Miller
4. Numerical prediction and Dynamic meteorology. G.J. Haltiner and R.T. Williams. John Wiley.
5. Atmosphere, ocean and Climate dynamics by John Marshall.
6. Numerical models for Ocean circulation – Pond S. and Bryan.
7. Climate Modeling. Stephen H. Schneider and Robert E.Dickinson
8. Dynamics and modeling of ocean waves – Komen G.J and Cavaleri L.

COs	**Upon successful completion of the course, the student will be able to:**	Cognitive level
CO1	Students of this course will be having a firsthand knowledge about the design of climate models and ocean models.	Understanding
CO2	climate models with reference to Zero dimensional, 1-Dimensional and 2-Dimensional climate.	Analysis

Course Specific Outcomes (CSOs)

Students pursuing this course will be learning about the

1. They will also learn about the general circulation modeling of the entire Earth's atmospheric system. In addition to this, they will learn about the nuances of designing standalone ocean model.
2. After learning this they will be in a position to design coupled ocean-atmospheric models which is the state of the art in climate modeling as per the agenda of the Inter-governmental panel on Climate Change.

Course Learning Outcomes (CLOs)

Students successfully finish this course will find a place as a climate scientist and researchers in the World Meteorological Organization, National climate centers and the other leading climate institutes in India and abroad.

Contribution of Course Outcomes towards achievement of Program Outcomes (1 – Low, 2 - Medium, 3 – High)														
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	2	2	-	-	-	-	-	-	-	-	-	-	2
CO2	1	1	2	1	-	-	-	-	-	-	-	-	-	2

Satellite Meteorology and Satellite Oceanography			
Common Syllabus for M.SC Meteorology/Physical Oceanography - IV semester			
Course Category	Basic Science core course	Course Code	PO-402
Course Type	Theory	Lectures-Training-Practical	3-1-0
Prerequisites	Basics of the concerned specialization	Internal Assessment Semester End Examination Total Marks	20 80 100

Course Objectives

1. The aim of this course is to give the students a broad knowledge of different remote sensing techniques in meteorology and oceanography, with special focus on satellite measurements.
2. In addition to a focus on the differences between measurements of surface conditions and the atmospheric profiles, it is focused on the different spectral regions that are used to measure different meteorological and oceanography parameters

PO-402: Satellite Meteorology and Satellite Oceanography

Unit-I

Elements of remote sensing.Satellite orbits: Newton's laws, Kepler's laws, Kepler's equation, orientation in space, orbital elements, Geostationary orbits, Sun synchronous orbits, visible and infrared radiometers, multiscanner radiometers; Radiative Transfer: Electromagnetic radiation, black body radiation laws, non black bodies radiative transfer equation, Schwarzschild equation, gaseous absorption and scattering.

Unit-II

Satellite imagery: Creating images, spatial resolution, visible imagery, infrared imagery, water vapor imagery, microwave imagery, Image enhancement. Atmospheric and surface phenomena, tropical cyclones, thunderstorms, sandstorms, fog. Temperature and Humidity Retrieval: Sounding theory, retrieval methods, Limb sounding retrievals, the split window techniques, cloud top temperatures

Unit-III

Winds: cloud motion winds, Ocean surface winds, Tropical Cyclone winds- Dvorak technique. Clouds: clods from imagers, Threshold technique, histogram technique, multispectral technique, cloud top temperature. Precipitation: Visible and Infrared technique, Passive microwave technique, GOES precipitation index. Estimation of earth radiation budget, outgoing Long wave Radiation, Soil moisture, vegetation index.

Unit-IV

Ocean properties measurable from satellites. Ocean Color Remote Sensing: optical theory for Ocean color remote sensing, recovering useful information from ocean color, estimating water parameters from spectral band ratios, identifying Potential Fishing Zones.IR measurement of Sea Surface Temperature – estimation of SST, AVHRR, Oceanographic application of IR SST data. Passive microwave Radiometers: Physical principle of passive microwave radiometry, retrieval of Salinity, SST and surface wind from microwave measurements, Oceanographic application of passive microwave data.

