Approved Course Pattern in M. Tech. Oceanic Science: w.e.f. 2008-2009 Academic Year.

M. Tech. Oceanic Science Course No. & Title	Periods per week			Sessional marks	Semester end marks	Total	Credits
	L	P	T				
I Semester:							
Theory:							
OS–501 Indian Ocean Dynamics	4	-	4	30	70	100	4
OS–502 Ocean-Atmosphere Interaction	4	-	4	30	70	100	4
OS–503 Physics and Dynamics of Oceans	4	-	4	30	70	100	4
OS–504 Data Processing Methods in Atmospheric and Oceanic Sciences	4	-	4	30	70	100	4
OS–505 Geophysical Fluid Dynamics	4		4	30	70	100	4
OS–506 Physics and Dynamics of the Atmosphere	4		4	30	70	100	4
OS–507 Ocean Resources	4		4	30	70	100	4
OS-508 Coastal Hazards	4		4				
Practicals:							
OS–509 Part A: Atmospheric Science Computations **Part B**: Oceanic Science Computations	-	3 3	3 3	25 25	25 25	50 50	4
OS–510 Part A : Observation Techniques **Part B :** Ocean-Atmosphere Interaction	-	3 3	3 3	25 25	25 25	50 50	4
OS–511 Viva-voce	-	-	-	-	50	50	2
Total (* Theory courses 5 + P + VV)	**20**	**12**	**32**	**250**	**500**	**750**	**30**
II Semester:							
Theory:							
OS–512 Ocean Acoustics	4	-	4	30	70	100	4
OS–513 Ocean Dynamics and Modeling	4	-	4	30	70	100	4
OS–514 Synoptic Meteorology and Monsoon Dynamics	4	-	4	30	70	100	4
OS–515 Remote Sensing and Satellite Oceanography	4	-	4	30	70	100	4
OS–516 Coastal Processes and Coastal Zone Management	4	-	4	30	70	100	4
Practicals:							
OS–517 Part A: Synoptic Analysis **Part B:** Satellite Oceanography	-	3 3	3 3	25 25	25 25	50 50	4
OS–518 Part A: Ocean Acoustics Computations **Part B:** Coastal Oceanography Computations	-	3 3	3 3	25 25	25 25	50 50	4
OS–519 Viva-voce Examination	-	-	-	-	50	50	2
Total	**20**	**12**	**32**	**250**	**500**	**750**	**30**
III and IV Semesters	12	-	12				
OS–520 Internship				100	100	200	8
OS–521 Dissertation	44	-	44	450	450	900	36
OS–522 Seminar	8	-	8	150	150	300	12
OS–523 Viva-voce Examination				-	100	100	4
Total	**64**		**64**	**700**	**800**	**1500**	**60**
Grand Total (1+2+3+4 Semesters)	**104**	**24**	**128**	**1200**	**1800**	**3000**	**120**

1st Semester theory: out of 8 theory courses 5 courses will be allotted to the student basing on their suitable educational back ground by the Departmental Committee (DC).

M. Tech. Oceanic Science

Syllabi for I year – First Semester

OS – 501: Indian Ocean Dynamics

Physical setting of Indian Ocean – Ocean basin and mid oceanic ridge system, Arabian Sea, Bay of Bengal, Andaman Sea. (4 hours)
Surface forcing – winds, radiation; river discharge, Ekman spiral/transport, Geostrophic currents, meanders and rings, Longmuir cells/circulation. Regions of upwelling and sinking along Indian ocean. (11 hours)

Surface circulation– Gyre systems along north and south Indian ocean - Indian Ocean currents - Agulhas current, East Madagascar current, Equatorial counter current, Indonesian through flow, Leeuwin current, Madagascar current, Mozambique current, Somali current, south Australian counter current, south equatorial current, SW & NE monsoon drift (Indian monsoon current), west Australian current, west wind drift. (15 hours)

Variability of Indian Ocean currents – monsoon circulation, circulation pattern during the events of ENSO and IOD. (10 hours)

Thermohaline circulation - Thermal structure of Indian Ocean, variability of Mixed Layer, thermocline, salinity fluctuations, water mass characteristics of Indian Ocean, under currents and thermohaline circulation. (10 hours)

References:

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

AS–502 / OS–502: Ocean-Atmosphere Interaction

[Common syllabus for M Tech Atmospheric Science/ Oceanic Science I semester]

Ocean-Atmosphere boundary layer.

Concept of Boundary Layer formation; Atmospheric Boundary Layer, Oceanic Boundary Layer, structure and Evolution, Temperature profile Evolution, wind profile Evolution, Turbulence, characteristics of Boundary Layer Spectrum. Integral scales of Eddies, Taylor micro scale, Kolmogorov scale and Larger Scale, K-theory and Monin Obukhov Similarity theory. (12 hours)

Different measurement Platforms. Measurement of wind, temperature, humidity, pressure, pilot balloon techniques, solar radiation. Rain Gauges, SODAR and LIDAR.

Methods for determination of vertical transports in the Maritime Friction Layer: Direct Method(Cross-correlation Method); Aerodynamic Methods- Aerodynamic Profile Method, Bulk Aerodynamic Method; Budget Method.

Oceanic Measurements: SST, measuring currents near the ocean surface- acoustic Doppler technique, ocean wave measurement techniques.

Methods used for calculation all surface fluxes(wind stress, heat and salt) and their role in the air-sea interaction (12 hours)

The significance of Ocean-Atmospheric Interaction.

Atmospheric and Oceanic Boundary Layer Physics.

Atmospheric and Oceanic scales of motion and interaction at various scales.

Atmospheric Circulation, Oceanic Circulation.

Atmospheric Heat Budget, Oceanic Heat Budget

Measurement of surface stress, drag generation mechanisms. Wind stress and resultant drag coefficient with variation to wind speed.

Coupling Mechanisms – Small Scale and Large Scale Air-Sea Interactios:

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, Indian Ocean Dipole (IOD). (16 hours)

Books:

1. Atmosphere – Ocean Interaction by E.B.Kraus and J.A.Businger, Oxford University Press, Oxford ,1994
2. Atmosphere and Ocean Our Fluid Environments by John G. Harvey; 1985.
3. Atmosphere – Ocean Dynamics, Adrian E. Gill, 1992.

Reference

1.Air-sea Interaction Instruments and Methods. Ed by F. Dobson, L. Hasse and R. Davis; 1980.

2.Climate and Circulation of the Tropics, S. Hastenrath, 1988.

3.Ocean – Atmosphere interaction and climate modeling, Beris A. Kagan, 1995

4.The Oceans and climate by G.R.Bigg, 1996.

5.Instrumentation for Atmospheric Boundary Layer Studies; K. G. Vernekar.

6.Meteorology for scientists and Engineers by Roland Stull; 2000

7.Wind Stress over the ocean by Jones, I.S.F and Y. Toba; 2001.

AS- 503 /OS- 503: Physics and Dynamics of Oceans

(Common syllabus for M Tech Atmospheric / Oceanic Science)

Physical properties of Sea water: Definition of Salinity, Temperature, Geographical Distribution of Temperature and Salinity, The oceanic Mixed Layer and Thermocline, Density, Potential Temperature, and Neutral Density, Measurement of Temperature, Conductivity, Pressure, Measurement of Temperature and salinity With Depth, Light in the Ocean, Sound in the sea. (7 hours)

Equations of Motion: Dominant Forces for Ocean Dynamics, Coordinate Systems, Types of Flow in the Ocean, Conservation of Mass and Salt, The Total Derivative, Momentum Equation, Conservation of Mass: Continuity Equation, Solutions to the Equations of Motion. (5hours)

Equations of Motion with Viscosity: Influence of Viscosity, Turbulence, Reynolds Stresses, Stability in the Ocean, Mixing in the Ocean. (4 hours)

Response of the Upper Ocean to Winds: Inertial Motion, Ekman Layer and Ekman currents, Ekman Transports, Application of Ekman Theory. (5 hours)

Geostrophic Currents: Hydrostatic Equation, Geostrophic Approximation, Geostrophic Currents, Barotropic and Baroclinic Flow. (5 hours)

Wind Driven Ocean Circulation: Sverdrup's theory of the oceanic circulation, Stommel's Theory for western boundary currents, Basin-scale theory: Munk's solution.Vorticity definition, Conservation of vorticity, Vorticity and Ekman pumping. General circulation of oceans, water mass characteristics. (7 hours)

The Oceanic Heat Budget: Terms in the oceanic heat budget, Direct calculation of fluxes, Indirect Calculation of fluxes from bulk formulas and other sources, Geographical and seasonal distribution of fluxes, Meridional Heat Transport. (6 hours)