Unit-V

Radar Altimeters over the Ocean: Principles of satellite altimetry, measuring distance with a radar altimeter, Ocean currents from altimetry, estimating wave height and wind speed. Uses of Altimetry. Sea surface roughness and Scatterometry : Measuring the radar energy reflected from Sea, microwave interaction with Sea surface. Empirical relationships between wind and radar back scattering.

Synthetic Aperture Radar (SAR) imaging of the Ocean: principle of SAR, Range resolution, Aperture synthesis, SAR imaging of Ocean waves. Hydrodynamic modulation, Tilt modulation, Velocity modulation, Ocean information from SAR images, SAR imaging of ocean phenomena.

Text books:

1. Measuring the oceans from space- Ian S.Robinson
2. The principles and methods of satellite oceanography- Ian S. Robinson
3. Discovering the ocean from space- Ian S. Robinson
4. The unique applications of satellite oceanography – Ians Robinson
5. Satellite meteorology an Introduction – stanley Q. Kidder, Thomas H. Vander Harr
6. Satellite Meteorology R.R.Kelkar
7. Applications with Meteorological satellites – W. Paul Menzel
8. Fundamentals of Remote sensing – George joseph

9. Oceanographic applications of Remote Sensing – Motoyoshi Ikeda, Frederic W.Dobson

COs	**Upon successful completion of the course, the student will be able to:**	Cognitive level
CO1	The aim of this course is to give the students a broad knowledge of different remote sensing techniques in meteorology and oceanography, with special focus on satellite measurement	Knowledge
CO2	Students of satellite meteorology and satellite oceanography will be exposed to various types of satellites and various data sets used for the analysis of both the atmosphere and the ocean.	Analysis
CO3	Satellite imagery, which is essentially a byproduct of satellite output, is the first source to interpret both the atmosphere and the state of the ocean. Various techniques used in the measurement of winds and precipitation will be taught in this course.	Knowledge
CO4	Apart from the above, the course teaches the ocean properties and their observations through satellites. The various techniques used in estimating the satellite derived SST and the salinity retrieval and the applications of satellite data in oceanography will be explained.	Analysis
CO5	Various instruments used in estimating the wave height and wind speed and the measurement of the radar energy in terms of back scattering along with SAR imaginary will be taught. Interpretation of satellite data and estimation of satellite derived products which are used as input to atmospheric and ocean models is the specific outcome of the course.	Analysis
CO6	Meteorological satellites have been shown to improve weather forecasts and early warning services of the Agency in its indispensable role as a source of data.	Knowledge

Course Specific Outcomes(CSOs)

CSO1: Meteorological satellites have been shown to improve weather forecasts and early warning services of the Agency in its indispensable role as a source of data.

CSO1: Students of this course will find employment in the Meteorology and Oceanography divisions of the various space agencies like ISRO, NASA, ESA and JAXA.

CSO2:Satellite meteorologists often work in groups or teams with people in related careers such as engineers, computer and communications technicians, science writers, data system analysts,

CSO3: The student has a good knowledge of the different remote sensing techniques used for meteorology and oceanography, including the strengths and limitations of the techniques

CSO4: The student has knowledge of the problems about the transfer of electromagnetic radiation through the atmosphere as well as having good knowledge on the interaction of the electromagnetic radiation and the surface.

Course Learning Outcomes (CLOs)

CLO1: Students of this course will find employment in the Meteorology and Oceanography divisions of the various space agencies like ISRO, NASA, ESA and JAXA. Satellite meteorologists often work in groups or teams with people in related careers such as engineers, computer and communications technicians, science writers, data system analysts,

CLO2: The student has a good knowledge of the different remote sensing techniques used for meteorology and oceanography, including the strengths and limitations of the techniques.