Deep circulation in the ocean: Importance of the deep circulation, role of the oceans in climate and abrupt climate change, Stommel-Arons' theory of the deep circulation, Antartic CircumpolarCurrent. (6 hours)

Equatorial Processes: Surface and subsurface currents, El Niño/La Niña: The variability of the equatorial currents El Niño influence global weather. (5 hours)

Text books:

- Elements of physical Oceanography by McClellan.
- Observing and forecasting of ocean waves – H.Q pub. No. 603, US Navy.
- Introduction to principles of dynamic oceanography by Neumann and Pierson

- Introductory dynamic oceanography by S. Pond and G.L. Pickard.
- Introduction to principles of dynamical oceanography by Neumann and Pierson.
- Descriptive physical oceanography by G.L. Pickard and W.J. Emery
- Oceans by Sverdrup, Johnson and Flemming
- Descriptive physical oceanography by M.P.M. Reddy

AS- 504 / OS-504: Data Processing Methods in Atmospheric and Oceanic Sciences

[Common syllabus for M Tech Atmospheric/ Oceanic Science - I semester]

DATA PROCESSING: Data presentation: Vertical profiles, Vertical sections, Horizontal maps, Map projections

STASTICAL METHODS: Sample distributions; Probability: Cumulative probability functions; Common probability density functions; Confidence intervals
Estimation methods: Minimum variance unbiased estimation, Method of moments, Maximum likelihood
Linear estimation (regression): Method of least squares, Standard error of the estimate, Multivariate regression; Relationship between regression and correlation
Hypothesis testing: Significance levels and confidence intervals for correlation, Analysis of variance and the F-distribution
Covariance and the covariance matrix: Covariance and structure functions, Multivariate distributions

THE SAPTIAL ANALYSIS:
Empirical orthogonal functions: Principal axes of a single vector time series (scatter plot), EOF computation using the scatter matrix method, EOF computation using singular value decomposition, Interpretation of EOF's, Variations on conventional EOF analysis.
Normal mode analysis: Vertical normal modes
Inverse methods: General inverse theory

TIME-SERIES ANALYSIS:
Basic concepts; Correlation functions; Fourier analysis; Spectral analysis; Autoregressive power spectral estimation, Maximum likelihood spectral estimation; Cross-spectral analysis
Wavelet analysis: The wavelet transform
Digital filters: Basic concepts, Running-mean filters, Butterworth filters, Frequency-domain (transform) filtering.

Text Books:

1. Data analysis methods in Physical Oceanography by Wiliam J. Emery and Richard E. Thomson, 1997, Pergamon Press.

2. Statistical Methods in the Atmospheric Sciences, 1995, Daniel S. Wilks, Academic Press.

AS-505/ OS-505: Geophysical Fluid Dynamics

[Common syllabus for M Tech Atmospheric/ Oceanic Science I semester]

Fundamentals: Vorticity, the circulation, Kelvin's theorem, the Taylor-Proudman theorm, geostrophic motion, consequences of the geostrophic and hydrostatic approximations

Inviscid shallow-water theory: The shallow-water equations, potential-vorticity conservation: shallow water theory, Poincare and Kelvin waves, the Rossby wave, dynamic diagnosis of the Rossby wave, the mechanism for the Rossby wave, the Beta-Plane, Rossby waves in a zonal current, energy and energy flux in Rossby waves, Rossby waves produced by an initial disturbance

Friction and viscous flow: Turbulent Reynolds stress, the Ekman layer, Ekman layer on a sloping surface, Ekman layer on a free surface, quasigeostrophic potential vorticity equation with friction and topography, the decay of a Rossby wave, the Ekman layer in a stratified fluid, Rossby waves in a stratified fluid,

Instability Theory: Instability, continuously stratified model, linear stability problem: conditions for instability, baroclinic instability: the basic mechanism, barotropic instability, instability of currents with horizontal and vertical shear, nonlinear theory of baroclinic instability

Reference:

Geophysical Fluid Dynamics: by Joseph Pedlosky, 1979

OS-506: Physics and Dynamics of the Atmosphere

Radiative transfer in the atmosphere : Fundamentals, thermal radiation, spectral composition of solar radiation, absorption spectra of atmospheric gases, equation of transfer, optically thick and thin approximations, scattering, radiative cooling rate calculations, Green house effect, the radiative heat balance of the atmosphere, earth-atmosphere system, Green house effect, radiation and cloud feed back, radiation and albedo coupling, radiation and climate.

Atmospheric Thermodynamics : First law, internal energy, heat capacities, Second law, Maxwell's relations, water-air mixture, aerological diagrams - T-Φ gram, potential temperature, Equivalent temperature, virtual temperature, thermodynamic stability.

Convection in the atmosphere : Types of clouds, Cloud microphysical processes, growth of cloud droplets, condensation, collision and coalescence, Bergeron-Findeisen theory, rain formation, cold and warm clouds, thunderstorms.

Forces governing the atmospheric motions and their classifications as body and surface forces, conservative and nonconservative forces, equation of motion, Coriolis force, equation of continuity, Hydrostatic approximation, atmospheric equations in pressure coordinate system.

Geostrophic flow, gradient flow, thermal wind equation, backing and veering of wind in relation to horizontal temperature advection , angular momentum and kinetic energy equation, total potential energy, conservation of total energy.
Circulation, vorticity, divergence and deformations; Bjerknes circulation theorems, land and sea breezes; barotropic and baroclinic atmospheres; vorticity equation; potential vorticity; divergence equation, linear and non-linear balance equations, scale analysis of vorticity and divergence equations for large and synoptic scale motions; quasi-geostrophic approximation; beta-plane approximation, Rossby waves.

Books for Study :

1. Physical Meteorology, B.J.Rettalack, WMO Compendium of Meteorology, 1973, Vol.1, No.2.
2. Physical Meteorology, H.G. Houghton, MIT Press
3. An Introduction to Dynamic Meteorology, J.R.Holton

Books for Reference :

1. Physical Meteorology, Johnson
2. Atmospheric Thermodynamics, J.V. Iribarne and W.L. Godson
3. Dynamical and Physical Meteorology, G.J.Haltiner and Martin
4. Dynamic Meteorology, B.Haurwitz
5. Dynamic Meteorology, Panchev
6. Dynamic Meteorology, Ed.Wiin Nielsen, WMO Publication

OS- 507: Ocean Resources

Earth structure and Plate tectonics: important physical parameters and properties of the planet earth; abundance of elements in the earth; primary differentiation of the earth and composition of its various zones; shape and internal structure of the earth. Uniformitarianism; mantle convection and plate tectonics; earthquakes and volcanoes; Isostasy. geological time scale. (7 hours)

Ocean Basins: Seafloor spreading and hydrothermal vents; marine sediments, their composition and uses; deep circulation. (4 hours)

Ocean Habitats and their biota: Land, biotic and mineral resources and their role in development; Biological controls on the composition of the oceans; oceanic modulation of climatic changes; estuary, bay and marine pollution. (5 hours)

Trophic dynamics of Marine Ecosystems: Ecology, ecosystem and biotic communities; carbon and nutrient cycling and food-chain; human impact on air, land, soil, water, climate and forest resources; conservation of resources; coping with natural hazards; problems of pollution and waste. (7 hours)

The physics and Biology of Upwelling water: the consequences, upwelling and sinking with special reference to the Indian ocean. Distribution and production of various species and their migration. (3 hours)

Conservation of Marine Bio-diversity and Marine habitats: Sea as a biological environment; divisions of the marine environment and their characteristics fauna and flora and their adaptations. Marine eco-systems; rocky shores, sandy shores, estuarine, mangroves and coral reefs; description of communities, community structure and function: plankton, nekton and benthos; primary, secondary and tertiary production; food web and trophic structure; living resources of the Indian seas; mariculture: culture of molluses, crustacean, fishes and seaweeds. (7 hours)

Drugs from the Oceans, their extraction and uses, Harnessing of the Ocean Thermal Energy Resource: Ocean Thermal Energy Conversion (OTEC) plants. Mineral Endowment of the Indian Ocean: nature and distribution of rocks and minerals in Indian Ocean. (11 hours)
The ocean as Waste dump: Inputs into the oceans from Land/Rivers and Pollution
Detection and Quantitative Assessment of Gas-hydrates an initiative along the continental margins of India; Non-Living Resources – Mapping and Exclusive Economic Zone of India. (6 hours)

References:

- Ocean Resources – Jenny Markert
- Managing the Ocean: Resources, Research, Law – Jacques Richardson
- Uses of the Seas – Edmund A. Gullion

OS-508 Coastal Hazards

Causes and drivers of coastal hazards – sea level fluctuations, tides, storms, tsunami & subsidence/ uplift.