CLO3: To develop knowledge about interpreting satellite image. knowledge about satellite retrieval of different atmospheric and oceanic parameters.

CLO4 Students will be able to demonstrate skills for the analysis and interpretation of satellites imagery of the Atmosphere from the different sources and can extract and analyses for the different extreme weather events (thunderstorms, cyclones).

Contribution of Course Outcomes towards achievement of Program Outcomes (1 – Low, 2 - Medium, 3 – High)

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	2	2	-	-	-	-	-	-	-	-	-	-	2
CO2	1	1	2	1	-	-	-	-	-	-	-	-	-	2
CO3	3	1	2	-	-	-	-	-	-	-	1	-	1	2

CO4	2	2	2	-	-	-	-	-	-	-	-	-	-	2
CO5	2	2	2	-	-	-	-	-	-	-	-	-	1	1

Coastal Zone Management and Ocean Resources			
Syllabus for M.SC Physical Oceanography- IV semester			
Course Category	Basic Science core course	Course Code	PO-403
Course Type	Theory	Lectures-Training-Practical	3-1-0
Prerequisites	Basics of the concerned specialization	Internal Assessment Semester End Examination Total Marks	20 80 100

Course Objectives

1. To study the rules and regulations of the coastal zone management
2. To understand the ocean resources and its application on real time basis
3. To develop the appropriate methods to reduce the coastal hazard risks.

M.Sc. Physical Oceanography
PO-403 : Coastal Zone Management and Ocean Resources

Unit-I

Coastal zone management: Classification of Coastal Regulatory Zone (CRZ), Genesis of CRZ and its importance. Integrated CZM program and its development. Management of Dune, Mangrove forest, urban runoff and seawage. Tourism Management- Marine and coastal recreation. GIS applications in CZM.

Unit-II

Coastal zone management: Laws relevant for coastal zone management, prohibited activities, relevant legislations, Coastal security, Tidal flats, deltas, Maintenance of Aquaculture farms

Unit-III

Ocean resources: Transportation and Shipping, minerals, water, fuels, Potential fishing zones (PFZ), Gas hydrates, Harnessing of the Ocean. Energy Resource: Ocean Thermal Energy Conversion (OTEC) plants, wave energy and tidal energy. Minerals of the deep seabed -Technology and economics. Indian Deep Sea mining program

Unit-IV

Coastal Hazards: dynamics of rip current, forecasting, tsunamis, storm surge, oil spills and disaster management. Coastal Erosion Mitigation, Coastal Flooding Mitigation. Management of coastal erosion and flooding under climate change.

Unit-V

Coastal constructions: Jetties, groins, Piers, breakwaters, maintenance of entrance channels, safety measures for coastal areas. Hard, soft, store and retreat strategies to protect the coast.

Text books

1. An Introduction to Coastal Zone Management by Timothy Beatley, David Brower, Anna K. Schwab
2. The Coast: Hazardous Interactions within the Coastal Environment by Timothy M. Kusky
3. GIS for Coastal Zone Management - by Darius J Bartlett, Jennifer L Smith
4. Coastal Zone Management Imperative for Maritime Devloping Nations - by Bilal U Haq, Gunnar Kullenberg
5. Coastal zone management handbook by John R. Clark

COs	**Upon successful completion of the course, the student will be able to:**	Cognitive level
CO1	Explain characteristics of CRZ and its classification. Development of Integrated CRZ program.	Knowledge
CO2	Using space technologies identify potential Fishing zones, helps to fisherman community.	Understanding
CO3	Innovative methods and designs to harnessing clean energy from ocean, which will support the power generation industry.	Analysis
CO4	Formation, development of deltas and its classification.	Knowledge
CO5	Create new management methods for urban runoff and sewage. Economical aspects of transportation and shipping.	Analysis

Course Specific Outcomes (CSOs)

1. Coastal tourism management and its different branches,Tidal flats, its surrounding ecosystem.
2. Develop best methods for maintenance of entrance channels particularly in Ports.
3. Create new mitigation plans for coastal flooding and erosion.
4. Modern eco-friendly marine and coastal parks for the development of tourism industry.
5. Oil spills and its management methods.