Tectonic converging plates producing tsunamigenic earthquakes, tsunami and earthquake mechanism in island arc regions, Tsunami propagation – Tsunami propagation in deep ocean, offshore regions, tsunami travel time, tsunami wave generation mechanism; frequency of tsunami occurrence, Available warning times to most populated areas. Importance of initial conditions, Importance of boundary reflections. Initial withdrawal of the ocean, coastal inundation.

Studies of individual tsunamis and tsunamigenic earthquakes, impact of tsunamis on structures, socio-economic effects of tsunami, Vulnerability of Indian coastline to tsunami threat, tsunami threats in Indian ocean – 2004 Indian Ocean tsunami,

Storm surges – effect of tides on storm surges, inverse barometric effect, coastal submergence and inundation, measuring surge, estimation of wave climate, hindrance to navigation.

Marine pollution – distribution and dispersion of pollutants, flushing time, oil spills, impact of coastal pollution on marine environment.

Sea level rise, erosion, seiches, rip currents.

Coastal hazard effects on different coastline types. Socio –economic importance of coastal hazards.

Mitigating coastal hazards - methods for forecasting tsunami, Indian tsunami warning system. Cyclone tracking and storm surge alarms, deactivating marine pollutants, hind casting waves, identification of rip current zone. Preventive measures of coastal erosion.

Text Books:

Coastal Hazards: perception, susceptibility and mitigation (1994) – By Charles W. Finkl, Coastal Education & Research Foundation (U.S.)

Natural and man made coastal hazards (1989) – Salvador F. Farreras and G. Pararas Carayannis

Reference:

S.K. Dube, "Air-Sea –Land Interactions with Special Emphasis on Coastal Marine Hazards" Edited by Harsh K. Gupta, Oceanology, Universities Press, 2005

Practicals

AS-509/ OS-509:

Part A: Atmospheric Science Computations

1. Calculation of horizontal divergence, absolute vorticity from wind data- Irregular spaced points, regular grid points.
2. Calculation of geostrophic wind and gradient wind.
3. Calculation of vertical velocity – Triangular, quadratic, regular spaced data.
4. T - Φ gram analysis: analysis of aerological data
   Lifting condensation level
   Equilibrium level
   Stability indices
   CAPE & CIN
5. Elsasser's Radiation chart: Flux determination

Part B: Oceanic Science Computations

1. Determination of Density and Specific volume anamoly.
2. Identification of upwelling and downwelling patterns
3. Computation of relative currents
4. Stability characteristics of water column and Richardson number
5. Estimation of tides
6. Preparation of T-S Diagram

AS-510 / OS-510:

PART A: Observation Techniques

1. Measurement of temperature, pressure, humidity, wind and precipitation
2. Measurement of Solar radiation and duration of sunshine.
3. Measurement of Aerosol Optical depth, Total columnar ozone and precipitable water vapour.
4. Estimation of upper wind from Pilot balloon observation.
5. Estimation of cloud cover.
6. Measurement of sea surface temperature and salinity and marine meteorological parameters.
7. Measurement of Ocean currents.
8. Measurement of Ocean depth.
9. Study of rainfall using Doppler Radar Reflectivity.
10. Study of upper winds using velocity product of Doppler Radar.
11. Identification of sea breeze setting time & Land breeze setting time using velocity product of Doppler Radar.

PART B : Ocean-Atmosphere Interaction

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 Latent Heat Flux at the Ocean surface-
   with variable coefficient of Ce
4. Computation of sensible heat flux at the ocean surface-
   with variable coefficient of Ch
5. Computation of Atmospheric Heat Budget.
6. Computation of Wind Stress at the ocean surface-
   with variable coefficient of Cd
7. Wind curl – Ekman transport
8. Computation of upper ocean heat content

OS-511: Viva-voce

M. Tech. Oceanic Science

Syllabi for I year – Second Semester

OS-512 Ocean Acoustics

Physics of sound in the Sea; Theory of sound transmission: Basic Concepts.
The acoustic properties of the sea, acoustic intensity and power. Basics of propagation losses, causes of absorption.
Physical characteristics of the sea – related to sound transmission; Density, temperature, salinity, temperature gradients, absorption, scattering, attenuation.
Sound velocity in the ocean – velocity models, variation with temperature, salinity and pressure. Sound velocity measurements, depth – velocity profiles.
Shadow zones, Surface Duct, Deep sound channels, Caustics and convergence zones, Shallow water ducts.
Conditions of sound transition - Boundary conditions: sea surface, sea bottom.
Reflection and refraction of plane waves, forward scattering and reflection loss, image interference and frequency effects, bubble layers, multi-paths in the sea, reliable acoustic path, sea surface, volume and sea floor reverberation, Deep Scattering Layer (DSL)and ambient noise in the sea.
Theory of sound propagation in the sea, wave equation – Normal mode theory, and Ray theory, parabolic equation models, three dimensional modeling, basic concepts of noise and reverberation modeling, acoustic daylight ocean noise imaging techniques. (15 hours)

The significance of hydro acoustical processes in the sea, Inverse methods for reflector mapping and sound speed profiling.
The sonar Equations – Transmission loss
The application of under water acoustics:Military applications, Civilian applications, Research applications, ocean acoustic tomography, Internal wave and their impact on sound propagation, climate change. (10 hours)

Basics in Geoacoustics: surface and sub-bottom sediment characteristics and their effects in underwater acoustics, core parameters in geoacoustics and their relative contributions, sediment classification along east and west coast of India, sediment transport rates in surf zone, seasonal variations of surface sediment characteristics along the coastal zone, effect of suspended sediments in the littoral zone, concept of geoacoustic modeling.
Acoustic probing: space and temporal scales in the Ocean, Coastal oceanography and littoral warfare, estimation and future directions of underwater detection. (15 hours)

Reference:

1. Introduction to the theory of sound transmission with Application to Ocean – OFFICER C. B; 1958
2. Under water sound – Albers V. M. (ed); 1972
3. Principles of underwater sound – URICK R. J; 1975
4. Acoustical Oceanography – Principles and Applications – Clay C. S; Medwin H; 1977

5. Fundamentals of Marine Acoustics – Jerald W. Caruthers; 1977
6. Ocean Acoustics; Topics in current physics – J. A. DeSanto; 1979

OS – 513: Ocean Dynamics and Modeling

Physics of ocean modeling, Lagrangian and Eularian approaches in modeling, diagnostic models, prognostic models, model domain, model initialization and model forcing, sub grid scale parameters. (10 hours)

Simple discretization of linear advection equation, analysis of numerical results, dissipation and dispersion, introduction to finite element methods, higher order methods, boundary value problems, primitive equation models, general circulation models, shallow water models. (10 hours)

Discrete methods for shallow water equations, special consideration for non-linear problems, conservation laws and conservative difference schemes, finite element methods in two space dimensions, open boundary conditions. (11 hours)

Numerical Models:
Mechananistic models, simulation models,
Global ocean Models:
Modular Ocean Model (MOM), Parallel Ocean Model (POM), Regional Oceanic Modeling Systems (ROMS).
Coastal Models:
Princeton Ocean model, Storm surge models,
SLOSH – Sea level & Over land surge assimilation model
Coupled Ocean and Atmospheric model
Princeton coupled model
Climate system model

(13 hours)

Indian Ocean boundary conditions, model forcing conditions over Indian ocean, status of operation models in Indian Ocean.
(7 hours)

References:

Numerical modeling of ocean circulation – Robert N. Miller
Numerical methods for ocean circulation – Pond S. and Bryan
Circulation models of lakes and inland seas – T.J. Simons

AS/OS-514 Synoptic Meteorology and Monsoon Dynamics

[Common syllabus with M Tech Atmospheric Science II semester]

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, Weather charts.
Air masses and fronts: Air mass production – Classification – Sources of air masses in winter and summer and their modification. Fronts and frontal surfaces – Principal frontal zones –frontogenesis and frontolysis. Extra-tropical cyclones- formation – Life cycle – Structure and movement. Anticyclones and blocking. Heat and cold waves.

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.
Kinematics of the wind field: Relation between streamlines and trajectories. Trajectories in moving cyclones and anticyclones. Differential properties of the wind field. Application of geostrophic, gradient, thermal winds, divergence and vertical velocity computations.