Course Learning Outcomes (CLOs)

1. Understand development and management of Dunes.
2. Knowledge on new managing methods to develop Mangrove forest.
3. Various defence strategies to protect the coast from natural and manmade calamities.
4. Breakwater construction and different methods.
5. Develop advance strategies in coastal security system.
6. Ocean economics, its relation to Deep Sea mining program.
7. Management strategies of entrance channels.

Contribution of Course Outcomes towards achievement of Program Outcomes (1 – Low, 2 - Medium, 3 – High)

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	2	2	-	-	-	-	-	-	-	-	-	-	2
CO2	1	1	2	1	-	-	-	-	-	-	-	-	-	2
CO3	3	1	2	-	-	-	-	-	-	-	1	-	1	2
CO4	2	2	2	-	-	-	-	-	-	-	-	-	-	2
CO5	2	2	2	-	-	-	-	-	-	-	-	-	1	1

Accoustical Oceanography			
Syllabus for M.SC Physical Oceanography - IV semester			
Course Category	Basic Science core course	Course Code	PO-404
Course Type	Theory	Lectures-Training-Practical	3-1-0
Prerequisites	Basics of the concerned specialization	Internal Assessment Semester End Examination Total Marks	20 80 100

Course Objectives

1. To understand the sound transmission in the Ocean
2, To evaluate the sound propagation through advanced mathematical equations
3. To understand the application of SONAR and bio acoustics

M.Sc. Physical Oceanography
PO-404: Acoustical Oceanography

Unit-I:
Physical and biological characteristics of sea: Ocean stratification, sound speed and Ray refraction: Fundamentals of acoustics: A review of basic vibration theory, basic acoustic theory, and the physics of sound propagation, reflection, and absorption phenomena.

Unit –II:
Physical characteristics of the sea related to sound transmission. Internal waves.
Types of sound losses – Cylindrical, Spherical and Tramission Loss. Sound velocity vertical structure of the sea. Concepts of absorption, scattering, attenuation, heat conduction, reflection and refraction of sound propagation in the sea. Temperature, salinity and depth effects on sound propagation, SOFAR channel.

Unit III:
Acoustic Wave Equation – Normal mode theory and Ray theory, GM theory. Transmission of sound in shallow waters and its applications. Transmission of sound in deep waters and its applications.

Unit-IV:
Sonar Concepts Overview: overview of the active and passive sonar equations. components in sonar equations in terms of the relevant physics and system parameters. Doppler effect; Different types of Sonars. Propagation and Scattering in Shallow Water: Ocean bottom imaging. Pollution monitoring.
. **Unit-V:**
Bioacoustics: Role of active and passive acoustic technology in studying organisms in the marine environment. Sensing of plankton and nekton; passive acoustics: rainfall at sea and marine animals, marine mammals. Acoustic tomography, time reversal and turbulence.

Reference books:

1. Fundamentals of Marine Acoustics - Jerald W.Caruthers, 1977
2. Introduction to the theory of sound transmission with Application to Ocean - C.B.Officer, 1958
3. An introduction to underwater acoustics, Xavier Lurton, 2002

COs	**Upon successful completion of the course, the student will be able to:**	Cognitive level
CO1	Effect of physical and biological characteristics on sound in the sea and Absorption of sound in the ocean, its effect in sound transmission.	Knowledge
CO2	Identification procedure for SOFAR channel, underwater communication over long distances.Scattering of ocean sounds and its role on finding different biological species	Understanding
CO3	Examine various types of loss in underwater sound transmission.	Analysis
CO4	Applications of sound in deep and shallow water, identifying shadow zones. Monitoring vertical distribution of sediment in the seabed using sound.	Analysis
CO5	Monitoring coastal pollution and underwater acoustic pollution. New sound technology to observation ocean temperature and salinity	Understanding

Course Specific Outcomes (CSOs)

1. Vertical structure of temperature and salinity on sound transmission.
2. Advanced sonar designs and its working methods, it helps submariners to detect objects and communicate information.
3. Mathematical derivation of acoustic wave theory and its solution
4. Understand and assess the importance of Acoustic tomography in ocean observations.
5. Familiarize with acoustic technology in studying marine organisms

Course Learning Outcomes (CLOs)

1. Ocean stratification, sound speed variability.
2. SOFAR channel Significance, the best channel for underwater communication over long distances.
3. Advanced acoustic methods for the mapping or imaging the ocean bottom.
4. Shallow water applications of sound
5. Sensing of small size species in the ocean
6. Monitoring rainfall over the ocean and its noise effect on sound transmission.

Contribution of Course Outcomes towards achievement of Program Outcomes (1 – Low, 2 - Medium, 3 – High)

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	2	2	-	-	-	-	-	-	-	-	-	-	2
CO2	1	1	2	1	-	-	-	-	-	-	-	-	-	2
CO3	3	1	2	-	-	-	-	-	-	-	1	-	1	2
CO4	2	2	2	-	-	-	-	-	-	-	-	-	-	2
CO5	2	2	2	-	-	-	-	-	-	-	-	-	1	1

Dissertation and Seminar Common Syllabus for M.Sc Meteorology and Physical Oceanography - IV semester			
Course Category	Basic Science core course	Course Code	PO-405
Course Type	Dissertation and Seminar	Training-Practical	3-1-0
Prerequisites	Basics of the Physical meteorology and Physical Oceanography, dynamical and synoptic meteorology	Internal Assessment Semester End Examination Total Marks	40 160 200

PO-405: Dissertation and Seminar

COs: **Upon successful completion of the course, the student will be able to:**		Cognitive level
CO1	Prepare synopsis for the research work.	Knowledge
CO2	Select the appropriate data sets and methodology for their research work	Analysis
CO3	Frame hypothesis regarding their research work.	Understanding
CO4	Carry out the research work in a systematic manner.	Analysis

Course Learning Outcomes (CLOs)

1.The student will learn the critical thinking of the work objectives and evaluate the methodology.
2. The analysis of the results will be carried out through oral and scientific communication

Contribution of Course Outcomes towards achievement of Program Outcomes (1 – Low, 2 - Medium, 3 – High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	-	-	-	-	-	-	-	-	-	-	2
CO2	1	1	2	1	-	-	-	-	-	-	-	-	-	2
CO3	3	1	2	-	-	-	-	-	-	-	1	-	1	2
CO4	2	2	2	-	-	-	-	-	-	-	-	-	-	2

Viva-Voce Common syllabus for M.SC Meteorology/Physical Oceanography - IV semester			
Course Category	Basic Science core course	Course Code	PO-406
Course Type	Viva-Voce	Lectures-Training-Practical	3-1-0
Prerequisites	Knowledge on Physical oceanography and applications	Total Marks	50

COURSE OBJECTIVES
To evaluate the performance and knowledge of the student orally in the field of meteorology and Oceanography. To get the better placement opportunities and better performance in future.

COs	Upon successful completion of the course, the student will be able to:	Cognitive level
CO1	Student can improve softskills , communication skills	Knowledge
CO2	Student can able to demonstrate the specific knowledge on the specialised area	Analysis
CO3	This viva-voce will help for his career progression to enhance profession etiquette	Analysis

Contribution of Course Outcomes towards achievement of Program Outcomes (1 – Low, 2 - Medium, 3 – High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	-	-	-	-	-	-	-	-	-	-	2
CO2	1	1	2	1	-	-	-	-	-	-	-	-	-	2
CO3	3	1	2	-	-	-	-	-	-	-	1	-	1	2