Global Jet streams and their characteristics.
Indian monsoon: Land and sea breezes – Definition of monsoon – Synoptic features associated with onset, withdrawal, active and break monsoon situations. Rainfall distribution and rain bearing systems during summer monsoon season - monsoon depression, Mid-tropospheric cyclones and Onset vortex. Winter monsoon.

Seasonal prediction of onset and rainfall of summer monsoon: Multiple Regression models, ARIMA model etc.
Prediction of weather elements: Maximum and minimum temperatures – Fog – Hail storm.
Aviation Meteorology: Meteorological hazards to aviation – Take-off, landing, in-flight, - Icing, turbulence, CAT, SIGMET, visibility and fog.

Text Books:

1. Weather analysis and forecasting – Vol.1 & 2 by B. Patterson, Mc Graw Hill Book Company, 1956.
2. Climate and Weather in the Tropics - H. Riehl, Academic Press, INC Ltd., 1979.
3. Climate and circulation of the tropics - S. Hasternath, 1985.
4. Tropical Meteorology – Vol. 1 & 2 by G.C.Asnani, 1993.
5. Atmospheric Circulation Systems - E. Palmen and C.W.Newton, Academic Press, 1969.
6. Monsoon Dynamics - T.N. Krishnamurthi, 1978.

Reference:

1. Monsoon meteorology - C.S. Ramage
2. Jet stream meteorology - E.R. Reiter

OS–515 Remote Sensing and Satellite Oceanography

Remote sensing systems:
History of Evolution of Meteorological/Oceanography satellites
Principles of Remote Sensing, Components of a remote sensing system
Radiative transfer: Basic quantities, black body radiation, The Plank Function, Non black bodies, The Radiative Transfer equation.
Gaseous absorption, scattering, clouds, surface reflection/emission, solar radiation.
Classification of remote sensing systems
Satellite orbits – Newton's law of motion, Keplarian orbits, Kepler's equation, orientation in space, orbital elements, orbit perturbations, sun synchronous orbits, Geo stationary orbits, polar orbits, low inclination orbits, Molniya orbit. Data dissemination.
SEASAT, NOAA series and other satellites
Indian remote sensing satellites related to Meteorology & Oceanographic parameters, INSAT, Ocean sat and future programmes. (8 hours)

Remote sensing of the sea:
Space and time scales in Satellite Oceanography
Information for ocean remote sensing and general information on sensor calibration
Atmospheric correction
Position registration
Oceanographic sampling of sea truth
Ocean properties using Remote Sensing data
Passive and Active sensors (8 hours)

Passive Sensors : Ocean color, VIS & IR radiometers,
Optical theory for ocean color remote sensing, recovering useful information from ocean color coastal zone color scanner, sea viewing wide field of view sensor. Biological studies

Physical principles of IR radiometers
Infrared measurement of sea surface temperature and validation
Interpretation of SST
Advanced Very High Resolution Radiometer – applications, Potential uses of SST data
Atmospheric IR sounder (AIRS)

Microwave radiometers:
Physical principles of passive microwave radiometers
Thermal emissions in the microwave
The radiation received by satellite antenna
Applications of passive microwave data

Potential applications
Advanced microwave scanning radiometer AMSR

Sea Surface Salinity program (10 hours)

Physical principles of active sensors
Scatterometry :
Radars, Radar reflection from sea surface
Back scatter cross - section
Specular reflection & scattering
Resonant Bragg's Scattering
Polarization
sea surface roughness and $\sigma_{o,}$ dependence of σ_o on surface winds and scatterometry:
Retrieving wind vector from scatterometer measurements
Scatterometer applications
QUIKSCAT

Radar altimeters over the ocean:
Distance measurement with a radar altimeter
Corrections for atmospheric transmission
Establishing the grid datum
Applications of altimetry; sea surface height, Tides, Geostrophic circulation

Synthetic Aperture Radar (SAR) imaging of the ocean:

SAR imaging of ocean waves
Internal waves imaged by SAR
Shallow sea bathymetry measured from SAR images

Remote sensing and GIS applications:
Geographic information system application in coastal zone management
Remote sensing and GIS applications in coastal processes (10 hours)

Ocean Prediction and Advisory Servises:
Air Sea interaction studies using satellite data
Potential Fishing Zone Advisory Services (4 hours)

Reference:

1. Measuring the Oceans from Space by Ian S. Robinson, 2004.

2. Satellite Meteorology an Introduction by Stanley Q. Kidder and Thomsas H. Vonder Haar, 1995.

3. Lecture Notes for Post Graduate Course on Satellite Meteorology and Global Climate, Vols.1,2 and 3. ISRO Publications, 1998, 2002

4. Fundamentals of Remote Sensing by George Joseph, 2003.

OS – 516: Coastal processes and Coastal Zone Management

Coastal Hydraulics: Wave theory including phenomena such as shoaling, refraction, diffraction, reflection, and wave breaking. Statistical wave theory and estimation of waves generated by wind. Nearshore currents and water level variations together with their causes. Forces on structures due to breaking and non-breaking waves. Planning and design of nearshore structures. (17 hours)

Coastal Sediment Transport: Basic sediment transport processes, morphologic response, alongshore transport, cross-shore transport. (8 hours)

Beaches: Beach profiles, sediment erosion and deposition, rate of sediment transport. Beach shape, Coastal features; longshore bars, swash bars, sand spits, atolls; minor beach forms and Artificial beach nourishment. (8 hours)

Coastal Management: Integrated coastal zone management issues, GIS, coastal classification, coastal protection strategies, design aspects of coastal protection, coastal protection measures. (17 hours)

Textbooks:

- Coastal Engineering by Kiyoshi Horikawa
- Beach processes and sedimentation by P.D. Komar
- Beaches and coasts by C.A.M. King
- Integrated Coastal and Ocean Management by Cicin-Sain & Knecht.
- An Introduction to Coastal Zone Management by Beatley, Brower & Schwab.
- Introduction to GIS, New York: Hawthorne and Sons, by Inc. Sibold, Robert.
- An Introduction to Coastal Zone Management by Timothy Beatley
- Integrated Coastal and Ocean Management . by Biliana Cicin Sain

Practicals

OS-517:

Part A: Synoptic Analysis

1. Plotting surface and upper air data
2. Analysis of mean climatic data; Pressure, Temperature, Rain Rainy-days, Fog and Thunderstorms representative of winter
3. Analysis of mean climatic data; Pressure, Temperature, Rain, Rainy-days, Fog and thunderstorms representative of summer.
4. Analysis of surface and upper-air charts - Monsoon depressions
5. Analysis of surface and upper-air charts - Tropical Cyclones
6. Analysis of surface and upper-air charts - Western disturbances
7. Analysis of surface and upper-air charts - Break monsoon
8. Analysis of surface and upper-air charts - Active monsoon
9. Analysis of thermodynamic diagram (T- ø diagram)
10. Time and cross sections

Part B: Satellite Oceanography

1. Image Processing Techniques
2. Objective analysis of satellite derived fields
3. INSAT –VHRR cloud characteristics- Feature extractions and Applications
4. NOAA-AVHRR Data processing - Feature extractions and Applications
5. Retrieval of Sea State parameters
    i. Sea Surface Temperature
    ii. Ocean surface wind vector from Scatterometer
    iii. Shallow water Bathymetry
    iv. Sea surface height signals from altimeter data
    v. Ocean colour and PFZ
6. Coastal processes & GIS Applications

OS-518:

Part A: Ocean Acoustics

1. Deep water column; spatial and temporal variability/distribution of sound velocity, SOFAR channel axis depth, channel velocity, conjugate depth and its velocity.
2. Shallow water; Spatial and temporal variability/distribution of subsurface duct parameters. Viz., critical angle, limiting angle, sonic layer depth (SLD), Transmission loss/ intensity etc.,
3. Identification and modeling of internal waves
4. Computation of intensity/transmission loss using Ray and Normal mode theory, and PE method; data source: In situ data sets, Lavitus, ARGO, and Satellite data.
5. Estimation of Barrier Layer from ARGO profile data
6. Computation of wave energy using significant wave height, density and gravity
7. Sound speed computations from hydrographic data.
8. Ray path computations.
9. Computation of Acoustic Intensity.
10. Preparation of maps of sound channel axis.

Part B: Coastal Oceanography

1. Wave Data Analysis - Rose Diagrams
2. Computation of Long shore Currents
3. Water Level Measurements in Estuary
4. Measurement of Tidal Currents
5. wave refraction diagram
6. Wave Forecasting Methods
7. Analysis of sea level data

OS-519: Viva-voce

III and IV Semesters

OS-520: Internship
OS-521: Dissertation
OS-522: Seminar
OS-523: Viva-voce